www.komyra.com

2022 02

Volume 9 No 2

ISSN 2383-6563 (Online)

The Myanmar JOURNAL

Co-published with Yangon University of Economics (YUE) and
Korea Myanmar Research Association (KOMYRA)

Letter from the Editor-in-Chief

Myanmar and Korea have many similarities and are complementary relationship. Therefore, we believe that research exchange will expand mutual understanding between Myanmar and Korea, and will be the cornerstone for mutual development.

KOMYRA and YUE have co-published The Myanmar Journal since August 2014. So far, many scholars have published numerous papers through the journal, and We are sure that this journal has helped many people understand Myanmar and Korea more clearly and closely.

The Myanmar Journal covers various issues in Myanmar and Korea. It covers various topics that can promote bilateral development and mutual understanding, not limited to specific topics such as economy, industry, society, education, welfare, culture, energy, engineering, healthcare, and agriculture.

We hope that this journal will continue to promote understanding of the current status and potential capabilities of Myanmar and South Korea and promote in-depth international exchange and cooperation.

We would like to express our deepest gratitude to the editorial board and YUE and KOMYRA for their valuable support in The Myanmar Journal publication.

February 28, 2022

Youngjun Choi

Editor-in-Chief of THE MYANMAR JOURNAL
Vice-President of KOMYRA
Email: yjchoi@khu.ac.kr
Office: +82-2-961-0485
Web address: komyra.com/doc/scope.php

INFORMATION ABOUT
The Myanmar Journal

The Myanmar Journal (ISSN 2383-6563) is the official international journal co-published by Yangon University of Economics (YUE) and Korea Myanmar Research Institute (KOMYRA).

This journal aims to promote the mutual cooperation and development of Myanmar and Korea through intensive researches in the entire filed of society, economy, culture, and industry.

It will cover all general academic and industrial issues, and share ideas, problems and solution for development of Myanmar.

Articles for publication will be on-line released twice a year at the end of February and August every year on the Myanmar Journal webpage (http://www.komyra.com/bbs/board.php?bo_table=articles).

The Myanmar Journal 9(2), 200-211 (2022)
http://www.komyra.com/doc/scope.php

Time Series Analysis Model for Production of On-shore Gas in Myanmar

Phyu Phyu Khaing* · Yin Yin Wint**
Meiktila University of Economics

ABSTRACT : This study uses time series models to predict the monthly on-shore gas production in Myanmar. The on-shore gas production data spanning from January 2011 to September 2021 was used. The Box-Jenkins model building strategy was applied. The Augmented Dickey Fuller (ADF) test showed that the on-shore gas production data was stationary. Three SARMA models were suggested based on the R-squared, Bayesian Information Criteria (BIC), mean absolute percent error (MAPE), root means square error (RMSE), and mean absolute error (MAE) of the differenced series, these were (1,0,0)(1,1,0)12, (1,1,0)(1,0,1)12 and (1,1,0)(1,0,0)12. The model based on higher value of R-squared and a lower value of MAE, MAPE, RMSE and Normalized BIC was chosen as the best model. The Ljung-Box statistics among others were used in assessing the quality of the model. According to the model selection criteria, SARMA (1,1,0) (1,0,1)12 was the best model for monthly on-shore gas production data in Myanmar. The results showed that the forecast values of on-shore gas production in Myanmar exhibited an upward trend for October to December in 2021 but the period of January to March in 2022 exhibited a downward trend. This was due to the fact that the white noise process values were statistically independent at various times.

Key words : *Box-Jenkins methodology, Seasonal models, Box-Ljung test, Augmented Dickey-Fuller test*

* Dr. Professor & Head , Department of Statistics, Meiktila University of Economics, Upper Myanmar
** Dr. Professor, Department of Statistics, Meiktila University of Economics, Upper Myanmar

I. Introduction

Natural gas has the fastest growing consumption rates among clean energy resources in the world. It is considered a common resource and is used in different sectors such as heating, electricity generation, transportation, cooking, and cooling. Myanmar's natural gas will play a greater role in providing energy security as the country will be exposed to increasing energy demand in all sectors particularly gas consumption in the power sector and industries. Myanmar's oil and gas sector faces several challenges that will have to be overcome to ensure its sustainability.

