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Public Sector Policy of Estimating Model for Renewable Energy

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ABSTRACT

Renewable energies are crucially needed right now. One of the them is ethanol as a non-fossil energy source. Data time-series of world demand for ethanol are very interesting to find its forecasting models, so that the production targets can be more accurate. Generalised auto-regressive conditional heteroscedasticity is one of the best models we use. Our findings AR(1) - Generalised Auto-Regressive Conditional Heteroskedasticity (GARCH) (1,1) modelsare considered as a good-fit measurement in predicting ethanol demand. Increasing the number of demand should be considered with the number of its processes. In this paper, we combine an analysis of economic considerations (predicting demand levels) with a political analysis of policies (describing renewable energy policy options).

Keywords: Renewable Energies, Ethanol, GARCH Model, Forecasting, Energy Policy
JEL Classifications: C5, C53, H2, H25, Q4, Q47

1. INTRODUCTION

Consumption of energy has increased significantly since the 1990s which has caused environmental quality to decline at an alarming level, in turn causing climate change (Kasman and Duman, 2015). Fossil-based energy production leaves a negative impact on the environment due to the use of unfriendly technologies in exploring, expanding, and producing energy. Hill et al. (2006) studied that the consequences of fossil fuels and concerns about petroleum supplies have encouraged the search for renewable transportation fuels that are clean, environmentally beneficial, economically competitive, and suitable for mass production.

Ethanol is one of the most important volume organic chemicals utilised in industrial and individual products that can be mass produced from plants (Strohm, 2014). Taghizadeh-Alisaraei et al. (2019) explored the use of date wastes as a basis of ethanol production, of which three design updated technologies are enabled. Another organic waste applied to produce ethanol is sugarcane bagasse that reduces the necessity for oil associated with an eviromental friendly method (de Araujo Guilherme et al., 2019). Agro residues have also been utilised for bio-ethanol production as anaupicious technology (Gupta and Verma, 2015). While several renewable energy sources have been discovered through time, world population also keeps increasing, as well as industrialisation. Hence, there becomes a massive demand for the use and necessity of renewable energy (Yeboah and Shaik, 2021). Forecasting studies are therefore essential to predict the amount of energy demand in the future. Applying an econometrics model is one of the methods to have an framework for accurate decision making (Diebold and Mariano, 1995).

To do forecast we build a model that has accurate estimating parameters. Bollerslev (1986) introduced GARCH model as an analytical tool in forecasting a time-series data set with an error level approaching zero. The model is able to capture three important empirical features observed on the data: leptokurtosis, skewness, and volatility clustering. The model is relatively complicated, but flexible enough that enables estimation of parameters with a high level of accuracy.

Several studies have applied the GARCH model in relation to energy and economics. Azhar et al. (2020) studied the forecasting of estimation on volatility stock prices of Indika Energy which employed AR(4)-GARCH(1,1) as a good-fit model. A study on forecasting daily future natural gas (FNG) was conducted by Ambya et al. (2020) suggesting that FNG volatility is relatively high for some time thereafter based on application of the GARCH model. Gunarto et al. (2020) added to the literature by studying high volatility of crude oil price, showing that the urge for use of crude oil as a renewable energy source was predicted to be more costly. A current study on crude oil prices during the Covid-19 pandemic which employes the GARCH(1,1) model confirmed a high level of uncertainty for oil prices, showing that renewable energy then is urgently needed (Hendrawaty et al., 2021).

Apart from forecasting ethanol demand estimates, this study aimed to review government policy for renewable energy use in Indonesia. The demand on ethanol is authorised by the government as main policy maker, and units who are particular on enviromental care are relatively demanding the renewable energy by a great number, and vice versa (Das, 2020). Therefore, study in forecasting ethanol demand will help them to formulate the right decision.

