

Original Article

Growth and Environmental Conservation of Japan's National Universities

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Abstract – This study examines how national universities in Japan can achieve institutional growth and environmental conservation by analyzing primary data on the management performance and environmental impact of 20 national universities, with the aim of obtaining insights. Each fiscal year from 2019 to 2023 is analyzed independently, covering the periods before, during, and after the COVID-19 pandemic. Three key findings are presented. First, regression analyses based on the Environmental Kuznets Curve (EKC) hypothesis identify turning points in revenue per person (REV/PRS), ranging from JPY 4.733 to 5.242. These thresholds represent achievable targets for universities seeking to reduce CO₂ emissions per person. Second, empirical support for the EKC hypothesis can be attributed to not only the efforts made by individual universities but also interactions of three critical factors: (1) stricter emission regulations and guidelines; (2) competition for government grants; and (3) ratings of and initiatives undertaken by external organizations focused on environment, social, and governance performance. Third, and crucially, reaching the identified REV/PRS thresholds offers an empirical benchmark for validating the EKC hypothesis and illustrates a viable pathway for achieving institutional growth while ensuring environmental conservation, especially for small and medium-sized universities in regional cities. Moreover, the study's framework contributes to advancing the research frontiers in environmental economics and industrial organizations.

Keywords - EKC hypothesis, ESG, CO₂ emissions per person, small and medium-sized universities, university rankings.

1. Introduction

This study examines how national universities in Japan can achieve institutional growth and environmental conservation. In particular, it analyzes primary data on the management performance and environmental impact of 20 national universities, aiming to generate insights related to advancing academic research, corporate strategy, and policymaking.

All Japanese universities are expected to enhance educational and research outcomes; implement digital transformation and artificial intelligence; manage personal data responsibly; and strengthen Environmental, Social, and Governance (ESG) initiatives. In fact, most universities, excluding top-tier institutions such as the University of Tokyo, face or are expected to face serious challenges in securing highly capable and motivated students, primarily owing to unfavorable demographic trends such as a declining youth population and an aging society.

In particular, within the environmental dimension, national universities are bound by law to disclose environmental information in accordance with government

policies. At the national level, the Japanese government has committed to reducing CO₂ emissions by 46% by 2030 compared with 2013 levels. In this context, it is increasingly important for universities to strengthen their educational, research, and administrative foundations while advancing environmental conservation efforts.

This study applies the Environmental Kuznets Curve (EKC) hypothesis to assess environmental performance at the level of national universities in Japan. Unlike traditional EKC studies that focus on countries or regions, this study extends the EKC framework—including its inverted N-shaped formulation—to the institutional level of higher education. A thorough review of the literature reveals that although university performance has often been examined using metrics such as staffing and financial resources, no study has applied the EKC framework to environmental performance using primary data. As such, this study offers a novel perspective and presents relevant information for research on universities in other countries as well.

Regression analyses based on the EKC hypothesis are conducted, identifying turning points in revenue per person (REV/PRS), ranging from JPY 4.733 to 5.242 (approximately



USD 0.031–0.035). These values serve as empirical benchmarks for universities aiming to reduce CO₂ emissions per person (*CO2/PRS*).

The achievement of these thresholds can empirically support the EKC hypothesis, highlighting a viable pathway to institutional growth that is compatible with environmental conservation objectives. By adopting an ESG-informed, *REV/PRS*-centred analytical framework, this study makes significant contributions to the fields of environmental economics and industrial organization. This study builds on the author's previous research and analytical methods. However, in accordance with the journal's editorial policy, those earlier works are not cited in this manuscript.

2. Conceptual Clarifications, Research Gaps, and Ongoing Issues

2.1. Conceptual Clarifications

First, it is necessary to outline the structure of Japan's national university system. In April 2004, national universities were reorganized as independent entities with corporate status, known as National University Corporations. This transition marked a shift from their status as administrative bodies operated by the Ministry of Education, Culture, Sports, Science and Technology (hereinafter referred to as the Ministry of Education) itself. Under the new framework, each university is granted enhanced autonomy and greater self-governance in key areas such as personnel management, budgeting, education, and research, compared to the previous structure. However, through mechanisms such as management expense grants (See Section 5), mandatory reporting requirements, and the secondment of Ministry officials to university posts, national universities effectively remain under the oversight of the Ministry of Education.

As of the end of fiscal year (FY) 2023 (i.e., the final year of the study period), Japan had a total of 810 universities, comprising 86 national, 102 public (prefectural or municipal), and 622 private universities. These institutions collectively enrolled approximately 2.945 million students and employed approximately 1.918 million academic and administrative staff.^[1] This study focuses on small and medium-sized universities in regional cities, specifically those ranked below the 11th position in terms of student and faculty population and situated outside the major metropolitan areas of Tokyo, Nagoya, and Osaka.

“Institutional growth” refers to the increase in key quantitative indicators, namely, the number of students and faculty members, total assets, and revenue. These indicators reflect the core dimensions of personnel, total assets, and financial resources. The number of personnel constitutes the official headcount and does not account for mid-year withdrawals or resignations.

“Environmental conservation” is defined in accordance with Article 2 of Japan's Basic Environment Act (No. 91 of 1995). As stipulated in the legislation, it encompasses precautionary measures against phenomena such as global warming, ozone depletion, marine contamination, and biodiversity loss—environmental disruptions triggered by human activity that impact the entire globe or specific regions.

“CO₂ emissions” refer to the combined total of Scope 1 and Scope 2 emissions. Scope 1 refers to the direct emissions of greenhouse gases from sources owned or controlled by the institution. Meanwhile, Scope 2 refers to indirect emissions resulting from the consumption of electricity, heat, or steam produced by other entities. As some universities do not disclose Scope 3 emissions—which refer to indirect emissions (excluding Scope 2 emissions) that originate from other entities involved in the university's operational activities—this study excludes them from the analysis.

This study uses the EKC hypothesis as a conceptual framework to examine the relationship between institutional growth and environmental impact at the university level. The EKC hypothesis adapts Dr. Simon Kuznets's original theory—formulated at the outset to describe the association between economic growth and income inequality—to the field of environmental economics. Since its introduction in the early 1990s, the EKC hypothesis has prompted extensive empirical investigation. Pioneering work by Grossman and Krueger and the World Bank laid the groundwork for analyzing a broad range of environmental issues, including air and water pollution and deforestation.^[2,3]

Prior studies on the EKC hypothesis have focused on addressing three key issues: (1) determining whether the hypothesis holds empirically, (2) identifying the income levels at which turning points occur, and (3) understanding the underlying mechanisms driving the curve. After the EKC hypothesis is confirmed, the focus of the literature shifts to estimating the income thresholds at which the environmental impact begins to decline. Even among studies validating the EKC hypothesis, the estimated turning points differ based on the methodological approach employed and the pollutants analyzed. For example, Grossman and Krueger estimated the turning point for sulfur dioxide (SO₂) at USD 4,053, whereas Selden et al. estimated turning points for SO₂ at USD 8,916 and for nitrogen oxide (NO_x) at USD 11,217.^[4,5]

Moreover, the literature presents varying interpretations of the underlying mechanisms driving the EKC hypothesis. Andreoni and Levinson attribute the observed pattern to advancements in production and emission-reducing technologies and structural shifts in the economy, such as reduced dependence on fossil fuels.^[6] Likewise, De Bruyn and Markandya et al. examine how regulatory reforms and institutional or policy changes can drive pollution reduction.

