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Grey Forecasting of the Exports of Indonesian Palm Oil to India

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Abstract: Palm oil is one of the leading export commodities of Indonesia. Knowing demand in advance can help policy-makers better prepare for the situation. India is one of the major importers of Indonesian palm oil. The study forecasted the Indonesian palm oil's exports to India from till 2025 using the grey forecasting model EGM (1,1, α, θ). The comparative analyses with Linear regression and exponential regression showed that the grey forecasting technique is relatively more accurate to forecast palm oil exports despite huge uncertainty in the data trend. The secondary data on Indonesian palm oil exports to India from 2011-2018 was obtained from the Indonesian Central Statistics Agency (BPS). Mean absolute percentage error was used for error measurement. Despite uncertainty in data, the results show an increasing trend in palm oil exports.

Keywords: Grey forecasting; palm oil; exports; Indonesia; India

1. Introduction

Indonesia is a country that has a wealth of natural resources that are widespread across its different regions. Also, it is an archipelagic country well-known for its agricultural products and green landscapes. It is primarily an agricultural country where most people earn their livelihood by working on farms. Besides, Indonesia is also famous for its fertile soil for planting and vegetation (Sjamsir, 2017). Also, its richness in natural resources, both on land and waters, makes Indonesia an ideal place to develop the agriculture sector. It is the largest tropical agricultural country in the world after Brazil. Of the 27% of the tropical zones in the world, Indonesia has 11% of the tropical area. These characteristics are a significant source of strength for the country's agriculture sector (Kandhani, 2020).

Agriculture is a prominent sector in the Indonesian economy. This means that agriculture is the prominent sector that develops almost half of the country's economy. Agriculture also has a fundamental role as a source of foreign exchange through exports (Sjamsir, 2017). Agriculture is the life and blood of nations and the long-term sustainability of any economy is impossible without sustainable development of its agriculture sector. The existence of farmers is essential for an agricultural country to participate in contributing to improving public welfare. In improving the economy and general welfare, the agriculture sector also has an essential role in fulfilling domestic food needs. Indonesia is known for its plantation products, such as rubber, palm oil, tobacco, cotton, coffee, rice and sugarcane (Gischa & Naifular, 2019).

Based on the statements in the previous paragraph, Indonesian Agriculture consists not only of the agriculture subsector and the food subsector but also have the plantation subsector, the livestock subsector and the fisheries subsector. The plantation subsector is an agricultural subsector that has traditionally been one of the country's exchange-earners (BPS, 2019). Plantation products that have become export commodities include rubber, palm oil, tea, coffee, cocoa, sugarcane and tobacco. Most of the plantation crops are smallholder plantations, while large farms cultivate the rest, both government and private (Soetrisno, 2002). Of the seven commodities, palm oil is in the top rank and is a mainstay of Indonesia (Supriyatna, 2017).

Palm oil is essential for the largest producer and consumer of palm oil in the world. Indonesia supplier approximately half of the world's palm oil supply (McClanahan, 2013). The area of palm oil plantations in Indonesia 6 million hectares (twice the size of Belgium). In 2015, Indonesia planned to build 4 million hectares of a farm to produce biofuel sourced from palm oil. In 2012, Indonesia produced 35% of the world's CSPO certified sustainable palm oil (Sarif, 2011).

The growth of palm oil, rubber, and cocoa is experiencing a rapid rate among other plantation crops, which is above 5%/year. Palm oil is one of the leading commodities in Indonesia. But it turns out that Indonesian palm oil is not only a commodity in Indonesia but also in the world because Indonesia is the largest producer of palm oil in the world (GreenPalm, 2015). However, Indonesia is not only the largest palm oil-producing country but also Malaysia, Thailand, Columbia and Nigeria (GreenPalm, 2015). Figure 1 (data from OurWorldInData.org) shows the five largest palm oil-producing countries. Based on data, Indonesia is in the top 5 palm oil-producing countries. The first place with the highest production results in 2018 reaching 40.57 million tones, Malaysia in the second place with the most increased production result in 2014 reaching 19.67 million tonnes, Thailand in the third place with the most increased production result in 2018 getting 2.78 million tonnes, Colombia in the fourth place with the highest show result in 2017 and 2018 reaching 1.63 million tonnes and Nigeria in the fifth place with the highest production result in 2018 reaching 1.05 million tonnes. Indonesia was the top exporter of palm oil in 2019 with the record output of 36.18 million tons, showing palm oil and its products are an important contributor to Indonesian economy (Reuters, 2020).

Based on data from The World Factbook, Indonesia is one of the 50 countries with the highest number of exports. For Indonesia, exports of goods and services are one of the primary sources of foreign exchange to fill the State Foreign Exchange Reserves (Sasono, 2012). Export activities have a positive relationship with a country's economic growth (Sutedi, 2014). The more export activities in that country that can make more economic growth will increase. The potential of palm oil exports in the past ten years has become a separate force for Indonesian economic growth. The government has also declared the palm oil industry as one of the strategic sectors in Indonesia's development (Purba, 2018).

