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# Interplay Between Carbon Trading and Supply Chain Management: A Case Study of the Taiwan Carbon Exchange

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## Abstract

This study conducts an in-depth examination of the Taiwan Carbon Exchange through a case study approach, employing diverse research methods such as data collection, corporate interviews, analysis, and the utilization of questionnaires to gain insights into its operational model and broader impact on the carbon market. Corporate interviews yield firsthand insights and opinions from key industry stakeholders, while questionnaires ensure a broader participant base, fostering a more diverse range of opinions and data. Focusing on the carbon exchange as the subject of research allows for a thorough analysis of Taiwan's practicalities in carbon trading. The empirical information gathered strengthens the study's conclusions and enhances their reliability. This research aims to provide a comprehensive understanding of the carbon exchange's operational framework, its influence on the carbon market, and the future trajectory of Taiwan's carbon trading development.

**Keywords:** Carbon Exchange, Environmental Sustainability, Emission Rights, Taiwan Carbon Market Climate Change

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## Introduction

Climate change and carbon emissions

Climate change stands as one of the most pressing global challenges, transcending geographical and industrial boundaries with its profound impacts. Scientific evidence unequivocally attributes the escalating planetary temperatures to the substantial release of greenhouse gases, particularly carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), stemming from human activities. This has induced a greenhouse effect, resulting in detrimental consequences such as extreme weather events—storms, floods, and droughts - that pose severe threats to ecosystems, economies, and societies (Hansen et al., 2013)

The Kyoto Protocol, established in 1997, aimed to curb greenhouse gas emissions from industrialized and transitioning economies by setting individual targets. It introduced three carbon trading market mechanisms: the Clean Development Mechanism, International Emissions Trading, and Common Reduction Mechanism. (Hepburn, 2007). Subsequently, the Paris Agreement, adopted in 2015, became a legally binding treaty necessitating the creation of new rules for carbon markets. Article 6 of the agreement outlines how countries can collaborate through the international carbon market to meet emission reduction goals (Falkner, 2016).

Human industrial activities, energy use, and transportation are the primary sources of carbon emissions, particularly from the combustion of fossil fuels. Carbon dioxide, a byproduct of this process, intensifies global warming, contributes to rising sea levels, and fuels frequent extreme weather events. Mitigating carbon emissions has evolved into a collective responsibility, integral to achieving sustainable development goals (Kharecha et al.,2013).

Addressing this challenge mandates coordinated global efforts. Governments must formulate effective policies to propel the shift toward a low-carbon economy, with active participation from companies in supply chain management playing a pivotal role. Implementing a carbon trading scheme serves as a financial incentive for companies to adopt cleaner and more sustainable practices, thereby reducing their carbon footprint. The establishment of the Taiwan Carbon Exchange stands as a significant stride in this direction, serving as an illustrative model. It offers insights into the symbiotic relationship between carbon trading and supply chain management to combat climate change, providing valuable references and inspiration for global regions grappling with similar challenges (Wang et al., 2019).

The rise of the global carbon market

The Urgency of Establishing an Efficient Voluntary Carbon Market in the Face of Climate Change

The urgency of addressing climate change necessitates the prompt establishment of a robust carbon market, serving as a pivotal tool in accelerating global efforts to combat rising temperatures. As the imperative to curb global warming intensifies, the creation of an efficient voluntary carbon market emerges as a crucial stride towards achieving net-zero emissions.

Distinguishing between compliance markets and voluntary markets, the former entails government-regulated emissions trading schemes, allocating carbon allowances to companies. Conversely, voluntary carbon markets focus on financing initiatives that diminish greenhouse gas emissions. Participants in this market can procure carbon credits from sellers to offset their emissions (Ahonen et al., 2022).

The significance of a carbon market stems from the Paris Agreement's mandate to limit global warming to below 1.5°C. Meeting this target necessitates a 45% reduction in greenhouse gas emissions by 2030 and achieving net-zero emissions by 2050. Despite this imperative, current emission levels indicate a substantial gap in reaching the 2050 net-zero target. In the pursuit of decarbonizing the climate value chain, establishing an efficient voluntary carbon market becomes a crucial step in attaining the net-zero emissions goal. Through the avoidance and elimination of emissions, carbon markets play a pivotal role in reducing net emissions. Companies can draw guidance from the Emissions Exchange's Net Zero Guidelines, providing a roadmap with key steps essential for achieving global net-zero targets (Fankhauser et al., 2022).

Significance of Investigating Carbon Trading and its Impact on Supply Chain Management

In the past, there was limited public awareness regarding the intricacies of carbon trading, particularly within the realm of supply chain management. For professionals in both practical and theoretical aspects of supply chain management, delving into comprehensive discussions and analyses of these subjects is paramount to enhancing their expertise and practical skills. The establishment of the Taiwan Carbon Exchange presents a unique opportunity to delve deeper into research and discussions surrounding carbon trading and its intersection with supply chain management.

Carbon trading is a nuanced domain encompassing intricate mechanisms and policies, necessitating a thorough understanding of its processes and content. Principally, two types of carbon trading exist: compliant markets and voluntary markets. Government-regulated compliance markets involve the issuance of carbon allowances to companies, with the government overseeing and facilitating the trading of carbon emissions. In contrast, voluntary markets primarily serve to finance activities that mitigate greenhouse gas emissions, allowing participants to acquire carbon credits for offsetting their emissions.