[7,8] Panayotou, however, criticizes earlier studies for treating these factors as a “black box,” emphasizing the lack of clarity in these studies about why the EKC pattern emerges. [9]

These studies suggest that the EKC is not the result of a single causal mechanism. Rather, it is likely shaped by the dynamic and cyclical interactions between key economic actors—including governments, firms, and citizens—who promote environmental improvements over time through heightened awareness, institutional development, the adoption of environmentally sound technologies and products, and a commitment toward sustainable economic practices.

The EKC hypothesis posits a nonlinear relationship wherein environmental degradation increases at the outset with economic growth but begins to decline after a certain income threshold is reached, producing an inverted U-shaped curve. Empirical validation of the EKC requires that the linear ($\beta > 0$) and squared ($\beta < 0$) terms in the regression model are statistically significant.

Figure 1 illustrates the relationship between CO_2/PRS and REV/PRS for 2022 and 2023 among the 20 national universities analyzed in this study. The identified turning points serve as empirical benchmarks for universities aiming to reduce CO_2 emissions in accordance with the EKC framework. Further methodological details are provided in Section 3.2.

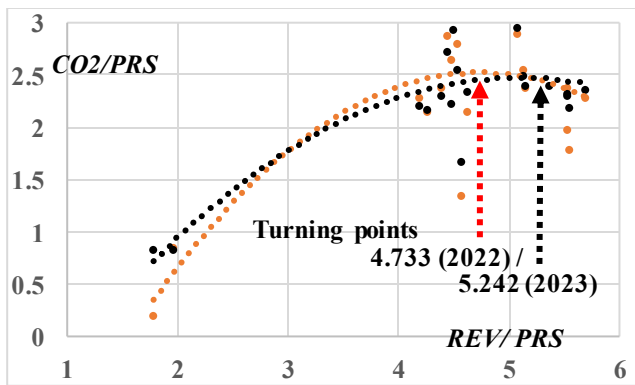


Fig. 1 CO_2 emissions per person vs. revenue per person in 2022 and 2023

2.2. Research Gaps

To the best of the author’s knowledge, no study has examined the relationship between institutional growth and environmental conservation by applying the EKC hypothesis to a comprehensive dataset of Japanese national universities. Although ESG-related research has expanded across various sectors, including the government, businesses, and public institutions, such research has notable methodological limitations that weaken its analytical rigor. A persistent challenge in ESG-related research lies in the heavy

dependence on aggregated ESG metrics, such as alphabetic grades (e.g., A+, AAA) or numerical scores (e.g., 90/100) published by rating institutions. These metrics often lack methodological clarity and fail to provide objective or reproducible benchmarks. In particular, the use of primary raw environmental data remains rare due to fragmented disclosure requirements and limited public access to environmental information, hindering the development of comprehensive empirical studies.

The disclosure of environmental performance data entails considerable investment in time and resources. It often involves third-party certification by auditing firms and may require the release of sensitive institutional information. Moreover, poor coordination between regulatory agencies, industry bodies, legal and accounting professionals, financial institutions, and media organizations has led to inconsistent disclosure practices, reinforcing systemic information asymmetries. Some universities only disclose simplified bar graphs, without providing the numerical data necessary for rigorous empirical analysis.

The inadequacy of environmental information disclosure is evident not only among private universities but also among publicly listed companies in Japan. For instance, the Tokyo Stock Exchange (TSE) has explicitly acknowledged shortcomings in the timeliness and precision of environmental disclosures. This concern is emphasized in the Corporate Governance Code issued by the TSE in 2021, which outlines fundamental principles for effective corporate governance. [10] The Code states the following:

“In Japan, the disclosure of financial information by listed firms tends to be highly standardized and comparable, as formatting protocols, reporting guidelines, and regulatory requirements are clearly stipulated. In contrast, non-financial disclosures—particularly those related to corporate strategy, risk management, governance practices, and ESG factors—have frequently drawn criticism for their formulaic language and insufficient detail, which undermines their decision-usefulness and informational value.”

Another major barrier to the effective use of raw ESG data is the considerable amount of manual processing required to collect, standardize, and validate the information. Unlike financial statements, which are typically disclosed in structured formats such as Excel or CSV, ESG data released by universities is consistently embedded in lengthy, non-standardized reports, rather than provided in machine-readable formats. In this study, relevant data were manually gathered from ESG reports—typically ranging from 40 to 50 pages—and official university websites, followed by extensive entry, cleaning, and consistency checks.

To overcome these limitations, the analysis is grounded entirely in primary sources disclosed by universities

themselves. This strategy minimizes distortions commonly found in third-party datasets and avoids the subjectivity inherent in secondary indicators. Although labor-intensive, this method departs meaningfully from prior research approaches and establishes a robust empirical basis for further academic inquiry.

2.3. Ongoing Issues

This study focuses on national universities in Japan, with particular emphasis on those ranked 11–30 in student and faculty size as of FY2023 (Table 1) for the following reasons.

Although environmental disclosures by national universities may not offer a comprehensive account, they nonetheless provide sufficient environmental information (e.g., CO₂ emissions and energy consumption) for analytical purposes. In contrast, private universities often provide inadequate environmental disclosures as they are not subject to the same regulatory obligations as national universities, which are required to report environmental performance under the Act on Promotion of Environmentally Conscious Business Activities by Specified Entities through the Advancement of Environmental Information Disclosure (Act No. 77 of 2004). See Section 3.3 for details on the legal framework.