The Central Bureau of Statistics (BPS) data suggests that the largest export destination countries for Indonesian palm oil are India, the Netherlands, China, Pakistan, and the US. The first highest palm oil export was in 2017, amounting to 7325100, the second in 2018 amounting to 6346200, and the third in 2013 amounting to 5752400 and all export destinations to India. The current study chose India for it is the largest export destination of Indonesian palm oil, as shown in Figure 2 (data from www.bps.go.id) and decided to forecast Indonesian palm oil exports to India using a grey forecasting model. For comparative analyses, two statistical models will be used.

The rest of the study is organized as follows: the second section presents the Indonesian palm oil industry background. The third section discussed the research methodology, presenting data collection, forecasting techniques, and forecast error measurement techniques. In the fourth section, results are presented. In the last section, the study is concluded.

2. Background

One of the most consumed and produced oils in the world is palm oil. Palm oil is obtained from the *mesocarp* of the oil palm tree. It is vegetable oil, generally from the *elaeis guineensis* species and a

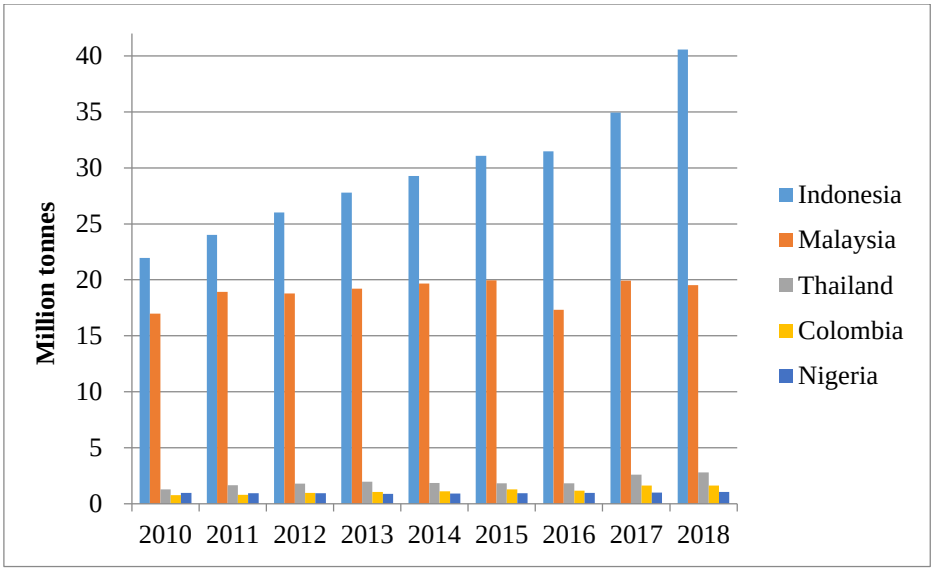

Figure 1. Major palm oil producing countries

little from *elaeis oleifera* and *attalea maripa* species. Naturally, palm oil has red colour due to its high alpha and beta-carotenoid content. Although it comes from the same fruit kernel, palm oil is different from palm kernel oil. Palm oil is also different from coconut oil which is produced from the kernel of the coconut fruit (Cocos nucifera) (McGee, 2004).

A common cooking ingredient in tropical countries in Africa, Southeast Asia and parts of Brazil is palm oil. Asia, Africa and South America have warm temperatures and high sunshine and rainfall, because of this, palm oil can grow well in these countries because palm oil needs it to maximize production. Its use in the commercial food industry in other parts of the country is driven by its low production cost (USDA, 2006) and its oxidative stability when used for frying. Almost all food products in supermarkets use palm oil. Palm oil has the advantage as a raw material for food products. Its advantages include (GAPKI, 2017): (a) relatively low price, (b) contains natural antioxidants that act as natural preservatives, (c) makes food textured smooth and creamy, (d) free of trans fats, (e) tasteless and odourless, and (f) enhances the taste of food. Besides being cheap, palm oil is easy to extract and is used for a wide variety of cosmetics, food, hygiene products, and can also be used as a source of biofuel or biodiesel (Indonesia Investments, 2017).

Although the Indonesian Palm Oil industry and plantations are more than century-old, they are still overgrowing. In 2006, Indonesia overtook Malaysia as the king of world palm oil and Indonesia also defeated the United States as the king of world vegetable oil. "Indonesian palm oil is the main actor in the tropical vegetable oil revolution that can shake the world vegetable oil market," says, *The Tropical Oil Crop Revolution* published by Standford University. Land for palm oil production in Indonesia reached 16.38 million hectares, proving that Indonesia is the largest producer and producer of palm oil in the world. Indonesia is also the first country in the world to successfully implement B30 and continue to develop its innovations until it reaches B100 (100% palm-based biofuels) (RedaksiWE, 2020).

