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Airlines' Corporate Growth and Environmental Conservation: Evidence from Global Carriers and Forwarders

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ABSTRACT

This study explores how global airlines can achieve growth and environmental conservation using transport, financial performance, and carbon dioxide (CO_2) emissions data before, during, and after the COVID-19 pandemic from 2019 to 2022 with manually collected data for 38 leading international airlines. First, the regression analyses identify a clear range of turning points that airlines should consider in terms of Scopes 1 and 2 CO_2 emissions per employee and cargo ton-kilometers per employee (cargo ton-kilometers (CTK)/EMP) considering the environmental Kuznets Curve (EKC) hypothesis. Second, the deciding factors, including fundamental efforts by the airlines themselves, result from the interaction of three points, which have been encouraged and promoted in the airline industry in recent years. (1) Tighter emissions controls for air transport, (2) investors' emphasis on environment, society, and governance (ESG), and (3) assessments and guidelines from ratings agencies and economic and environmental organizations. Third, increasing CTK/EMP to verified thresholds and taking an ESG-oriented approach can contribute to airlines' combined achievement of growth and environmental conservation and related data will expand academic and policy-related research.

Keywords: EKC Hypothesis, Environment, Society, and Governance, Airline Economics
JEL Classifications: L21, L93, Q40, Q56

1. INTRODUCTION

This study explores how global airlines can achieve growth and environmental conservation while providing essential information for researchers, corporate strategists, and policymakers by clarifying associated results. The resulting conclusions have practical implications for decoupling airlines' transport, financial growth, and carbon dioxide (CO_2) emissions. In particular, this study focuses on environment, society, and governance (ESG) activities applying regression analyses to examine transport and financial performance and CO_2 emissions data before, during, and after the COVID-19 pandemic from 2019 to 2022.

This study investigates airlines' growth and environmental conservation based on the following global trends. First, airlines around the globe face common challenges. They are required to advance environmental conservation while maintaining and increasing transport and financial performance amid increased competition for customers and investors, while overcoming the economic downturn caused by the COVID-19 pandemic. Sometimes, competition makes alliances with competitors a necessary strategy, as demonstrated by the three major global alliances in the airline industry, Star Alliance, oneworld, and SkyTeam. Competition can also lead to alliances with companies in other industries, as in the case of the alliance between Japan Airlines (JAL), one of Japan's largest airlines, and NTT Docomo, Japan's largest mobile operator, to attract customers through frequent flyer programs.

Second, an evolution in research on balancing the two major issues of business competition and environmental conservation can be expected in the future. Two Nobel Prizes in Economics expanded academic frontiers. The first was for an analysis of market power and regulations in the field of industrial organization theory, which was awarded to Dr. Jean Tirole in 2014. The second focused on the integration of climate change into long-term macroeconomic analyses in the field of environmental economics, for which Dr. William D. Nordhaus was awarded in 2018.

Although the findings of the two Nobel Prize winners demonstrated the possibility of exploring academic frontiers in competition and conservation, a thorough review of international academic journals reveals that almost no previous study has used the approach adopted in this study.

This study differs from previous studies in three notable ways. First, the Environmental Kuznets Curve (EKC) hypothesis and its advanced theory of an inverted N-shaped curve are applied to the analysis of airlines, rather than the conventional and traditional approaches applied to those of countries and regions. To the best of the author's knowledge, the application of the EKC hypothesis to global aviation firms presents a novel academic approach. This study investigates the relationship between transport and financial performance and the environmental impacts of CO_2 emissions, revealing a clear range of turning points that can achieve airline growth and environmental conservation. The EKC hypothesis is explained in Section 2.1.

Second, the scope of coverage is comprehensive. The study uses transport and financial performance and CO_2 emissions of major global passenger carriers and freight forwarders from 2019 to 2022 (before, during, and after COVID-19). The research includes 38 leading worldwide air transport companies in passenger and cargo traffic, including firms headquartered in the Asia Pacific, Europe, the Middle East, and North and Latin America, comprising traditional full-service carriers such as American Airlines and emerging low-cost carriers such as Southwest Airlines. The 38 airlines also include freight forwarders such as FedEx and airlines that transport passengers and cargo such as Delta Airlines.

Some of the airlines examined, such as American Airlines and Delta Airlines, are global leaders in terms of revenue passenger-kilometers (RPK), cargo ton-kilometers (CTK), number of passengers and employees, and amount of operating revenue. Some major carriers are also responsible for air transportation to and from unprofitable mountainous areas and islands in response to surpluses on trunk lines. Therefore, all the 38 covered airlines provide essential services, despite differences in RPK, CTK, and number of passengers (see the complete list of airlines examined in Table Appendix 1 (A1).

In particular, the 38 airlines investigated in this study include the top 20 airlines in RPK in 2022. Although several airlines (i.e., easyJet) are not members of the International Air Transport Association (IATA), their total RPK when included in the calculations is equivalent to 56.9% that of IATA member airlines, and the total CTK is 31.4% that of IATA members in the same year (author's calculations based on IATA [2023]).

Third, this study's calculations focus on corporate raw data (e.g., CO_2 tons, US dollars (USD), and numbers of passengers and employees) rather than rating agencies' scores (e.g., A+, 90 points). Hence, overcoming the difficulties of raw data collection, this study endeavors to study the unexplored field of the relationship between growth in air transport and environmental conservation.

2. DEFINITIONS, PRIOR STUDIES AND CHALLENGES

2.1. Definitions

First, this study focuses on civil aviation services based on Article 3 of the International Civil Aviation Organization Convention (ICAO DOC 7300/9), which says,

a. This Convention shall be applicable only to civil aircraft, and shall not be applicable to state aircraft.
b. Aircraft used in military, customs and police services shall be deemed state aircraft.

In this context, the term "airlines" refers to freight forwarders and air transport carriers that handle civilian passengers and cargo.

Next, "environmental conservation" is defined by the Article 2 of the Act (No. 91 of 1995) on Basic Environment in Japan. It means preventive measures against global warming, ozone layer depletion, marine pollution, decrease in wildlife species, or situations affecting the whole or part of the world caused by human activities, which contributes to the welfare of humankind as well as wholesome and cultured living.

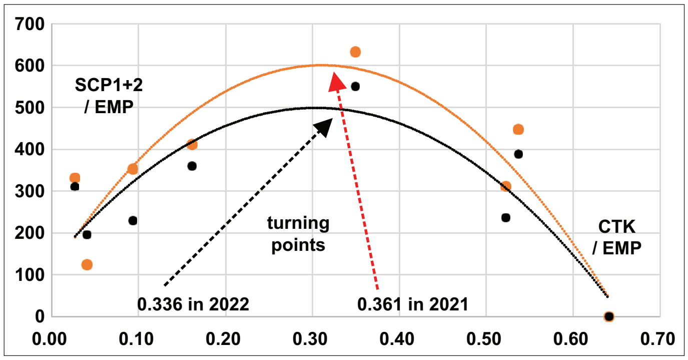
This study applies the EKC hypothesis to airline analysis, which is an economic theory that illustrates the relationship between economic growth and environmental impact. This study applies the theory of economic growth and income inequality postulated by Dr. Simon Kuznets, a Nobel laureate in economics.

Academic research regarding the EKC hypothesis began in the 1990s with Grossman and Krueger (1991) and the World Bank (1992), extending from air pollution to water contamination and deforestation (Benoit Mougenot et al., 2022; Csereklyei et al., 2017; Galeotti et al., 2009; Gopakumar et al., 2022; Markandya et al., 2006; Panayotou, 1997; Perman and Stern, 1999; Selden and Song, 1999; Sorgea and Neumann, 2020; Stern and Common, 2001; Tsujimoto, 2022; 2023).

The ECK hypothesis asserts that environmental impact increases up to a certain threshold of economic growth and then begins to decrease, with an inverted U-shaped curve at the turning point. The hypothesis is valid when the linear term (positive: $\beta > 0$) and the squared term (negative: $\beta < 0$) are significant (Figure 1 in Section 3.2).

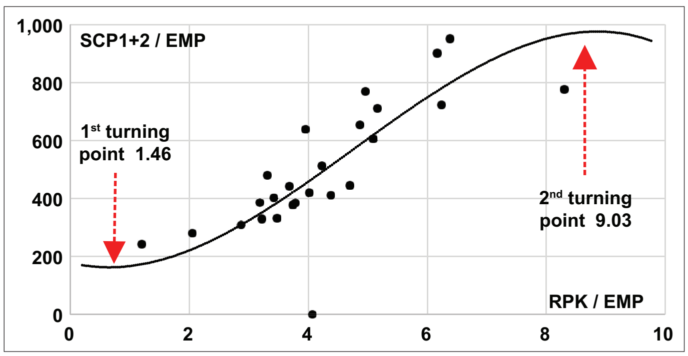
In addition, this study tests the success or failure of a cubic curve as an applied form of the EKC hypothesis. When investigating the relationship between growth and environmental impact it is desirable to illustrate an inverted N-shaped curve. The inverted N-shape is valid in cases when environmental impact increases (positive: $\beta > 0$) at the first turning point (bottom) and decreases (negative: $\beta < 0$) at the second turning point (top) (Figure 2 in Section 3.2).

Figure 1: Scope 1+2 CO_2/per employees–Cargo Ton Kilometers/per employees in 2021 and 2022



Sources: Author's calculation

Figure 2: 2 Scope 1+2 CO_2 / per employees–Revenue Per Kilometers / per employees in 2019



Sources: Author's calculation

AQ4 **Table 1 : Recovery of RPK and CTK**

Areas	RPK		CTK	
	September 2020	April 2023	September 2020	April 2023
Africa	−85.6	−16.2	8.2	0.9
Asia-Pacific	−63.5	−18.4	−15.9	−0.4
Europe	−75.8	−7.8	−15.4	−8.2
Latin America	−76.2	−1.5	−22.5	−1.6
Middle East	−88.9	−12.1	−2.6	−6.8
North America	−74.7	2.1	8.6	−13.1
Global	−72.8	−9.5	−8.0	−6.6

Source: Airline Business, 2020, 2021, 2022

2.2. Prior Studies

First, Tanrıverdi et al. (2023) investigated airlines' transport and financial performance and CO_2 emissions, using data from 56 airlines for the period before and during the COVID-19 pandemic (2017-2021). The conclusions revealed that Ryanair, IndiGo, and Eurowings were the most sustainable airlines. While the study is a pioneering achievement, three points for improvement are apparent. First, there is a problem with the time frame. As the authors state as "early after the pandemic (2017-2021)," they do not cover the period after the official end of COVID-19. In fact, the first submission of the article was in November 2021, when COVID-19 was in the final stages of abatement. Second, the study lacks consideration of cargo air transport, which has a significant role in the global economy. Furthermore, it does not consider the differences in airlines' scale such as the number of passengers and employees.