2. STATISTICAL METHODOLOGY

Some models were employed to investigate the forecast in depth from the ethanol demand data. The first assumption is if *ET1, ET2, ET3,…., ETn* is time-series data from ethanol demand data, and *ETt* is part of AR (p), where the mean of the model is µ (Tsay, 2010). Then the formula for these assumptions can be seen as follows:

$$ET_t = \mu + \gamma_1 ET_{t-1} + \sum_{k=1}^{p-1} \gamma_k \Delta ET_{t-1} + \varepsilon_t \quad (1)$$

Furthermore, the combination of the autoregressive (AR) and moving average (MA) schemes is a model that can be implemented into the time-series data with customisable p and q sequences. The general formulas of AR (p) and MA (q) are shown as follows.

$$ET_t = \mu + \gamma_1 ET_{t-1} + \gamma_2 ET_{t-2} + \gamma_3 ET_{t-3} + \ldots + \gamma_p ET_{t-p} + \varepsilon_t \quad (2)$$

$$ET_t = \mu + \varepsilon_t - \lambda_1 \varepsilon_{t-1} + \lambda_2 \varepsilon_{t-2} + \lambda_3 \varepsilon_{t-3} + \ldots + \lambda_q \varepsilon_{t-q}; \varepsilon_t \sim N(0, \sigma^2) \quad (3)$$

$$\begin{aligned} ET_t &= \mu + \gamma_1 ET_{t-1} + \gamma_2 ET_{t-2} + \gamma_3 ET_{t-3} + \ldots + \gamma_p ET_{t-p} \\ &\quad + \varepsilon_t - \lambda_1 \varepsilon_{t-1} - \lambda_2 \varepsilon_{t-2} + \ldots + \lambda_q \varepsilon_{t-q} \\ &= \mu + \sum_{i=1}^{p} {}^{3}{}_{i} ET_{t-i} + \varepsilon_t - \sum_{k=1}^{q} \lambda_k \varepsilon_{t-i} \end{aligned} \quad (4)$$

Yet, there might be an issue on constructing ARMA model, as most financial time-series data having high order of heteroscedasticity. To avoid that, GARCH was introduced by Bollerslev (1986). Relationships on residuals are observable, and depending on previous residuals, GARCH equation can be constructed as follows.

$$\sigma_t^2 = \varpi + \sum_{i=1}^{q} \varrho_i \varepsilon_{t-i}^2 + \sum_{k=1}^{p} \varsigma_j \varepsilon_{t-j}^2 .. \quad (5)$$

The GARCH model exists in AR and MA, where the q lag of the squared residual and the p lag of the conditional variant is equalised to the GARCH (p, q) shown in the following equation.

$$ET_t = \beta + \sum_{i=1}^{p} \phi_i ET_{t-i} + \varepsilon_t - \sum_{k=1}^{q} \lambda_k \varepsilon_{t-i}$$

$$\varepsilon_t \sim N(0, var(ET)^2)$$

$$\sigma_t^2 = \varpi + \sum_{i=1}^{q} \varrho_i \varepsilon_{t-i}^2 + \sum_{k=1}^{p} \varsigma_j \varepsilon_{t-j}^2 . \quad (6)$$

3. RESULT AND DISCUSION

The data set is weekly ethanol demand from 2014 to 2019, obtained from the Energy Information Administration 2020. Figure 1 shows the demand on ethanol worldwide which consists of 313 data points. It can be seen that the data set was gradually increasing and relatively stable at 885,000 barrels per week.

For constructing a good model, the data set should be first satisfied stationary criterion. To do so, Augmented Dickey-Fuller (ADF) unit-root test is applied to assess stationary data set. Table 1 presents that probability value in lag 3 is above significant level of 5%, indicating that the data set is not stationary in means and variances. Trend correlation test shown in Figure 2 also indicates that the data set is not stationary, since the ADF graph has a slow movement toward zero mean.

In this stage, we conducted differencing method to transform non-stationary data set into stationary, in order to have a smooth movement of volatility. Table 1 demonstrates the ADF test after conducting differencing 1 (d=1), showing that probability value has a significant result. This indicates that data set is already stationary in means and variances. This statistic measurement is supported with Figure 3, in which ACF graph has a quick fall after lag 0 as well as the plotting data set are at around zero (Table 2).

