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GREEN TRANSFORMATION AND PUNISHMENT IN THE MACHINERY MANUFACTURERS: FOCUS ON THE SUPPLY CHAIN OF TAIWAN'S IT INDUSTRY

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Abstract

With the goal of Carbon Neutrality (CN) by 2050, governments and companies are seeking strategies to balance economic and environmental measures. In response to this market environment, the purpose of this paper is to examine the efforts of machinery manufacturers to achieve Green Transformation (GX). First, this study conducted that the pilot study is the major machinery manufacturers (heavy electrical machinery, aircraft, automotive and IT manufacturing industries) and their suppliers in their supply chains to verify Greenhouse Gas (GHG) emissions based on the GHG Protocol. Based on the results of the pilot study, this study focuses on and interviews Taiwan's IT manufacturing industry and the financial companies that support them. As a result, this study showed that the progress of GX in the machinery manufacturing supply chain characteristics of the core companies and the weight of their GHG emissions, and that the conditions for effective disposal vary with each trend. And it revealed that the machinery manufacturing supply chain can be divided into three categories of suppliers.

Key words: Green Transformation (GX), Carbon Neutrality (CN), Innovation, Greenhouse Gas (GHG) Protocol, Machinery Manufacturers

Introduction

In 2020, governments declared the goal of achieving CN by 2050. The purpose of this paper is to examine the efforts of machinery manufacturers to achieve GX. In this paper, CN is defined as a balance between greenhouse gas emissions and absorption. And GX is defined that the transformation of the industrial and social structure centered on fossil energy since the Industrial Revolution to clean energy. This transition should facilitate innovation in business operations and societal structures as

companies become increasingly focus on reducing GHG emissions.

Background and Research Context

This paper first reviews the trends in GX. According to NIES (2019), the industrial sector accounts for 35% of Japan's GHG emissions, of which the manufacturing sector emits 94%.

This study focuses specifically on the machinery manufacturing sector because of its important role in realizing CN. The reason is that the steel and chemical sectors are also GHG emitters, but as material suppliers, but it is difficult to confirm their supply chains, which are diverse in their applications. However, the machinery manufacturing sector has a clear supply chain from the purchase of materials and parts to the shipment of products, so the GHG emissions can be confirmed from the perspective of the entire supply chain.

Companies are increasingly required to calculate and disclose their GHG emissions by the mandatory. The GHG Protocol is a de facto standard for calculating and reporting GHG emissions developed by WRI & WBCSD (1998). It calculates GHG emissions by dividing the scope of their business activities into three scopes. Scope 1 covers the direct GHG emissions of companies (fuel use, manufacturing processes, etc.); Scope 2 covers the indirect GHG emissions from the use of heat and electricity purchased by companies. Both are emitted by their own operations. According to WRI & WBCSD (2013), Scope 3 covers indirect GHG emissions from all of company's activities. Only Scope 3 emissions are generated by other companies in the supply chain. Therefore, companies are required to calculate the total amount of GHG emissions generated by other companies, such as suppliers. Scope 3 provides the following 15 categories for calculating the GHG emissions from stakeholders throughout the supply chain. Suppliers are required to make efforts to reduce GHG emissions from the core supply chain companies (Table 1).

Table 1.

Categories of GHG Protocol Scope 3

Category 1: Purchased Goods and Services
Category 2: Capital Goods
Category 3: Fuel- and Energy-Related Activities Not Included in Scope 1 or Scope 2
Category 4: Upstream Transportation and Distribution
Category 5: Waste Generated in Operations
Category 6: Business Travel
Category 7: Employee Commuting
Category 8: Upstream Leased Assets
Category 9: Downstream Transportation and Distribution
Category 10: Processing of Sold Products
Category 11: Use of Sold Products
Category 12: End-of-Life Treatment of Sold Products
Category 13: Downstream Leased Assets
Category 14: Franchises
Category 15: Investments

Source: WRI & WBCSD (2013)

Literature Review and Research Question (RQ)

This paper reviews the research on the effects of punishment and cooperation on performance. Cooperative behavior should be eliminated in the evolutionary process because it increases the other party's profits and decreases one's own, but it is present in many economic activities. Mechanisms can explain the evolution of cooperative behavior (e.g., spatial structure) (Nowak, 2006).