Notably, this study's findings indicate that focusing on per-unit (per passenger or employee) figures is more significant than bare figures for achieving airlines' growth and environmental conservation to obtain results that are not affected by the size of the airline company (Section 3.2 for details).

Chiambaretto et. al. (2021) conducted a study on flight shame, assuming that it is caused by a lack of knowledge or "carbon literacy" regarding the actual environmental impact of air transport. The authors found that more than 90% of respondents overestimated the share of air transport in global carbon emissions and 98% of the respondents underestimated the reductions in carbon emissions per passenger. Therefore, they suggest that airlines and airports must adopt a "destigmatization" strategy to alter negative sentiment by highlighting misperceptions and emphasizing the environmental efforts undertaken by airlines and airports.

Dube et al. (2021) recommended that the airline industry should continue decommissioning old and fuel-inefficient aircrafts that are financially and environmentally costly. Financing is required to enable the sector to embrace sustainability in alignment with the United Nations' (UN) Sustainable Development Goals (SDGs), particularly sustainable energy (SDG 7) and climate action (SDG 13).

Second, focusing on the relationship between ESG ratings and airline stock prices, Chen et al. (2022) concluded that promoting ESG has a defensive function in market crashes, and ESG performance aids stock performance. This study was also pioneering, but had two limitations. First, the authors only included four US companies, American Airlines, Delta, United, and Southwest. Moreover, the study used S&P Global ESG Scores for ESG evaluation rather than raw data.

Previous research has predominantly not used raw data (i.e., tons and USD), relying on secondary ESG scores (e.g., A, AA, and 80 points) issued by rating agencies based on unique criteria. The reason that this study places so much importance on raw data rather than ratings or criteria is to eliminate inherent issues of nonneutrality and arbitrariness. For example, Dobruszkes and Efthymiou (2021) criticized aviation noise assessments, arguing that the established social, economic, environmental, and health indicators are the result of political compromises that should be reviewed, and thresholds have been the subject of debate and are outdated and unusable in some cases in Belgium.

Yuyama (2019) has been another critic, asserting that it is difficult to objectively verify whether ESG scores are appropriate. Therefore, as argued in this study, it is appropriate to directly analyze the raw nonfinancial data regarding airlines' CO_2 emissions (tons) to ensure objectivity.

It is essential to consider why most studies have not relied on raw data. The primary reason for the inadequacy of previous research employing raw data is airlines' insufficient disclosure of environmental information and inconsistent disclosure standards among companies and rating agencies during the transition period of global standard setting. Disclosure requires a certain amount of time and expenditure, including certification by auditing firms, and may involve confidential corporate information. Moreover, conflicting perspectives among regulatory authorities, industry associations, legal and accounting firms, financial institutions, and media organizations have left the extent of disclosure to the discretion of each airline. As a result, listed companies that should have engaged in public disclosure following a series of stringent legal and financial screening processes at the time of listing do not always disclose environmental data that are amenable to academic verification, compared with the common systematic and comprehensive disclosure of financial data.

The second reason for the absence of previous research using raw data is that environmental and ESG raw data have been inconsistently disclosed and it often requires considerable time and effort to collect. Unlike transport and financial disclosure, ESG data disclosure via Excel or CSV is not widely used. Therefore, this study employed a manual investigation of relevant sections of environmental and/or ESG reports of over 50-100 pages or companies' websites, inputting the data into Excel sheets, and reconfirming each individual figure.

Despite the time and effort required, the method used in this study contributes to the exploration of the academic frontier by ensuring the availability of manually collected data.

2.3. Impacts and Challenges

This section examines airlines' recovery from COVID-19, future prospects, and the economic and environmental impacts of the 38 airlines included in this study.

The aviation journal, *Airline Business* analyzes the degree of COVID-19 business recovery based on the beginning of 2020 in its Coronavirus Crisis Recovery Tracker, indicating that, globally, both RPK and CTK have recovered to some extent, but not to pre-COVID-19 levels.

Regarding COVID-19 and aviation management, Linden (2021) recommended that aviation managers should introduce uncertainty as a standard factor for long-term planning and proactively manage uncertainty with various shareholders.

While airline performance is on the road to recovery, notably, the total Scope 1 CO_2 emissions of the 38 airlines examined in this study (defined as direct emissions by the business) was 350 million tons in 2021, which is equivalent to the total emissions of 330 million tons in the United Kingdom in the same year for which the latest data are available (European Commission, 2023; IATA, 2023).

Scope 1 CO_2 emissions in 2022 for the 38 companies were approximately 384 million tons, representing only 68.1% of the 2019 level (~564 million tons); however, they are on an increasing trend, increasing by 21.1% from 2020 (~317 million tons) and 9.7% from 2021, following the recovery of global economy and aviation operations.

Balancing growth and environmental conservation is even more important than it was before COVID-19. Moreover, as established above, despite its importance from academic research, policymaking, and corporate strategy perspectives, previous studies have been insufficient. Therefore, this study explores this unexplored frontier using raw data.

3. VERIFICATION

3.1. Methods

This section examines the relationship between transport and financial performance for airlines and environmental impact data, employing linear, quadratic, and cubic regressions. The methodology of this study is detailed below.

- This study chose 38 airlines for which environmental data are available. The targeted companies include traditional full-service carriers (i.e., American Airlines) as well as emerging low-cost carriers (i.e., Southwest Airlines), freight forwarders (i.e., FedEx), and conventional carriers (i.e., Delta Airlines).

Some airlines are not members of the IATA (i.e., easyJet, IndiGo, Southwest, and Ryan). The number of IATA member airlines was around 310 as of August 2023. One of the main reasons for not joining the IATA is the registration fees associated with IATA membership, with a fixed fee of 11,624 USD per year based on the year 2023, and the variable fee calculated based on RTK. Nevertheless, nonmembers must comply with the safety, security, and environmental standards set by the IATA, which have become international standards.

- The 38 airlines examined in this study by region include 11 in the Asia-Pacific, 12 in Europe, 2 in Latin America, 10 in North America, and 3 in the Middle East.
- The dependent and explanatory variables are presented in Table 2. This study endeavors to provide a more accurate analysis of airline" emissions, transportation, and financial performance by focusing on per-passenger and per-employee figures.

Table 2: Basic and advanced combinations of dependent and explanatory variables (abbreviation)

Dependent variables: 3	Explanatory variables: 7
Basic	Basic
(1) Scope 1 CO_2 emissions (SCP1)	(1) Revenue Passenger-Kilometers (RPK)
(2) Scope 2 CO_2 emissions (SCP2)	(2) Number of Passengers (PAX)
(3) Scope 1+2 CO_2 emissions (SCP1+2)	(3) Cargo Ton-Kilometers (CTK)
Advanced	(4) Number of Employees (EMP)
	(5) Operating Revenues (OPR)
Value per unit (PAX)	Advanced
(4) SCP1/PAX	Value per unit (PAX)
(5) SCP2/PAX	(6) EMP/PAX
(6) SCP1+2/PAX	(7) OPR/PAX
Value per unit (EMP)	Value per unit (EMP)
(7) SCP1/EMP	(8) RPK/EMP
(8) SCP2/EMP	(9) PAX/EMP
(9) SCP1+2/EMP	(10) CTK/EMP
(Unit: CO_2, thousand metric tons)	(11) OPR/EMP
	(Unit): million, (5, 7, 11): USD

Target year of data

- Nine dependent variables are employed in this study. In addition to the basic variables 1–3, advanced variables are also set by dividing by the number of passengers (PAX; variables 4–6) and the number of employees (EMP; variables 7–9).
- Eleven explanatory variables are introduced. In addition to the basic variables 1–5, advanced variables are also set by dividing by the number of passengers (PAX; variables 6 and 7) and the number of employees (EMP; variables 8–11). Note that RPK, which indicates the number of passengers, and CTK, which indicates the volume of cargo, are excluded because it does not make sense to divide them by PAX.
- The total number of regression equations is 1,188. The breakdown is as follows:
  - The number of equations is 297 for 2019, 297 for 2020, 297 for 2021, and 297 for 2022, respectively.
  - The 297 equations are broken down as follows: 297 equations = 99 (linear) + 99 (quadratic) + 99 (cubic).
  - The smallest breakdown of 99 linear equations = 9 (dependent variables) × 11 (explanatory variables).
  - The smallest breakdown of 99 quadratic and 99 cubic equations is the same as that of the linear equation.

Definitions of Scope 1 and 2 (US Environment Agency, 2021) are as follows.

- Scope 1: direct emissions by the business itself.
- Scope 2: indirect emissions from the use of electricity, heat, and steam supplied by other companies.
- Scope 3 is not considered in this study because some companies do not disclose it.
- Target year of data:

Cross-sectional data analysis for 2019, 2020, 2021, and 2022. Available data on environmental impacts before 2018 are sometimes insufficient or inconsistent, making time series analysis impossible; in addition, regression analysis requires at least three or four years of data in the difference equation to avoid spurious regressions.

Although the data are limited, the study illustrates the airlines' circumstances before, during, and after the COVID-19 pandemic, with certain implications regarding the relationship between growth and conservation. This study inductively investigates performance based on certain criteria and rules from the information disclosed.

- The sources referenced for this study include transport and financial data from the IATA (2023) and environmental impact data that are manually gathered from each airline's environmental, ESG, and/or sustainability reports. Consolidated data are examined because non-consolidated financial and environmental data are not disclosed in detail.

First, the linear regression model is as follows, where environmental impact of Scope 1 CO_2 emissions (SCP1) is the dependent variable and each variable from (1) RPK to (5) OPR is placed as the explanatory variable.

$$Y\,(SCP1) = \alpha + \beta\,(RPK) + \varepsilon \quad (1.1.1.)$$

$$Y\,(SCP1) = \alpha + \beta\,(PAX) + \varepsilon \quad (1.2.1.)$$

$$Y\,(SCP1) = \alpha + \beta\,(CTK) + \varepsilon \quad (1.3.1.)$$

$$Y\,(SCP1) = \alpha + \beta\,(EMP) + \varepsilon \quad (1.4.1.)$$

$$Y\,(SCP1) = \alpha + \beta\,(OPR) + \varepsilon \quad (1.5.1.)$$

The P-value significance level is set at 5% ($P < 0.05$). In principle, insignificant results are omitted in the text for brevity. α and ε indicate constant and error terms, respectively. The significance of the constant term is not considered. The data are presented with three digits after the decimal point to ensure rigor. If zero continues after the third digit (e.g., 0.0000152678), it is not presented as 0.000 but as an exponent, i.e., 1.526E-05.

