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Forecasting of ISO 9001 and ISO 14001 Certifications in Bangladesh Through ARIMA Model

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Abstract

ISO 9001 and ISO 14001 are widely accepted international standards worldwide for continual improvement in terms of quality and environmental impact respectively. This study aims to predict the diffusion of ISO 9001 and ISO 14001 certifications in Bangladesh from 2022 to 2030. Auto-Regressive Integrated Moving Average (ARIMA) approach has been applied to choose the best fit model. The ISO survey of certifications was considered as main source of data. From the analysis, it is observed that, ARIMA (1, 0, 1) and ARIMA (2,1,0) are the best fitted models for ISO 9001 and ISO 14001 respectively in predicting the certification in Bangladesh. The forecasted number of certification for the year 2030 is obtained as 833 for ISO 9001 and 494 for ISO 14001 in Bangladesh. The finding of the study concludes wide scope of diffusion in future. This study will contribute to enrich existing literature and guide policy makers in policy formulation. This study will also encourage researchers for further analysis in different context.

Keywords
ARIMA model, Forecast, ISO 9001, ISO 14001 and Management System

1. Introduction

Sustainable management practice is a modern concept in businesses. It plays a vital role in mitigating risks for stable economy. Sustainable business practice optimizes the business strategy focusing on environmental and social responsibility, customer and stakeholder demand as well as long term economic prosperity. Consequently, organizations are now integrating sustainable management practices into their core business strategy to ensure the expectations of customers and other stakeholders. ISO standards serve as strong basis for business sustainability to reduce barriers of international trade by obeying national and international regulations. Moreover, ISO standards promote methodical management, continuous performance improvement, factual decision-making, and beneficial supplier relationships. Additionally, the application of ISO standards can be an instrument of marketing (Ehsan 2010). Due to global competition and complex supply chain, customers and stakeholders are concerned about quality of products and services with environmental sustainability. ISO 9001 and ISO 14001 standards have achieved global acceptance for continuous improvement in terms of ensuring quality and environmental aspects respectively (Franceschini et al. 2008) (Casadesus et al. 2010) (Marimon et al. 2010). Furthermore, ISO 9001 and ISO 14001 also contribute to the achievement of Sustainable Development Goals **(**SDGs**)** (Smith 2022) (ISO 9001:2015, 2021) (ISO 14001:2015, 2022**),** which is reflected in Table 1.

Table 1. Contribution of ISO 9001 and ISO 14001 to Sustainable Development Goals

ISO Standards	Contribution to Sustainable Development Goals
ISO 9001	1,9,12,14
ISO 14001	1,2,3,4,6,7,8,9,12,13,14,15

From Table 1. It is evident that a single ISO standard contributes to multiple goals of the SDGs. As a result, organizations are increasingly adopting internationally recognized standards (ISO 9001 and ISO 14001) to improve their business processes and demonstrate their commitment to quality and corporate sustainability (Ferreira et al. 2019) (Marimon et al. 2009). Bangladesh's economic growth (GDP) is significantly impacted by international trade like exports and imports, with a strong positive correlation (Ahamad 2016). Due to global competition, stakeholder's

expectations, international legislation regarding quality and environment, ISO 9001 and ISO 14001 have also achieved popularity in Bangladesh. Some industrial sectors in Bangladesh consider ISO certification to be solely important for exports. According to the study of (Pushpo and Uddin 2022), it is clear that compared to other ISO standards, the certification of ISO 9001 and ISO 14001 have covered 80% and 13% of the total certification in Bangladesh.

The widespread adoption of ISO 9001 and ISO 14001 has made it necessary to predict the future trend of implementation of both ISO standards in Bangladesh for sustainable business management. Previous studies on diffusion of ISO standards have been conducted in European countries like Germany, African Countries: (South Africa, Morocco, Egypt, Tunisia), Oceania Countries: (Australia, New Zealand), Asian Countries: (China, Japan, India, South Korea, Pakistan), Brazil, Canada, Mexico, Argentina, Russian Federation, Australia, Saudi Arabia, Italy, USA, UK etc. But, No study on the diffusion of ISO implementation have been conducted in Bangladesh so far. In this consequence, this study to focus on forecasting future growth of both standards in context of Bangladesh. This study will help organizations to identify potential risks and opportunities and make informed decisions that support long-term growth and success. The study will also guide the professionals in formulating a framework for sustainable business practices with reduced environmental impact, improve efficiency, and enhance their reputation among customers and stakeholders.