For supply chain managers, a comprehensive grasp of carbon trading content becomes instrumental in aiding companies to adeptly navigate the challenges posed by climate change. Participation in carbon trading enables companies to align with environmental objectives by curbing their carbon footprint, all while reaping corresponding economic incentives. This underscores the necessity for supply chain management to prioritize the assessment, monitoring, and reduction of carbon emissions, ensuring active company engagement in the carbon market. Consequently, through in-depth discussions and analyses centered around the establishment of the Taiwan Carbon Exchange, a clearer comprehension of the impact and challenges of carbon trading on supply chain management emerges. This endeavor not only contributes to academic research but also furnishes practical guidance and insights for supply chain managers in real-world applications.

## Research Objectives

1. Amidst the establishment of the Taiwan Carbon Exchange, what strategies should supply chain managers adopt to comprehend and navigate the intricate mechanisms and policies of carbon trading, enhancing both the environmental efficiency and economic benefits of enterprises?

2. What delineates the characteristics and roles of the compliance market and voluntary market within the realm of carbon trading? Furthermore, how do firms' engagements in these markets differ in terms of impact on supply chain management and overall firm performance?

3. Within the landscape of carbon trading mechanisms, with a specific focus on voluntary carbon markets, how can supply chain management achieve a symbiotic relationship between carbon emission reduction and economic incentives? What exemplifies best practices and strategies that companies can adopt to align with global net-zero emission targets?

## Research Questions

1. Supply Chain Strategies: How can managers balance environmental efficiency and economic benefits in navigating carbon trading within the Taiwan Carbon Exchange?
2. Market Impact: What sets compliance and voluntary carbon markets apart, and how do they influence supply chain management and overall firm performance?
3. Sustainable Practices: In carbon trading mechanisms, particularly voluntary markets, how can supply chain management harmonize carbon reduction with economic incentives and adopt strategies for global net-zero emission targets?

## Literature Review

Carbon trading concepts and principles

Basic concepts of carbon trading

Carbon Emission Reduction. Targets To achieve carbon neutrality, various carbon pricing mechanisms such as carbon credits, taxes, or fees are implemented to incentivize enterprises to curtail carbon emissions. Companies are required not only to conduct comprehensive carbon inventories, devise pathways towards net-zero emissions, and embrace green energy but also to actively minimize their greenhouse gas emissions. For sectors facing challenges in immediate emission reduction, the acquisition of carbon credits and offsetting emissions play a pivotal role until technological advancements allow for more sustainable practices (Newel et al., 2013).

Carbon Trading Strategies. In the realm of carbon trading, two distinct categories emerge voluntary reduction quota trading and incremental offset trading. Enterprises holding surplus carbon credits can opt to sell them to buyers in need through the carbon exchange. Voluntary Reduction Quota Trading: This involves enterprises voluntarily adopting measures for emission reduction within the bounds of non-mandatory legal provisions. By proactively reducing emissions, companies earn carbon credits and position themselves as suppliers within the carbon trading market. Incremental Offset Trading: Compliant with EPA regulations, incremental offsets pertain to greenhouse gas emission reductions undertaken by development units. These offsets encompass various strategies, such as transitioning to natural gas, biogas, or biomass instead of coal or oil-fired equipment, utilizing greenhouse gas recovery and reuse technologies, and upgrading or replacing existing boilers. This approach aims to incentivize companies to invest in environmental protection and technological innovation, fostering more efficient greenhouse gas reductions.

Carbon Pricing Strategies. Carbon pricing involves incorporating carbon emissions into the economic system and using pricing mechanisms to drive the reduction of greenhouse gas emissions. Various practices fall under carbon pricing, namely carbon trading, carbon tax, and carbon fee (Narasimhan et al., 2018). Carbon

Trading: Facilitated through the carbon trading market, enterprises engage in buying and selling carbon credits, with prices subject to market supply and demand fluctuations. This dynamic pricing encourages companies to actively partake in emission reduction activities, offering economic incentives within the market mechanism.

1) Carbon Tax: In this approach, the government imposes a fixed-price tax on each unit of carbon emissions. The collection of carbon tax falls under the purview of financial authorities, and the generated revenue may be allocated to diverse purposes, including social welfare, income tax reduction, and the development of low-carbon infrastructure.

2) Carbon Fee: Resembling a carbon tax, the carbon fee's price may vary based on environmental policy adjustments. As proposed in Taiwan's amendment, the carbon fee, overseen by the Environmental Protection Agency, will be collected from major carbon emitters. The collected funds will contribute to a climate fund supporting low-carbon initiatives, green energy, and subsidizing industrial transformation.

Whether through carbon trading, carbon tax, or carbon fee, their shared objective is to economically incentivize companies, integrating carbon emissions into the economic system to achieve substantial reductions in greenhouse gas emissions. This pricing approach is widely recognized as the most effective tool for carbon reduction, collectively known as carbon pricing (Steinebach et al., 2021).

**Table 1** Comparison of carbon pricing methods

| Carbon Pricing | peculiarity | channel | Actuator | use |
|---|---|---|---|---|
| Carbon trading | Prices fluctuate with the market | Carbon trading market | Government, carbon exchange | Carbon trading, voluntary reduction and incremental offsetting by enterprises |
| Carbon tax, carbon fee | Fixed price | Determined by the government | government | Tax purposes include social welfare, income tax reduction, and the development of low-carbon infrastructure |
| Carbon fee | Variable price | EPD | EPD | It will be used to develop low-carbon, green energy, and subsidize industrial transformation |

Models of the Carbon Trading Market

Table 2 offers a comparative analysis of various carbon credit generation methods, enhancing comprehension of the distinctive characteristics and providing illustrative examples for each method

