Journal of Infrastructure, Policy and Development 2024, 8(12), 8161.
https://doi.org/10.24294/jipd.v8i12.8161

Article

ISO 14000 as a driver of sustainability: Exploring its alternative drivers beyond ISO 9000 standards

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CITATION

Zaher HF, Setyaningsih S. (2024). ISO 14000 as a driver of sustainability: Exploring its alternative drivers beyond ISO 9000 standards. Journal of Infrastructure, Policy and Development. 8(12): 8161.
https://doi.org/10.24294/jipd.v8i12.8161

ARTICLE INFO

Received: 23 July 2024
Accepted: 2 September 2024
Available online: 5 November 2024

Abstract: This study replicates and extends Corbett and Kirsch (2001) and Vastag (2004) using a new data set to investigate the drivers of ISO 14000 certification diffusions using decision tree analysis. The findings indicate that at the national level, ISO 14000 certification diffusions are influenced by factors other than ISO 9000 certification diffusions, such as the number of environmental treaties signed and ratified, industrial activities as a percentage of GDP, and GDP per capita, thus provides a range of managerial insights and enhances scholarly understanding of sustainability beyond the influence of ISO 9000. Future studies might extend the countries included in this study to see if the results are the same. Future research may include other factors like a country's Environmental, Social, and Governance (ESG) indicators to better understand its commitment to sustainability, including environmental sustainability. The country's culture may influence customers, investors, and other stakeholders' knowledge and desire for sustainable practices and inspire firms to obtain ISO 14000 certifications. Since larger firms may seek ISO 14000 certification, future studies may evaluate the influence of the number of large firms in various countries as drivers of ISO certification diffusions.

Keywords: ISO 14000 certification; ISO 9000 certification; sustainability; replication study; regression tree

1. Introduction

The modern economic environment's attribute of global competitiveness has forced businesses to allocate an increasing number of resources toward improving the effectiveness of their management by having international standardization. This standardization was issued by the International Organization for Standardization (ISO), which are ISO 9000 series and ISO 14000 series. ISO 9000 is a series of quality management meanwhile ISO 14000 is a series of environment management standards based on the success of the international quality standard ISO 9000 and in response to the growing environmental concern worldwide (Aba and Badar, 2013). The purpose of this research is to comment on Corbett and Kirsch's (2004) response to Vastag's (2004) research 'Revisiting ISO 14000 Diffusion: A New "Look" at the Drivers of Certification'. This study is a replication of the previous replication done by Vastag (2004) towards Corbett and Kirsch (2001) to provide new insight related to the drivers of ISO 14000 based on a new data set.

Though widely employed today, the consequences of ISO 9000, which was first published in 1987, following a consensus-building process overseen by the ISO Technical Committee, are documented, verifiable, and readily adjustable. Since their inception, revisions and modifications to ISO 9000 standards have been made every three years due to their adaptability. Alongside the quality tool, ISO 9000 offers

businesses strategic advantages and internal improvements. British Standard 7750, which contains the requirements for environmental management systems and is often regarded as the cornerstone of solid environmental performance, is partially the source of ISO 14000. According to ISO in 2011, an organization that achieves ISO 14000 certification reduces the negative environmental effects of its operations and achieves ongoing environmental performance improvement (Aba and Badar, 2013).

Replication studies are those that replicate the findings of earlier research. Replication studies look for or examine identical stimuli, procedures, samples, and data analysis to see whether the initial study's outcomes have similarities (Toncar and Munch, 2010). Abreu (2023) mentioned that there are 3 types of replication studies: direct replication, conceptual replication, and systemic replication. In order to confirm the results of the initial study, direct replication entails carefully replicating it. Conversely, conceptual replication is concerned with testing underlying theories or concepts through various techniques. The goal of systematic replication is to investigate how well study results apply to various populations, environments, or circumstances. Therefore, this study is classified into systematic replication since it uses a different set of populations and settings. This kind of replication offers insights into the generalizability of scientific conclusions and aids in identifying the variables that affect results' reproducibility.

This research is divided into several sections. The literature review section will describe the difference between ISO 9000 and ISO 14000 and the summary of feedback from Corbett and Kirsch (2004) towards Vastag (2004). Furthermore, it describes the idea of further replication of the original study by Corbett and Kirsch (2001). The methodology section will provide the study's approach, which will be shared completely as well as the data used in this paper, and the analysis of the replication outcome. First, it examines the descriptive statistics to see if they align with or diverge from earlier studies. The results show that most of the variables do not follow a normal distribution, thus this study uses decision tree analysis to investigate the drivers of ISO 14000 diffusion. The analysis indicates that apart from ISO 9000 diffusion, the drivers of ISO 14000 diffusion are the number of environmental treaties signed and ratified, industrial activities as a percentage of GDP, and GDP per capita.