In a preliminary analysis, the author used a sample comprising the top 30 universities by student and staff numbers, including the University of Tokyo and Kyoto University, widely regarded as Japan's most prestigious institutions based on admissions competitiveness and the number of Nobel laureates among alumni. However, the turning points in this sample were disproportionately high. That is, the thresholds were realistically only attainable by the University of Tokyo and Kyoto University, which benefit from preferential allocation of financial resources by the Ministry of Education. For example, if the management expense grant (See Section 3.3) allocated to the University of Tokyo is indexed at 100, the corresponding values for the universities in this study would range from a maximum of 26.2 for Hiroshima University to a minimum of 11.3 for Shizuoka University, indicating substantial disparity.^[11]

Therefore, the main analysis was conducted using a revised sample that excluded the top 10 universities in terms of faculty and staff size. The selection of 20 universities reflects practical constraints related to the time and effort required for collecting and analyzing primary data. Despite the limited sample size, the 20 universities exhibit meaningful representativeness. As of April 2023, these institutions accounted for 234,272 of the 693,383 (33.8%) students and faculty in Japan's 86 national universities. In particular, these universities enrolled 183,803 of the total 539,521 students (34.1%) and employed 50,469 of the 153,862 faculty members (32.8%).^[1]

Moreover, these 20 national universities are distributed in prefectural capital cities across Japan, ensuring a degree of geographic balance. The distance from Hirosaki University in Aomori Prefecture (northern Japan) to the University of the Ryukyus in Okinawa Prefecture (southern Japan) is approximately 2,000 km. These universities tend to attract diligent high school students who prefer to remain in their local regions, thereby offering a representative profile of the national average. The sample intentionally excludes the most prestigious universities in Japan, which are concentrated in the three major metropolitan areas of Tokyo, Aichi, and Osaka.

The aggregated revenue of the 20 national universities in this study amounted to JPY 1.090 trillion (approximately USD 7.01 billion) in FY2023. According to the 2020 Input–Output Tables, the estimated spillover effect is 1.146 times this figure, reaching JPY 1.549 trillion (approximately USD 10.76 billion).^[12]

The total CO₂ emissions of the 20 universities reached approximately 532,979 tons in FY2023. This figure showed a 1.1% increase from the previous year but marked a 6.0% decrease compared with FY2019 levels. The average CO₂ emissions per student or staff member in FY2023 were approximately 2.275 tons, based on the author's calculations using data from the 20 universities, as discussed in Section 3.1. For context, Japan's total greenhouse gas emissions in FY2023 were 1.017 billion tons, a 4.2% decline from the previous year and a 27.1% reduction compared with FY2013. Therefore, emissions have shown a prevailing downward trend over the past decade.^[13]

As a basis for comparison, the average CO₂ emissions of the 20 universities in FY2023 were 26,649 tons. Hiroshima University recorded the highest average emissions at 43,360 tons, whereas Yokohama National University recorded the lowest at 8,032 tons. For reference, the University of Toronto and the Swiss Federal Institute of Technology in Zurich (ETH Zurich)—the first- and second-highest ranked institutions in the Quacquarelli Symonds (QS) World University Rankings—reported emissions of 96,710 and 20,455 tons, respectively.^[14–16]

Moreover, the total number of students and academic and administrative staff at the 20 universities—234,272 individuals—is comparable to the total workforce of Panasonic Holdings Corporation, one of Japan's leading electronics manufacturers, which employed 228,420 people in 2024.^[17] These comparisons indicate that the 20 universities have a substantial institutional scale and environmental impact.

Furthermore, according to the National Institute of Science and Technology Policy, a research body under the Ministry of Education, the university enrollment rate for 18-

year-olds increased from 43.3% in 2004 (the birth year of most current undergraduates) to 55.5% in 2023, despite the ongoing decline in the youth population.^[18] Over the past two decades, the total number of undergraduate students increased by 5.8%. Notably, enrollment declined in several major disciplines—including humanities (−13.3%), social sciences (−8.2%), natural sciences (−3.5%), and engineering (−10.8%)—but increased in others: agriculture, including environmental sciences, animal husbandry, and veterinary medicine, grew by 16.9%, and healthcare experienced an 81.9% increase.

This trend suggests a generational shift in academic interests. Although Japan once dominated global markets in automobiles and consumer electronics during the 1980s and 1990s, younger generations appear to be more drawn toward fields related to food, health, and the environment. This generational shift underscores the relevance of focusing on national universities' growth and environmental commitments in contemporary higher education discourse. Hence, this paper's emphasis on institutional growth and environmental conservation represents a timely and valuable contribution to academic discourse.

3. Verification

3.1. Methods

This study focuses on 20 national universities ranked 11–30 in terms of combined student and faculty size among Japan's 86 national universities as of FY2023 (Table 1).

3.1.1. Data Coverage and Methodology

Cross-sectional analyses are conducted for each year from FY2019 to FY2023. Each year is examined independently to capture year-specific trends and contextual factors. Although regression analysis requires at least 3–4 years of data to ensure statistical robustness, environmental impact data before FY2017 or FY2018 were often incomplete or inconsistently reported, rendering them unsuitable for empirical analysis. To avoid the risk of spurious regression results, this study does not employ time-series analysis. Rather, it adopts an inductive approach, evaluating university performance based solely on disclosed data.

Table 1. Twenty national universities analyzed in this study

Chiba	Ehime	Gifu	Hiroshima
Hiroshima	Kagoshima	Kanazawa	Kumamoto
Mie	Nagasaki	Niigata	Okayama
Shinshu	Shizuoka	Tokushima	Toyoma
Yamagata	Yamaguchi	Yokohama	Ryukyus

Words like “National” and “University” are omitted for simplicity.

3.1.2. Variables

Table 2 outlines the dependent and explanatory variables used in this study.

Dependent Variables

This study defines eight dependent variables. Four core indicators are used as basic dependent variables: (1) CO₂ emissions (*CO2*), Energy Consumption (*ENG*), water consumption (*AQU*), and waste generation (*WST*). To enhance analytical precision and ensure comparability across institutions, four additional variables are derived by normalizing the above indicators with respect to the total number of students and academic and administrative staff: *CO2/PRS*, *ENG/PRS*, *AQU/PRS*, and *WST/PRS*.

Explanatory Variables

Five explanatory variables are defined. Three basic indicators are used: number of students and academic and administrative staff (*PRS*), total assets (*ASS*), and ordinary revenue (*REV*). Moreover, two normalized indicators are included: *ASS/PRS* and *REV/PRS*.

3.1.3. Regression Model Specifications

This study estimates 300 regression equations, categorized into two types: 180 equations in the basic regression model and 120 equations in the advanced regression model (Table 2).