Besides introduction, this paper is structured with literature review of previous researches and theoretical review of relevant topics. Third section explains the research methodology. The fourth and fifth section describes the source of data as well as findings of the research. Finally, the last section concludes with the scope of further research.

2. Literature Review

2.1 Previous Researches

Several past studies analyzed the diffusion of ISO 9001 and ISO 14001 with the application of different forecasting models. Ikram et al. (2021) used Even Grey Model, Discrete Grey Model, and Nonhomogeneous Discrete Grey Model to analyze the diffusion of ISO 9001 certification for 2018-2026 in China, Italy, Germany, Japan, the United Kingdom, and India. According to their findings, China and India have higher growth phases for ISO 9001 followed by Italy, Germany, Japan, and the United Kingdom. Ikram et al. (2019) applied Even Grey Model GM (1,1), Discrete Grey Model GM (1,1), and Nonhomogeneous Discrete Grey Model (NDGM) to forecast the ISO 14001 certifications from 2017 to 2026 for China, India, the USA, Italy, Japan, and Germany. The results of the empirical study showed that China would continue to be in the lead in terms of ISO 14001 certificates until 2026, and that emerging nations would do very well. Salgado et al. (2016) analyzed 18 American countries into six clusters using economic metrics and regression models. They found a positive correlation between ISO 9001 certificate issued per 1000 residents and economic development metrics, such as Gross National Income Per Capita. Llach et al. (2011) examined the global adoption of the ISO 9000 family of quality standards from 1998 to 2008 with an emphasis on industrial sectors. The analysis measured heterogeneity across various sectors using information from the ISO and two instability indexes. Results indicated that the spread of ISO 9001 follows a logistic curve across all industries, with variations in the initial, expansionary, and saturation stages. The sectors are classified into three groups based on their potential future evolution.

Albuquerque et al. (2007) investigated the global diffusion of ISO 9000 and ISO 14000 certification using a network diffusion approach. Country influences, rates of diffusion, and contagion effects were examined. Cross-country effects and Bayesian techniques are included in the model. According to the study, Geographical factors and bilateral economic ties are the main drivers of ISO9000 diffusion, whereas geographic factors and cultural similarity are the main drivers of ISO14000 diffusion. The diffusion of ISO 9001 and ISO 14001 have also been analyzed with the help of logistic curve/model (Marimon et al. 2010) (Casadesús et al. 2008) (Marimon et al. 2009). Franceschini et al. (2004) investigated the spread and prospects of ISO 9001 certification in European nations using a logistic model. They compared certificate issuing to bio population expansion. The study found that after rapid expansion, certified enterprises lose their favorable connotation, leading to a drop in interest in certification. The outcome of this study expressed concerns about the future of ISO 9001 as many nations have reached the threshold.

In recent years, ARIMA models have been used in many researches to predict the diffusion of ISO standard. In contrast to the regression models, the ARIMA model allows time series to be explained by its past or lagged values and stochastic error terms (Rahman and Hasan 2017). ARIMA models are often considered as delivering more accurate forecasts then econometric techniques (Song et al. 2003). Hikichi et al. (2017) used ARIMA models to forecast the number of ISO 14001 certifications in the Americas. Sousa Lira et al. (2020) proposed ARIMA models as an

alternative to predict ISO 14001 certification in Europe in which ARIMA model showed an accuracy of 90% for some countries. Furthermore, another research has been conducted by (Sousa Lira et al. 2021) where ARIMA models were applied to analyze the diffusion of ISO 14001 across Africa, Asia and Oceania on the basis of ISO 14001 certifications data from 1999 to 2017. The annual relative growth rate (RGR) was also calculated.

2.2 ARIMA Model:

ARIMA is one of the most traditional time series analysis methods. To find the best fit model in time series analysis, the statisticians George Box and Gwilym Jenkins (1970) applied ARIMA models, which is the combination of three processes (Abonazel and Abd-Elftah 2019): Autoregressive (AR) process, Differencing process and Moving-Average (MA) process. The ARIMA model is generally written as ARIMA (p,d,q), where "p" represents the order of the auto regressive process, "d" indicates the order of the data stationary and "q" represents the order of the moving average process (Rahman and Hasan 2017). When the time series becomes stationary through differentiation, an ARIMA model is usually given by the following equation:

$$Wt = \Phi_1 w_t\text{-}p + \varepsilon_t - \theta_1 \varepsilon_t\text{-}1 \ldots \theta q\ \alpha_t\text{-}q,$$

Where, t = time, W_t = dth series differences, Φ = p, θ = d, ε = error and α= white noise.