This study has academic and managerial implications. From an academic perspective, it opens the door for investigating the drivers of the ISO certification implementations other than the factors that are used in this study such as the environmental sustainability practices measured at the country level such as ESG indicators, or the effect of culture at the national level. From a managerial perspective, it helps the practitioners in determining the factors they should improve to promote ISO 14000 implementations by the companies in the country.

1.1. ISO 9000 and ISO 14000

The International Organization for Standardization was formed in 1947 in Geneva, Switzerland to develop global technical standards for engineering and industrial parts and processes (Arora and Chaudhry, 2010). Currently, it has a membership of 171 national standards institutes from large and small, industrialized, developing, and in transition countries, in all regions of the world. The purpose of ISO

is to bring together professionals from around the world to reach a consensus on optimal practices, ranging from process management to product creation. Being among the world's first non-governmental organizations, ISO has facilitated global trade and collaboration between individuals and businesses. The International Standards that ISO publishes improve, simplify, and increase the quality of people's lives (ISO, 2024).

The ISO 9000 set of standards, which includes Quality Management Systems—Fundamentals and Vocabulary, offers the basic ideas, precepts, and terminology. It provides the framework for comprehending the fundamentals of quality management as outlined in ISO standards. The seven quality management principles and the use of the process technique to achieve continuous improvement are introduced to users of ISO 9000 (ISO, 2016). The standards guarantee that an organization's products follow customer requirements (Jain and Ahuja, 2016).

ISO 9000 aims to give confidence in the organization's ability to provide products that conform with standards to its customers. Implementing ISO 9000 often gives several advantages such as higher perceived quality, more efficient and effective operation, reduced audits, and enhanced marketing. On the other hand, it was also able to improve employee motivation, awareness, and morale which impacted the competitive advantages (Pawliczek and Piszczur, 2013) in addition to improving employee quality awareness (Hutchens, 2008).

A description of a set of standards created in response to this widespread environmental concern is ISO 14000 (Arora and Chaudhry, 2010). An international standard known as ISO 14000 lays out the specifications needed to create an environmental management system that uses resources more effectively and reduces waste, which helps firms enhance their environmental performance and acquire the trust of stakeholders as well as a competitive advantage. Of the ISO 14000 family of standards, only ISO 14001 on Environmental Management Systems (EMS) is certified. It lays out a structure that an enterprise or group might adhere to establish a successful EMS. This standard which is made to fit any kind of business, no matter what its industry or kind of operation, may reassure stakeholders outside the company, including management and staff, that environmental impact is being monitored and reduced (ISO, 2015).

ISO 9000 and ISO 14000 are similar in their processes, but they target different elements and audiences. ISO 9000 aims to improve quality and facilitate business objectives. ISO 14000 targets the improvement of environmental performance and the facilitation of relationships with not only market actors but also non-market actors. Therefore, the success of implementing ISO 9000 might promote the adoption of ISO 14000 (Aba and Badar, 2013).

The adoption of ISO 14000 leads to positive outcomes at both firm and country levels, such as a reduction in carbon emissions, improved sustainability performance, and increased business profitability (Arocena et al., 2021; Ikram et al., 2020). This positive impact is more pronounced for larger firms and those in countries with strong environmental awareness (Arocena et al., 2021). The decision to adopt ISO 14000 is influenced by various socio-political factors. Research indicates that regulations, legislation, and the desire for legitimation significantly drive the initial choice to implement ISO 14000 (Johnstone and Hallberg, 2020). Therefore, the benefits seen

from ISO 14000 adoption are not just a result of the standard itself but also the factors that make it easier for firms to implement the standard. However, previous studies find that several factors such as complex environmental procedures, increasing bureaucracy, and challenges in raising environmental awareness among employees are key obstacles to implementing ISO 14001 (Bravi et al., 2020).

1.2. Related previous research on the extension replication

Corbett and Kirsch (2001) created research related to the diffusion of ISO 14000 certification. In the beginning, the authors conducted interviews with professionals worldwide to find out what variables, in their opinion, account for variations in national ISO 14000 certification counts. After gathering quantitative data for these variables, Corbett and Kirsch (2001) used regression analysis and found out that exports, the number of ISO 9000 certifications, and environmental attitudes, when paired with economic development, were significant determinants of ISO 14000 diffusion. Given that ISO 9000 is cited as a key component in the explanation of the spread of ISO 14000 certifications, it might be that the motivations for the two are likely substantially similar. As a result, ISO 14000 needs to be examined from a wider angle rather than only an environmental one. This is because, although being an environmental standard, many of the factors influencing national certification patterns have nothing to do with the environment.