Furthermore, once stationary data set has been reached, next step is to check whether it involved heteroscedasticity issue or not. Portmanteau (Q) and Lagrange Multiplier (LM) test were applied for measuring such that issue. Table 3 shows that probability value for Q and LM test are <0.0001. This means there is an auto-regressive conditional heteroscedasticity (ARCH) effect on

Figure 1: Data plotting for ethanol demand

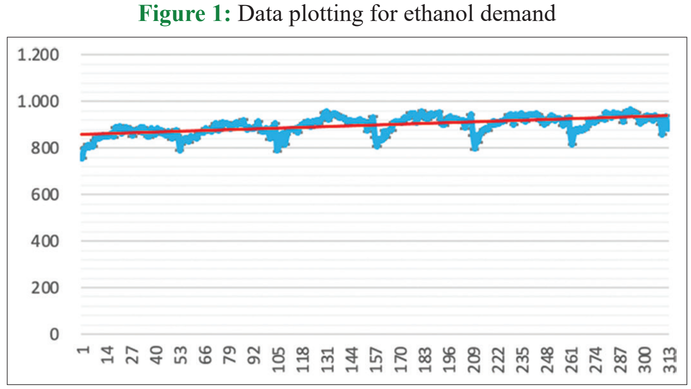


Figure 2: Correlation analysis for ethanol demand

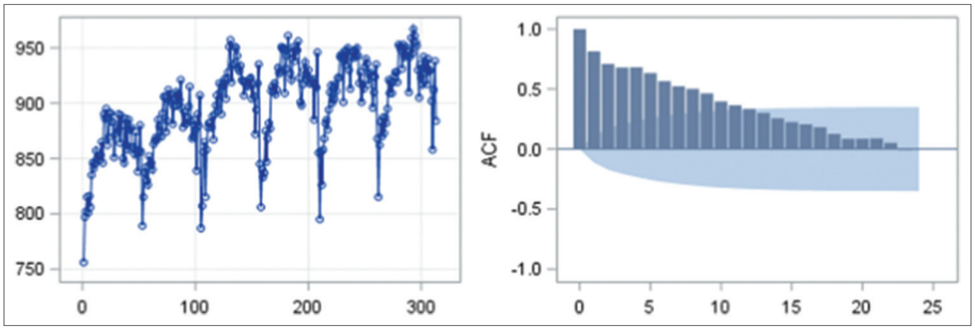


Figure 3: Correlation analysis for the data of ethanol demand after differencing 1 (D=1)

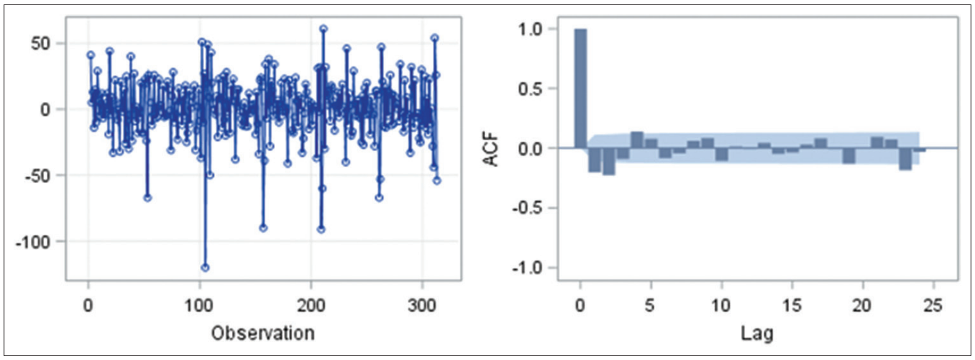


Table 1: Augmented dickey-fuller (ADF) unit-root tests

Type	Lags	Rho	Pr<Rho	Tau	Pr<Tau	F	Pr>F
Zero Mean	3	0.0766	0.7002	0.3696	0.7906		
Single Mean	3	−19.3293	0.0127	−3.4078	0.0117	5.9360	0.0131
Trend	3	−29.5826	0.0079	−3.7314	0.0218	7.4108	0.0206

Table 2: ADF unit-root test after differencing 1 (D=1)

Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	F	Pr > F
Zero mean	3	−5832.69	0.0001	−12.01	<0.0001		
Single mean	3	−6215.14	0.0001	−12.00	<0.0001	72.04	0.0010
Trend	3	−7925.74	0.0001	−12.04	<0.0001	72.45	0.0010

squared residuals of data set. Therefore, it allows us to construct model of GARCH, to solve such an issue.