The order of the equation numbers indicates the dependent variable, the explanatory variable, and the monomial/polynomial equation. 1.1.1 refers the SCP1–RPK–linear equation. The combinations of the dependent and explanatory variables are computed in order. To avoid unnecessary complexity, the author omits the details, showing only some combinations.

Next, examples of the formulas for Scope 2 CO_2 emissions (SCP2) are:

$$Y\,(SCP2) = \alpha + \beta\,(RPK) + \varepsilon \quad (2.1.1)$$

- - - - - omitted - - - - -

$$Y\,(SCP2) = \alpha + \beta\,(OPR) + \varepsilon \quad (2.5.1)$$

Moreover, the examples of the formulas for Scope 1+2 CO_2 emissions (SCP1+2) are:

$$Y\,(SCP1{+}2) = \alpha + \beta\,(RPK) + \varepsilon \quad (3.1.1.)$$

- - - - - omitted - - - - -

$$Y\,(SCP1{+}2) = \alpha + \beta\,(OPR) + \varepsilon \quad (3.5.1.)$$

Furthermore, the formulas for Scope 1, 2, and 1+2 CO_2 emissions per-passenger (SCP1/PAX, SCP2/PAX, and SCP1+2/PAX) are:

$$Y\,(SCP1/PAX) = \alpha + \beta\,(EMP/PAX) + \varepsilon \quad (4.6.1)$$

- - - - - omitted - - - - -

$$Y\,(SCP2/PAX) = \alpha + \beta\,(EMP/PAX) + \varepsilon \quad (5.6.1)$$

- - - - - omitted - - - - -

$$Y\,(SCP1{+}2/PAX) = \alpha + \beta\,(EMP/PAX) + \varepsilon \quad (6.6.1)$$

- - - - - omitted - - - - -

Then, the formulas for Scope 1, 2, and 1+2 CO_2 emissions per-employee (SCP1/EMP, SCP2/EMP, SCP1+2/EMP) are:

$$Y\,(SCP1/EMP) = \alpha + \beta\,(RPK/EMP) + \varepsilon \quad (7.8.1)$$

--- omitted---

$$Y\,(SCP2/EMP) = \alpha + \beta\,(RPK/EMP) + \varepsilon, \quad (8.8.1)$$

---omitted---

$Y (SCP1+2/EMP) = \alpha + \beta (RPK/EMP) + \varepsilon$ (9.8.1)

---omitted---.

The second is to examine the EKC hypothesis. The examples of the formulas of Scope 1 CO_2 emissions are:

$Y (SCP1) = \alpha + \beta (RPK) + \beta (RPK)^2 + \varepsilon$ (1.1.2)

$Y (SCP1) = \alpha + \beta (PAX) + \beta (PAX)^2 + \varepsilon$ (1.2.2)

$Y (SCP1) = \alpha + \beta (CTK) + \beta (CTK)^2 + \varepsilon$ (1.3.2)

$Y (SCP1) = \alpha + \beta (EMP) + \beta (EMP)^2 + \varepsilon$ (1.4.2)

$Y (SCP1) = \alpha + \beta (OPR) + \beta (OPR)^2 + \varepsilon$ (1.5.2)

- - - - - omitted - - - - -

$Y (SCP2) = \alpha + \beta (RPK) + \beta (RPK)^2 + \varepsilon$ (2.1.2)

- - - - - omitted - - - - -

$Y (SCP1+2) = \alpha + \beta (RPK) + \beta (RPK)^2 + \varepsilon$ (3.1.2)

- - - - - omitted - - - - -.

The formulas for Scope 1, 2, and 1+2 CO_2 emissions per-passenger (SCP1/PAX, SCP2/PAX, and SCP1+2/PAX) are:

$Y (SCP1/PAX) = \alpha + \beta (EMP/PAX) + \beta (EMP/PAX)^2 + \varepsilon$ (4.6.2)

- - - - - omitted - - - - -

$Y (SCP2/PAX) = \alpha + \beta (EMP/PAX) + \beta (EMP/PAX)^2 + \varepsilon$ (5.6.2)

- - - - - omitted - - - - -

$Y (SCP1+2/PAX) = \alpha + \beta (EMP/PAX) + \beta (EMP/PAX)^2 + \varepsilon$ (6.6.2)

- - - - - omitted - - - - -.

Moreover, the formulas for Scope 1, 2, and 1+2 CO_2 emissions per-employee (SCP1/EMP, SCP2/EMP, and SCP1+2/EMP) are:

$Y (SCP1/EMP) = \alpha + \beta (RPK/EMP) + \beta (RPK/EMP)^2 + \varepsilon$ (7.8.2)

- - - - - omitted - - - - -.

$Y (SCP2/EMP) = \alpha + \beta (RPK/EMP) + \beta (RPK/EMP)^2 + \varepsilon$ (8.8.2)

- - - - - omitted - - - - -.

$Y (SCP1+2/EMP) = \alpha + \beta (RPK/EMP) + \beta (RPK/EMP)^2 + \varepsilon$ (9.8.2)

- - - - - omitted - - - - -

The third is to verify whether or not an inverted N-shaped curve is established. The examples of the formulas of Scope 1 CO_2 emissions are:

$Y (SCP1) = \alpha + \beta (RPK) + \beta (RPK)^2 + \beta (RPK)^3 + \varepsilon$ (1.1.3)

- - - - - omitted - - - - -

$Y (SCP2) = \alpha + \beta (RPK) + \beta (RPK)^2 + \beta (RPK)^3 + \varepsilon$ (2.1.3)

- - - - - omitted - - - - -

$Y (SCP1+2) = \alpha + \beta (RPK) + \beta (RPK)^2 + \beta (RPK)^3 + \varepsilon$ (3.1.3)

- - - - - omitted - - - - -

The formulas for Scope 1, 2, and 1+2 CO_2 emissions per-passenger (SCP1/PAX, SCP2/PAX, and SCP1+2/PAX) are

$Y (SCP1/PAX) = \alpha + \beta (EMP/PAX) + \beta (RPK/PAX)^2 + \beta (EMP/PAX)^3 + \varepsilon$ (4.6.3)

- - - - - omitted - - - - -

$Y (SCP2/PAX) = \alpha + \beta (EMP/PAX) + \beta (EMP/PAX)^2 + \beta (EMP/PAX)^3 + \varepsilon$ (5.6.3)

- - - - - omitted - - - - -

$Y (SCP1+2/PAX) = \alpha + \beta (EMP/PAX) + \beta (EMP/PAX)^2 + \beta (EMP/PAX)^3 + \varepsilon$ (6.6.3)

- - - - - omitted - - - - -.

Moreover, the formulas for Scope 1, 2, and 1+2 CO_2 emissions per-employee (SCP1/EMP, SCP2/EMP, and SCP1+2/EMP) are:

$Y (SCP1/EMP) = \alpha + \beta (RPK/EMP) + \beta (RPK/EMP)^2 + \beta (RPK/EMP)^3 + \varepsilon$ (7.8.3)

- - - - - omitted - - - - -

$Y (SCP2/EMP) = \alpha + \beta (RPK/EMP) + \beta (RPK/EMP)^2 + \beta (RPK/EMP)^3 + \varepsilon$ (8.8.3)

- - - - - omitted - - - - -

$Y (SCP1+2/EMP) = \alpha + \beta (RPK/EMP) + \beta (RPK/EMP)^2 + \beta (RPK/EMP)^3 + \varepsilon$ (9.8.3)

- - - - - omitted - - - - -.

3.2. Results

The findings of this study are as follows. First, the linear regression analysis of the 99 cases tested reveals significant monotonic relationships in 19 cases (19.2%) in 2019, 23 (23.2%) in 2020, 20 (20.2%) in 2021, and 21 (21.2%) in 2022, as shown in Table 3 and Table Appendix 2 (A2). The results indicate a trend in which environmental impact increases as financial performance expands.

More importantly, the regression analyses confirm the EKC hypothesis in 2019, 2020, 2021, and 2022 (the years prior to, in the vortex of, and after COVID-19). The quadratic regression analysis of the EKC hypothesis confirms the validity of 11 cases (11.1%) in

Table 3: Number of significant cases and percentage (%)

Years	1 linear (%)	2 EKC (%)	3 inv. N-shaped (%)
2019	19 (19.2)	11 (11.1)	4 (4.0)
2020	23 (23.2)	13 (13.1)	0 (0)
2021	20 (20.2)	6 (6.1)	1 (1.0)
2022	21 (21.2)	3 (3.0)	0 (0)

Source: Author's calculations

2019, 13 (13.1%) in 2020, 6 (6.1%) in 2021, and 3 (3.0%) in 2022. Furthermore, cubic regression analysis of the inverted N-shaped curve, which is an advanced model of the EKC hypothesis, confirms the validity of four (4.0%) cases in 2019 and one case (1.0%) in 2021. The asterisk (*) in Table A2 indicates confirmation of the EKC hypothesis or the inverted N-shaped curve.

Based on the calculation results, this study further explores the two following combinations of dependent and explanatory variables that airlines should focus on in terms of growth and environmental conservation. First, the EKC hypothesis and the inverted N-shaped curve should hold for more years. Second, more companies have already crossed the thresholds among the combinations for which the hypothesis holds.

At first glance, it appears that the combination of SCP1–EMP is valid for the years 2019 to 2022. However, the turning points are too high to achieve because they involve unfeasibly large numbers of employees. For example, the number of employees at the turning point in 2021 is 299,314.

Instead, the combination of SCP1+2/EMP–CTK/EMP was confirmed in 2019, 2021, and 2022.

Although the 2019 turning point is a theoretical value that will take a considerable number of years to achieve based on the current status of performance, four to five airlines have already exceeded the turning point in 2021 and 2022 and are at a feasible level as a target setting for other companies.

Figure 1 illustrates the explanatory variables (CTK/EMP) on the x-axis, and the dependent variables (SCP1+2/EMP) are on the y-axis, revealing an inverted U-shaped curve relationship with turning points of 0.361 in 2021 and 0.336 in 2022, focusing on the period after the end of COVID-19.