**Table 2** Carbon credit generation mode

| How it is generated | peculiarity | channel | Actuator | example |
|---|---|---|---|---|
| Cap control and trading | From mandatory control, the government sets a cap on the total amount of emissions, and enterprises need to buy carbon credits if they exceed the quota, and if the emissions of enterprises are less than the quota, they can be converted into carbon credits and sold. | government, carbon trading market | EU carbon trading market, US RGGI, South Korea | Tesla sells carbon rights to gasoline car manufacturers |
| Voluntary carbon markets | Enterprises take the initiative to obtain carbon credits through carbon reduction, renewable energy and other projects, which can be sold or exchanged in the voluntary market. | Gold Standard, VCS, Taiwan Environmental Protection Agency's reduction and offset management mechanism | International agencies, Environmental Protection Agency | Companies earn carbon credits by supporting emission reduction programs, which can be used for carbon offsets. |

Economic Benefits of Carbon Trading

Research on carbon trading indicates the successful outcomes of both the Regional Greenhouse Gas Initiative (RGGI) and EU Emissions Trading System (EU ETS) in emission reduction (Van Den Berg et al., 2014). The EU ETS, in particular, has not only facilitated an eco-friendly technological transition but has also demonstrated no adverse effects on economic performance (Zhang et al., 2020).

Challenging the conventional wisdom that the means to solve a problem cannot be the culprit, carbon trading introduces a counter-intuitive perspective. It views the factors contributing to the problem as potential solutions. This approach, exemplified by carbon trading, presents an innovative method of addressing environmental issues through capitalist means. According to a 2016 World Bank analysis, as of May 1, 2016, 90 countries were planning to implement emissions trading schemes, carbon taxes, or other policies to price carbon, indicating a global shift towards recognizing the cost of carbon emissions. With 17 existing emissions trading schemes worldwide and potential establishment of 13 more in the future, the scope of global carbon emission control is expected to widen. Emissions Trading Schemes (ETS) will emerge as a crucial policy tool for greenhouse gas management, fostering the rapid development of the corresponding carbon trading market.

ETS not only aids in reducing greenhouse gas emissions but also opens up new opportunities in green businesses. This mechanism attains emission reduction targets through commercial avenues, allowing companies to engage in buying and selling emission quantities on trading platforms. This, in turn, encourages

industry players to invest in and develop carbon reduction technologies, creating a positive cycle. Consequently, ETS not only accomplishes emission reduction goals but also propels the advancement of related technology industries.

Supply Chain Management and Carbon Footprint

Fundamentals of Supply Chain Management

At its core, Supply Chain Management (SCM) entails the comprehensive oversight of goods, data, and financial processes associated with products or services, spanning from raw material procurement to final product delivery. While some may consider the supply chain synonymous with logistics, logistics constitutes just one facet of the broader supply chain.

Introduced by American management scientist Michael Porter in 1985, supply chain management is a strategic concept with various definitions. As a strategic concept, SCM seamlessly integrates the entire spectrum of corporate activities, from raw material procurement to end-customer sales, leveraging corresponding information systems and computer management technology.

SCM involves the holistic management of material (product) flow, information flow, and capital flow, constituting a vital aspect of enterprise operational management. It typically encompasses procurement, manufacturing, logistics, and supply chain planning, along with relevant information analysis and financial management. With the evolution of economic globalization, the domain and scope of supply chain management have expanded to encompass international logistics, production outsourcing, strategic procurement, and more. This expansion aligns with a focus on global market industry operations, value chain management, and associated risk and sustainability considerations (Lee, 2011).

Quantifying Carbon Emissions

A carbon footprint signifies the volume of greenhouse gas emissions attributed to a specific individual, organization, product, or activity. Human activities, ranging from food cultivation and transportation to household electricity use, contribute to varying degrees of greenhouse gas emissions. Typically expressed as the amount of carbon dioxide per unit, examples include an individual's daily carbon footprint of 30 kilograms of carbon dioxide, Google's 2022 carbon footprint of 10.2 million tons of carbon dioxide, a Renouvo sugarcane straw with a carbon footprint of 2.83 grams of carbon dioxide, or a flight from London Heathrow Airport to New York JFK with a carbon footprint of 0.9 metric tons of carbon dioxide (Ou et al., 2013).

Calculating a carbon footprint is intricate due to numerous indirect emissions, alongside direct emissions and electricity usage. Individuals often use online calculation software to estimate average values. Meanwhile, businesses adhere to ISO14064 criteria for organizational carbon footprint calculations, ensuring a credible representation of the carbon footprint's boundary range, emission sources, activity data, and emission factors. Complying with ISO14064 standards allows organizations to disclose carbon footprint information through Environmental, Social, and Governance (ESG) reports.

To assess a product's carbon footprint, ISO14067 criteria are employed. This standard evaluates the complete product life cycle, encompassing raw material acquisition, manufacturing, transportation, product use, and end-of-life disposal. The resulting carbon footprint data, endorsed by carbon label approval organizations globally, provides a comprehensive understanding of a product's environmental impact ( Lacoste, et al., 2019).

Carbon Footprint Reduction Strategies

Addressing and mitigating one's carbon footprint is a vital concern that warrants universal attention. While global leaders are tasked with comprehensive climate change initiatives, individual daily actions significantly contribute to environmental impact. Several strategies empower individuals to diminish their carbon footprint, including maintaining energy-efficient homes, minimizing food waste, adopting a plant-centric diet, reducing driving and air travel, and practicing mindful consumption habits. Despite these changes appearing modest, collective efforts yield positive environmental and climate benefits (Zheng & Suh, 2019).

Carbon Neutrality and Supply Chain Sustainability

The United Nations Global Compact (UNGC) underscores the formidable challenge businesses face in transitioning toward sustainability, particularly concerning the intricate nature of supply chains. While setting carbon neutrality and net-zero emission goals is not inherently difficult, the true challenge lies in translating these commitments into tangible actions. Managing supply chain emissions is a hurdle not exclusive to large corporations; it is equally critical for small and medium-sized enterprises (SMEs), comprising 90% of the global business population, to comprehend and implement sustainable practices. As 80% of corporate carbon emissions emanate from the supply chain, driving decarbonization within this framework becomes a pivotal concern (Zhang et al., 2023).