Use of natural gas in Myanmar started with onshore gas production in the early 1970s, together with the construction of the Kyunchaung gas turbine power plant, the Kyunchaung fertilizer plant, and the Sale fertilizer plant. Before then, most of the associated gas was flared off. Later in 1985 and in the early 1990s, a few more gas processing plants—such as the Kyawzwa fertilizer plant, the Seiktha Methanol plant, and the Minbu LPG extraction plant—were constructed to make use of the natural gas. Several gas turbine plants were also constructed in the regions of Myanaung, Shwedaung and Yangon. MOGE had the peak production of onshore natural gas in the mid-1990s producing nearly 200 million cubic feet per day, supplying natural gas to fertilizer plants, LPG plants, power generation plants (60% of gas production), and various other industries.

Myanmar's proven gas reserves total 10.3 trillion cubic feet (TCF) as of September 2014, with huge potential for further discoveries and offshore gas is the country's most important source of export revenues. Myanmar has become one of the five major energy exporters in the region. The daily oil production is about 20,000 barrels per day (8,000 barrels of crude oil from onshore and about 12,000 barrels of condensate from an offshore field), which supplies around 30% of domestic consumption as of 2013. Some 550 coal occurrences have been identified in Myanmar, although many of them are of minor importance and in various qualities. At present half of the production is used at one minor coal-fired power plant with the balance used in the cement and steel industries. The entire base of the Myanmar oil and gas production is handled with significant government involvement. Because of this, it is important to use forecasting techniques and methods, since they are tools that help industries and companies to solve problems.

The objective of this research is to model the historical data of the monthly production of on-shore gas in Myanmar between January 2011 and September 2021, performing a detailed analysis of the data to reduce the forecast error. This will allow us to make a stochastic model to forecast the monthly production of on-shore gas. The resulting model will help predict the country's gas generation and can be used for natural gas master planning from different sources of gas production.

II. LITERATURE REVIEW

The Autoregressive (AR), Moving Average (MA) and the mixed autoregressive moving average (ARMA) models are often very useful in modeling most time series data. However, they have the assumption of homoscedasticity (Madsen, 2008). Box et al. (1994) introduced a SARIMA model as an adaptation of an autoregressive integrated moving average (ARIMA) model, which was earlier proposed to specifically explain the variation of seasonal time series. The best forecasts in Box et al. (1994) as judged by the root mean-square error (RMSE) and other criteria were obtained with the family of periodic autoregressive models. It was found that a periodic auto-regression which was determined by choosing as small as possible to achieve an adequate fit gave the best model forecasts. This was accomplished by initially determining based on a plot of the periodic partial autocorrelation function and then checking the adequacy of the fitted model. This approach is thus a natural extension of that of Box and Jenkins (1976).

Ediger et al. used autoregressive moving average (ARIMA), seasonal ARIMA (SARIMA) and comparative regression techniques to forecast the production of fossil fuel sources in Turkey, which include natural gas. They made annual forecasts from 2004 to 2038 and used different regression types such as linear, logarithmic, inverse, quadratic, cubic, compound, power, growth, exponential, and logistic. They concluded that ARIMA is a suitable technique for natural gas consumption.

Gutiérrez et al. used the Gompertz-type innovation diffusion process as a stochastic growth model to forecast annual natural gas in Spain from 1973 to 1997. They compared the results between 1998 and 2000 with stochastic logistic innovation modelling and the Gompertz model was found to be more suitable.

Ma and Wu studied China's annual natural gas consumption and production prediction with the Grey model. They used data from 1990 to 2003 and generated forecasts for 2004 to 2007. In a comparison between the Grey model (with one variable and rank 1 differential equation—GM(1,1)) and Grey-Markov model, the Grey-Markov gave better results.