Table 2. Combinations of dependent and explanatory variables (abbreviations)

Basic Variables	
Dependent Variables: 4	Explanatory Variables: 3
(1) CO ₂ Emissions (<i>CO2</i> , tons) (2) Energy Consumption (<i>ENG</i> , GJ) (3) Water Consumption (<i>AQU</i> , thousand m ³) (4) Waste Generation (<i>WST</i> , tons)	(1) Number of students and academic/administrative staff (<i>PRS</i> , persons) (2) Total assets (<i>ASS</i> , Million JPY) (3) Ordinary revenue (<i>REV</i> , Million JPY)
Total 180 regressions; Dependent Variables × Explanatory Variables × Yearly Observations: 4 × 3 × 5 = 60 estimations Model Specifications (Linear, Quadratic, Cubic): 60 × 3	
Advanced Variables	
Dependent Variables: 4	Explanatory Variables: 2
(5) <i>CO2/PRS</i> (6) <i>ENG/PRS</i> (7) <i>AQU/PRS</i> (8) <i>WST/PRS</i>	(4) <i>ASS/PRS</i> (5) <i>REV/PRS</i>
Total 120 regressions; Dependent Variables × Explanatory Variables × Yearly Observations: 4 × 2 × 5 = 40 estimations Model Specifications (Linear, Quadratic, Cubic): 40 × 3	

3.1.4. Data Sources and Collection Process

Management-related indicators are manually extracted from each university's annual financial reports. Environmental performance indicators are also manually

extracted from each university's annual environmental reports and conservation reports.

The management and environmental data of the universities analyzed in this study are as follows: Chiba (2024ab), Ehime (2024ab), Gifu (2024ab), Hirosaki (2024ab), Hiroshima (2024ab), Kagoshima (2024ab), Kanazawa (2024ab), Kumamoto (2024ab), Mie (2024ab), Nagasaki (2024ab), Niigata (2024ab), Okayama (2024ab), Ryukyus (2024ab), Shinshu (2024ab), Shizuoka (2024ab), Tokushima (2024ab), Yamagata (2024ab), Yamaguchi (2024ab), Toyoma (2024ab), and Yokohama (2024ab).^{[19]-[58]}

Due to the limited availability and fragmented nature of non-consolidated environmental disclosures, this study relies on consolidated data for empirical analysis. Statistical significance was assessed at the 5% level ($p < 0.05$). For clarity and brevity, results failing to meet this criterion are not presented in the main text. Numerical values are generally reported to three decimal places for accuracy. In cases where the first three digits are zeros (e.g., 0.0000086954), values are written in exponential format (e.g., 8.695E 06) rather than rounded to 0.000.

In the linear regression model, CO_2 is treated as the dependent variable, whereas PRS , ASS , and REV serve as explanatory variables. Only select variable combinations are presented in this paper to maintain clarity and avoid unnecessary complexity.

Regression equations are presented with linear model specification. The regression models are defined as follows.

$$\begin{aligned} Y(CO_2) &= \alpha + \beta (PRS) + \varepsilon \\ Y(CO_2) &= \alpha + \beta (ASS) + \varepsilon \\ Y(CO_2) &= \alpha + \beta (REV) + \varepsilon \\ &\vdots \\ Y(ENG) &= \alpha + \beta (PRS) + \varepsilon \\ &\vdots \\ Y(AQU) &= \alpha + \beta (PRS) + \varepsilon \\ &\vdots \\ Y(WST) &= \alpha + \beta (PRS) + \varepsilon \\ &\vdots \\ &\text{(omitted for brevity)} \end{aligned}$$

The “:” symbol indicates omissions.

Where Y is the dependent variable, α is the intercept, β is the coefficient of the explanatory variable, and ε is the error term. The significance of the intercept is not considered in the analysis.

The abovementioned CO_2 , ENG , AQU , and WST formulas are also expressed in per-person unit formats: CO_2/PRS , ENG/PRS , AQU/PRS , and WST/PRS .

$$\begin{aligned} Y(CO_2/PRS) &= \alpha + \beta (ASS/PRS) + \varepsilon \\ &\vdots \\ Y(CO_2/RRS) &= \alpha + \beta (REV/PRS) + \varepsilon \\ &\vdots \\ Y(ENG/PRS) &= \alpha + \beta (ASS/PRS) + \varepsilon \\ &\vdots \\ Y(AQU/PRS) &= \alpha + \beta (ASS/PRS) + \varepsilon \\ &\vdots \\ Y(WST/PRS) &= \alpha + \beta (ASS/PRS) + \varepsilon \\ &\vdots \\ &\text{(omitted for brevity)} \end{aligned}$$

The second objective is to evaluate the EKC hypothesis. The indicators CO_2 , ENG , AQU , and WST are formulated as follows:

$$\begin{aligned} Y(CO_2) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \varepsilon \\ Y(CO_2) &= \alpha + \beta (ASS) + \beta (ASS)^2 + \varepsilon \\ Y(CO_2) &= \alpha + \beta (REV) + \beta (REV)^2 + \varepsilon \\ &\vdots \\ Y(ENG) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \varepsilon \\ &\vdots \\ Y(AQU) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \varepsilon \\ &\vdots \\ Y(WST) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \varepsilon \\ &\vdots \\ &\text{(omitted for brevity)} \end{aligned}$$

Building on this analysis, the validity of the EKC hypothesis is examined on a per-unit basis. Hence, the CO_2 , ENG , AQU , and WST formulas are expressed as CO_2/PRS , ENG/PRS , AQU/PRS , and WST/PRS , respectively.

$$\begin{aligned} Y(CO_2/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \varepsilon \\ &\vdots \\ Y(CO_2/PRS) &= \alpha + \beta (REV/PRS) + \beta (REV/PRS)^2 + \varepsilon \\ &\vdots \\ Y(ENG/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \varepsilon \\ &\vdots \\ Y(AQU/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \varepsilon \\ &\vdots \\ Y(WST/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \varepsilon \\ &\vdots \\ &\text{(omitted for brevity)} \end{aligned}$$

The third objective is to verify the existence of an inverted N-shaped curve. CO_2 , ENG , AQU , and WST are formulated as follows:

$$\begin{aligned}
Y(CO2) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \beta (PRS)^3 + \varepsilon \\
&\vdots \\
Y(CO2) &= \alpha + \beta (ASS) + \beta (ASS)^2 + \beta (ASS)^3 + \varepsilon \\
&\vdots \\
Y(CO2) &= \alpha + \beta (REV) + \beta (REV)^2 + \beta (REV)^3 + \varepsilon \\
&\vdots \\
Y(ENG) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \beta (PRS)^3 + \varepsilon \\
&\vdots \\
Y(AQU) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \beta (PRS)^3 + \varepsilon \\
&\vdots \\
Y(WST) &= \alpha + \beta (PRS) + \beta (PRS)^2 + \beta (PRS)^3 + \varepsilon \\
&\vdots \\
&\text{(omitted for brevity)}
\end{aligned}$$

Building upon this, different normalization units are used to verify the presence of an inverted N-shaped curve.