Model of AR(p)-GARCH (p,q) can then be applied to have a good-fit measurement. While the former model is conditional to have mean model, the latter is to have a variance and squared residual model.

From Table 4, the parameter estimates are used to build the models. As all variables have significant probability value, it can be said that the models would be a good-fit measurement to make forecasting. AR (1) model show the mean model and GARCH (1, 1) indicates variance and squared residual model, which mathematically can be presented as follows.

- Mean Model AR(1):

$$ET_t = 779.6265 - 0.9855 ET_{t-1} \quad (7)$$

- And the variance model, GARCH(1,1):

$$\sigma_t^2 = 125.7892 + 0.3379\varepsilon_{t-1}^2 + 0.4416\sigma_{t-1}^2. \quad (8)$$

Table 3: ARCH-LM test data of weekly ethanol demand

Order	Q	Pr>Q	LM	Pr>LM
1	65.6800	<0.0001	56.9964	<0.0001
2	91.2462	<0.0001	59.1980	<0.0001
3	103.3476	<0.0001	59.5686	<0.0001
4	113.7264	<0.0001	60.9179	<0.0001
5	117.0109	<0.0001	61.2272	<0.0001
6	117.1060	<0.0001	64.4687	<0.0001
7	118.3737	<0.0001	65.3465	<0.0001
8	121.8145	<0.0001	66.6461	<0.0001
9	127.0474	<0.0001	67.5990	<0.0001
10	132.7587	<0.0001	67.8568	<0.0001
11	139.7560	<0.0001	68.4869	<0.0001
12	146.2583	<0.0001	68.8534	<0.0001

Furthermore, to ensure us that models could do forecasting more accurately; the data descriptions from the models are shown in Table 5. The model has 0.67 of R-square, indicating that variables can explain models by 67%. The value of Mean squared error (MSE) is also relatively small, that can be used to measure Root Mean Squared Error (RMSE). RMSE is calculated of 22.3 which

Table 4: Parameter estimates

Variable	DF	Estimate	Standard Error	t value	Approx Pr >t|
Intercept	1	779.6265	17.8913	43.58	<0.0001
AR1	1	−0.9855	0.008207	−120.08	<0.0001
ARCH0	1	125.7892	44.9683	2.80	0.0052
ARCH1	1	0.3379	0.0990	3.41	0.0006
GARCH1	1	0.4416	0.1427	3.10	0.0020

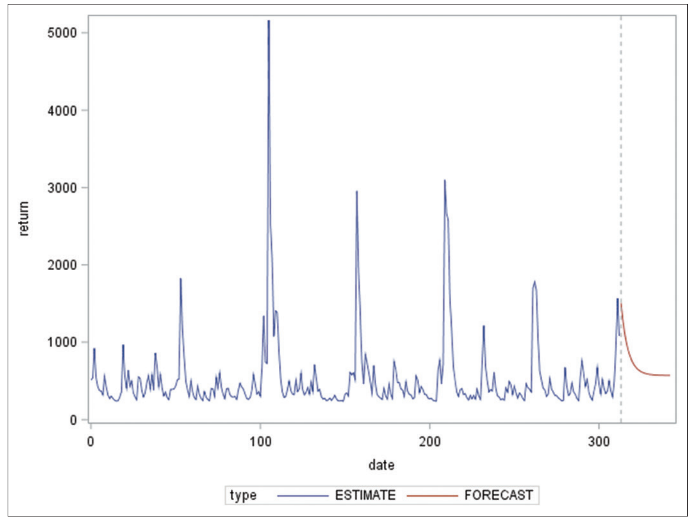
Table 5: GARCH estimates

SSE	155683.088	Observations	313
MSE	497.39006	Uncond Var	570.555581
Log Likelihood	–1393.715	Total R-Square	0.6739
SBC	2816.16095	AIC	2797.42993
MAE	16.1924425	AICC	2797.62537
MAPE	1.83061192	HQC	2804.91532
		Normality test	61.2109
		Pr > Chi. Sq.	<0.0001

is a significantly small. Therefore, we conclude that the models have a good ability to do forecasting data set.