Xie and Li also used the Grey model to predict China's annual natural gas forecasting. Unlike Ma and Wu, they used a genetic algorithm for optimizing the GM(1,1) model. They used data from 1996 to 2002 and predict for the forecast range of 2003 to 2005. Here, genetic optimization performed better results.

III. MATERIALS AND METHODS

The data for this research comprises the on-shore gas production on monthly basis for the periods of January 2011 to September 2021. The time series SARIMA methodology adopted is subsequently discussed and analyzed.

1. Seasonal models

Seasonal movement is usually due to the recurring events which takes place annually or quarterly as the case may be. Seasonal models have pronounced regular ACF and PACF patterns with a periodicity equal to the order of seasonality. If the seasonality is annual, the ACF spikes are heightened at seasonal lags over and above the regular non-seasonal variation once per year. If the seasonality is quarterly, there will be prominent ACF spikes four times per year.

Seasonal Autoregressive (SAR) model

Seasonal Autoregressive model contains autoregressive parameters at seasonal lags. The time sequence plot of ACF or PACF can be used as a primary instrument for identifying seasonal autoregressive model.

Seasonal autoregressive models is given as:

$X_t = \Phi X_{t-12} + \varepsilon_t$

where $|\Phi| < 1$ and is independent of , ..., it is obvious that $|\Phi| < 1$ ensures stationarity.

Generally, a seasonal AR (P) model and a seasonal period's s is given as:

$X_t = \Phi X_{t-s} + \Phi X_{t-2s} + \ldots + \Phi p X_{t-ps} + \varepsilon_t$

It is required that is independent of Xt-1, Xt-2, and, for stationarity, that the roots of Φ(x) = 0 be greater than 1 in absolute value.

Seasonal Moving Average (SMA) model

A seasonal moving average model of order Q with seasonal period s is given as:

$X_t = \varepsilon_t + \Theta_1\varepsilon_{t-s} - \Theta_2\varepsilon_{t-2s} - \Theta_3\varepsilon_{t-3s} - \ldots - \Theta Q\varepsilon_{t-Qs}$

Seasonal Autoregressive Integrated Moving Average (SARIMA) model

An important tool in modeling non-stationary seasonal processes is the seasonal difference. The seasonal difference of period s for the series is denoted by and is defined as:

$\nabla_s X_t = X_t - X_{t-s}$

For a series of length n, the seasonal difference series will be of length n-s; that is, s data values are lost due to seasonal differencing.

In a non-stationary seasonal model, a process is said to be a multiplicative seasonal ARIMA model with non-seasonal (regular) orders p, d and q, seasonal orders P, D and Q and seasonal period s if the differenced series:

$W_t = \nabla^d \nabla_s^D X_t$

satisfies an ARMA (p,q) x (P Q)s model with seasonal period s. We say that [ ] is an ARIMA (p, d, q) x (P, D, Q)s model with seasonal periods.

In practice, many time series contains a seasonal periodic component which repeats every s observations. Box-Jenkins has generalized the ARIMA model to deal with seasonality and defines a general multiplicative seasonal ARIMA model in the form:

$\varnothing(B)\ \Phi(B)(1-B)(1-B^{12})X_t = \theta(B)\Theta(B^{12})\varepsilon_t$

where B denotes the backward shift operator, ∅, Φ, θ and Θ are polynomials for order p, P, q, and Q respectively. is the observed time series and   represent an unobserved white noise series, that is, a sequence of independently (uncorrelated) identically distributed random variables with zero mean and constant variance $\sigma\varepsilon 2$.

All the identified parameters shall be estimated using the method of maximum likelihood.

Upon the fitting of the above discussed model, diagnostic checks shall be carried out to ensure normalcy using the following validity checks

(i) Residual analysis

(ii) Shapiro-Wilk Test of Normality

(iii) The Ljung-Box Test - A portmanteau test according to Box and Pierce (1970) proposed the statistic:

$$Q = n \ (\hat{\rho}_1^2 + \hat{\rho}_2^2 + \ldots + \hat{\rho}_k^2) = n \sum_{k=1}^{n} \hat{\rho}_k^2$$

Thus, a general "portmanteau" test would reject the ARMA (p, q) model if the observed value of Q exceeds an appropriate critical value in a Chi-Square distribution with k-p-q degrees of freedom.