3. Methodology

This section is devoted to describe the step by step procedure to conduct the research. These are as follows:

3.1 Research Design:

The Box-Jenkins approach has been applied to select the appropriate Autoregressive-Integrated Moving-Average (ARIMA) model which comprises of four iterative stages- identification, estimation, diagnostic checking and forecasting (Abonazel and Abd-Elftah 2019). The detail is shown in Figure 1.

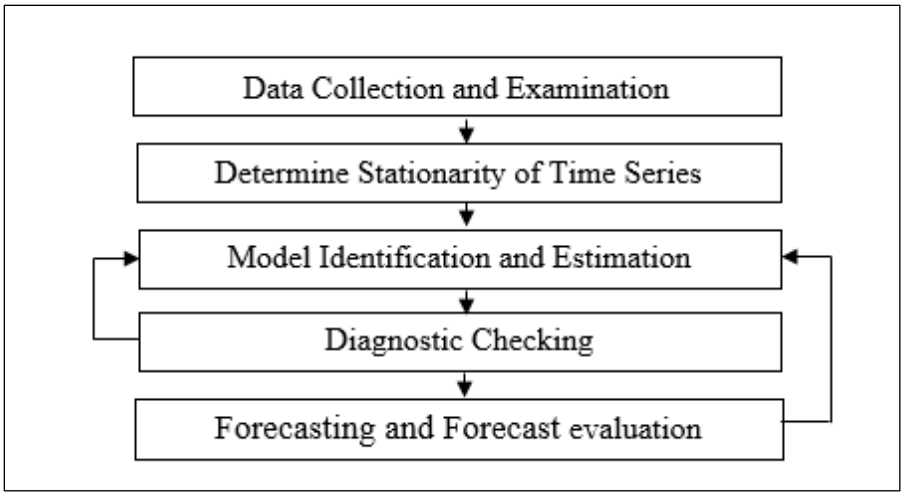

Figure 1. ARIMA Forecasting Procedure

3.2 Data Analysis:

a) Analysis of Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) were performed for ISO 9001 and ISO 14001 to identify the values of (p, d, q) for Auto-Regressive Integrated Moving Average (ARIMA) models. The data was analysed with the help of the Statistical Package for Social Science (SPSS) software 26.0.

b) Comparison of different ARIMA models was done to choose the best fit model, on the basis of minimum value of Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), and Bayesian information criteria (BIC). RMSE, MAE and MAPE measures the average difference, absolute difference

and percentage difference between the predicted values and the actual values respectively. So, the lower values of RMSE, MAE and MAPE indicate the better performance of the models. The appropriateness of the models is confirmed by investigating Normalized BIC. BIC measures the trade-off between the model's goodness of fit and the complexity of the model. The models with least BIC value, upheld the significance of the model. Moreover, the values of R-square and stationary R-square was also checked. R square measures the proportion of variance in dependent variable explained by independent variables, whereas Stationary R square measures the proportion of variance in stationary dependent variable explained by independent variables. The higher values of R-square and Stationary R square indicate better performance of the model.

c) Finally, the forecast was conducted for ISO 9001 and ISO 14001 for the period 2022-2030, using the best fit ARIMA model.

4. Data Collection

The official website of ISO is used as the main source of data to collect the number of certificates for ISO 9001 and ISO 14001 in Bangladesh up to 2021.

5. Results and Discussion

In this section, numerical and graphical results with discussion are provided. Based on the analysis of ACF and PACF, the ARIMA models have been selected to forecast ISO 9001 certification in Bangladesh. The performance criteria of the selected ARIMA (p,d,q) models are shown in Table 2.

Table 2. Performance of ARIMA models to predict of ISO 9001 certification in Bangladesh

ISO Standard	ARIMA Model	R-Square	Stationary R-Square	Model Selection Criteria			
				RMSE	MAE	MAPE	BIC
ISO 9001	(1,0,1)	0.703	0.703	153.035	85.517	356.164	10.563
	(2,1,2)	0.663	0.444	169.909	95.657	165.160	11.043

Table 2. indicates that, the ARIMA (1,0,1) model has higher R-squared and stationary R-squared values compared to the ARIMA (2,1,2) model for ISO 9001. The ARIMA model with higher R-squared and stationary R-squared values typically indicates a better fit to the data. Therefore, the ARIMA (1,0,1) model will have better accuracy than the ARIMA (2,1,2) model. However, other metrics- RMSE, MAE, MAPE and BIC has been checked to evaluate the accuracy of a model. ARIMA (1,0,1) model is a better fit, as it has a lower BIC value (10.563) compared to the ARIMA (2,1,2) model (11.043). Furthermore, the ARIMA (1,0,1) model has a lower RMSE (153.035) compared to the ARIMA (2,1,2) model (169.909), indicating that it has better accuracy. The ARIMA (1,0,1) model has also a lower value of MAE (85.517) compared to the ARIMA (2,1,2) model (95.657), which indicates better accuracy. Again, the ARIMA (2,1,2) model has a lower MAPE (165.160) compared to the ARIMA (1,0,1) model (356.164), indicating that it has better accuracy.