The two cases in which the EKC hypothesis was established with CTK/EMP in 2021 and 2022 are listed below.

2021

Y (SCP1+2/EMP) = α + β (CTK/EMP) + β (CTK/EMP) ^{2} *+ ε,*

= 95.169 +2,190.997(CTK/EMP) − 3,036.566 (CTK/EMP)^2

(P = 0.021) (1.351E-04) (0.004)

+89.319

Adj.-R^2 *= 0.657, F = 23.006 (P = 5.114E-06),*

turning point: 0.361.

2022

Y (SCP1+2/EMP) = α + β (CTK/EMP) + β (CTK/EMP) ^{2} *+ ε,*

= 119.947 + 2,897.028(CTK/EMP) − 4,313.057(CTK/EMP)^2

(P = 0.115) (5.964E-03) (0.043)

+ 4,313.057.

Adj.-R^2 *= 0.482, F = 147.065 (P = 0.002),*

turning point: 0.336

Figure 2 presents an example of the establishment of an inverted N-shaped curve for which a cubic curve can be drawn relatively clearly. The figure illustrates the explanatory variables (RPK/EMP) on the x-axis, and the dependent variables (SCP1+2/EMP) are on the y-axis, revealing an inverted N-shaped curve relationship with two turning points.

However, this combination also presents a theoretical value that is too high and will take a considerable number of years to achieve. In addition, unlike in the EKC cases, no combination had a significant instance of SCP1+2/EMP– CTK/EMP in the inverted N-shaped curve.

Y (SCP1+2/EMP) = α + β (RPK/EMP) + β (RPK/EMP)^2 *+ β (RPK/EMP)*^{3} *+ ε*

= 521.356 – 328.936 (RPK/EMP) + 112.534 (RPK/EMP)^2

(P = 0.018) (0.040) (0.004)

− 8.304 (RPK/EMP)^3 *+ 86.873*

(0.003)

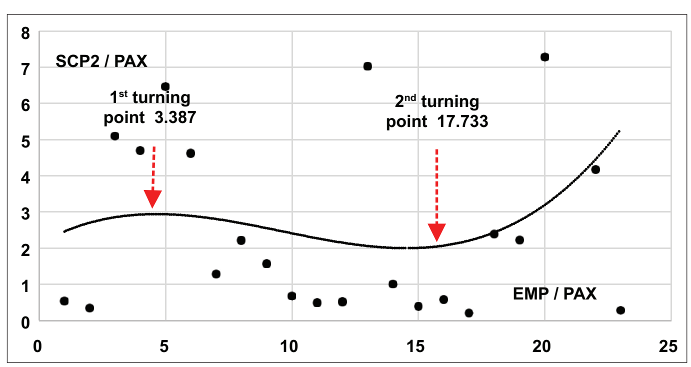
Adj.-R^2 *= 0.814, F = 34.52 (P = 4.196E-08),*

Turning points: 1.462 and 9.035

Indeed, employment appears to be the key to growth and environmental conservation. However, overemployment beyond the appropriate level can be a double-edged sword in which environmental impact will increase again when the appropriate level is exceeded, which is indicated by the second turning point of the inverted N-shaped curve in the figure. Figure 3 demonstrates that the environmental impact per unit, i.e., Scope 2 CO_2/per passenger (SCP2/PAX), increases after the second turning point in the relationship Scope 2 CO_2/per passenger (SCP2/PAX) – Employee/per passenger (EMP/PAX).

Y (SCP2/PAX) = α + β(EMP/PAX) + β (EMP/PAX)^2 *+ β (EMP/PAX)*^{3} *+ ε*

Figure 3: Scope 2 CO_2 / per passengers–Employees / per passengers in 2021



Sources: Author's calculation

$= -1.641{+}06 + 4.168\ (EMP/PAX) - 0.615\ (EMP/PAX)^2$

$(P = 0.188)\ (0.001)\ (0.003)$

$+ 2.313E{-}02\ (EMP/PAX)^3 + 2.143$

$(8.012E{-}04)$

$Adj.{-}R^2 = 0.962,\ F = 188.802\ (P = 2.563E{-}14),$

Turning points: 3.387 and 17.733

First, four or five firms that exceeded the CTK/EMP threshold above the turning points of 0.331-0.336 in the EKC hypothesis. In 2021, All Nippon Airways (ANA), Cathay Pacific, Korean Air, and Singapore Airlines, and in 2022, these four airlines and Qatar Airways passed the turning points in Table 4 in Section 3.3. Notably, these airlines are not among the top-ranked firms in terms of RPK and operating revenue. Therefore, this can be an achievable goal for other airlines in the middle and lower rankings.

Furthermore, the confirmation of clear turning points in Figure 1 indicates the emergence of growth and environmental impact decoupling. The increase CTK/EMP to the thresholds of 0.336–0.361 in 2021 and 2022 in the EKC can serve as guidelines or benchmarks for decoupling. Therefore, CTK/EMP could be key for establishing the EKC hypothesis and realizing environmental conservation and economic growth.

3.3. Discussion

This section discusses the relevant factors of the significance of the results analyzed. First, the results of the linear regression indicate that environmental impacts rise as financial scale increases. For example, the results demonstrate that SCP1 increased as RPK increased in 2019, 2020, 2021, and 2022. Similarly, SCP2 increased as PAX increased in 2019, 2020, and 2021. These results indicate that emissions rise with growth.

Table 4: Airlines' signatures (☑) and ratings

Airlines which exceed				
Names		**TCFD**	**CDP**	**MSCI**
ANA		☑	A	AA
2021	0.361			Leader
2022	0.333			
Cathay Pacific		☑	B	NA
2021	0.491			
2022	0.351			
Korean Air		NO	C	BBB
2021	0.537			Average
2022	0.497			
Singapore Airlines		☑	C	A Average
2021	0.380			
2022	0.345			
Qatar Airways		NO	NA	NA
2021	NO) 0.060			
2022	0.433			
Top-ranked airlines, not exceeding the CTK/EMP threshold				
Names		**TCFD**	**CDP**	**MSCI**
American Airlines		☑	A-	NA
Delta Airlines		NO	B	AA Leader
United Airlines		NO	B	NA

Sources: Each website as of October 2023

Of course, CO_2 emissions include external factors that cannot be solved by the airlines' independent efforts. This is because the emissions include various activities in companies' upstream to downstream in addition to the market expansion of rising demand.

However, the factors that contribute to the establishment of the EKC hypothesis are the result of the interaction of the following three points other than endogenous airlines' efforts, which have been strengthened and gained more attention in the aviation industry in recent years.

The fundamental factor prior to the following three deciding factors is the airlines' endogenous efforts as members of society. In the first place, all airlines, whether state-owned or private, are a collection of citizens. As citizens' interest in advancing environmental conservation and social contributions rises, discussions on ESG-oriented issues within airlines will naturally increase. Subsequently, both management and employees will pursue more ESG-oriented strategies and actions. For example, shifting from prioritizing sales and name recognition in the growth phase to emphasizing ESG activities in the mature phase. In addition, expensive, high-performance, and state-of-the-art technologies and equipment are introduced based on elevated access to financing in more favorable conditions due to increased credibility and name recognition.

Therefore, the following three points are considered to be determinants:

1. Tighter emissions controls for air transport
2. Investors' emphasis on ESG; and
3. Assessments and guidelines by rating agencies and economic and environmental organizations.

First, a series of tighter controls affecting airlines' CO_2 emissions measures have been adopted by the UN, the European Union (EU), and industry associations. In alignment with the goals of the Paris Agreement adopted in 2015, the 39th Assembly of the ICAO of the UN agreed in 2016 on a new global market-based measure to control CO_2 emissions from international aviation, announcing that the implementation of the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) would begin with a pilot phase from 2021 through 2023 (ICAO, 2022; 2023a; 2023b). Then, in 2022, the 41st Assembly of the ICAO agreed on a long-term target of net zero carbon emissions in international aviation by 2050. In particular, Resolution A41-22 of ICAO stipulated that the pilot phase of CORSIA applies from 2021 through 2023 in nations that have volunteered to participate in the scheme. States participating in this phase may determine the basis of operators' offsetting requirements. The resolution also stipulated that the first phase from 2024 to 2026 and the second phase from 2027 to 2035 applies to all nations.

In alignment with the goals of the Paris Agreement and the ICAO's series of resolutions, the 77th Annual General Meeting (AGM) of IATA also approved a resolution for the global air transport industry to achieve net zero carbon emissions by 2050 (IATA, 2021). The 79th AGM in 2021 unveiled a series of roadmaps for aviation to achieve net zero carbon emissions. Press Release No. 26 of June 4, 2023 from the 79th AGM highlighted each roadmap, including the development of more efficient aircraft and engines and the steps required to enable aircraft powered by 100% sustainable aviation fuel (SAF), hydrogen, or batteries. The press release also referred to energy and new fuel infrastructure at airports to facilitate the use of aircraft powered by SAF or hydrogen. The press release also highlighted the importance of financing the cumulative 5 trillion USD needed for aviation to achieve net zero by 2050. Financing issues are discussed further below.

Moreover, consistent with ICAO decisions, the EU extended the EU Emission Trading System to the aviation sector in 2012 through a series of Directives, including

- Directive 2003/87/EC "establishing a scheme for greenhouse gas emission allowance trading within the Community"
- Directive 2008/101/EC "to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community," and
- Directive 2023/958 "as regards aviation's contribution to the Union's economy-wide emission reduction target and the appropriate implementation of a global market-based measure."

The second deciding factor is increased investor emphasis on ESG. This growing sentiment among investors functions as a driving force to advance airlines' environmental conservation activities, particularly through financing requirements, such as loans and underwriting of securities and bonds.

In particular, disclosure is important in scoring. Airlines that lack appropriate ESG information disclosure face challenges in raising funds through the issuance of bonds and securities, bank financing with more favorable terms, and recruiting human resources. In addition, disclosure necessitates the formulation and execution of corporate strategies that are worthy of disclosure and the promotion of ESG-activities, such as participation and commitment to global ESG initiatives. Furthermore, data regarding whether airlines signify and associated ratings are disclosed on sponsoring organizations' websites. As a result, airlines are driven to compete with rivals in terms of disclosure.