Vastag (2004) conducted replication research to Corbett and Kirsch (2001). The research offers an alternative and more straightforward forecast model of the variables influencing the rise in ISO 14000 certifications. The primary conclusion is that, on a national scale, ISO 14000 certification density might be determined by two variables, those are the quantity of environmental treaties ratified and signed, as well as the density of ISO 9000 certificates. The first aspect emphasizes the relevance of political-economic factors, while the second points to circumstances of infrastructure convenience based on the common elements of the two standards. The research makes use of a novel set of tools (graphical displays, distribution-free computer-intensive approaches) that are more appropriate for exploratory research when results from linear regression may be questioned due to discontinuities and the existence of subgroups in the data set.

Corbett and Kirsch (2004) had comments on Vastag's (2004) replication study. Corbett and Kirsch (2004) agreed that Vastag's replication study does confirm their central findings and identifies crucial lines of investigation for more research on the factors influencing companies' adoption of international management systems standards like ISO 14000. However, there are disagreements towards Vastag (2004).

Vastag's research yielded a four-group classification that is straightforward but not intuitive. The countries in the first group have low ISO 9000 penetration; the countries in the second have medium penetration and low-to-medium environmentally; the countries in the third have high penetration and low-to-medium environmentally; and the countries in the fourth have medium-to-high penetration and high environmentally. Despite the restricted range of variables and cutoff points, it is evident that multiple additional combinations may have been achieved. The reason this specific grouping appears to be the best is not evident from a theoretical or

intuitive standpoint. In summary, while Vastag's final model is simpler mathematically, it does not always offer a clearer understanding of the factors that promote the spread of ISO 14000 certification throughout the world. Vastag (2004) supports the idea that explanations with fewer "causes"—that is, independent variables—are better than those with more "causes" by using Occam's Razor principle. When utilizing a model to forecast ISO 14000 certification densities in countries outside of the sample, a high R-square is undoubtedly preferred (Corbett and Kirsch, 2004). The replication study itself provided Corbett and Kirsch with evidence that the results of Vastag's research are considerably supported by additional research using a different approach.

2. Materials and methods

2.1. Data and variables

This study is fundamentally exploratory, and it is an extension of the previous studies by Corbett and Kirsch (2001), Vastag (2004), and Corbett and Kirsch (2004) using new data about the same 63 countries studied by these authors. It represents an effort to map and explain global certification patterns for ISO 14000 standards, offering insights into the factors driving certification based on additional longitudinal data that become available to test if the findings from the previous studies are held. In addition, the study uses the classification and regression decision trees (CRT) and excludes ISO 9000 as one of the independent variables that might influence ISO 14000 certification densities due to the expectations that those two certifications are affected by the same factors and the aim is to know separately what these factors will be. It is also similar to Corbett and Kirsch's (2001) model 3 which excludes ISO 9000 for statistical analysis. Moreover, the study also includes ISO 9000 as an independent variable in another model because it's expected that the application of ISO 9000 makes it possible for firms to adopt ISO 14000.

The variables considered for the study were those that had been used in the works of Vastag (2004) and Corbett and Kirsch (2001). The research aims to apply a different dataset to the original studies to test how well and how broadly their results hold up. Following Corbett and Kirsch (2001), Vastag (2004), and Corbett and Kirsch (2004), this study uses the following variables: the dependent variable is I4GDP, calculated as the number of ISO 14000 certificates in each country to the country's GDP. The independent variables are the following. Firstly, I9GDP is calculated as the number of ISO 9000 certificates in each country to the country's GDP. The data about the number of ISO certificates is collected from the ISO Survey for the year 2022. The authors divided the number of certificates by the country's GDP to consider the country's size. Organizations that have already achieved ISO 9000 certification are more likely to switch to ISO 14000 because of the similarities between the two standards (Vastag, 2004). As a result, it is crucial to investigate if ISO 9000 is still a factor in the spread of ISO 14000. Secondly, EXPGDP in percentage and is calculated as the country's exports divided by GDP. Export plays a vital role in this study as it reflects a country's involvement in international markets, which can have a significant impact on the adoption of global standards such as ISO 14000. Companies engaged in exporting activities often face international customer and regulatory requirements to comply

with environmental management standards (Vastag, 2004). Thirdly, GDPPOP is GDP per capita given in thousands of dollars. This is a proxy for economic development, which can influence a country's capacity and willingness to adopt international standards. The economic data regarding the countries' GDP, exports, and population are collected from the World Bank Development Indicators (World Bank DataBank, 2022). The World Bank does not provide data for Taiwan, so this information was sourced from Statista (Statista, 2022). In addition, data about Lebanon and Venezuela (GDP and exports) and Oman's exports are collected from Statista (Statista, 2022).