Overall, based on the evaluation metrics, it seems that the ARIMA (1,0,1) model is a better fit. The forecast of ISO 9001 certification of Bangladesh for the period 2022 to 2030 is presented in Table 3.

Table 3. Forecast of ISO 9001 certifications in Bangladesh

Forecast										
Model		2022	2023	2024	2025	2026	2027	2028	2029	2030
ISO9001-ARIMA (1,0,1)	Forecast	732	663	692	715	739	762	786	810	833
	UCL	1047	1075	1104	1127	1151	1174	1198	1222	1245
	LCL	417	252	280	303	327	350	374	398	421

Table 3. describes that, the forecasted value of ISO 9001 certification in 2030 is 833. Figure 2 demonstrates the plot between observed and predicted values for number of certificates in Bangladesh for ISO 9001.

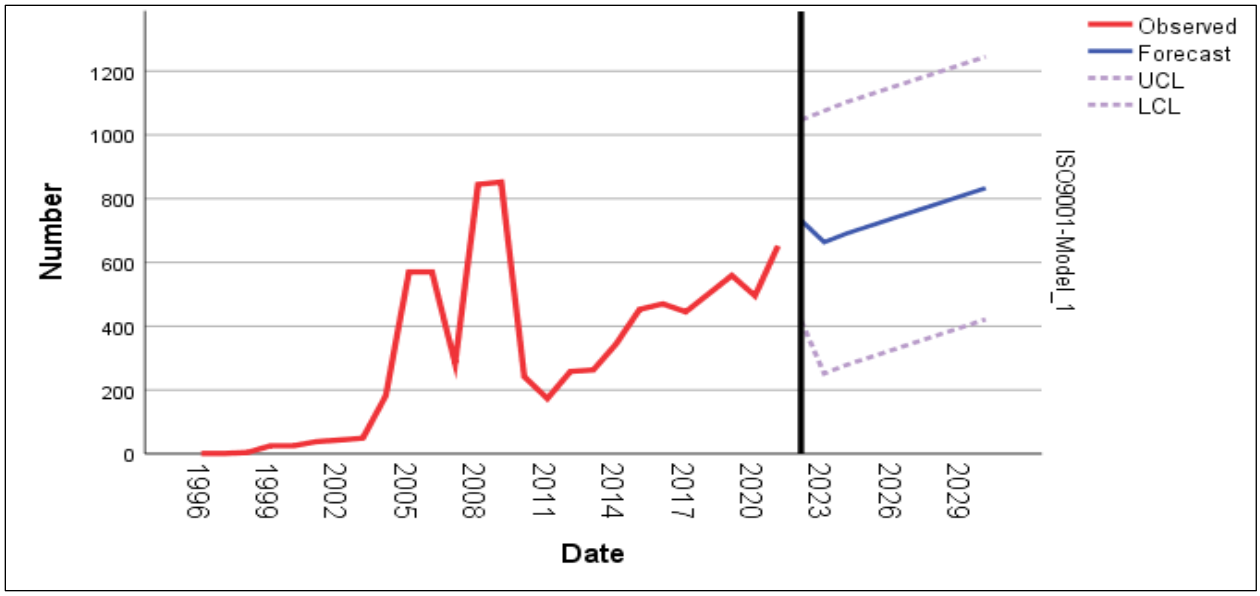

Figure 2. The observed and predicted values of ISO 9001 certifications in Bangladesh.

The performance criteria of ARIMA models to forecast ISO 14001 certification are highlighted in Table 4.