Among ESG initiatives, the influence of the UN Principles for Responsible Investment (PRI) has been increasing (PRI, 2022). Signatory investors are bound by the associated Six Principles. For example, "We (signatory investors) will incorporate ESG issues into investment analysis and decision-making processes" (Principle 1), and "We will seek appropriate disclosure on ESG issues by the entities in which we invest" (Principle 3). Consequently, the Principles require signatory investors, including life and nonlife insurance companies, asset managers, and pension funds to make ESG-conscious investment and holding decisions, disclose information to investors, and even obligate disclosures from the investors themselves. The number of signatory investors increased globally from 63 in 2006 (start year) to 5319 by the end of 2022, and 5372 as of June 30, 2023. Furthermore, the total amount of assets under management rose from 6.5 trillion USD in 2006 to 121 trillion USD as of June 2023.

Of the airlines that have surpassed the turning points, focusing on ANA in Japan, the major shareholders that are signatories of the UNPRI are Tokio Marine & Nichido Fire Insurance (5th in terms of shareholding) and Nippon Life Insurance (7th in terms of shareholding). These signatories exercise a certain degree of influence on ESG management.

In recent years, the issuance of environment-related bonds, known as green bonds, and sustainable, or social, bonds, which are related to ESG issues overall, have also been attracting attention. In 2018, ANA became the first airline in the world to issue a green bond at an amount of JPY 10 billion (68 million USD) with a maturity of 10 years. ANA also issued a social bond of JPY 5 billion in 2019 and a sustainability bond of JPY 20 billion in 2021. Moreover, in 2014, ANA agreed to set favorable financing terms according to the results of an ESG disclosure and sustainability implementation assessment prepared by Sumitomo Mitsui Banking Corporation. Furthermore, Korean Air and Cathay Pacific issued ESG-related bonds in 2021 and 2022, respectively, indicating that these funds contributed to the EKC hypothesis through investment in environmental conservation.

The third deciding factor is assessments and guidelines from rating agencies and economic and environmental organizations. Airlines have been forced to compete in terms of nonfinancial information with industry competitors and other industries, particularly concerning environmental ratings. The ratings and initiatives detailed below are also relatively large and influential.

1. Task Force on Climate-related Financial Disclosures (TCFD): This task force examines and recommends climate-related information disclosure and targets; 4,885 companies as of October 2023 (TCFD, 2023)
2. The CDP (formerly known as Carbon Disclosure Project) advocates disclosing information on climate change mitigation, water security, and forests while maintaining consistency with the TCFD. More than 23,000 companies worldwide will disclose environmental information using CDP questionnaires by 2023. Assets under management by these firms total 136 trillion USD (CDP, 2023).
3. Morgan Stanley Capital International (MSCI) ESG Ratings is an index of global research affiliated with Morgan Stanley that covers approximately 2900 companies (MSCI, 2023).

Table 4 presents the signatories and ratings of the five airlines that exceeded the CTK/EMP threshold in Table 3 and the top-ranked airlines by passengers in 2022 that have not yet exceeded the threshold.

The Japanese transport sector also indicates invisible competition for environment-related ratings between different modes of transport, including airlines and even railway companies. For example, Table 5 shows the ratings of ANA, which exceeded the standard values and JAL, which did not exceed the standard values, and the ratings of major railroad companies.

The annual article entitled The SDG Company Ranking Top 500 that is published by Toyo Keizai—one of the bestselling weekly economic magazines—is also influential in Japan. Toyo Keizai

Table 5: Airlines versus major railway companies in Japan

Company name	TCFD	CDP	MSCI
ANA	☑	A	AA Leader
JAL	☑	A	BBB Average
Central Japan Railway	☑	B	BBB Average
East Japan Railway	☑	A-	A Average
West Japan Railway	☑	B	AA Leader

Sources: Each website as of October 2023

(2021) placed ANA in the 40th position, while JAL is ranked below 500, and East Japan Railway is the highest ranked railway company, in 134th place.

The result indicates that competition is occurring in terms of transport and financial performance as well as nonfinancial environmental scores. Although ESG/SDGs scores can be considered arbitrary, as argued in Section 2.2, and it is inappropriate to conduct a purely academic analysis of such scores, a good score contributes to improving companies' external image and is advantageous for recruiting human resources.

The ESG-oriented guidelines of Keidanren (the Japan Business Federation) are also worth mentioning. Keidanren is the most influential business organization in Japan. A total of 1699 Japanese listed companies, including Toyota Motor Corporation and two of the largest domestic airlines, ANA and JAL, are members of Keidanren. Keidanren also makes policy recommendations regarding economic and environmental issues and issues binding corporate guidelines, including an expulsion clause for members.

Most notably, Keidanren revised its Charter of Corporate Behavior for the achievement of SDGs in 2017 (Keidanren, 2017). "As good corporate citizens, we [member companies] will actively participate in society and contribute to its development," the charter states, in addition to "We will promote social responsibility initiatives through ESG-conscious management," and "We will work to achieve a sustainable society." Keidanren also shares ESG best practices. For example, while airlines and railway companies compete with one another, they share ESG-related knowledge with competitors.

Similar associations include, the Singapore Business Federation, which includes about 30 member airlines with offices in Singapore, including Singapore Airlines, ANA's cargo subsidiaries, and Cathay Pacific, and shares ESG activities and knowledge.

Furthermore, member airlines of the three major alliances—Star Alliance, SkyTeam, and oneworld—share knowledge on environmental conservation based on guidelines from the ICAO and other organizations.

It is essential to examine the reasons why certain combinations are significant in the EKC hypothesis, even if it is difficult to prove all combinations mathematically. For example, in the SCP1+2/EMP–CTK/EMP combination, the reduction of CO_2 emissions is an easily understandable target that appeals to investors. For example, the green bonds issued by ANA were used to finance the construction of ANA's training center. The facility was designed to be environmentally friendly by introducing solar power generation, LED lighting fixtures, highly insulated and airtight pair glass, rooftop greenery, natural ventilation, high-efficiency heat source equipment, and a building energy management system. These investments are considered to have contributed to the EKC hypothesis.

Moreover, firms that emphasize ESG engagement have an advantage in recruiting over other firms. A survey by the major Japanese recruiting firm Disco (2022) targeting university students concluded that a company's social contribution, including environmental conservation, influences job selection (number of respondents: 1024; response rate: unpublished). When asked whether a company's positive approach to ESG/SDGs affected job seekers' choice of company, 12.2% chose "very influential" and 39.2% chose "influential" (51.4% total); thus, one of the deciding factors is a rise in citizens' professional ethics and willingness to contribute to environmental conservation and society.

In addition, a survey on university students' attitudes conducted in May 2020 by the Japan Research Institute, a leading think tank in Japan, revealed that when asked about "willingness to work in companies that address environmental and social issues," 11.5% of university students answered "very willing" and 43.8% answered "somewhat willing," for a total of 55.3% (400 respondents; response rate unknown).

In summary, ESG/SDGs appeal to investors and potential job applicants, and airlines must continue to increase strategic focus on these considerations.

4. CONCLUSIONS AND IMPLICATIONS

The regression analyses conducted in this study confirmed the EKC hypothesis in 2019, 2020, 2021, and 2022, revealing the validity of 11 cases (11.1%) in 2019, 13 (13.1%) in 2020, 6 (6.1%) in 2021, and 3 (3.0%) in 2022 considering the 38 leading airlines' financial performance and environmental impacts.

Moreover, the deciding factors, including fundamental efforts by airlines themselves supporting the EKC hypothesis are the result of the interaction of three considerations that have been increasingly encouraged and promoted in the airline industry in recent years: (1) tighter emissions controls for air transport, (2) investors' emphasis on ESG, and (3) assessments and guidelines by rating agencies and economic and environmental organizations.

Undoubtedly, additional issues remain to be examined. For example, it is crucial to further consider why only some cases in the EKC hypothesis and in the inverted N-shaped test are significant, whereas others are not. Long-term verification is also needed because environmental statistics are subject to fluctuation and revision. Additionally, airlines themselves, like the railways, face various challenges, such as abuse of monopolistic market power, improving corporate governance, protecting personal data, and energy savings.

However, the emergence of the turning points in Figure 1 indicates the start of a decoupling of growth and environmental impact. Hence, increasing Scope 1 and 2 CO_2 emissions per employee (SCP1+2/EMP) and cargo ton-kilometers per employee (CTK/EMP) to the thresholds (i.e., JPY 3.36–3.61) in the EKC, can serve as guidelines or benchmarks for airlines that have not reached these levels for decoupling. As the sales and emissions of the airlines analyzed in this study correspond to single countries, ESG-oriented management and increasing CTK/EMP to the thresholds can ultimately contribute to domestic and global environmental conservation.

Moreover, an approach that focuses on ESG and CTK/EMP demonstrated in this study contributes to expanding the research frontier of environmental economics and industrial organization theory. Therefore, it is essential that the academic community continue to investigate the relationship between growth and environmental conservation from multiple industrial perspectives.