The consequence of imposing a punishment on a non-cooperator is that it is compelled to bear the associated cost. Conversely, the player who imposes the punishment bears a certain degree of burden too (Nakamaru, 2020). However, in a study of subjects, it was observed that the option of punishment increased cooperation rates, even when the subjects did not administer punishment (Fehr and Gachter, 2002).

The nature of punishment in the public goods games evolves in such a way that under conditions of spatial structure with multiple elements, severe punishment leads to a higher degree of cooperation than progressive punishment. However, in the absence of spatial structure, progressive punishment tends to evolve in a manner that increases the degree of cooperation. The severity of punishment co-evolves with the internal rate of cooperation even in the absence of exogenously imposed conditions (Nakamaru and Iwasa, 2005, 2006).

And there are empty spaces on the spatial structure lattice, a free-riding problem also occurs when punishment behavior is required (Sekiguchi and Nakamaru, 2008).

In the context of GX and its relationship with suppliers, there is minimal reason for suppliers to directly pursue GX directly from a management perspective, unless the company states in its mission (e.g., purpose) that it is solving social problems or contributing to the environment. Consequently, it is difficult for a supplier to adopt a direct stance on GX. However, if suppliers are asked by a core supply chain company to reduce GHG emissions or take other environmental measures, and there is a need to respond to this request, the supplier takes action to realize GX. An additional reason for suppliers to comply with core supply chain companies could be the fear of punishment, such as suspension of trade or a shift in the transaction price.

It is desirable for management, the information system department, and the user department to work as a triumvirate and reach a consensus on IT investments. Similarly, in implementing GX, it is also necessary to build consensus among the core supply chain companies and their suppliers to define the mission of GX (Matsushima, 2007).

However, Previous studies have examined the nature of punishment in public goods, they have not sufficiently examined whether punishment is effective in realizing GX as applied to specific industries, such as machinery manufacturing sector. Therefore, this study poses and discusses the following research question (RQ).

RQ: If the core supply chain companies in the machinery manufacturing sector were to require suppliers in its supply chain to contribute to carbon neutrality, what punishment would be expected and what would be the consequences of punishment?

Research Methodology

First, this study conducted a pilot study to explore trends in the machinery manufacturing sector. The pilot study covered four industries in this sector with large sales and global supply chains (heavy electrical machinery, aircraft, automotive, and IT manufacturing) in accordance with the GHG Protocol.

Second, the findings of the pilot study have led to the focus of this study on IT manufacturing industry that require GX in its supply chains, with further detailed analysis to be conducted. The reason is that the GHG emissions characteristic of its supply chain requires that suppliers to address GX. This paper conducted interviews with Taiwan's IT manufacturing companies and the financial companies that support them. The reason is that due to its suppliers must address GX to avoid punishments.

Interview-based case studies are an ideal research method for asking why and how (Yin ,2018) and help transform private knowledge into public knowledge (Sawabe ,2013). In addition, the narrative details provided by the case studies and told by the wealth of interviewees examined increase the potential for novel theories and creative insights (Cooper and Morgan, 2008).

The interview period was April 18-19, 2024, and the interviewees were ASUS, its manufacturing subsidiary ASKEY, and CTBC Financial holdings. The interviewees were interviewed for one hour each (Table 2).

Table 2.

Interview Survey Participants

No.	Firm	Grade	Interview date
1	ASUS	Division Director	18 Apr. 2024
2	ASKEY	Project Senior Manager	18 Apr. 2024
3	CTBC	Vice President	19 Apr. 2024
4	CTBC	Manager	19 Apr. 2024

Pilot Study

(1) Machinery Manufacturing Sector Driving GX by the core supply chain companies requires suppliers to calculate their GHG emissions and make efforts to reduce them, whether the suppliers are willing to do so or not. This study focuses on the GX efforts of machinery manufacturers (heavy electrical machinery, aircraft, automobile, and IT manufacturing industries) and their suppliers through the GHG Protocol.