From the models, we compute forecasting data set of ethanol demand for some days ahead. Figure 4 displays that a red-line forecasting data is on a downtrend. Therefore, the role of government as the authorities of renewable energy policy should be firm in order to make environmentally-friendly energy use.

Figure 4: Forecasting graph of AR (1) GARCH (1, 1) models for weekly ethanol demand data



4. DISCUSSION

In the last decade, research and discussion have been widely conducted on the topic of what and how fossil energy can be reduced, given the various post-use problems from this. One of the motives for this movement is to mitigate extreme changes in temperature and climate of the Earth. Currently, good technology is readily available for new and renewable energy, but the amount of consumption is still limited. On the other hand, it is still difficult for consumers to leave fossil energy, and there are still a few people who have not switched to being green energy users. This is evidenced by the studies that we have conducted and from our forecasting model estimates that the demand for ethanol data will decline for some time to come. Our study supports the findings from Arango-Aramburo et al. (2020) in which installation of hydropower facilities was decreased in some countries in South America from 2007 to 2017, indicating decreased demand for renewable energy share.

This study uses an economic approach, specifically forecasting, in order to provide recommendations for the design of government policies, especially in the renewable energy sector. An earlier study by McDowall and Eames (2006) used scenarios, roadmaps, and foresight methods to address uncertainty in areas such as energy policy with long planning timescales. The contribution of the study under this scheme can play an important role in developing a vision for the future, for example creating expectations of the potential for renewable energy. The expectation of this potential will be useful as an initial resource needed to make realisation in the future. In other hand, survey conducted by the International Energy Agency in 2020 describes renewable energy data only around 10% and requires accelerated consumption of about 30% of the energy currently consumed, and the energy sector is still dominated by fossil fuel. Therefore, efforts to change habits and behaviour in responding to renewable energy requires a policy stimulus and political direction from the government that is in favour of the development of renewable energy, especially ethanol.

The policy instruments used by the government and the political process should lead to how the regulatory framework has legal force and is supported by all elements of government, so that renewable energy policies that are sourced from good energy can be implemented and developed in a sustainable manner and not continue to be hampered because of the interests of carbon energy, namely nuclear and coal (Jacobsson and Lauber, 2006). However, renewable energies like ethanol and others need sustainable space to remain available and replace old energy. Special efforts are needed for renewable energy resources because of the potential problems that may be encountered, for example the problem of ranges of hazardous pollutants, acid rainfall, ozone depletion in the stratosphere, and global climate change (Dincer and Rosen, 2005). Wolsink (2007) argues that policy-making decisions can achieve success to increase the implementation of renewable energy if each country can take steps by creating an energy policy, optimising the potential resources available in the country so that fair implementation can be supported by all parties.

5. CONCLUSION

Energy fossils have been massively used in various ways around the world. However, their use is environmentally hazardous, that in the long run can extremely change the climate. Authorities have made some policies to reduce fossil energies and changed them with green energies like ethanol. Yet, individual and industrial consumers are still low, making the implementation of such policies less effective. Our study observed this phenomenon and hence was to construct the forecasting model for data of ethanol demand.

The models constructed to have good-fit forecasting parameters are AR (1)-GARCH (1, 1). The forecasting shows that the demand for ethanol will be declining in some days ahead. In this stage, proper policies from the government as policy makers should be implemented to develop renewable energies, like ethanol. Additionally, opportunity to have policies for utilisation of local renewable energy sources to provide beneficial interest for all parties involved in energy policies.

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