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APPENDIX

Table A1: The 38 airlines names

Asia-Pacific - 11
Air China, Air New Zealand, All Nippon Airways Cathay Pacific, China Eastern Airlines,
China Southern Airlines, IndiGo, Japan Airlines, Korean Air, Singapore Airlines, Qantas,
Europe - 13
Aeroflot, Air France, British Airways, Cargo Lux, DHL, easyJet Airline, Finnair, Iberia,
KLM Royal Dutch Airlines, Lufthansa, Ryan Air, Scandinavian Airlines, Turkish Airlines
Latin America - 2
Aero Mexico, LATAM Airlines
Middle East - 3
Etihad Airways, Emirates Airlines, Qatar Airways,
North America - 9
Air Canada, Alaska Airlines,
American Airlines, Delta Airlines, FedEx,
Jet Blue Airways, South West Airlines,
United Airlines, United Parcel Service

Corporation, Group, etc., are omitted for simplicity

Table A2: Significant combinations of dependent and explanatory valuables (*asterisk marks indicate the EKC hypothesis, or the inverted N-shaped curve)

	Constant	(P)	x	(P)	x^2	(p)	x^3
2019							
1-1) SCP1-RPK	1,184,015.735	0.374	108.657	1.860E-14			
1-2) SCP1-PAX	7,331,721.932	0.003	155.617	1.527E-05			
1-5) SCP1-OPR	9,210,661.635	1.815E-04	0.434	1.951E-04			
2-3) SCP2-CTK	−24,217.745	0.704	35.945	6.350E-04			
2-4) SCP2-EMP	108,459.812	0.065	0.769	4.271E-02			
3-1) SCP1+2-RPK	1,506,006.824	0.256	109.193	1.140E-13			
3-2) SCP1+2-PAX	6,751,033.725	0.006	180.109	6.225E-06			
3-5) SCP1+2-OPR	9,584,204.230	4.879E-04	0.416	7.852E-04			
4-6) SCP1/PAX-EMP/PAX	141.068	0.029	281.750	9.059E-04			
4-7) SCP1/PAX-OPR/PAX	2.571	0.965	1.197	8.423E-07			
6-6) SCP1+2/PAX-EMP/PAX	156.286	0.034	274.913	0.004			
6-7) SCP1+2/PAX-OPR/PAX	−16.245	0.818	1.280	8.141E-06			
7-8) SCP1/EMP-RPK/EMP	165.717	0.017	77.843	4.981E-06			
7-10) SCP1/EMP-CTK/EMP	389.876	9.847E-10	487.023	1.615E-08			
8-9) SCP2/EMP-PAX/EMP	−6.367	0.235	6.221	0.036			
8-11) SCP2/EMP-OPR/EMP	−6.610	0.065	0.025	0.001			
9-8) SCP1+2/EMP-RPK/EMP	33.054	0.622	114.107	8.831E-08			
9-10) SCP1+2/EMP-CTK/EMP	398.014	8.613E-09	485.241	8.712E-08			
9-11) SCP1+2/EMP-OPR/EMP	156.205	0.015	0.727	1.948E-06			
*1-3) SCP1-CTK	5,222,752.927	0.190	3,899.599	6.656E-03	−0.199	0.023	
*1-4) SCP1-EMP	7,447,738.383	0.001	246.996	5.443E-06	−4.668E-04	5.247E-06	
*1-5) SCP1-OPR	−1256,730.385	0.603	1.819	5.583E-08	−2.445E-08	3.252E-06	
2019							
*2-4) SCP2-EMP	−15,158.466	0.817	4.425	2.074E-03	−7.078E-06	0.007	
* 3-4) SCP1+2-EMP	7,902,524.575	0.002	246.809	1.730E-05	−4.668E-04	1.558E-05	
*3-5) SCP1+2-OPR	−1,339,132.866	0.626	1.848	7.479E-07	−2.491E-08	1.929E-05	
*4-6) SCP1/PAX-EMP/PAX	−43.581	0.649	746.132	1.230E-03	−225.371	0.023	
*6-6) SCP1+2/PAX-EMP/PAX	−88.770	0.464	857.723	2.700E-03	−266.433	0.025	
*7-8) SCP1/EMP-RPK/EMP	−192.954	0.108	226.735	2.793E-05	−13.151	0.002	
*8-9) SCP2/EMP-PAX/EMP	26.269	0.022	−33.524	1.131E-02	10.021	0.003	
*8-11) SCP2/EMP-OPR/EMP	6.641	0.076	−0.037	9.891E-03	5.270E-05	4.454E-05	
*9-10) SCP1+2/EMP-CTK/EMP	232.649	5.206E-05	1,718.234	8.967E-07	−355.066	6.514E-05	
*9-11) SCP1+2/EMP-OPR/EMP	4.607	0.954	1.432	5.717E-05	−0.001	0.016	
1-4) SCP1-EMP	2,822,026.739	0.188	491.938	3.508E-07	−0.002	5.506E-05	2.578E-09
*1-5) SCP1-OPR	6,197,668.796	0.026	0.269	5.335E-01	4.498E-08	0.014	−7.778E-16
*2-4) SCP2-EMP	106,495.204	0.116	−1.927	3.861E-01	3.958E-05	0.010	−6.660E-11
3-4) SCP1+2-EMP	3,343,059.322	0.160	484.876	1.984E-06	−2.215E-03	1.805E-04	2.496E-09
*3-5) SCP1+2-OPR	6,445,635.662	0.042	0.255	5.973E-01	4.520E-08	0.024	−7.779E-16
8-9) SCP2/EMP-PAX/EMP	−28.028	0.047	74.569	4.760E-03	−52.739	5.796E-04	10.776
*9-8) SCP1+2/EMP-RPK/EMP	521.356	0.018	−328.936	0.040	112.534	0.004	−8.304
9-10) SCP1+2/EMP-CTK/EMP	131.722	0.045	3,753.896	5.839E-04	−5,923.536	0.025	1,444.814
2020							
1-1) SCP1-RPK	1,391,182.093	0.039	148.938	4.374E-14			
1-2) SCP1-PAX	3,709,746.669	8.779E-05	205.885	1.226E-08			
1-3) SCP1-CTK	5,903,129.392	1.767E-05	584.216	0.003			
2-1) SCP2-RPK	−9,111.498	0.638	1.602	5.781E-05			
2-2) SCP2-PAX	29,179.948	0.169	1.729	0.015			

(Contd...)

Table A2: ***(Continued)***

	Constant	(P)	x	(P)	x^2	(p)	x^3
3-1) SCP1+2-RPK	1,477,527.410	0.045	148.225	1.194E-12			
3-2) SCP1+2-PAX	3,853,761.902	2.282E-04	207.822	1.330E-07			
3-3) SCP1+2-CTK	6,241,228.563	2.657E-05	561.110	0.007			
4-6) SCP1/PAX-EMP/PAX	152.009	0.134	206.601	3.299E-05			
4-7) SCP1/PAX-OPR/PAX	268.701	0.003	0.564	5.025E-05			
5-6) SCP2/PAX-EMP/PAX	0.583	0.682	1.876	0.004			
5-7) SCP2/PAX-OPR/PAX	1.624	0.175	0.005	0.006			
6-6) SCP1+2/PAX-EMP/PAX	141.855	0.197	219.517	5.239E-05			
7-8) SCP1/EMP-RPK/EMP	80.953	0.036	142.063	4.749E-08			
7-9) SCP1/EMP-PAX/EMP	185.194	2.955E-05	166.367	9.138E-05			
7-10) SCP1/EMP-CTK/EMP	203.866	1.442E-09	537.147	7.227E-15			
7-11) SCP1/EMP-OPR/EMP	180.955	0.001	0.467	0.006			
8-11) SCP2/EMP-OPR/EMP	0.748	0.202	0.005	0.012			
9-8) SCP1+2/EMP-RPK/EMP	117.734	0.007	119.220	1.459E-05			
9-9) SCP1+2/EMP-PAX/EMP	223.164	1.180E-04	117.077	0.049			
6-7) SCP1+2/PAX-OPR/PAX	275.537	0.006	0.567	1.480E-04			
2020							
9-10) SCP1+2/EMP-CTK/EMP	207.580	7.077E-09	535.857	6.519E-14			
9-11) SCP1+2/EMP-OPR/EMP	146.531	0.001	0.543	1.312E-04			
*2-5) SCP2-OPR	−16,062.532	0.392	0.014	8.189E-06	−2.057E-10	1.860E-05	
*3-4) SCP1+2-EMP	4,124,461.052	1.312E-04	133.271	6.253E-07	−2.204E-04	2.007E-06	
*3-5) SCP1+2-OPR	2,617,701.263	0.044	1.045	2.101E-06	−1.489E-08	6.285E-06	
*1-4) SCP1-EMP	4,225,025.031	4.915E-05	130.448	6.399E-07	−2.158E-04	2.265E-06	
*1-5) SCP1-OPR	2,967,804.176	0.019	0.992	3.425E-06	−1.417E-08	1.110E-05	
*4-6) SCP1/PAX-EMP/PAX	−113.582	0.482	462.656	1.480E-03	−39.972	0.050	
*4-7) SCP1/PAX-OPR/PAX	−36.138	0.739	1.757	1.621E-05	−0.001	9.614E-04	
*5-7) SCP2/PAX-OPR/PAX	−2.867	0.072	0.022	9.858E-05	−8.368E-06	9.077E-04	
*6-6) SCP1+2/PAX-EMP/PAX	−258.708	0.154	595.537	3.793E-04	−56.658	0.012	
*6-7) SCP1+2/PAX-OPR/PAX	−84.251	0.480	1.962	1.766E-05	−0.001	6.204E-04	
*7-11) SCP1/EMP-OPR/EMP	64.446	0.402	1.447	0.010	−0.001	0.061	
*8-10) SCP2/EMP-CTK/EMP	0.877	0.090	8.458	0.004	−2.499	0.004	
9-9) SCP1+2/EMP-PAX/EMP	374.600	1.648E-05	−276.753	0.078	193.611	0.011	
*9-11) SCP1+2/EMP-OPR/EMP	13.488	0.801	1.671	1.006E-04	−0.002	0.003	
1-4) SCP1-EMP	2,860,994.988	0.010	207.839	1.460E-05	−7.881E-04	0.005	7.875E-10
2-4) SCP2-EMP	−3,943.710	0.850	3.160	3.183E-04	−1.497E-05	0.005	1.694E-11
3-4) SCP1+2-EMP	2,672,686.544	0.017	213.933	8.654E-06	−8.145E-04	0.003	8.166E-10
3-5) SCP1+2-OPR	−413,812.897	0.827	2.051	3.896E-04	−7.637E-08	0.015	7.075E-16
2021							
1-1) SCP1-RPK	3,148,844.225	4.580E-04	109.055	4.082E-12			
1-2) SCP1-PAX	4,330,692.884	1.396E-04	175.727	6.318E-09			
1-3) SCP1-CTK	6,566,803.260	0.001	643.423	1.571E-02			
2-1) SCP2-RPK	8,551.120	0.540	0.733	1.541E-04			
2-2) SCP2-PAX	23,423.864	0.145	1.028	4.859E-03			
2-3) SCP2-CTK	−31,405.580	22.810	0.388	1.476E-04			
3-1) SCP1+2-RPK	3,295,763.471	4.116E-04	108.917	9.723E-12			
3-2) SCP1+2-PAX	4,504,249.416	1.585E-04	174.916	1.562E-08			
3-3) SCP1+2-CTK	6,794,360.656	0.001	641.121	0.019			
3-5) SCP1+2-OPR	7,891,271.313	0.189	2.026E-06	0.023			
4-6) SCP1/PAX-EMP/PAX	−85.233	0.467	361.850	2.282E-14			

(Contd...)