The formulas for *CO2*, *ENG*, *AQU*, and *WST* are presented using per-person units (*CO2/PRS*, *ENG/PRS*, *AQU/PRS*, and *WST/PRS*) as follows:

$$\begin{aligned}
Y(CO2/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \beta (ASS/PRS)^3 + \varepsilon \\
&\vdots \\
Y(CO2/PRS) &= \alpha + \beta (REV/PRS) + \beta (REV/PRS)^2 + \beta (REV/PRS)^3 + \varepsilon \\
&\vdots \\
Y(ENG/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \beta (ASS/PRS)^3 + \varepsilon \\
&\vdots \\
Y(AQU/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \beta (ASS/PRS)^3 + \varepsilon \\
&\vdots \\
Y(WST/PRS) &= \alpha + \beta (ASS/PRS) + \beta (ASS/PRS)^2 + \beta (ASS/PRS)^3 + \varepsilon \\
&\vdots \\
&\text{(omitted for brevity)}
\end{aligned}$$

4. Results

Table 3 summarizes the number of statistically significant cases identified each year through linear regression analysis. Of the 20 cases tested annually, the following show significant monotonic relationships between environmental impact and institutional scale: 8 cases (40.0%) in 2019, 7 cases (35.0%) in 2020, 6 cases (30.0%) in 2021, 6 (30.0%) in 2022, and 7 cases (35.0%) in 2023. These results suggest a consistent pattern in which the environmental impact increases with growth on an institutional scale.

Table 3. Number of statistically significant cases and percentages (%)

FYs	1	2	3 inv.
	linear	EKC	N-shaped
2019	8 (40.0%)	0 (0%)	1 (5.0%)
2020	7 (35.0%)	0 (0%)	2 (10.0%)
2021	6 (30.0%)	0 (0%)	0 (0%)
2022	6 (30.0%)	1 (5.0%)	0 (0%)
2023	7 (35.0%)	1 (5.0%)	0 (%)

The regression results offer empirical evidence supporting the EKC hypothesis in specific instances. In particular, quadratic regressions validate the EKC in one case each in 2022 (5.0%) and 2023 (5.0%). Moreover, the cubic regression analyses confirm the presence of an inverted N-shaped curve in one case (5.0%) in 2019 and two cases (10.0%) in 2020.

In 2020, the COVID-19 pandemic prompted Japan to declare a state of emergency in April, urging the public to refrain from nonessential outings. Although the EKC hypothesis is statistically supported in 2022 and 2023, the number of cases exhibiting a linear (primary) trend did not decline during this period. Therefore, it cannot be concluded that a significant structural shift occurred as a result of the pandemic.

The regression analysis results provide empirical support for the EKC hypothesis, with quadratic regressions statistically validating it in one case (5.0%) in 2022 and 2023 in the relationship between *CO2/PRS* and *REV/PRS*. The turning point for *REV/PRS* was JPY 4.733 (approximately USD 0.031) in 2022, a threshold reached by nine universities, and JPY 5.242 (approximately USD 0.035) in 2023, achieved by five universities. These thresholds represent realistic targets for institutions aiming to achieve institutional growth while ensuring environmental conservation.

These findings also highlight the need for a more nuanced and contextualized interpretation of the EKC hypothesis and the inverted-N-shaped curve when applied to national universities. It is essential to explore combinations in which the hypothesis or the curve holds over an extended period. However, turning points that are statistically significant but practically unattainable (e.g., those observed in top-tier institutions such as the University of Tokyo and Kyoto University, which benefit from substantially higher financial resources) cannot serve as meaningful benchmarks for medium-sized regional universities with limited resources.

For example, Figure 2 presents a regression with *PRS* as the explanatory variable on the x-axis and *CO2* as the dependent variable on the y-axis. In this model, the theoretical turning point corresponds to 26,079 persons for *CO₂* in 2019, which far exceeds actual university sizes. Thus, this result should be regarded as theoretical and unattainable,

given that the institutions in this study range from approximately 8,500 people at Hirosaki University to 17,000 at Hiroshima University.

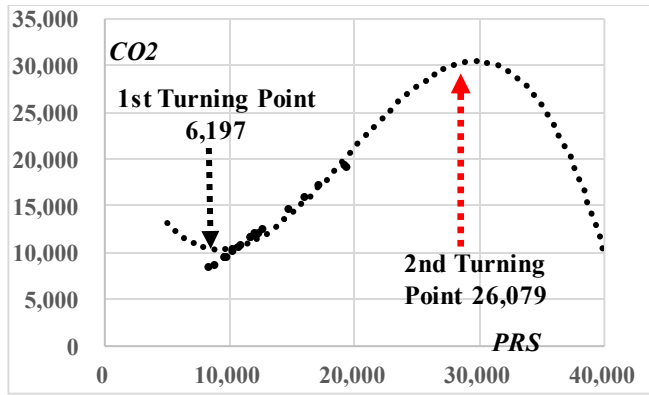


Fig. 2 CO2-PRS in 2019

$$\begin{aligned}
 & 2019 \\
 Y(CO2) &= \alpha + \beta (PRS) + (PRS)^2 + (PRS)^3 \\
 &= 399,262.089 - 93.853 + 0.008 - 1.936E-07 \\
 & \quad (p = 0.015) \quad (0.014) \quad (0.009) \quad (0.007) \\
 & \quad + 8,038.824
 \end{aligned}$$

$$\begin{aligned}
 Adj.-R^2 &= 0.364, F = 4.626 \quad (p = 0.016) \\
 Turning \ Points &= 6,197.376 \text{ and } 26,079.852.
 \end{aligned}$$

By contrast, Figure 3 (a reproduction of Figure 1) shows the relationship between $CO2/PRS$ on the x-axis and REV/PRS on the y-axis. The resulting curve displays a clear inverted U shape, with turning points at JPY 4.733 in 2022 and JPY 5.242 in 2023.

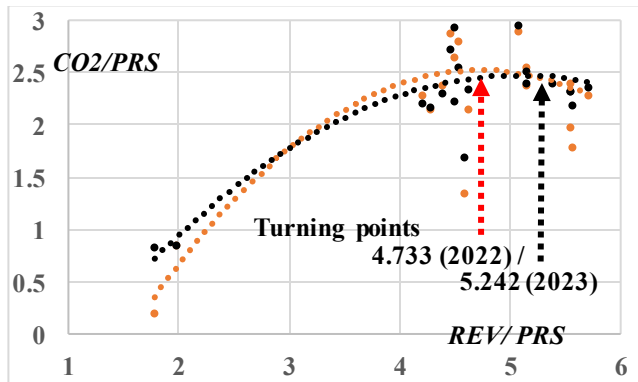


Fig. 3 CO2/PRS-REV/PRS in 2022 and 2023 (Reproduced from Figure 1)