The last two independent variables are INDUGDP and ETPARTY. INDUGDP is the industrial activities as a percentage of GDP. This variable reflects a country's economic structure, namely the weight of industries that are more likely to implement environmental management standards such as ISO 14000. Moreover, this variable reflects the level of the country's development, in which firms in more developed countries are more able to handle the cost of environmental certifications compared to firms in less developed countries (Vastag, 2004). ETPARTY is the number of environmental treaties each country has signed and ratified (from a list of 58 International Environmental Agreements). The reasoning for implementing this measure is that when a government decides to join a treaty, it indicates their understanding of the level of concern among citizens regarding the issue, as well as their belief that corporations can be compelled to adhere to the treaty's requirements (Corbett and Kirsch, 2001). Data regarding the country's percentage of industrial activities and the number of environmental treaties is collected from THE WORLD FACTBOOK (CIA).

2.2. Descriptive analysis

Initially, the authors conducted a descriptive statistical analysis to understand the basic characteristics of the dataset. This step includes examining means, medians, standard deviations, and distributions of the variables.

Table 1 provides descriptive statistics of the dependent and independent variables.

Table 1. Summary of statistics.

	N	Minimum	Maximum	Mean	Std. Deviation
I4GDP	63	0.160	19.230	5.392	5.005
I9GDP	63	1.160	45.960	14.693	11.274
EXPGDP	63	0.060	193.860	50.217	38.349
ETPARTY	63	11.000	31.000	20.905	5.567
GDPPOP	63	1456.900	108,729.190	29,772.498	26,355.070
INDUGDP	63	7.600	46.400	28.919	7.735

Table 1 presents the means, minimum, maximum, and standard deviations of the variables considered in the models. The distribution of the dependent variable, I4GDP, shows that the ISO 14000 density in the sample fluctuates between 0.16 and 19.23, with a mean of 5.392. Regarding the independent variables, the statistics indicate that they exhibit sufficient variability, enabling us to draw generalizable conclusions.

The results for kurtosis and skewness for all the variables are presented in **Table 2**.

Table 2. Skewness and Kurtosis tests.

		I4GDP	I9GDP	EXPGDP	ETPARTY	GDPPOP	INDUGDP
N	Valid	63	63	63	63	63	63
	Missing	0	0	0	0	0	0
Skewness		1.470	1.095	1.737	0.170	1.193	−0.125
Std. Error of Skewness		0.302	0.302	0.302	0.302	0.302	0.302
Kurtosis		1.196	0.280	4.215	−0.956	0.990	−0.047
Std. Error of Kurtosis		0.595	0.595	0.595	0.595	0.595	0.595

Skewness measures the degree of symmetry in a distribution, while Kurtosis measures the degree of peakedness in a distribution. The data is normally distributed if the skewness is equal to 0 and the kurtosis is also equal to 0. However, an approximation normal distribution is characterized by data that has skewness or kurtosis values falling within the range of −1 to +1 (Mishra et al., 2019).

Table 2 shows that I4GDP, I9GDP, EXPGDP, and GDPPOP have high positive skewness, meaning that most of the data distribution is on the left side of the mean for these variables, thus, they are not normally distributed. For the Kurtosis test, **Table 2** shows that I4GDP and EXPGDP have a Leptokurtic distribution (i.e., distribution is fat-tailed with many outliers), thus, they are not normally distributed.

2.3. Normal distributions and correlations tests

The authors conducted further normality tests for all variables, and the results are presented in **Table 3**. **Table 4** shows the correlations between variables, and **Figure 1** shows the patterns of relations between the variables and the histogram of each variable.

Table 3. Tests of normality.

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
I4GDP	0.229	63	0	0.8	63	0
I9GDP	0.178	63	0	0.877	63	0
EXPGDP	0.143	63	0.003	0.856	63	0
ETPARTY	0.089	63	0.200*	0.955	63	0.022
GDPPOP	0.141	63	0.003	0.875	63	0
INDUGDP	0.051	63	0.200*	0.992	63	0.957

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction.

Table 3 presents the results of the Kolmogorov-Smirnov test and the Shapiro-Wilk test. Both tests assume that the data is derived from a population with a normal distribution. When the *p*-value is greater than 0.05, the null hypothesis is accepted and

the data is referred to as normally distributed. **Table 3** shows that all the variables are not normally distributed except the variable INDUGDP and the variable ETPARTY which is normally distributed according to the Kolmogorov-Smirnov test but is not significant according to the Shapiro-Wilk test. However, as mentioned in the table note, the Kolmogorov-Smirnov test result for the variable ETPARTY has a lower bound of the true significance.