2. Model Estimation

The models were designed and implemented. Then, the best model was selected using adjustment statistics such as Mean Absolute Percentage Error (MAPE), Coefficient of Determination (R2), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC).

3. Model Validation

The selected model proceeds to determine if it fulfils all the hypothesis of validation of the residues, although the estimation error is first plotted to analyze if there is a presence of atypical errors, which indicate a presence of intervention. Among the validation tests of the model, the Box-Ljung test with the null hypothesis being that the gas production series is uncorrelated was used. For the constant variance of the residuals, the Box-Ljung test with squared residues with the null hypothesis that the gas production series has constant variance, and finally the Jarque-Bera test for then ormality of the residues being the null hypothesis that the residues are normal.

4. Model Forecast

Once the ARIMA combined model has been validated, hydroelectric production is forecasted for a 60 months horizon, corresponding for the period 2020to 2024. The predicted values have been estimated with a 95% confidence interval.

IV. Results and Discussion

Figure 1 shows the time series of the gross monthly on-shore gas Production of the data, in which it is observed that the gross monthly production series presents an upward trend over time, annual cyclical with peaks of on-shore gas production from January to March and strong seasonality. The monthly on-shore gas production series presents mean and variance not constant over time, producing variability over time. The on-shore gas production series as non-stationary in mean, variance and covariance not consistent over time. The on-shore gas production series as non-stationary in mean, variance and covariance not consistent over time. In the period January 2011- November 2020, the on-shore gas production increased due to the potential nominal and effective potential increase of the on-shore gas production in Myanmar.

Figure 1. Series of Monthly On-shore Gas Production in Myanmar (January 2011- September 2021)

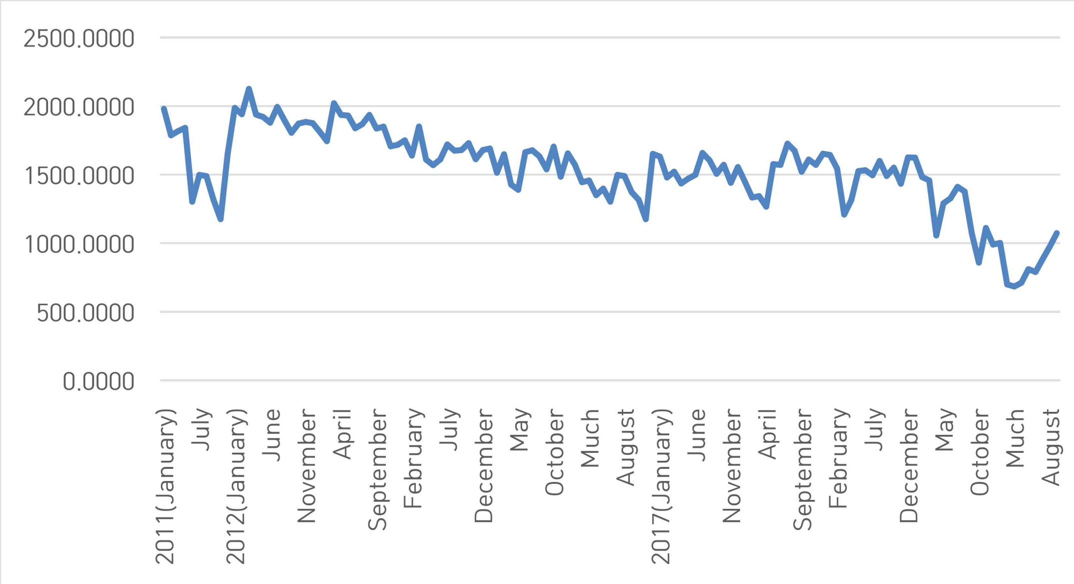


Table (1) presents the statistics calculated for testing the seasonality in the on-shore gas production series from January 2011 to September 2021.