The cases presented in Figure 3, in which the EKC hypothesis was validated using REV/PRS in 2022 and 2023, are as follows:

$$\begin{aligned}
 & 2022 \\
 Y(CO2/PRS - REV/PRS) &= \alpha + \beta (REV/PRS) + (REV/PRS)^2 + e \\
 &= -1.615 + 1.564 (REV/PRS) - 0.149 (REV/PRS)^2 \\
 & \quad (p = 0.063) \quad (0.003) \quad (0.019) \\
 & \quad + 0.344
 \end{aligned}$$

$$\begin{aligned}
 &= 3.063 + 2.360 (REV/PRS) - 0.249 (REV/PRS)^2 \\
 & \quad (p = 0.015) \quad (0.002) \quad (0.008) \\
 & \quad + 0.473
 \end{aligned}$$

$$\begin{aligned}
 Adj.-R^2 &= 0.611, F = 15.897 \quad (p = 1.282E-04) \\
 Turning \ point &= 4.733.
 \end{aligned}$$

$$\begin{aligned}
 & 2023 \\
 Y(CO2/PRS - REV/PRS) &= \alpha + \beta (REV/PRS) + (REV/PRS)^2 + e \\
 &= -1.615 + 1.564 (REV/PRS) - 0.149 (REV/PRS)^2 \\
 & \quad (p = 0.063) \quad (0.003) \quad (0.019) \\
 & \quad + 0.344
 \end{aligned}$$

$$\begin{aligned}
 Adj.-R^2 &= 0.668, F = 20.084 \quad (p = 3.334E-05) \\
 Turning \ point &= 5.242
 \end{aligned}$$

In 2022, nine universities surpassed the JPY 4.733 threshold. In 2023, five universities reached the JPY 5.242 threshold. Five universities—Gifu, Kumamoto, Mie, Nagasaki, and Tokushima—met the thresholds in both years.

Table 4. Universities reaching REV/PRS turning points in 2022 and 2023 (JPY)

	2022	2023
Chiba	5.148	-
Gifu	5.697	5.737
Hirosaki	5.160	-
Hiroshima	5.144	-
Kanazawa	5.073	-
Kumamoto	5.538	5.581
Mie	5.536	5.740
Nagasaki	5.561	5.485
Tokushima	5.379	5.500

- marks indicate “not yet achieved”

These outcomes suggest that a threshold range of JPY 4.733–5.242 constitutes a feasible and meaningful target for other small and medium-sized national universities. Improving performance in the $CO2/PRS$ – REV/PRS relationship up to this threshold within the EKC framework can serve as an empirical benchmark for achieving institutional growth alongside environmental conservation. In essence, this approach illustrates a pathway for decoupling growth from environmental degradation.

5. Discussion

Empirical support for the EKC hypothesis can be attributed not only to the efforts of individual universities but also to the combined influence of three key factors:

- Stricter emission regulations and guidelines,
- Competition for government grants, and
- Ratings of and initiatives undertaken by external organizations focused on ESG performance.

First, stricter regulatory enforcement related to emissions has gained momentum. The Japanese government has committed to reducing CO₂ emissions by 46% by 2030, 60% by 2035, and 70% by 2040, using 2013 levels as the baseline, as part of its nationally defined goal of achieving net-zero emissions by 2050. This series of targets is consistent with Japan's long-term climate policy under the 2015 Paris Climate Agreement. Reflecting this commitment, the 2021 Revised Act (No. 117 of 1998) on the Promotion of Global Warming Countermeasures uses stronger language, changing the mandate from “controlling” to “reducing” greenhouse gas emissions.

The 2021 Revised Act provides the legal foundation for the Act on Promotion of Environmentally Conscious Business Activities by Specified Entities through the Advancement of Environmental Information Disclosure (Act No. 77 of 2004, hereinafter the 2004 Act), which applies to national universities.

Article 1 of the 2004 Act stipulates that “specified entities” shall give appropriate consideration to environmental conservation by disclosing environmental reports, thereby contributing to the realization of a healthy and culturally enriched society. Article 9 further requires that “specified entities” shall prepare and publicly disclose an environmental report for each fiscal year.

Article 2, Paragraph 4 of the 2004 Act lists the national universities covered by this requirement as those designated in the Cabinet Order Specifying Corporations (Cabinet Order No. 42 of 2005).

Article 16 of the 2004 Act stipulates that executives of the specified entities who fail to disclose an environmental report or submit a false report shall be subject to a civil fine of up to JPY 200,000 (~1,400 USD). Although the financial penalty is minor, compliance is encouraged through nonmonetary mechanisms, such as point deductions when applying for government subsidies (as detailed below) and the risk of reputational damage, which could jeopardize future institutional management.

The second contributing factor is competition for governmental grants. The primary source of revenue for national universities is the management expense grant allocated by the Ministry of Education. This grant amounts to JPY 1.078 trillion (~7.49 billion USD), covering faculty and staff salaries, facility maintenance, and research funding. Among the 20 universities analyzed in this study, management expense grants account for an average of 39.4% of total revenue—substantially more than the average tuition revenue, which stands at 13.0%.

In its 2025 Governance Code, the Japan Association of National Universities emphasizes in Principle 4-1

(“Thorough Disclosure of Information Based on Laws and Regulations”) that national universities must recognize the management expense grant as a public asset funded by a range of stakeholders. To secure continued support from these varied stakeholders, universities are required to enhance transparency.^[59] Given the substantial share of these grants in their budgets, national universities have incorporated environmental initiatives as part of their institutional responsibility.

Moreover, the Ministry of Education has adopted a “performance-based allocation policy,” which evaluates universities based on 11 indicators across education, research, and management reform domains. One of these indicators is the reduction of energy consumption relative to FY2013 levels. Under this allocation framework, which amounts to approximately JPY 100 billion (around 700 million USD), universities can receive additional points based on their environmental performance. These benchmark values vary annually. For instance, in FY2023, universities that reduced energy consumption per square meter of site area by at least 11.76% relative to FY2013 were awarded 1.5 points, whereas those achieving a reduction of 16.18% or more received 2.0 points.^[60]

Because the Ministry of Education's annual budget is determined by the National Diet, national universities are forced to compete in a zero-sum environment for a limited pool of funds. While the point-based rewards for environmental efforts may seem modest, they are strategically significant in competition—especially for regional national universities, which receive fewer donations and external funding than top-tier institutions.

The third factor involves ratings of and initiatives undertaken by external organizations focused on ESG performance. The Times Higher Education (THE) University Impact Rankings 2024 evaluated 2,152 universities worldwide based on their contributions to the United Nations Sustainable Development Goals (SDGs).^[61] In Japan, Hokkaido University received a score of 90.6 (ranked 1st domestically and 72nd globally) and Kyoto University scored 89.5 (2nd domestically and 95th globally).