Table A2: *(Continued)*

	Constant	(P)	x	(P)	x^2	(p)	x^3
4-7) SCP1/PAX-OPR/PAX	36.090	0.733	1.315	7.000E-16			
5-6) SCP2/PAX-EMP/PAX	−1.132	0.296	2.088	2.652E-10			
5-7) SCP2/PAX-OPR/PAX	−0.678	0.319	0.008	4.364E-15			
6-6) SCP1+2/PAX-EMP/PAX	−73.387	0.545	363.468	7.302E-14			
6-7) SCP1+2/PAX-OPR/PAX	42.979	0.695	1.322	2.007E-15			
7-8) SCP1/EMP-RPK/EMP	185.485	7.414E-06	693.639	6.152E-05			
7-11) SCP1/EMP-OPR/EMP	81.381	0.178	0.947	2.490E-04			
9-10) SCP1+2/EMP-CTK/EMP	189.300	1.378E-05	689.931	1.092E-04			
9-11) SCP1+2/EMP-OPR/EMP	89.321	0.151	0.935	3.659E-04			
*1-4) SCP1-EMP	4,968,471.752	0.003	159.608	3.229E-05	−2.666E-04	4.502E-05	
2-3) SCP2-CTK	79,303.393	0.035	−26.363	2.420E-02	0.003	5.356E-05	
*2-4) SCP2-EMP	−77,673.217	0.035	4.698	0.716E-07	−7.552E-06	1.959E-06	
*3-4) SCP1+2-EMP	5,215,743.190	0.003	160.632	3.641E-05	−2.688E-04	4.791E-05	
2021							
*7-10) SCP1/EMP-CTK/EMP	95.169	0.021	2,190.997	1.351E-04	−3,036.566	0.004	
*9-10) SCP1+2/EMP-CTK/EMP	97.576	0.024	2,191.137	2.074E-04	−3,037.029	0.004	
*3-5) SCP1+2-OPR	1,483,239.751	0.135	1.301	4.772E-12	−1.507E-08	5.381E-11	
1-4) SCP1-EMP	481,865.486	0.755	377.508	6.150E-07	−0.002	3.728E-05	1.960E-09
2-3) SCP2-CTK	−21,371.049	0.518	57.843	3.967E-03	−0.010	0.001	4.338E-07
*2-4) SCP2-EMP	42,288.787	0.130	−1.024	0.291	3.197E-05	2.557E-05	−5.117E-11
3-4) SCP1+2-EMP	818,316.977	0.613	370.372	1.547E-06	−1.718E-03	8.383E-05	1.876E-09
5-6) SCP2/PAX-EMP/PAX	−1.641	0.188	4.168	1.392E-03	−0.615	0.003	0.023
2022							
1-1) SCP1-RPK	2,188,480.883	0.043	97.597	1.401E-12			
1-2) SCP1-PAX	4501279.331	0.003	206.835	2.963E-08			
1-4) SCP1-EMP	9,584,777.960	2.120E-04	63.454	2.431E-02			
1-5) SCP1-OPR	4,737,645.337	0.002	0.586	3.695E-08			
2-1) SCP2-RPK	22,397.418	0.217	0.355	1.289E-02			
2-2) SCP2-PAX	31580.224	0.106	0.928	9.893E-03			
2-3) SCP2-CTK	−20,371.782	0.574	24.641	1.487E-04			
2-4) SCP2-EMP	−33,500.263	0.062	2.502	3.883E-11			
3-1) SCP1+2-RPK	2,559,242.992	0.025	96.995	6.735E-12			
3-2) SCP1+2-PAX	4768208.218	0.003	205.656	7.356E-08			
3-4) SCP1+2-EMP	9,929,813.171	2.289E-04	63.845	0.026			
3-5) SCP1+2-OPR	5,172,967.475	0.004	0.578	3.504E-07			
4-6) SCP1/PAX-EMP/PAX	84.323	0.264	284.373	6.307E-07			
4-7) SCP1/PAX-OPR/PAX	37.108−0.341	0.467	0.914	1.093E-08			
5-6) SCP2/PAX-EMP/PAX	0.0162	0.714	2.013	4.233E-04			
5-7) SCP2/PAX-OPR/PAX		0.909	0.005	0.015			
2022							
6-6) SCP1+2/PAX-EMP/PAX	70.355	0.530	311.366	4.444E-07			
6-7) SCP1+2/PAX-OPR/PAX	45.942	0.4022	0.9155	4.373E-08			
9-8) SCP1+2/EMP-RPK/EMP	149.013	0.014	77.424	4.692E-05			
9-10) SCP1+2/EMP-CTK/EMP	236.101	3.555E-04	949.736	0.003			
9-11) SCP1+2/EMP-OPR/EMP	74.238	0.368	0.767	8.601E-04			
*1-4) SCP1-EMP	1,577,392.578	0.462	348.431	3.830E-06	−0.001	2.545E-05	
*3-4) SCP1+2-EMP	1,864,202.134	0.410	345.138	8.229E-06	−0.001	5.099E-05	
*9-10) SCP1+2/EMP-CTK/EMP	119.947	0.115	2897.028	0.006	−4313.057	0.043	0.030
2-3) SCP2-CTK	39,016.249	0.329	78.260	0.002	−0.013	6.084E-04	5.813E-07
5-6) SCP2/PAX-EMP/PAX	−3.623	0.138	9.199	0.032	−3.6798	0.0418	0.447

(Contd...)

Table A2: ***(Continued)***

	(P)	Standard errors	Adj.-R²	F	(P)	1st turning points	2nd turning points
2019							
1-1) SCP1-RPK		3,969,949.952	0.858	188.009	1.860E-14		
1-2) SCP1-PAX		7,796,987.570	0.452	26.519	1.527E-05		
1-5) SCP1-OPR		8,499,995.387	0.345	17.844	1.951E-04		
2-3) SCP2-CTK		213,756.354	0.343	15.072	6.350E-04		
2-4) SCP2-EMP		249,472.470	0.120	4.560	0.043		
3-1) SCP1+2-RPK		3,765,889.944	0.879	197.987	1.140E-13		
3-2) SCP1+2-PAX		7,411,080.658	0.533	31.836	6.225E-06		
3-5) SCP1+2-OPR		8,906,635.370	0.322	14.305	7.852E-04		
4-6) SCP1/PAX-EMP/PAX		148.224	0.336	14.168	9.059E-04		
4-7) SCP1/PAX-OPR/PAX		117.301	0.571	39.561	8.423E-07		
6-6) SCP1+2/PAX-EMP/PAX		155.946	0.296	10.674	0.004		
6-7) SCP1+2/PAX-OPR/PAX		124.011	0.553	31.903	8.141E-06		
7-8) SCP1/EMP-RPK/EMP		127.408	0.555	33.457	4.981E-06		
7-10) SCP1/EMP-CTK/EMP		197.372	0.716	66.672	1.615E-08		
8-9) SCP2/EMP-PAX/EMP		10.560	0.147	4.970	0.036		
8-11) SCP2/EMP-OPR/EMP		8.974	0.332	13.451	0.001		
9-8) SCP1+2/EMP-RPK/EMP		106.054	0.723	60.951	8.831E-08		
9-10) SCP1+2/EMP-CTK/EMP		208.682	0.707	58.873	8.712E-08		
9-11) SCP1+2/EMP-OPR/EMP		155.896	0.602	38.795	1.948E-06		
*1-3) SCP1-CTK		9,517,925.315	0.216	5.135	0.013	9,796.082	
*1-4) SCP1-EMP		7,558,098.008	0.512	16.214	2.369E-05	264,538.462	
*1-5) SCP1-OPR		5,987,895.040	0.675	34.212	1.821E-08	37,194,889.013	
2019							
*2-4) SCP2-EMP		218,268.732	0.327	7.308	0.003	312,551.294	
* 3-4) SCP1+2-EMP		7,860,575.539	0.512	14.646	6.960E-05	264,355.739	
*3-5) SCP1+2-OPR		6,348,038.429	0.656	27.656	3.653E-07	37,081,630.852	
*4-6) SCP1/PAX-EMP/PAX		135.628	0.444	11.390	3.325E-04	1.655	
*6-6) SCP1+2/PAX-EMP/PAX		141.106	0.424	9.454	0.001	1.610	
*7-8) SCP1/EMP-RPK/EMP		105.790	0.693	30.394	2.645E-07	8.620	
*8-9) SCP2/EMP-PAX/EMP		8.723	0.418	9.265	0.001	1.673	
*8-11) SCP2/EMP-OPR/EMP		6.333	0.668	26.096	1.213E-06	351.429	
*9-10) SCP1+2/EMP-CTK/EMP		147.349	0.854	71.109	2.495E-10	2.420	
*9-11) SCP1+2/EMP-OPR/EMP		140.041	0.679	27.410	8.173E-07	1,187.877	
1-4) SCP1-EMP	6.679E-04	6,139,281.270	0.678	21.357	3.459E-07	108,298.174	587,383.627
*1-5) SCP1-OPR	2.823E-04	4,833,552.801	0.788	40.683	1.617E-10	−2,994,501.954	38,558,293.391
*2-4) SCP2-EMP	0.003	182,872.366	0.527	10.671	1.367E-04	24,350.984	396,173.959
3-4) SCP1+2-EMP	0.002	6,451,399.270	0.671	18.705	2.285E-06	109,434.577	591,712.094
*3-5) SCP1+2-OPR	0.001	5,147,352.394	0.774	32.890	7.754E-09	−2,826,298.262	38,734,883.843
8-9) SCP2/EMP-PAX/EMP	8.233E-05	6.011	0.724	21.080	2.097E-06	0.707	3.263
*9-8) SCP1+2/EMP-RPK/EMP	0.002	86.873	0.814	34.542	4.196E-08	1.462	9.035
9-10) SCP1+2/EMP-CTK/EMP	0.034	135.185	0.877	58.033	2.462E-10	0.317	2.733
2020							
1-1) SCP1-RPK		2,177,897.429	0.830	162.536	4.374E-14		
1-2) SCP1-PAX		3,125,287.967	0.655	59.945	1.226E-08		
1-3) SCP1-CTK		4,808,438.977	0.220	10.025	3.454E-03		
2-1) SCP2-RPK		62,167.371	0.413	22.122	5.781E-05		
2-2) SCP2-PAX		74,950.661	0.169	6.684	1.545E-02		

(Contd...)