Table 4. Performance of ARIMA models to predict of ISO 14001 certification in Bangladesh

ISO Standard	ARIMA Model	R-Square	Stationary R-Square	Model Selection Criteria			
				RMSE	MAE	MAPE	BIC
ISO 14001	(2,1,0)	0.959	0.400	15.511	10.675	82.967	6.082
	(0,1,11)	0.979	0.689	16.888	7.218	70.337	7.600

Table 4. depicts that, ARIMA (2,1,0) has a lower RMSE and MAE than ARIMA (0,1,11), indicating better predictive accuracy. ARIMA (0,1,11) has a lower MAPE than ARIMA (2,1,0), indicating that it has a better performance in terms of percentage errors. ARIMA (2,1,0) has a lower BIC than ARIMA (0,1,11), indicating that it is a better trade-off between goodness of fit and model complexity. ARIMA (0,1,11) has a higher R squared and stationary R squared than ARIMA (2,1,0), indicating that it has a better performance on stationary data. However, comparing the two models, ARIMA (2,1,0) seems to be the better forecasting model. The number of ISO 14001 certification for Bangladesh is forecasted for the period 2022 to 2030 which is presented in Table 5.

Table 5. Forecast of ISO 14001 certifications in Bangladesh

Forecast									
Model		2022	2023	2024	2025	2026	2027	2028	2029	2030
ISO14001-ARIMA (2,1,0)	Forecast	247	266	297	328	357	389	424	458	494
	UCL	280	303	337	373	405	441	478	516	555
	LCL	214	228	258	283	308	338	369	401	434

Table 5. shows that, the forecasted number of certification for ISO 14001 in 2030 is 494 where Figure 3 illustrates the plot between observed and predicted values for number of certificates in Bangladesh for ISO 14001.

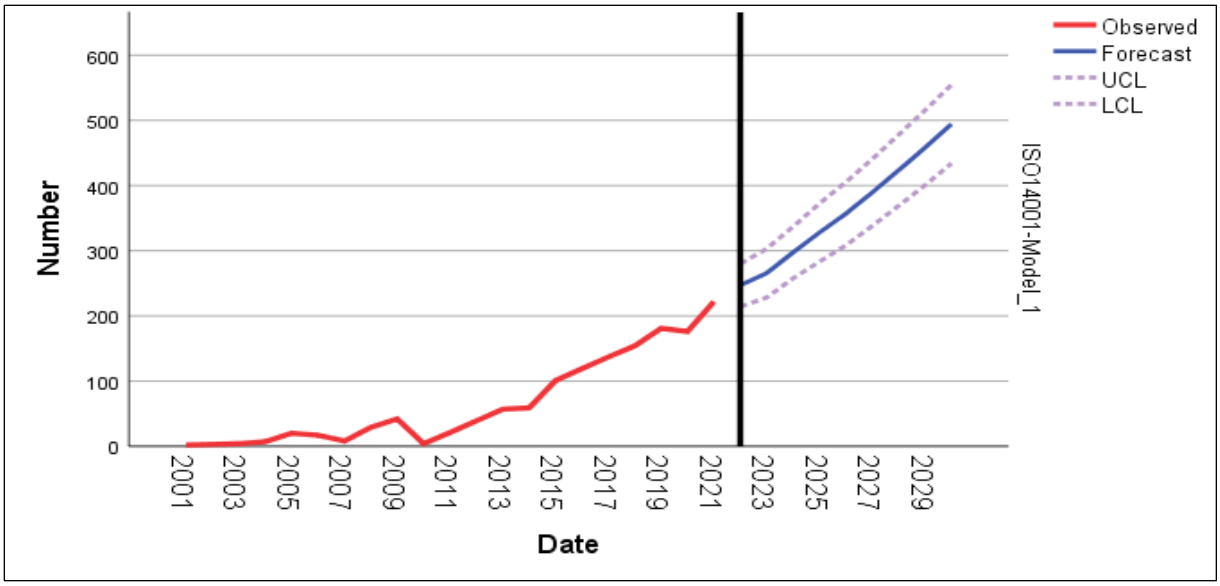

Figure 3. The observed and predicted values of ISO 14001 certifications in Bangladesh.

Figure 3 indicates a positive growth of certification in future.

6. Conclusion

Sustainable business practice has become a matter of concern nowadays since the resources are limited and the competition is high. The main focus of the study is to predict the diffusion of ISO 9001 and ISO 14001 in upcoming years. The ARIMA model has been applied to choose the best fit models. The findings conclude that the diffusion of ISO 9001 and ISO 14001 standards is expected to have a positive growth of adoption in future. This study will enhance the existing literature by proposing ARIMA model for diffusion analysis of ISO standards and help stakeholders in decision making. This study will create scope for the researchers to employ ARIMA models in analyzing the diffusion of other ISO standards. The study will also guide the professionals in formulating sustainable business policy for continual improvement.

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