(2) Heavy Electrical Machinery Industry GE (2022) announced that it will achieve carbon neutrality for GHG Protocol Scope 3 / Category 11 (use of sold products) by 2050. GE's GHG emissions from mainly the power generation equipment and the aviation equipment, accounted for 99.5% of total GHG emis-

sions (including Scope 1 and Scope 2) in FY2022. Mitsubishi Heavy Industries (MHI) (2022) announced its "Declaration of Carbon Naturality by 2040." In FY2022, MHI's Scope 3 / Category 11 GHG emissions, mainly from thermal power generation equipment, accounted for 99.95% of the company's total GHG emissions (including Scope 1 and Scope 2). SIEMENS (2023) also showed that Scope 3 / Category 11 GHG emissions account for 99.7% of the total (including Scope 1 and Scope 2).

Almost all the GHG emissions come from the Scope 3 / Category 11 This industry itself would benefit from sustainable product design and product life cycle management. The source of GHG emissions that this industry focuses on is its customers (e.g., thermal power generation, transportation, data centers). As a result, GHG emissions from upstream and downstream suppliers are not considered a problem in the core supply chain companies of this industry because they are underrepresented.

(3) Aircraft Industry
This industry is trending in the same direction as the heavy electrical machinery industry. Boeing (2023)'s GHG emissions (including Scope 1 and Scope 2) in FY2022 were 99.8% of the total in Scope 3 / Category 11 (use of sold products). Similarly, 97.4% of Airbus's total GHG emissions (including Scope 1 and Scope 2) in FY2022 were Scope 3 / Category 11. The source of GHG emissions that this industry focuses on is airlines. Therefore, even in the aircraft industry, the GHG emissions of upstream and downstream suppliers are not seen as a problem.

(4) Automotive Industry
In the automotive industry, HONDA's Scope 3 emissions accounted for 98.7% of its GHG emissions in FY2022 (including Scope 1 and Scope 2), of which Category 11 (use of sold products) accounted for 79% the share of the total. In 2021, HONDA requested its major suppliers to submit GHG emission reduction targets (Note 1).

At TOYOTA, Scope 3 accounts for 98.4% of total GHG emissions in FY2022, the same level as HONDA, Category 11 accounts for 76.3%, and Category 1 (purchased goods and services) accounts for 19.2%. Even though the percentage of Scope 3 / Category 1 is low, this is a driving force to strengthen the response to suppliers and TOYOTA has requested major parts suppliers to reduce GHG emissions by 3% in 2021 compared to the previous year. However, neither company has mentioned punishing suppliers for setting targets or for meeting or failing to meet reduction targets.

As a result, significant GHG emission reductions in the heavy electrical machinery, aircraft, and automotive industries are focused on Scope 3 / Category 11 reduction measures, with little attention paid to supplier measures. However, in the automotive industry, as the share of Scope 3 / Category 1 GHG emissions increases, the demands on suppliers become more serious and punishment more likely.

(5) IT Manufacturing Industry

The IT manufacturing industry's approach to reducing GHG emissions differs from the other machinery manufacturer.

For example, Apple (2022) claims that all its new products, such as iPhones and iPads, are designed in an environmentally friendly way, and that it uses renewable energy to power all its offices, retail stores, and data centers around the world. However, these efforts fall under Scope 1 and Scope 2 of the GHG Protocol and account for only 0.3% of Apple's total GHG emissions. Of the remaining 99.7% of GHG emissions, Scope 3 / Category 1 (purchased goods and services) accounts for 65% of the total, and Scope 3 / Category 11 (use of sold products) accounts for 23.8% of the total. Compared to the other machinery manufacturers (heavy electrical machinery, aircraft, and automobile industries), the tendency for Scope 3 / Category 1 to account for a larger share is unique to the IT manufacturing industry, where GHG emissions from products are relatively low.