In industries such as cement and steel, where emissions primarily stem from the manufacturing process, the urgency to prompt supply chain decarbonization may be less pronounced. Here, a priority strategy involves reducing internal emissions and embracing renewable energy. Conversely, sectors like food, information technology, healthcare, or financial services attribute emissions mainly to "purchased products and services" and "investment." The former entails raw material procurement, presenting opportunities for emission reduction through material redesign or transitioning to recycled alternatives. The latter emphasizes incorporating sustainability performance into lending criteria within the financial industry, making it challenging for underperforming companies to secure funding.

Industries dealing with non-consumable products like oil, gas, and metals contribute significantly to Scope 3 emissions due to the substantial carbon output during the "processing of sold products" and "use of sold products," both falling under Scope 3 classifications.

## Research Methods

This study adopts a case study approach to conduct an in-depth examination of the Taiwan Carbon Exchange. Employing a diverse set of research methods, including data collection, analysis, and corporate interviews, as well as questionnaire surveys with response statistics, the research aims to present a comprehensive understanding of the exchange's operations and its impact on the carbon market. Corporate interviews serve as a valuable source of firsthand insights from industry stakeholders, ensuring a practical perspective, while questionnaires broaden the participation base, capturing diverse opinions and data. Focusing on the Taiwan Carbon Exchange as the research subject facilitates a thorough analysis of the country's carbon trading landscape. The incorporation of empirical information enhances the reliability of research conclusions, providing robust support for the study's findings.

## Results and Discussion

Establishment of the Taiwan Carbon Exchange

Historical Context

The official establishment of the Taiwan Carbon Exchange on August 7, 2023, marks a significant milestone for Taiwan in confronting the challenges posed by climate change. It stands as a pivotal component of Taiwan's commitment to align with the global net-zero goal. In the face of increasing global awareness of climate change threats, carbon trading markets have emerged as vital tools for addressing environmental concerns. Notably, various Asian countries, including China, Japan, South Korea, and Singapore, have already implemented their carbon exchanges. The European Union's Emissions Trading System (EU-ETS) has been in operation since 2005, the United States has its carbon trading system, and Southeast Asian nations are actively considering carbon trading in their policy frameworks. Taiwan's establishment of a carbon exchange signifies a positive stride in enhancing its emission reduction infrastructure, aligning with international standards, and progressing towards the adoption of a comprehensive carbon trading market mechanism (Lee, 2023).

Purpose and Positioning of the Establishment

The inception of the Taiwan Carbon Exchange serves a dual purpose, not only fostering international trade relations for Taiwan but also positioning the nation as an active participant in global climate risk management. Beyond these diplomatic and environmental considerations, the establishment of the Taiwan Carbon Exchange acts as a catalyst for enterprises to embrace low-carbon practices, propelling them toward accelerated sustainable development. By engaging in meticulous methodological demonstrations on both domestic and international fronts, companies can augment their carbon credits. This can be achieved through the implementation of technological solutions aimed at reducing or sequestering greenhouse gases, leveraging natural carbon sinks to mitigate or eliminate greenhouse gases, and influencing behavioral changes. Beyond serving internal consumption needs, businesses can further capitalize on their sustainability endeavors by entering the trading market, thus turning their environmental commitments into profitable ventures (Lin et al., 2015).

Modes and Mechanisms of Operation

1. Emission Rights Allocation.

Within an emissions trading scheme, a central authority or government agency takes charge of allocating or selling a predetermined quantity ("cap") of permits, each granting the holder the right to emit a specific amount of a particular pollutant over a defined timeframe. Emitters are obligated to possess permits corresponding to their actual emissions. Those seeking to increase their emissions must acquire additional permits from willing sellers. Furthermore, financial derivatives related to these emission quotas can be actively traded on the secondary market (Pan et al., 2014).

Emissions trading represents a flexible approach to environmental regulation, allowing organizations and markets the autonomy to determine optimal strategies for achieving policy objectives. This stands in contrast to more prescriptive environmental regulations like Best Available Technology (BAT) standards and government subsidies. Many economists endorse emissions trading as an efficient and effective policy tool for curbing pollutant emissions.

2. Market Trading Rules and Establishing a Carbon Trading Mechanism

The market trading mechanism of carbon credits is as follows.

**Table 3** Comparison of carbon trading mechanisms

| Carbon trading mechanism | introduce |
|---|---|
| Carbon credits | Carbon rights refer to the right to carbon emissions, and its design mechanism is derived from the concept of carbon pricing, which is based on 1 ton of carbon emissions. Companies and countries can calculate the total amount of carbon reduction based on this unit, which will gradually develop into a tradable product after the signing of the Kyoto Protocol. The government or private units can buy and sell carbon credits as carbon offsets. |
| Mandatory carbon market | Mandatory carbon markets to implement total carbon emission controls, such as EU countries, New Zealand and other countries. The amount of carbon emitted by enterprises is subject to a cap and cannot be infinitely emitted. Enterprises are committed to carbon reduction, so that carbon emissions are below the upper limit, so that carbon credits can be sold to other enterprises. If an enterprise's carbon emissions exceed the cap, it must purchase excess carbon credits from other enterprises to achieve the carbon reduction target. |
| Voluntary carbon markets | The voluntary carbon market is a voluntary carbon market for enterprises to take the initiative to reduce carbon emissions and capture carbon emissions, such as using renewable energy, investing in afforestation, etc. After the implementation of carbon reduction projects, enterprises apply for certification from international carbon reduction verification agencies and obtain carbon rights. It is an uncapped and non-mandatory system, allowing even companies that are not subject to government carbon emission controls to participate. |