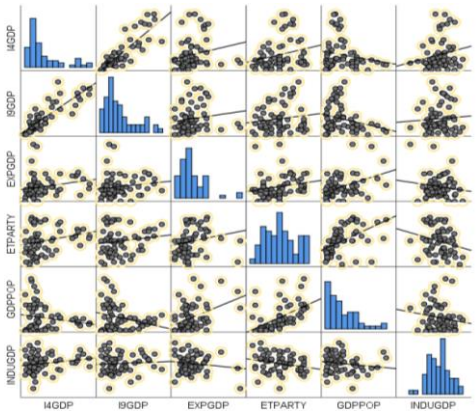

Figure 1. Scatterplot matrix and histogram of the variables used.

Table 4. Correlations (spearman's rho).

		I4GDP	I9GDP	EXPGDP	ETPARTY	GDPPOP	INDUGDP
I4GDP	Correlation Coefficient	1	0.823**	0.334**	0.285*	0.001	0.193
I9GDP	Correlation Coefficient	0.823**	1	0.236	0.102	−0.183	0.053
EXPGDP	Correlation Coefficient	0.334**	0.236	1	0.389**	0.395**	0.029
ETPARTY	Correlation Coefficient	0.285*	0.102	0.389**	1	0.630**	−0.226
GDPPOP	Correlation Coefficient	0.001	−0.183	0.395**	0.630**	1	−0.186
INDUGDP	Correlation Coefficient	0.193	0.053	0.029	−0.226	−0.186	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Figure 1 presents the histogram chart of each variable in this study, which supports the normality test results that all the variables except INDUGDP are not normally distributed. In addition, **Figure 1** shows other patterns between one and other variables in the scatterplot matrix.

Since the variables do not follow the normal distribution, the study uses Spearman's Rank Correlation Coefficient. **Table 4** presents Spearman's Rank Correlations between all the variables in this study. Results indicate that I4GDP is significantly positively correlated with I9GDP (r = 0.823, p-value < 0.01), EXPGDP (r = 0.334, p-value < 0.01), and ETPARTY (r = 0.285, p-value < 0.05). Moreover, **Table 4** shows that there are some significant correlations between some independent variables.

3. Empirical results

The authors would like to commend the paper of Corbett and Kirsch (2004) that refers to Vastag (2004). Corbett and Kirsch (2004) mentioned that based on their objective to identify factors that are correlated with ISO 14000 certification densities, they maintain that the standard linear regression models are preferable. However, if prediction were the objective, the regression tree model used in Vastag (2004) might be preferred.

Regression analysis is one of the analyses that is most often used in a variety of sciences and techniques in order to know functional relationships between variables. One example of the analysis that is often used is multiple linear regression modeling, which aims to predict values of one or more response variables from any factor of interest; the independent variables. Regression analysis is usually based on a model in which the error terms are usually identically distributed as random variables (Andagie and Rao, 2013).

After examining the descriptive statistics and normality tests, it became apparent that the majority of variables in the dataset do not follow a normal distribution. This was determined through kurtosis and skewness descriptive analysis tests, and the use of specific tests, such as the Shapiro-Wilk test and the Kolmogorov-Smirnov test. Due to the non-normality of the data, and the small size of the sample, it was determined that traditional parametric methods such as regression analysis were not suitable. The authors follow Vastag (2004) and employ regression tree analysis, that parallels traditional regression modeling and discriminant analysis. The decision tree analysis is a non-parametric method that is used in this study to investigate the factors influencing the diffusion of ISO 14000.

The authors implement decision tree analysis using SPSS statistical software version 26. Two sections comprised the decision tree analysis, the first one is similar to Vastag (2004) to prove whether the results are still valid for the new set of data. For the second one, this study excluded ISO 9000, one of the independent variables from the decision tree analysis to check other variables affecting certification density for ISO 14000 other than the ISO 9000 variable.

The growing method of decision tree in SPSS software has three methods, CHAID (Chi-squared automatic interaction detection), QUEST (Quick, Unbiased, Efficient Statistical Tree), and CRT (Classification and Regression). In the analysis, given that both dependent and independent variables are continuous, the study employs the classification and regression tree test (CRT or CART) (Lin and Fan, 2019). The CRT algorithm builds the classification tree by using binary splits of attributes into left and right nodes based on class labels. It employs the Gini index to select the most appropriate attribute for the classification tree (Gunduz and Al-Ajji, 2022). This method is a recursive partitioning method that can be used for both regression and classification. It operates by iteratively dividing the subsets of the dataset, starting with the entire dataset, and utilizing all independent variables to generate two child nodes. The best predictor variable is chosen based on various diversity or impurity measures. The goal is to generate subsets of the data that exhibit a high level of homogeneity concerning the target variable and maximize the purity of nodes (Al-batah, 2014; Machuca et al., 2017). The feature of regression in the CRT (CART) method is

commonly utilized for forecasting a target variable based on a set of predictor variables over a specific period (Gupta et al., 2017).