Therefore, Apple (2022) requires its global supply chain partners to decarbonize by 2030, and Apple itself tracks and audits their progress annually. To reduce its most significant Scope 3 / Category 1 GHG emissions.

Apple (2023) strictly required its upstream and downstream suppliers in its global supply chain to use 100% renewable energy or face a trade embargo. As a result, Apple (2024) has received commitments from 320 suppliers, representing 95% of its direct manufacturing spend in 2024. The top four regions where the 250 publicly announced committed suppliers are headquartered are China (83), Taiwan (52), Japan (35), and the United States (28), accounting for 79% of the total. The large share of Taiwanese companies is particularly notable (Note 2). Apple (2022) has stated that it will terminate the contract if the suppliers cannot meet its GHG reduction requirements. In other words, Apple is creating a situation where suppliers have no choice but to work on GX by showing the punishment of termination of the deal. This clarified that the IT manufacturing industry is characterized by a large proportion of in Scope 3 / Category 1 GHG emissions than other machinery manufacturers. Therefore, companies in this industry are asked to contribute to GX for their core supply chain companies under the assumption that strict monitoring and punishment.

Interview Research

The findings of the pilot study have identified the IT manufacturing supply chain and its suppliers as the focus of this study. The interviewees were ASUS, a major Taiwanese IT manufacturer, its manufacturing subsidiary Askey, and CTBC Financial holdings (CTBC).

(1) ASUS and Askey
This study conducted interviews with ASUS and Askey. ASUS (2022a) is an IT manufacturing company with operations in more than 200 countries and over 14,500 employees. Askey was founded in 1989, and it joined the ASUS group in 2006.

The interviews were conducted at Askey's Smart Factory in Taipei, in collaboration with ASUS. ASUS's GHG emissions in FY2022, Scope 3 accounts for 99.3% of all GHG emissions (including Scope 1 and Scope 2). Scope 3 / Category 1 (purchased goods and services) accounts for 52.3% of the total, and Category 11 (use of sold products) accounts for 35.4% of the total. ASUS and its suppliers worked together to reduce Scope 3 / Category 1 GHG emissions by 30% between 2021 and 2022 (ASUS, 2022b). Incidentally, other Taiwanese IT manufacturing industries such as TSMC also tend to have a high percentage of Scope 3 / Category 1.

Askey's Smart Factory in Taipei established in 2021. Each process is equipped with "ASUS AIoT (AI and IoT)" equipment, and all manufacturing equipment is networked via a dedicated Wi-Fi line. For security measures, the factory network is not connected to the public network.

> "The sensor data collected in the smart factory is sent to the ASUS strategy office in real time, and on the ASUS side, the aggregated production information is projected onto a digital twin environment, combining the multiple factories in the supply chain to optimize production management system" (#2).

After sensor data acquired by ASKEY's smart factory is sent to ASUS' strategy office, the data is deleted on ASKEY's side. The data is collected in a data lake at ASUS' data center, where data analysis is performed using AI. Environment-related data on power consumption and GHG emissions are also collected by ASUS IoT.

> "We are encouraging our suppliers to reduce GHG emissions now. And we focus on collecting environmental data in this factory. In the future, we'll look at full-scale solutions to AI-enabled analysis by ASUS AIoT to achieve carbon neutrality" (#1).

The results of the interview research revealed that ASUS hopes to equip itself with the latest AIoT technology and use the data collected to reduce GHG emissions in the future. However, it was revealed that ASUS is currently promoting reductions by requiring suppliers to cooperate with them on GHG emissions.

(2) CTBC

CTBC (2022) is one of the leading financial conglomerate groups in Taiwan with 370 offices in 14 countries and regions, holding 8 subsidiaries in securities, insurance, asset management and venture capital, including its core business of banking. The interviews revealed that CTBC is developing its financial services in two main directions to achieve CN.