Table 1. ANOVA Table for On-shore Gas Production (January2011- September 2021)

Sources of variation	Sum of square	Degree of Freedom	Mean Square Error	F-ratio	Sig.
Due to month Due to year Error	550298.567 10673565.356 1457076.994	11 10 107	50027.142 1067356.536 13617.542	3.674	0.000
Total	12680940.9				

Source: SPSS output

According to Table (1), it can be concluded that the monthly data of on-shore gas production series in Myanmar exists seasonality because of Sig. (0.000) is less than 0.01 (1%). Therefore, the best ARIMA with seasonality based on higher value of R-squared and a lower value of MAE, MAPE, RMSE and Normalized BIC was identified in this paper.

The ADF test is used to study that the MGP series is stationary or not. The null hypothesis and the all findings of the ADF test are presented in Table (2).

Table 2. ADF Test at level of Stationary for On-shore Gas Production

Test		t-statistic	Prob.*
ADF	Level	-1.697971	0.4299
	1st Difference	-9.119531	0.0000
Critical Value	1% 5% 10%	-3.482453 -2.884291 -2.578981	

Source: SPSS output

According to Table (2), there is evidence to reject the null hypothesis: first seasonal difference of on-shore gas production does not have a unit root because the P value= 0.000 is less than 0.01 (1%). This means that first seasonal difference of on-shore gas production is stationary at 1% level.

Table 3. Possible SARIMA Models for On-shore Gas Production

Model	R-squared	Normalized BIC	MAPE	MAE	RMSE
(1,0,0) (1,1,0)12	0.827	9.794	6.978	95.55	125.93
(1,1,0) (1,0,1)12	0.857	9.727	5.991	84.94	120.04
(1,1,0) (1,0,0)12	0.847	9.746	6.573	92.63	123.50

In Table (3), the best ARIMA with seasonality is (1,1,0) (1,0,1)12 based on higher value of R-squared and a lower value of MAE, MAPE, RMSE and Normalized BIC.

Table 4. Estimated Parameters and Model Statistics for SARIMA (1,1,0)(1,0,1)12 Model

	Estimate	SE	t	Sig.
Constant	-7.216	18.013	-0.401	0.689
AR	-0.2140	0.090	-2.391	0.018
SAR(1)	0.856	0.118	7.288	0.000
SMA(1)	0.593	0.190	3.126	0.002

Source: SPSS output

The following estimated model was obtained

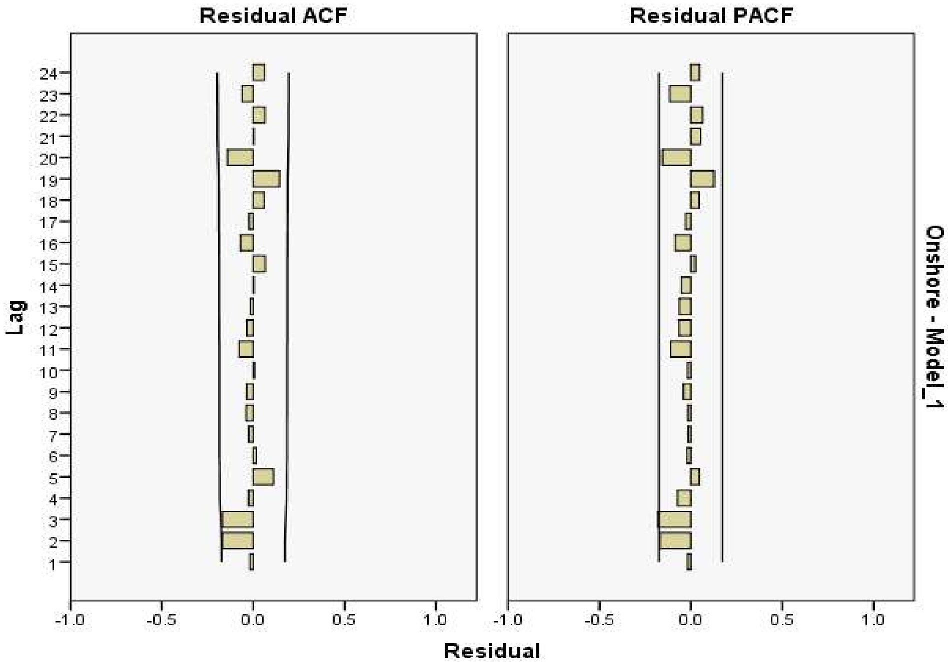
$(1+ 0.214B)\ (1-0.856B)\ (1-B)\ (1-B^{12})\ Xt = (1+0.593)\varepsilon_t$