Herewith are the steps to run the CRT analysis by activating the following criteria:

- Since the sample size is small, the parent node is chosen at 10 and the Child node at 5 for the minimum number of cases.
- Choose the minimum change in improvement from each splitting to be 0.5.
- Activate the option prune tree to avoid overfitting. As mentioned in the criteria, after the tree is grown to its full depth, pruning trims the tree down to the smallest subtree with an acceptable risk value. Next, select the maximum difference in risk (in standard errors) to be 0, which produces the subtree with the smallest risk.

3.1. Decision tree analysis with ISO 9000 as an independent variable

Figure 2 shows the result of the classification and regression tree (CRT) for ISO14000 density (I4GDP) using the ISO 9000 density (I9GDP) as one of the independent variables.

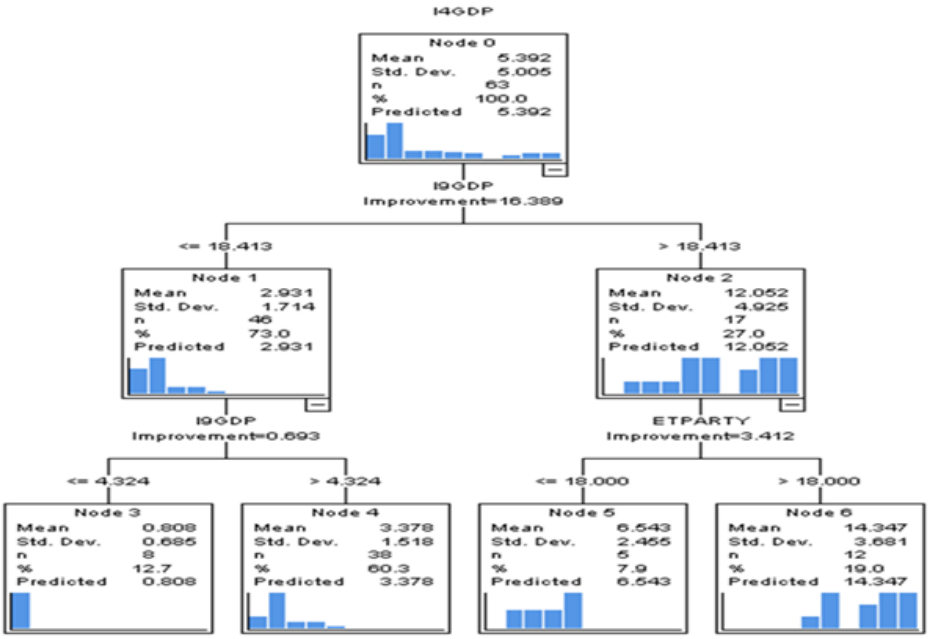

Figure 2. CRT with ISO 9000 as an independent variable.

Table 5. Risk.

Estimate	Std. Error
4.155	0.89

Growing Method: CRT.
Dependent Variable: I4GDP.

Figure 2 shows that the independent variables that are included in the final model are I9GDP and ETPARTY. The countries are first split based on the number of I9GDP densities (those equal to or less than 18.413 are on the left, and the others are on the right). The first split resulted in 16.389 improvements in prediction. In the second level, the splits are based on the ETPARTY which resulted in a 3.412 improvement, and I9GDP which resulted in a 0.693 improvement in the prediction. The improvement

values indicate the enhancement in the model's performance resulting from a specific split in the decision tree.

The risk estimate from **Table 5** is a key indicator of the model's performance. It measures the within-node variance, but on its own, it may not be very informative. A lower variance suggests a better model; however, this variance is relative to the measurement unit. To provide the goodness of the model, it used the results from **Figure 2** and **Table 5** to calculate the following:

The proportion of variance that is explained by the model =

$$\frac{\text{within} - \text{node variance}(\text{i.e, risk estimate value})}{\text{Total variance (within} - \text{node variance} + \text{between} - \text{node variance)}} = \frac{4.155}{5.005^2} = 0.834 = 83.4\% \quad (1)$$

The result indicates that this model is relatively good.