Table 5. University impact rankings of Times Higher Education in 2024

	Scores	Domestic	Global
Chiba	NA	NA	NA
Gifu	NA	NA	NA
Hirosaki	NA	NA	NA
Hiroshima	84.0-891.1	3	101-200
Kanazawa	69.9-75.7	18	401-600
Kumamoto	75.8-79.1	14	301-400
Mie	64.5-69.8	30	601-800
Nagasaki	NA	NA	336
Tokushima	69.9-75.7	18	NA

Source: THE (2024)

Table 5 presents the rankings of universities that met this study's EKC hypothesis turning points.

Hiroshima University and Kumamoto University—both included in this study—have expressed appreciation for their evaluations in the THE rankings. Their official press releases indicate a strong institutional interest in maintaining or improving their positions in international university rankings. Hiroshima University scored 84.0 and 89.1 (3rd domestically and within the 101–200 range globally), and Kumamoto University scored 75.8 and 79.2 (14th domestically and within the 301–400 range globally). In a press release issued on June 13, 2024, Hiroshima University stated that securing 3rd place domestically for the third consecutive year reflects the synergistic effects of its pioneering university reforms and comprehensive initiatives toward achieving the SDGs, along with its ongoing diverse efforts in education, research, and social contribution. ^[62]

A separate press release issued by Kumamoto University on June 12, 2024, stated,

“The university ranked within the 301–400 range globally and tied for 14th domestically in the THE overall ranking. These achievements are attributed to initiatives such as the Aitsu Marine Station and activities conducted by the Kumamoto University Center for Water Cycle and Disaster Mitigation Studies. Kumamoto University will continue to promote the achievement of the SDGs through a ‘One Team’ approach across the entire institution.” ^[63] The “Sustainability 2025” section of the QS World University Rankings, which includes an environmental impact indicator, provides another strong incentive for universities to implement or strengthen their environmental strategies. The University of Tokyo scored 97.8 (1st domestically and 4th globally), and Kyoto University scored 82.3 (2nd domestically and 91st globally). Among the universities analyzed in this study, Hiroshima University received a score of 73.1 (8th domestically and 182nd globally) and Nagasaki University scored 63.2 (15th domestically and 336th globally). The rankings of each university that reached the turning points of the EKC hypothesis thresholds are presented in Table 4. ^[14]

Table 6. Scores and domestic and global rankings of The environmental impact of QS World University Rankings (2025)

	Scores	Domestic	Global
Chiba	48.1	22	648
Gifu	48.6	21	637
Hirosaki	NA	NA	NA
Hiroshima	73.1	8	182
Kanazawa	54.9	17	494
Kumamoto	52.6	18	539
Mie	NA	NA	NA
Nagasaki	63.2	15	336
Tokushima	NA	NA	NA

Source: Quacquarelli Symonds (2025)

The findings indicate that institutional competition extends beyond financial and human resource metrics, including environmental performance and ESG/SDG indicators. As discussed in Section 2.2, ESG and SDG scores are subjective by nature; thus, exclusive reliance on them for academic analysis may be misleading. Nevertheless, favorable ESG ratings can enhance a university's public reputation to a considerable extent, providing a competitive advantage in attracting donations, fostering industry–academia collaborations, and securing management expense grants from the Ministry of Education. Conversely, a poor ESG reputation or noncompliance may result in reputational damage and limit access to secure these resources.

Moreover, the Campus Sustainability Network in Japan promotes and recognizes exemplary environmental practices through awards given to faculty, staff, students, and corporations advancing the SDGs. Among the universities that surpassed the EKC hypothesis turning points in this study, Gifu University and Nagoya University, as part of the Tokai National Higher Education and Research System, received the Grand Prize in 2022; Chiba University received the Grand Prize in 2023. ^[64]

These initiatives reflect increasing institutional commitment to environmental conservation across Japanese universities, regardless of ownership status. Whether national, prefectural, or private, universities function as socially embedded institutions. With growing public awareness and interest in environmental conservation and social responsibility, ESG-related discussions within universities are expected to expand, encouraging greater adoption of ESG-oriented strategies by students, faculty, and administrative staff.

Many of these initiatives are relatively easy to implement, including installing energy-saving devices such as light-emitting diodes, motion sensors, wireless switches, and water-saving faucets in offices and laboratories, along with efforts to reduce plastic and paper waste. Moreover, waste separation practices at universities tend to include categories such as “combustible waste,” “noncombustible waste,” “cans,” “bottles,” and “PET bottles.”

Thus, empirical support for the EKC hypothesis can be attributed not only to the initiatives undertaken by individual universities but also to the combined influence of the three key factors of stricter emission regulations and guidelines, competition for government grants, and rankings of and initiatives undertaken by external organizations focused on ESG performance.

6. Conclusion

This study provides empirical support for the EKC hypothesis among Japanese national universities across the

period from 2019 to 2023. The quadratic regression analysis results validate the EKC hypothesis in one case each (5.0%) in 2022 and 2023. Moreover, the cubic regression analyses confirm the presence of an inverted N-shaped curve in one case (5.0%) in 2019 and in two cases (10.0%) in 2020.

This empirical support is attributable not only to the actions of individual universities but also to the synergistic effects of three external drivers:

- (1) stricter emission regulations and guidelines;
- (2) competition for government grants; and
- (3) ratings of and initiatives undertaken by external organizations focused on ESG performance.

Several dimensions of this study merit continued investigation within the realms of academic research, public policy, and institutional strategy. Subsequent research should undertake refined empirical analyses to clarify the characteristics that differentiate universities exhibiting statistically significant patterns under the EKC hypothesis and the inverted N-shape model from those that do not. As environmental reporting standards and statistical methodologies continue to evolve, future iterations of the dataset are likely. Therefore, extended longitudinal validation will be essential. Moreover, future studies should scrutinize the phenomenon of “greenwashing,” in which institutions publicly align with ESG principles while failing to implement concrete environmental actions.

The 20 national universities analyzed in this study are expected to strengthen their corporate governance measures,

protect personal information, promote environmental conservation, and adopt sustainable business practices. They would also play a key role in regional development through their educational and research activities. These institutional efforts should align with national and local government policy goals and societal expectations.

Nonetheless, the emergence of turning points in Figure 3 indicates meaningful progress toward decoupling institutional growth from environmental degradation. Achieving consistency in the relationship between CO_2/PRS and REV/PRS within the identified threshold range of JPY 4.733–5.242 can serve as a practical benchmark for empirically validating the EKC hypothesis and achieving institutional growth while ensuring environmental conservation.

The combined revenue and staffing levels of the 20 universities are comparable to those of large multinational corporations in Japan. Consequently, efforts to enhance REV/PRS within an ESG-oriented management framework can contribute to domestic and global environmental conservation to a significant extent.