According to table (4), there is evidence that the parameters of best ARIMA with seasonality model are significant at 5%. Moreover, diagnostic check on SARIMA (1,1,0)(1,0,1)12 model are presented the following section.

Diagnostic check on SARIMA (1,1,0)(1,0,1)12 model

The Ljung-Box test statistic examines the null hypothesis of independence in the residuals of the on-shore gas series with a Chi-squared value of 12.863 with a P-value of 0.613 which lead to the acceptance of null hypothesis that all the autocorrelation functions are zero. Moreover, autocorrelation function (ACF) and partial autocorrelation function (PACF) of residuals values for SARIMA (1,1,0)(1,0,1)12 model are represented with more or less three standard deviations in figure (2). It was observed that it was not necessary to apply an intervention variable because there are no atypical values.

Figure 2. Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of Residuals Values for SARIMA (1,1,0)(1,0,1)12 Model



Source: SPSS output

From Figure 2 the plots of residuals ACF and PACF, all residual values at various lags lie inside interval at 95% confidence limits. This means each residual is very small relative to its standard error and shows the existence of no significant correlation between residuals. As a result, the errors obtained from the seasonal ARIMA (1,1,0) (1,0,1)12 model are white noise or independent. Thus, this mode is adequate. Figure 3 shows the actual values and predicted values for the SARIMA model identified in this paper.

Figure 3. Fitted Seasonal ARIMA (1,1,0) (1,0,1)12Model for Monthly On-shore Gas Production for January 2011 to September 2021

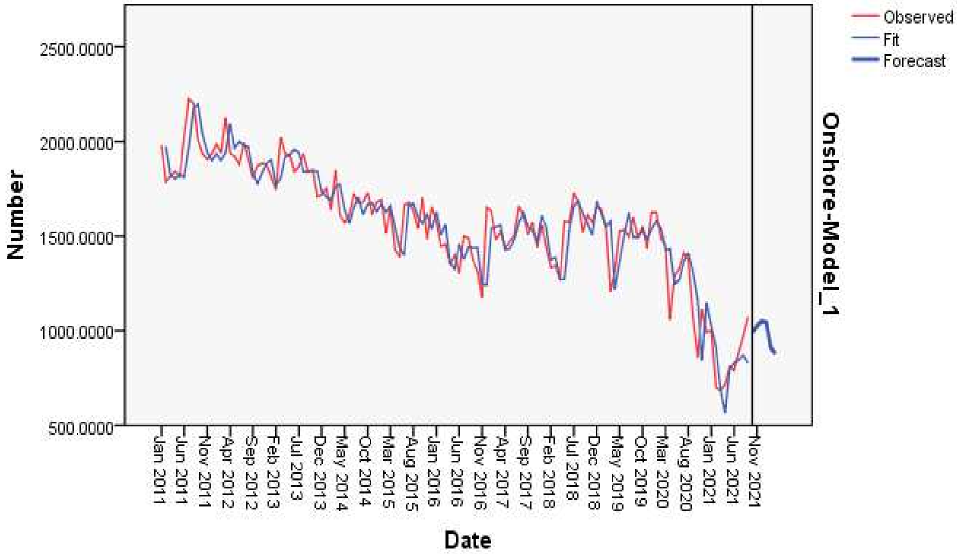


Table 5 shows the predicted values for next October to December in 2021 and January to March in 2022. It is observed that the predicted values are within the designated confidence interval.