Table A2: ***(Continued)***

	(P)	Standard errors	Adj.-R^2	F	(P)	1st turning points	2nd turning points
3-1) SCP1+2-RPK		2,280,042.835	0.823	140.764	1.194E-12		
3-2) SCP1+2-PAX		3,293,036.573	0.636	50.001	1.330E-07		
3-3) SCP1+2-CTK		4,961,465.129	0.199	8.454	0.007		
4-6) SCP1/PAX-EMP/PAX		317.998	0.446	24.369	3.299E-05		
4-7) SCP1/PAX-OPR/PAX		322.361	0.419	22.600	5.025E-05		
5-6) SCP2/PAX-EMP/PAX		4.326	0.258	10.036	0.004		
5-7) SCP2/PAX-OPR/PAX		4.376	0.224	8.810	0.006		
6-6) SCP1+2/PAX-EMP/PAX		329.278	0.466	23.702	5.239E-05		
7-8) SCP1/EMP-RPK/EMP		94.146	0.649	54.642	4.749E-08		
7-9) SCP1/EMP-PAX/EMP		122.483	0.406	20.826	9.138E-05		
7-10) SCP1/EMP-CTK/EMP		116.315	0.885	223.172	7.227E-15		
7-11) SCP1/EMP-OPR/EMP		155.453	0.198	8.650	0.006		
8-11) SCP2/EMP-OPR/EMP		1.741	0.182	7.242	0.012		
9-8) SCP1+2/EMP-RPK/EMP		92.727	0.516	28.768	1.459E-05		
9-9) SCP1+2/EMP-PAX/EMP		125.626	0.112	4.294	0.049		
6-7) SCP1+2/PAX-OPR/PAX		342.110	0.409	19.699	1.480E-04		
2020							
9-10) SCP1+2/EMP-CTK/EMP		119.885	0.885	207.778	6.519E-14		
9-11) SCP1+2/EMP-OPR/EMP		117.794	0.402	19.857	1.312E-04		
*2-5) SCP2-OPR		57,899.045	0.456	14.420	4.090E-05	34,613,119.040	
*3-4) SCP1+2-EMP		3,404,359.389	0.588	21.729	2.379E-06	302,288.528	
*3-5) SCP1+2-OPR		3,896,869.725	0.502	17.153	1.079E-05	35,074,774.873	
*1-4) SCP1-EMP		3,472,466.962	0.550	20.591	2.351E-06	302,259.841	
*1-5) SCP1-OPR		3,987,402.757	0.454	15.544	1.753E-05	35,002,251.338	
*4-6) SCP1/PAX-EMP/PAX		301.140	0.503	15.698	3.001E-05	5.787	
*4-7) SCP1/PAX-OPR/PAX		269.126	0.595	23.016	1.226E-06	1,510.053	
*5-7) SCP2/PAX-OPR/PAX		3.565	0.485	13.716	9.536E-05	1,329.697	
*6-6) SCP1+2/PAX-EMP/PAX		293.934	0.575	18.559	1.344E-05	5.256	
*6-7) SCP1+2/PAX-OPR/PAX		274.769	0.619	22.922	2.215E-06	1,462.864	
*7-11) SCP1/EMP-OPR/EMP		148.673	0.266	6.628	4.260E-03	516.029	
*8-10) SCP2/EMP-CTK/EMP		1.723	0.236	5.159	1.331E-02	1.692	
9-9) SCP1+2/EMP-PAX/EMP		111.568	0.300	6.570	5.301E-03	0.715	
*9-11) SCP1+2/EMP-OPR/EMP		101.396	0.557	18.619	9.591E-06	519.310	
1-4) SCP1-EMP	0.034	3,265,526.299	0.602	17.163	1.338E-06	131,866.579	667,149.665
2-4) SCP2-EMP	0.018	61,742.418	0.401	7.464	9.202E-04	105,590.088	589,061.034
3-4) SCP1+2-EMP	0.025	3,142,070.127	0.649	18.904	1.030E-06	131,325.463	664,924.430
3-5) SCP1+2-OPR	0.046	3,696,245.277	0.552	14.159	7.240E-06	13,426,667.166	
2021							
1-1) SCP1-RPK		3,291,940.994	0.786	118.460	4.082E-12		
1-2) SCP1-PAX		4,019,282.560	0.696	67.246	6.318E-09		
1-3) SCP1-CTK		6,652,410.024	0.152	6.558	1.571E-02		
2-1) SCP2-RPK		55,404.520	0.364	18.729	1.541E-04		
2-2) SCP2-PAX		62,367.805	0.231	9.414	4.859E-03		
2-3) SCP2-CTK		136,717.247	0.376	19.048	1.476E-04		
3-1) SCP1+2-RPK		3,334,991.880	0.785	114.013	9.723E-12		
3-2) SCP1+2-PAX		4,100,720.009	0.689	63.016	1.562E-08		
3-3) SCP1+2-CTK		6,760,476.517	0.147	6.154	1.916E-02		
3-5) SCP1+2-OPR		6,687,297.381	0.122	5.707	2.277E-02		

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Table A2: ***(Continued)***

	(P)	Standard errors	Adj.-R²	F	(P)	1st turning points	2nd turning points
4-6) SCP1/PAX-EMP/PAX		477.215	0.929	304.171	2.282E-14		
4-7) SCP1/PAX-OPR/PAX		493.790	0.910	285.408	7.000E-16		
5-6) SCP2/PAX-EMP/PAX		4.292	0.849	125.010	2.652E-10		
5-7) SCP2/PAX-OPR/PAX		3.096	0.906	261.590	4.364E-15		
6-6) SCP1+2/PAX-EMP/PAX		485.087	0.931	296.550	7.302E-14		
6-7) SCP1+2/PAX-OPR/PAX		501.415	0.912	279.235	2.007E-15		
7-8) SCP1/EMP-RPK/EMP		107.381	0.504	24.364	6.152E-05		
7-11) SCP1/EMP-OPR/EMP		117.086	0.411	18.452	2.490E-04		
9-10) SCP1+2/EMP-CTK/EMP		109.846	0.495	22.534	1.092E-04		
9-11) SCP1+2/EMP-OPR/EMP		118.612	0.406	17.413	3.659E-04		
*1-4) SCP1-EMP		5,067,589.818	0.496	13.283	1.463E-04	299,314.722	
2-3) SCP2-CTK		103,450.110	0.643	27.960	2.119E-07	4,593.363	
*2-4) SCP2-EMP		111,849.085	0.650	23.314	3.674E-06	311,034.727	
*3-4) SCP1+2-EMP		5,051,925.291	0.507	13.325	1.617E-04	298,786.128	
2021							
*7-10) SCP1/EMP-CTK/EMP		89.319	0.657	23.006	5.114E-06	0.361	
*9-10) SCP1+2/EMP-CTK/EMP		91.534	0.649	21.348	1.091E-05	0.361	
*3-5) SCP1+2-OPR		3,434,312.587	0.768	57.381	2.610E-11	43,155,355.265	
1-4) SCP1-EMP	2.265E-04	3,778,539.059	0.720	22.385	7.028E-07	106,130.866	605,062.721
2-3) SCP2-CTK	2.327E-05	75,183.486	0.811	43.961	1.588E-10	3,015.715	14,738.148
*2-4) SCP2-EMP	1.321E-06	64,801.908	0.883	61.151	1.509E-10	16,007.768	416,564.472
3-4) SCP1+2-EMP	4.817E-04	3,843,072.198	0.715	21.023	1.572E-06	107,809.858	610,495.909
5-6) SCP2/PAX-EMP/PAX	0.001	2.143	0.962	188.802	2.563E-14	3.387	17.733
2022							
1-1) SCP1-RPK		3,617,530.855	0.843	151.355	1.401E-12		
1-2) SCP1-PAX		4395170.270	0.799	80.385	2.963E-08		
1-4) SCP1-EMP		8,415,734.961	0.174	5.849	2.431E-02		
1-5) SCP1-OPR		4,491,654.295	0.794	78.128	3.695E-08		
2-1) SCP2-RPK		60,044.580	0.192	7.173	1.289E-02		
2-2) SCP2-PAX		60801.4122	0.278	8.314	9.893E-03		
2-3) SCP2-CTK		128,257.004	0.435	20.236	1.487E-04		
2-4) SCP2-EMP		64,270.670	0.874	154.117	3.883E-11		
3-1) SCP1+2-RPK		3,651,385.956	0.847	144.868	6.735E-12		
3-2) SCP1+2-PAX		4471009.623	0.797	75.574	7.356E-08		
3-4) SCP1+2-EMP		8,479,153.533	0.178	5.768	2.566E-02		
3-5) SCP1+2-OPR		4,778,056.212	0.779	64.383	3.504E-07		
4-6) SCP1/PAX-EMP/PAX		211.991	0.763	59.021	6.307E-07		
4-7) SCP1/PAX-OPR/PAX		124.276	0.935	187.613	1.093E-08		
5-6) SCP2/PAX-EMP/PAX		2.600	0.522	19.594	4.233E-04		
5-7) SCP2/PAX-OPR/PAX		3.398	0.375	8.209	0.015		
2022							
6-6) SCP1+2/PAX-EMP/PAX		358.949	0.773	62.171	4.444E-07		
6-7) SCP1+2/PAX-OPR/PAX		128.660	0.9351	174.007	4.373E-08		
9-8) SCP1+2/EMP-RPK/EMP		129.178	0.532	26.049	4.692E-05		
9-10) SCP1+2/EMP-CTK/EMP		161.839	0.372	12.272	0.003		
9-11) SCP1+2/EMP-OPR/EMP		117.981	0.503	17.199	8.601E-04		
*1-4) SCP1-EMP		5,588,436.733	0.648	21.244	1.128E-05	192,108.069	
*3-4) SCP1+2-EMP		5,701,592.861	0.641	19.711	2.321E-05	193,538.581	

(Contd...)

Table A2: ***(Continued)***

	(P)	Standard errors	Adj.-R^2	F	(P)	1st turning points	2nd turning points
*9-10) SCP1+2/EMP-CTK/EMP		147.065	0.482	9.830	1.456E-03	0.336	
2-3) SCP2-CTK	8.458E-05	78,834.512	0.786	31.696	3.627E-08	2,974.963	15,084.891
5-6) SCP2/PAX-EMP/PAX	0.030	2.2824	0.6320	10.7301	6.328E-04	1.250	5.484

Sources: author's calculation based on the environmental reports/ESG data of each company. The data is presented to three digits after the decimal point to ensure rigor. If zero continues after the third digit (e.g., 0.0000152678), it is not presented as 0.000, but as an exponent, 1.527E-05. The amount exceeding one million yen, i.e., seven digits, is also indicated as an exponent