Finally, this study’s ESG-oriented, REV/PRS -based approach advances the research frontier in environmental economics and industrial organization. It encourages the academic community to continue exploring the relationship between institutional and corporate growth and environmental conservation from multiple perspectives.

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Appendix 1: Significant combinations of dependent and explanatory variables

	constant	(p)	x	(p)	x ²	(p)	x ³	(p)	st. errors	adj.-R ₂	F	(p)	1st turning points	2nd turning points
CO2														
CO2-19-PRS	14,894.999	0.023	0.120	0.024					9,030.386	0.221	6.120	0.024		
CO2-19/PRS -SST/PRS	1.511	0.004	0.099	0.035					0.729	0.192	5.280	0.035		
CO2-19-REV	0.870	779.269	0.550	8.695 E-06					5,895.915	0.658	37.542	8.695 E-06		
CO2-19/PRS -REV/PRS	0.256	0.513	0.507	1.356 E-05					0.507	0.641	34.929	1.356 E-05		
CO2-20-SST	14,336.522	0.009	0.101	0.018					8,119.066	0.234	6.819	0.018		
CO2-20/PRS -SST/PRS	1.219	0.004	0.103	0.007					0.690	0.307	9.420	0.007		
CO2-20 -REV	1,732.996	0.680	0.486	7.667 E-06					5,390.425	0.663	38.306	7.667 E-06		
CO2-20/PRS -REV/PRS	0.190	0.606	0.481	1.180 E-05					0.493	0.646	35.733	1.180 E-05		
CO2-21-SST	13,957.017	0.006	0.111	0.005					7,201.011	0.330	10.377	0.005		
CO2-21/PRS -SST/PRS	1.054	0.008	0.127	0.001					0.651	0.442	16.063	0.001		
CO2-21-REV	3,949.875	0.300	0.439	3.405 E-06					4,891.296	0.691	43.505	3.405 E-06		
CO2-21/PRS -REV/PRS	0.158	0.639	0.485	1.665 E-06					0.466	0.714	48.497	1.665 E-06		
CO2-22-PRS	-1,947.805	0.824	2.426	0.004					8,128.538	0.351	11.278	0.004		
CO2-23-PRS	-3,059.462	0.650	2.536	2.326 E-04					6,241.774	0.512	20.969	2.326 E-04		
CO2-22-SST	11,757.044	0.044	0.119	0.010					8,581.951	0.277	8.266	0.010		
CO2-22-REV	1,366.171	0.771	0.463	2.244 E-05					6,212.859	0.621	32.116	2.244 E-05		
CO2-22/PRS -REV/PRS	-0.018	0.976	0.495	0.001					0.569	0.438	15.783	0.001		
CO2-23-SST	11,575.315	0.031	0.121	0.004					7,269.371	0.358	11.030	0.004		
CO2-23-REV	1,688.568	0.595	0.458	1.279 E-07					4,152.169	0.784	70.062	1.279 E-07		
CO2-23/PRS -REV/PRS	0.277	0.502	0.429	8.503 E-05					0.395	0.585	25.408	8.503 E-05		
CO2-22/PRS -REV/PRS	-3.063	0.015	2.360	0.002	-0.249	0.008			0.473	0.611	15.897	1.282 E-04	4.733	
CO2-23/PRS -REV/PRS	-1.615	0.063	1.564	0.003	-0.149	0.019			0.344	0.668	20.084	3.334 E-05	5.242	
CO2-19-PRS	399,262.089	0.015	-93.853	0.014	0.008	0.009	-1.936 E-07	0.007	8,038.824	0.364	4.626	0.016	6,197.376	26,079.852
CO2-20-PRS	392,004.006	0.013	-91.581	0.013	0.007	0.009	-1.869 E-07	0.006	7,386.633	0.366	4.662	0.016	6,239.459	26,172.676

Table Appendix 1 Significant combinations of dependent and explanatory variables (continued)

	constant	(p)	x	(p)	x ²	(p)	x ³	(p)	st. errors	adj.-R ₂	F	(p)	1st turning points	2nd turning points
<i>ENG</i>														
<i>ENG-19-PRS</i>	-6.627 E+05	0.005	101.162	1.286 E-05						2.015 E+05	0.711	40.421	1.286 E-05	
<i>ENG-20-PRS</i>	-6.14 1E+05	0.008	96.166	2.274 E-05						2.014 E+05	0.708	36.451	2.274 E-05	
<i>ENG-21-PRS</i>	-5.984 E+05	0.008	95.522	2.060 E-05						2.029 E+05	0.693	37.119	2.060 E-05	
<i>ENG20/PRS -SST/PRS</i>	142.403	1.626 E-04	-2.310	0.003	0.015	0.004	-2.230 E-05	0.004	12.963	0.486	6.035	0.008	77.934	443.062
<i>AQU</i>														
<i>AQU-19/PRS -SST/PRS</i>	20.634	0.007	1.359	0.048					10.764	0.165	4.554	0.048		
<i>AQU-19 -REV</i>	80,413.503	0.365	6.391	0.001					1.088 E+05	0.422	14.869	0.001		
<i>AQU-19/PRS -REV/PRS</i>	8.030	0.220	6.030	4.671 E-04					8.356	0.475	18.181	4.671 E-04		
<i>AQU-20/PRS -SST/PRS</i>	20.832	0.001	1.008	0.049					9.833	0.154	4.446	0.049		
<i>AQU20- REV</i>	111,817.752	0.200	5.043	0.005					1.093 E+05	0.322	10.006	0.005		
<i>AQU-21/PRS -REV/PRS</i>	8.389	0.166	5.260	0.001					7.927	0.450	16.531	0.001		
<i>AQU-22 -REV</i>	108,390.490	0.142	4.690	0.001					9.473 E+04	0.409	14.147	0.001		
<i>AQU-22/PRS -REV/PRS</i>	1.791	0.840	6.436	0.003					8.464	0.368	12.064	0.003		
<i>AQU-23-SST</i>	187,698.062	0.027	1.267	0.042					1.145 E+05	0.176	4.847	0.042		
<i>AQU-23 -REV</i>	69,894.573	0.320	5.088	0.001					9.001 E+04	0.491	18.361	0.001		
<i>AQU-23/PRS -REV/PRS</i>	1.240	0.875	6.175	0.002					7.443	0.418	13.908	0.002		
<i>WST</i>														
<i>NONE</i>														

Sources: The author's calculations are based on each university's environmental reports/ESG data.

As a guide to interpreting the table, CO2-19-PRS denotes a statistically significant combination of CO2 and PRS in 2019.

To ensure rigour, the data is presented to three digits after the decimal point. If zero continues after the third digit (e.g., 0.0000086954), it is not presented as 0.000, but as an exponent, 8.695-E06. Due to space constraints, exponential notation is used for some large numerical values.