The official establishment of the Taiwan Carbon Exchange on August 7, 2023, signifies a significant stride in Taiwan's commitment to addressing climate change and aligning with the global net-zero carbon goal. In the wake of heightened global attention to climate change, carbon trading markets have emerged as pivotal tools for managing this challenge, with countries like China, Japan, South Korea, and Singapore already having established their own carbon exchanges. The Taiwan government's establishment of the carbon exchange serves a dual purpose: not only does it enhance Taiwan's role in international trade, but it also incentivizes enterprises through low-carbon dividends, fostering sustainable development. The operational framework of the carbon exchange involves the allocation of emission rights. A central authority or government agency assigns a finite number of permits, with enterprises holding corresponding carbon credits based on their emissions.

The market trading rules encompass both a mandatory carbon market and a voluntary carbon market. The mandatory carbon market regulates the overall carbon emissions allocated to enterprises, whereas the voluntary carbon market empowers enterprises to proactively engage in carbon reduction projects, gaining

carbon credits upon successful certification. These credits represent the rights to carbon emissions, conceptualized around carbon pricing, where one ton of carbon emissions equals one tradable unit—a product for carbon offsetting.

These measures are instrumental in shaping Taiwan's robust emission reduction system, promoting adherence to international standards, and advancing towards a comprehensive carbon trading market mechanism.

3. The Evolving Role of the Regulator in Carbon Trading

Currently, the Taiwan Carbon Exchange primarily focuses on delivering carbon consulting and education/training services. However, as regulations about greenhouse gas emissions reach completion, the role of carbon exchanges is poised for expansion. In the forthcoming landscape, the carbon exchange will facilitate industries across the island in proposing voluntary reduction projects and acquiring carbon emission reduction quotas. These credits will undergo transparent and open trading on the exchange, not only fostering carbon trading within China but also aiding Taiwanese companies in meeting the escalating carbon reduction demands of the global supply chain market (Lederer, 2012). The introduction of the European Union's (EU) Carbon Border Adjustment Mechanism (CBAM) in October this year, incorporating carbon tariffs, mandates importers to procure CBAM certificates or demonstrate carbon emission payment proof for carbon-intensive goods sold to the EU. This underscores the rising expectations for corporate carbon reduction responsibilities within the global supply chain. In this context, the official listing of the Taiwan Carbon Exchange, impending carbon fee enforcement, and the establishment of a comprehensive carbon credit system are anticipated to empower Taiwanese enterprises in successfully navigating the challenges of green transformation.

Impacts and challenges

1. Corporate Engagement: A Case Study on CHIMEI's Global Carbon Trading Initiatives

In a significant move, CHIMEI declared its participation in Climate Impact X (CIX), a prominent global carbon trading platform based in Singapore, back in April of this year. This milestone positions CHIMEI as one of the few Taiwanese companies actively engaged in the international carbon trading market and notably the first Taiwanese company to successfully conduct carbon trading and offsetting on the CIX platform. The company, renowned for its "Clean & Green" commitment, further solidified its dedication to global carbon neutrality trends.

Marking another achievement, CHIMEI procured 10,000 tons of carbon credits from forest conservation projects in Cambodia and Peru, a noteworthy step in its pursuit of sustainable practices. These acquired carbon credits, certified by the Verified Carbon Standard (VCS), adhere to various United Nations Sustainable Development Goals (SDGs), including initiatives promoting local women's employment, ensuring clean water resources, and supporting biodiversity.

The intended utilization of these carbon credits by CHIMEI is to offset the carbon emissions stemming from internal employees' daily commuting and business travel spanning 2021 to 2025. Notably, the company has already successfully offset a total of 1,416 metric tons of carbon emissions in 2021, underscoring its commitment to operational sustainability.

Despite ongoing international debates on the legitimacy of companies purchasing carbon credits for offsetting, CHIMEI remains steadfast in seeking solutions that contribute to global greenhouse gas reduction. By actively participating in the voluntary carbon market, the company aims to take proactive responsibility for its carbon emissions, aligning with broader sustainability objectives on a global scale (Chimei Cooperation, 2022).

2. Government Policy Facilitation for Carbon Trading in Taiwan

Taiwan's Environmental Protection Agency (EPA) recently outlined the future trajectory of carbon trading in the country, unveiling plans centered around the Taiwan Carbon Rights Exchange and the EPA's matchmaking trading platform. This comprehensive approach aims to address carbon trading and Environmental Impact Assessment (EIA) incremental offsets for both enterprises and government entities. To further assist businesses in navigating carbon-related intricacies, the Environmental Protection Department has established a dedicated hotline to promptly address inquiries (Huang & Wu, 2009).

The current domestic demand for carbon credits in Taiwan falls into two primary categories. Firstly, there's the incremental offset mandated by EIA regulations, and secondly, voluntary initiatives by enterprises aiming for carbon neutrality due to factors like Environmental, Social, and Governance (ESG) sustainability promotion. Projects such as Zhuke Baoshan, Zhongke Expansion, and the establishment of industrial parks by the Ministry of Economic Affairs already require substantial annual carbon credits. As Taiwan's carbon trading landscape evolves, the demand for carbon credits is anticipated to surge.

The EPA's strategy involves categorizing Taiwan's carbon allowance exchange into two types: domestic reduction quota and international reduction quota. The domestic reduction quota is earmarked for domestic trading, primarily catering to enterprises with EIA offset requirements to prevent carbon price manipulation. In contrast, the international reduction quota will serve industries pursuing their carbon reduction goals. The carbon credit exchange will meticulously vet and provide high-quality carbon credits, validated by relevant units, to prevent duplicate trading. Simultaneously, the EPA will introduce a matchmaking trading platform to address specific needs such as the transition from old fuel vehicles and locomotives to electric alternatives. This initiative aims to facilitate developers with EIA needs in securing stable and cost-effective carbon credits.