First, CTBC will stop financing coal and conventional oil and gas projects by 2035, and concentrate on "Renewable Energy" (offshore wind farm, waste-to-energy incinerator, solar power).

The other is in the "Corporate Client" area, CTBC understands the current demand for companies to reduce GHG emissions in their supply chains

and are inspiring their loan recipients to avoid punishment.

> "CTBC has set up a financial service called "Sustainable Supply Chain Financing" to assist our loan recipient companies meet sustainability targets set by the core supply chain companies. If it can be determined that the loan terms are met, CTBC offers reduced interest rates or subsidies to the loan recipient companies" (#4).

This is a financial support package for suppliers who must contribute to the sustainable goals imposed by core supply chain companies such as Apple.

> "Carbon neutrality is a very hard commitment for a company, but it is better than losing business with Apple" (#3).

This interview revealed that not only manufacturers, but also financial institutions play important stakeholder in the CN realization of the supply chain of IT manufacturing industry.

Discussion

This paper discusses the research questions. This study revealed that the progress of GX in the machinery manufacturing industry is highly dependent on the business characteristics of the core supply chain companies and the weight of Scope 3 / Category 1 (purchased goods and services) and Scope 3 / Category 11 (use of sold products). And the conditions of the core supply chain companies for effective address vary with their suppliers in the supply chain.

First, in the supply chain of machinery manufacturers (heavy electric machinery, aircraft, and automobile industries), suppliers do not receive much attention because their customers emit huge amounts of GHGs (Scope 3 / Category 11) in the use of their products and services after the products and services are sold. This makes it difficult for suppliers in this supply chain to be motivated to calculate and reduce their GHG emissions. In particular, the heavy electrical machinery and aircraft industries are extremely heavily weighted toward Scope 3 / Category 11, which means that there are no specific requirements and punishment imposed on suppliers.

However, for the automotive industry, the ratio of Scope 3/Category 1 is slightly higher than for others, so as the ratio of Scope 3 / Category 1 increases, more attention will be paid to suppliers, and monitoring and punishment from the major automotive companies that the core supply chain companies become progressively stronger according to the ratio of Scope 3 / Category 1 inside the supply chain, and GX for suppliers will progress somewhat.

On the other hand, the IT industry tends to have a large Scope 3 / Category 1 ratio. Therefore, suppliers in the IT industry supply chain are strictly monitored for GHG emissions by major IT companies, who demand strict calculations and emission reductions, and present exogenously strict punishments to suppliers, who work hard on GX to avoid the punishments, so the punishments are effective. As a result, the efforts of companies in the IT industry

supply chain may lead to innovation in the environmental domain.

The above reveals that the machinery manufacturing supply chain can be divided into three categories of suppliers:

(1) The first category includes those who are enthusiastic about GX to avoid punishment (IT manufacturing suppliers),
(2) The second category includes those who need to address GX gradually because of a slightly higher proportion of Scope 3/Category 1 (automotive suppliers)
(3) The third category includes those who are not interested in GX and are free riders (heavy electrical machinery and aircraft suppliers).

Although this result seems unfavorable for suppliers in the IT manufacturing industry supply chain, it is anticipated that the innovation brought by GX will diffuse in the future as other industries increase their share of power generation from renewable energy sources.

Conclusion

The findings of this study indicate that the impact of GX developments and punishments in the supply chain varies across industries, even within the same sector. This impact is highly dependent on the business characteristics of the core supply chain companies and their share of GHG emissions.

In terms of challenges, the study focuses on machinery manufacturers and observes the GX initiatives that are expected to accelerate between the IT industry and its suppliers, as well as explores mechanisms to ensure that suppliers belonging to supply chains other than the IT industry.

Notes

Note 1: Both Honda and TOYOTA's efforts are described based on an article in the Nihon Keizai Shimbun (June 2, 2021).

Note 2: The breakdown of the list of 320 companies announced in Apple (2024) is not disclosed.

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