The final model of the CRT study confirmed that the diffusion of ISO 9000 had a strong influence on the diffusion of ISO 14000, which aligns with previous research findings of Corbett and Kirsch (2001) and Vastag (2004). More specifically, the model demonstrated that countries with a higher number of ISO 9000 certifications were substantially more likely to also have a greater prevalence of ISO 14000 certifications. This finding implies that ISO 9000 certification serves as an enabler for the implementation of ISO 14000. This is likely because organizations that have already implemented quality management systems are more capable of integrating environmental management standards. In addition, the tree analysis took into account another important factor which is the number of environmental treaties signed. The results show that countries with a higher number of environmental treaties are more likely to have a higher number of ISO 14000 certificates.

3.2. Decision tree analysis without ISO 9000 as an independent variable

Since ISO 9000 is more focused on quality improvement, whereas ISO 14000 is more focused on environmental impact, that being said, some similar characteristics impact both ISO 9000 and ISO 14000 certifications. Therefore, in this case, without considering other ISO kinds, it would like to observe other elements that affect the ISO 14000 certification density.

Figure 3 shows the result of the classification and regression tree (CRT) for ISO14000 density (I4GDP) excluding the ISO 9000 density (I9GDP) as one of the independent variables.

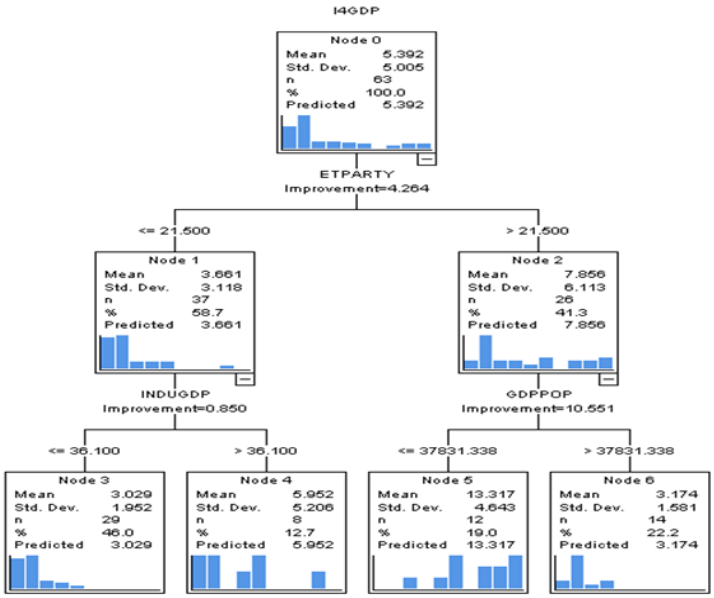

Figure 3. CRT without ISO 9000 as an independent variable.

Table 6. Risk.

Estimate	Std. Error
8.984	2.343

Growing Method: CRT.
Dependent Variable: I4GDP.

Figure 3 shows that the independent variables that are included in the final model are ETPARTY, INDUGDP, and GDPPOP. The countries are first split based on the number of ETPARTY (those are equal to or less than 21.5 are on the left, and the others are on the right). The first split resulted in 4.264 improvements in prediction. In the second level, the splits are based on the GDPPOP which resulted in a 10.551 improvement, and INDUGDP which resulted in a 0.850 improvement in the prediction. The improvement values indicate the enhancement in the model's performance resulting from a specific split in the decision tree.

The risk estimate from **Table 6** is a key indicator of the model's performance. It measures the within-node variance, but on its own, it may not be very informative. A lower variance suggests a better model; however, this variance is relative to the measurement unit. To provide the goodness of the model, it used the results from **Figure 3** and **Table 6** to calculate the following:

The proportion of variance that is explained by the model =

$$\frac{\text{within} - \text{node variance (i. e, risk estimate value)}}{\text{Total variance (within} - \text{node variance} + \text{between} - \text{node variance)}} = \frac{8.984}{5.005^2} = 0.641 = 64.1\% \quad (2)$$

The result indicates that this model is relatively good.

The results imply that the adoption of ISO 14000 is influenced by the number of ratified environmental treaties (ETPARTY), which means that the adoption of ISO 14000 may be influenced by international environmental commitments. Thus, in countries with a high number of environmental treaties, the number of ISO 14000 is high. The analysis also shows that the proportion of industrial activities to GDP

(INDUGDP) and the GDP per capita (GDPPOP) affect the adoption of ISO 14000. Specifically, the number of ISO 14000 certificates is higher in countries with a high proportion of industrial activities to GDP and low GDP per capita.

After several analyses explored above, it can be seen the summary of the result comparison between Vastag (2004) based on the old dataset and this study using a new dataset with two models, one including ISO 9000 density as an independent variable and the other model that excludes ISO 9000 density variable. **Table 7** shows the comparison of the studies' results.

Table 7. Summary of comparison studies results.