To disseminate accurate carbon reduction information encompassing aspects like carbon inventory, inspection, carbon fee collection planning, the EU's Carbon Border Adjustment Mechanism (CBAM), carbon sinks, carbon rights, and carbon trading, the Environmental Protection Department has established a dedicated hotline and email service. Five telephone lines are operational during working hours to promptly respond to pertinent questions from enterprises and the public.

Carbon Trading and Supply Chain Management Practices of Taiwanese Enterprises

Corporate Engagement and Impact in Carbon Trading

In a significant move towards addressing carbon emissions, the Taiwan Carbon Rights Exchange recently inaugurated the "International Carbon Rights Trading Platform." This platform, featuring seven carbon rights products accredited by the international independent carbon rights issuing agency "Gold Standard" (GS), witnessed active participation from 27 Taiwanese companies on its launch day. Notable participants include industry giants like TSMC, Sinosteel, and private financial entities. The inaugural trading session resulted in an

international carbon rights trading volume of 88,520 metric tons, translating to a total transaction value of approximately $800,000 (equivalent to NT$24 million) (Han, et al., 2023).

Expressing satisfaction with the enthusiastic response, Sherman Lin, Chairman of the carbon exchange, highlighted the significance of this initiative. While the initial participation primarily comprised large enterprises, the carbon exchange aims to extend support to small and medium-sized enterprises (SMEs). By eliminating the need for SMEs to open cross-border accounts for acquiring carbon rights, the exchange seeks to reduce trading costs and facilitate the broader goal of achieving industrial carbon neutrality (TCX, 2023).

Carbon Trading's Integration and Influence on Supply Chain Management

The impact of the Taiwan Carbon Exchange has reverberated positively throughout supply chain management, steering enterprises toward environmentally sustainable practices. The establishment of carbon exchanges acts as a catalyst, urging companies to proactively address their carbon emissions, thereby significantly influencing the environmental sustainability of the entire supply chain. The presence of carbon exchanges motivates companies to actively curtail carbon emissions to lower carbon trading costs. This impetus to reduce emissions directly shapes a company's approach to supply chain management, fostering a more eco-friendly and sustainable strategy. Companies extend their focus beyond internal carbon emissions, encouraging suppliers and partners to engage in emission reduction initiatives, collectively forging an environmentally responsible supply chain system.

Furthermore, carbon exchanges establish an equitable marketplace for carbon trading, ensuring that the cost of carbon is transparently reflected in product prices. Consequently, supply chain management necessitates a more meticulous evaluation of suppliers, considering their carbon footprint and environmental practices. This paradigm shift challenges the conventional emphasis solely on cost, compelling companies to holistically integrate environmental considerations into their supply chain decision-making.

Ultimately, the operation of the carbon exchange prompts companies to institute proactive internal carbon management measures. These measures encompass the adoption of emission reduction technologies and enhancements in energy efficiency. Beyond reducing carbon costs, these internal initiatives enhance enterprise competitiveness within the supply chain, positioning companies favorably in the carbon trading market (TCX, 2023).

Carbon Trading Triumphs and Trials

Since its launch on August 7, the Taiwan Carbon Exchange has celebrated its initial success with the completion of the first batch of carbon credit trading on December 22. The inauguration of the international carbon credit trading platform witnessed the active participation of 27 prominent enterprises, including industry leaders such as TSMC, Hon Hai, CLP, and Yushan Gold. The estimated first-day turnover exceeded $800,000, with the financial holding industry emerging as the largest contributor.

Sherman Lin, the chairman of the carbon exchange, highlighted the global development of the international carbon pricing mechanism, with various countries actively establishing carbon trading platforms. Yushan Financial Holdings, a participant in the first batch, declared its commitment to achieving a net-zero goal by 2050. Through the purchase of 5,000 tons of carbon credits, the company plans to offset the carbon footprint associated with its buildings, zero-carbon credit cards, zero-carbon ATMs, and financial products and services.

Yushan Financial Holdings has been proactive in environmental initiatives since 2017, implementing ISO14064 greenhouse gas inventories across its domestic and foreign business bases. The company has embraced green building concepts, utilized low-pollution materials, adopted energy-efficient appliances, and promoted water-saving practices. In the credit card sector, Yushan Financial Holdings has achieved carbon neutrality for new credit cards issued yearly since 2019, with plans to transition all cards to zero-carbon status by 2025. Moreover, the company obtained carbon footprint certification for ATM transactions in 2023, making every transaction at Yushan ATMs a carbon-neutral, green initiative.

Chen Maoqin, the general manager of Yushan Financial Holdings, expressed optimism about the new milestone in carbon trading. Recognizing the market mechanism's crucial role in achieving net-zero goals, he pledged to continue promoting industry-wide net-zero transformations through financial guidance, leveraging financial influence, and collaborating with customers and partners to build a sustainable and carbon-neutral future (Yao, 2023).

## Questions and Suggestions

Addressing Challenges and Seeking Solutions

Despite the successful launch and completion of the first batch of carbon trading on August 7 by the Taiwan Carbon Exchange, there are notable areas of concern demanding attention. Firstly, the participation of 27 companies, including industry giants like TSMC, Hon Hai, and CLP, raises questions about whether it adequately represents the comprehensive involvement of various industry leaders in achieving carbon neutrality objectives. Secondly, the projected turnover of the carbon trading market at $800,000 appears relatively modest compared to the global carbon trading market, potentially impacting its competitiveness on a global scale. Furthermore, the practical implications of companies utilizing carbon offsets through carbon rights on their internal operations and sustainable development are yet to be thoroughly observed (TCX, 2023).