Table(5) Forecast Values for On-shore Gas Production in Myanmar Selected Best Fitted Model [ARIMA (1,1,0) (1,0,1)12 with Seasonality]

	Oct. 2021	Nov. 2021	Dec. 2021	Jan. 2022	Feb. 2022	Mar. 2022
Forecast values (million cubic feet)	990.7672	1024.9307	1051.6703	1043.7464	912.7370	878.2223
UCL	1224.7987	1322.5308	1407.2479	1447.9883	1360.5966	1365.7713
LCL	756.7357	727.3306	696.0927	639.5045	464.8774	390.6733

V. CONCLUSION AND SUGGESTION

The ARIMA (1,1,0) (1,0,1)12 model with selected random walk in this research reflects the trend of gross monthly 0n-shore gas production. This random walk mean zero model with has estimated that the occurrence of the production is for the parameter p = 1 for the regular component. For the seasonal component, it is Q = 1 and the strong seasonality of S = 12. The result suggests that the model adequately adjusts the data of the series, although the series presents periods with greater production of on-shore gas. The value of the standard absolute deviation MAPE presented 5.991% and R2 of 85.70 % concluding that the estimation was quite good.

It should be emphasized that the model estimated the monthly production over six months (October to December in 2021 and January to March in 2022) based on the times series of 129 months. Based on the set objectives of this research, forecasting was done using the fitted SARIMA model and the forecast values of on-shore gas production in Myanmar exhibited upward trend for October to December in 2021 and downward trend for January to March in 2022. Based on this, it can conclude that these models can be used for the better understanding of the on-shore gas production trend and thus, can help with the future planning in the energy sector. Furthermore, the model can be updated regularly using more up to date time series data to improve the model's performance. By generalizing the results of this study, similar models can be used to predict off-shore gas production and comparisons (on-shore and off-shore) may be drawn in Myanmar. Other forecasting methods should be examined and so that comparisons may be drawn between the predictions made.

Hence, it would be advisable in the future to develop new models incorporating representative new variables with respect to this activity, to construct an economical model and to make predictions that allow the governmental authorities in the energy area to make decisions in the production of energy.

Acknowledgements

I would like to express my deep gratitude and thanks to Professor Dr. Tun Aung, Rector, Meiktila University of Economics for their kind permission to submit this paper.

References

Box GEP, Jenkins GM, Reinsel GC. 1994. Time Series Analysis, Forecasting and Control, 2nd ed. New York, Prentice-Hall.

Box GEP, Jenkins GM. 1976. Time Series Analysis, revised edition. San Francisco.

Ediger VS, Akar S, Ugurlu B. 2006. Forecasting production of fossil fuel sources in Turkey using a comparative regression and ARIMA model. Energy Policy 2006, 34: 3836–3846.

Gutierrez R, Nafidi A, Gutierrez SR. 2005. Forecasting total natural-gas consumption in Spain by using the stochastic Gompertz innovation diffusion model. Appl. Energy 2005, 80: 115–124.

Ma H, Wu Y. 2009. Grey predictive on natural gas consumption and production in China. In Proceedings of the 2009 2nd Pacific-Asia Conference on Web Mining and Web-Based Application, Wuhan, China, 6–7, June 2009.

Madsen H. 2008.Time Series Analysis, Chapman & Hall, London.

Xie Y, Li M. 2009. Research on Prediction Model of Natural Gas Consumption Based on Grey Modeling Optimized by Genetic Algorithm. In Proceedings of the 2009 IITA International Conference on Control, Automation and Systems Engineering (CASE 2009), Zhangjiajie, China, 11–12, July 2009.

The Myanmar JOURNAL

- Volume 9 Number 2 February 2022

28 February 2022

Yangon University of Economics (Myanmar)
Korea Myanmar Research Association (Korea)
2014~, Semiannual
ISSN : 2383-6563(Online)

Co-published with **Yangon University of Economics (YUE)** and
Korea Myanmar Research Association (KOMYRA)
http://www.komyra.com/doc/submission.php