Method and findings	**Vastag (2004)**	**This study**	
		Include ISO9000 as an independent variable	**Exclude ISO9000 as an independent variable**
Drivers of ISO14000 certification density	ISO9000 certification density	ISO9000 certification density	Number of Environmental Treaties
	Number of Environmental Treaties	Number of Environmental Treaties	GDP per Capita
			Industrial Activities/ GDP
R-Square (Proportional reduction in error (PRE))	72.80%	83.40%	64.10%

The comparison between Vastag (2004) and Corbett and Kirsch (2001) that has been explained in Vastag (2004) shows that the decision tree model outperforms the multiple regression analysis that Corbett and Kirsch (2001) use. **Table 7** shows that the decision tree model is still valid and gives good results based on the new dataset, this means that decision tree models help in determining the drivers of ISO 14000 certification density.

4. Conclusion

The number of ISO 14000 certifications within a country is a significant measure of its dedication to environmental sustainability which is essential for maintaining long-term ecological balance and promoting human well-being. By thoroughly examining the various factors that impact the number of ISO 14000 certifications, valuable insights can be obtained regarding the facilitators and barriers to the adoption of environmentally sustainable practices in different regions. The study conducted by Corbett and Kirsch (2001) followed by the study of Vastag (2004) are the trigger for further analysis by carrying out replication analysis on the same sample of 63 countries using new available data. This study seeks to conduct a replication analysis of the factors that impact the number of ISO 14000 certifications across different countries. Through these efforts, authors aim to validate the applicability and relevance of past research findings in the current context and offer current insights to guide future initiatives focused on improving environmental sustainability through the implementation of ISO 14000 standards. This study uses two models to perform decision tree analysis: one with ISO 9000 certifications included as an independent variable and the other without including ISO 9000 certifications. The first model is driven by the idea that applying ISO 9000 makes it possible for firms to adopt

ISO14000, whereas the second model is driven by the idea that those two certifications are affected by the same factors, therefore, in addition to the density of ISO 9000 certifications, authors would like to find out what are these other factors.

In this study, it was found that the density of ISO 9000 certifications is a significant determinant of ISO 14000 certification density. Previous studies support this finding since the adoption of ISO 9000 reduced some of the uncertainties about the economic value and importance of management systems standards, thus making it easier for firms to adopt ISO 14000 (Albuquerque et al., 2007). In the second model that excludes the ISO 9000 certification densities, it was found that an important factor influencing ISO 14000 adoption is the number of environmental treaties signed and ratified. This finding aligns with previous studies (e.g., Goldar and Majumder, 2022). The study found that countries with high GDP per capita have a lower number of ISO 14000 certificates compared to countries with low GDP per capita. This aligns with previous findings that firms from less developed countries show a greater inclination towards adopting ISO 14001 compared to firms from more developed countries (Fura and Wang, 2017). This study showed that the levels of a country's industrial activities as a percentage of GDP is a significant determinant of ISO 14000 adoption, which confirms the findings of Lagodimos et al. (2007). Finally, while previous studies found that exports have a significant positive effect on ISO 14000 adoption (Goldar and Majumder, 2022; To and Lee, 2014), this study does not find any effect. Therefore, on a practical basis, the country could support its industrial sector, increase the number of environmental treaties to promote environmental practices in society, and promote the adoption of ISO (9000 and 14000) certifications among companies to improve their competitiveness in the global markets.

When interpreting the study's findings, its limitations should also be considered. This study focuses on the same factors influencing the density of ISO 14000 certifications that were studied in the previous research. Future studies might include other factors such as the indicator of Environmental, Social, and Governance (ESG) in the countries that provide a comprehensive understanding of a country's commitment to sustainability including environmental sustainability. Another potential factor could be the country's culture which might impact the awareness and desire for sustainable practices among customers, investors, and other stakeholders and might motivate organizations to pursue ISO 14000 certifications. In addition, future research might examine the effect of the proportion of large companies in different countries, as there have been suggestions that ISO 14000 certification is primarily pursued by larger firms.

Finally, this study is limited to a predetermined group of countries, which may not provide a comprehensive worldwide viewpoint. Including other countries, especially developing countries, might provide a more comprehensive view of the factors influencing the density of ISO 14000 certifications.

Author contributions: Conceptualization, HFZ and SS; methodology, HFZ and SS; software, HFZ; validation, HFZ and SS; formal analysis, HFZ and SS; investigation, HFZ; resources, HFZ; data curation, HFZ; writing—original draft preparation, HFZ and SS; writing—review and editing, HFZ and SS; visualization, HFZ; supervision,

HFZ; project administration, HFZ; funding acquisition, HFZ. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

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