Charting the Future Trajectory of Taiwan's Carbon Trading

After a successful inauguration, the Taiwan Carbon Exchange is poised to overcome challenges and chart a more expansive and competitive course. To bolster future development, the exchange should proactively align with global carbon market trends, fostering collaborations with international carbon trading platforms to attract wider participation from global enterprises and investors. Emphasizing the inclusion of small and medium-sized enterprises (SMEs) will diversify carbon neutrality practices.

To invigorate the market, a commitment to innovation in trading mechanisms is essential. Introducing additional financial instruments linked to the carbon market will enhance transparency and stability in carbon prices. Collaboration between carbon exchanges and governments is recommended for the formulation of clear regulations and policies, establishing a standardized and secure carbon trading environment. Strengthening the credibility of the carbon market will attract more enterprises, positioning the Taiwan Carbon Exchange as a key player regionally and globally.

In a final strategic move, fostering close collaboration with enterprises and environmental protection organizations will empower the Taiwan Carbon Credit Exchange to offer comprehensive carbon-neutral solutions. This collaborative model incentivizes enterprises to integrate carbon offsets into their core business

operations, advancing corporate sustainability objectives. Through such synergistic efforts, Taiwanese companies can achieve substantial progress in addressing climate change, elevating the Taiwan Carbon Exchange to a prominent position in global green finance.

Proposals for Government and Corporate Responses:

To address the identified challenges, proactive measures are recommended. The carbon credit exchange should undertake extensive publicity efforts, promoting the diversification of the carbon trading market by attracting industries beyond manufacturing and finance. The creation of additional carbon credit trading platforms will enhance market vibrancy, enticing a broader spectrum of enterprises to engage in carbon neutrality initiatives. Encouraging enterprises to actively integrate carbon offsets into their internal operations post-acquisition of carbon credits is crucial for driving genuine green transformations. This step aligns the possession of carbon credits with tangible actions that foster sustainability within enterprises. Government and environmental protection agencies play a pivotal role by providing comprehensive support, including supervisory measures for the carbon market and strategic policy guidance. This collaboration ensures seamless operation and sustained development of carbon exchanges. These recommendations aim to optimize the functionality of the carbon credit exchange, empowering it to catalyze meaningful change in the carbon market. By aligning with these proposals, Taiwanese enterprises can navigate toward a more sustainable future (TCX, 2023).

## Conclusion

Study Summary

The inauguration of the Taiwan Carbon Exchange stands as a pivotal advancement in Taiwan's response to the climate crisis. The enthusiastic participation of prominent enterprises, including industry leaders like TSMC, Hon Hai, and CLP, underscores the business community's profound commitment to carbon reduction and sustainable development. This initial success in domestic carbon trading showcases tangible outcomes at the enterprise level, reflecting Taiwanese companies' dedication to achieving net-zero goals.

To chart the future course of the carbon market, the Taiwan Carbon Exchange is urged to fortify international collaborations, actively integrating into the global carbon market system for enhanced competitiveness. Collaborative efforts with the government are pivotal in establishing standardized carbon market regulations, fostering transparency, and ensuring market stability. The exchange should strategically diversify market participants, with a particular focus on engaging small and medium-sized enterprises, injecting vitality into the carbon market.

Crucially, through symbiotic partnerships with enterprises and environmental protection agencies, the Carbon Exchange can offer comprehensive carbon-neutral solutions. By facilitating the translation of carbon reduction measures into actionable initiatives, the exchange is poised to propel Taiwanese enterprises towards substantial achievements in sustainable development. This holistic approach aims to position the Taiwan Carbon Exchange as a global leader in green finance, contributing significantly to the planet's sustainable future.

Academic Contributions

This study delves into the establishment and operational intricacies of the Taiwan Carbon Exchange, offering not just on-the-ground insights into carbon trading market development but also contributing valuable empirical data to the academic realm. Firstly, it scrutinizes the global carbon trading market's international trends, shedding light on countries' responses to climate change challenges, and serving as a crucial reference for global carbon market studies. Secondly, by analyzing specific cases, the research provides an in-depth examination of Taiwan's carbon exchange operation mode and associated policy measures, offering scholars concrete insights for carbon market planning and development. Lastly, the identified issues and suggestions for the carbon exchange serve as enlightening contributions, guiding future academic research directions.

This research is poised to enrich the academic community's comprehension of the carbon trading market and furnish abundant materials for subsequent in-depth investigations in related fields. Future research endeavors are anticipated to delve deeper into aspects such as the carbon market's regulatory environment, market participant behavior patterns, and the tangible impact of the carbon market on enterprises' sustainable development. This comprehensive perspective aims to explore the evolution of the carbon trading market and its broader implications for climate change response.

Practical Implications:

The study outcomes carry significant practical implications for the application of carbon exchanges. Firstly, the success of Taiwan's carbon exchange underscores the feasibility and importance of other nations or regions establishing carbon trading mechanisms. By introducing a carbon market, governments, enterprises, and investors can actively engage in climate change prevention and control, working towards more ambitious carbon reduction objectives. Secondly, findings indicate that companies like Taiwan's Yushan Financial Holdings, committed to net-zero targets and achieving carbon neutrality through carbon credit purchases, not only foster the growth of green finance but also enhance their competitive edge in sustainable development. Lastly, the burgeoning carbon trading market opens up new business prospects. Financial institutions engaging in carbon credit trading and companies specializing in carbon inventory and emission reduction technologies stand to capitalize on growth opportunities in this emerging sector.

In summary, the study's results offer tangible suggestions for the practical application of carbon trading. These insights hold reference value for government agencies shaping policies and provide concrete, viable directions for enterprises developing sustainable strategies. This, in turn, can expedite the advancement of carbon markets and catalyze broader initiatives to combat climate change.

## Reference

Ahonen, H. M., Kessler, J., Michaelowa, A., Espelage, A., & Hoch, S. (2022). Governance of fragmented compliance and voluntary carbon markets under the Paris Agreement. Politics and Governance, 10(1), epub.

Chimei Cooperation. (2022). Chimei becomes the first Taiwanese company to complete carbon credit trading and offsetting on the CIX platform. Retrieved from https://www.chimeicorp.com/zh-TW/?page=article&id=62c6763c34d886f39314b29a.

Falkner, R. (2016). The Paris Agreement and the new logic of international climate politics. International Affairs, 92(5), 1107-1125.

Fankhauser, S., Smith, S. M., Allen, M., Axelsson, K., Hale, T., Hepburn, C., ... & Wetzer, T. (2022). The meaning of net zero and how to get it right. Nature Climate Change, 12(1), 15-21.

Han, Y. G., Huang, H. W., Liu, W. P., & Hsu, Y. L. (2023). Firm-value effects of carbon emissions and carbon disclosures: evidence from Taiwan. Accounting Horizons, 1-21.

Hansen, J., Kharecha, P., Sato, M., Masson-Delmotte, V., Ackerman, F., Beerling, D. J., ... & Zachos, J. C. (2013). Assessing “dangerous climate change”: Required reduction of carbon emissions to protect young people, future generations, and nature. PloS one, 8(12), e81648.Hepburn, C. (2007). Carbon trading: a review of the Kyoto mechanisms. Annu. Rev. Environ. Resource., 32, 375-393.

Huang, Y. H.,& Wu, J. H. (2009). Energy policy in Taiwan: Historical developments, current status and potential improvements. Energies, 2(3), 623-645.

Kharecha, P., Sato, M., Masson-Delmotte, V., Ackerman, F., Beerling, D. J., ... & Zachos, J. C. (2013). Assessing “dangerous climate change”: Required reduction of carbon emissions to protect young people, future generations, and nature. PloS one, 8(12), e81648.

Lacoste, A., Luccioni, A., Schmidt, V., & Dandres, T. (2019). Quantifying the carbon emissions of machine learning. arXiv preprint arXiv:1910.09700.

Lederer, M. (2012). Market making via regulation: The role of the state in carbon markets. Regulation & Governance, 6(4), 524-544.

Lee, K. H. (2011). Integrating carbon footprint into supply chain management: the case of Hyundai Motor Company (HMC) in the automobile industry. Journal of cleaner production, 19(11), 1216-1223.

Lee J.M. (2023). The dawn of Taiwan’s net zero-Taiwan Carbon Exchange is established. Accounting Research Monthly, (452), 64-75.

Lin T.R., Wang R.S., Hsie B.H., & Hsu C.S. (2015). Advantage analysis and integration planning of Taiwan’s carbon rights trading platform. Business Management Science and Technology Quarterly, 16(2), 269-289.

Narassimhan, E., Gallagher, K. S., Koester, S., & Alejo, J. R. (2018). Carbon pricing in practice: A review of existing emissions trading systems. Climate Policy, 18(8), 967-991.

Newell, R. G., Pizer, W. A., & Raimi, D. (2013). Carbon markets 15 years after Kyoto: Lessons learned, new challenges. Journal of Economic Perspectives, 27(1), 123-146.

Ou, J., Liu, X., Li, X., & Chen, Y. (2013). Quantifying the relationship between urban forms and carbon emissions using panel data analysis. Landscape ecology, 28, 1889-1907.

Pan, X., Teng, F., Ha, Y., & Wang, G. (2014). Equitable access to sustainable development: based on the comparative study of carbon emission rights allocation schemes. Applied Energy, 130, 632-640.

Steinebach, Y., Fernández-i-Marín, X., & Aschenbrenner, C. (2021). Who puts a price on carbon, and why and how? A global empirical analysis of carbon pricing policies. Climate Policy, 21(3), 277-289.

TCX. (2023). Business: International carbon credits available by the end of 2023. Focus Taiwan. https://focustaiwan.tw/business/202310190022

Van Den Berg, C., Couwenberg, O., & Weishaar, S. E. (2014). Carbon Leakage in the Regional Greenhouse Gas Initiative: Lessons Learn for the European Union Emissions Trading Scheme. University of Groningen Faculty of Law Research Paper, 6.

Wang, H., Chen, Z., Wu, X., & Nie, X. (2019). Can a carbon trading system promote the transformation of a low-carbon economy under the framework of the Porter hypothesis? - Empirical analysis based on the PSM-DID method. Energy policy, 129, 930-938.

Yao, H.R. (2023, December 22). Responding to Carbon Exchange's Launch of First Carbon Rights Trading! Yuanta Gold Actively Purchases 5,000 Tons of Carbon Rights. TechNews Finance News. https://finance.technews.tw/2023/12/22/carbon-rights-trading/

Zhang, A., Tay, H. L., Alvi, M. F., Wang, J. X., & Gong, Y. (2023). Carbon neutrality drivers and implications for firm performance and supply chain management. Business Strategy and the Environment, 32(4), 1966-1980. change, 9(5), 374-378.

Zhang, Y. J., Liang, T., Jin, Y. L., & Shen, B. (2020). The impact of carbon trading on economic output and carbon emissions reduction in China's industrial sectors. Applied Energy, 260, 114290.

Zheng, J., & Suh, S. (2019). Strategies to reduce the global carbon footprint of plastics. Nature climate.