Indonesia's Palm Oil production continues to increase every year. In 2015, Indonesia's Palm Oil production reached 31.07 million tons and increased to 51.8 million tons in 2019. The majority of palm oil production in Indonesia is allocated for export and generates a foreign exchange of more than US$20 billion per year (RedaksiWE, 2020)

There are 1,731 oil palm plantation companies consisting of 162 PBNs (Large State Companies), and 1,569 PBS (Large State Companies) spread across 25 provinces in Indonesia. Based on the percentage of distribution, around 57% of the total plantation companies are located in Sumatra, and 38% are on the island of Borneo. North Sumatra province has the largest number of oil palm plantation companies in Indonesia, namely 329 companies (RedaksiWE, 2020).

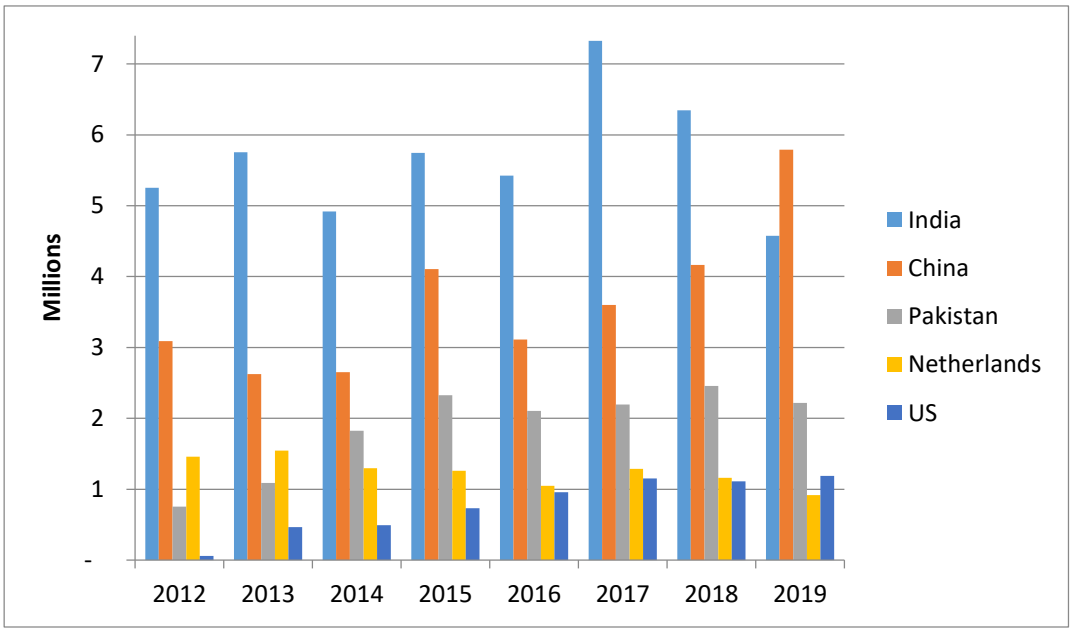

Figure 2. The five biggest export destinations for Indonesian palm oil

Because forest destruction for palm oil plantations is threatening the habitat of Orangutans in Indonesia, which is an endangered species. In 2004, the Roundtable on Sustainable Palm Oil (RSPO) was formed to deal with palm oil plantations in its territory by imposing minimum limits on state land as forest (Scott-Thomas, 2012).

In recent years, Indonesia has experienced a weakening trade balance due to the relatively low growth in exports compared to imports. At the same time, the export of goods and services plays an essential role in driving economic growth, reducing unemployment and poverty. To maintain export growth, it is essential to increase the quality or value-added of products and expand the export market. Indonesia's 5 leading non-oil and gas export commodities are commodity palm oil, fisheries, textile and textile products, wood and wood processing, and paper and paper goods. In 2018, the cumulative total non-oil and gas exports reached the US $ 162.65 billion, an increase of 6..25% from 2017 and continued to increase in 2019. In 2019, the non-oil and gas trade balance contributed to a surplus of US $ 2.8 billion (Boestami, 2020).

Since a long time ago, palm oil is one of Indonesia's natural products that has entered the world market. The two largest export destinations for Indonesian Palm Oil are India and the European Union. The two countries have so far contributed around 40% of the total Palm Oil Export (Boestami, 2020).

The Indian market is very welcoming to palm oil products from Indonesia. Because although there are several policies to increase import duties and imports of Indonesian palm products, these policies have been reviewed. India's condition, which requires products with very competitive characteristics in terms of price, has made palm oil products more likely to have a bigger market than other vegetable oil products (Boestami, 2020).

3. Research Methodology

3.1 Data Collection

Availability of reliable data is a prerequisite for running a forecasting model. For the current study, secondary data concerning Indonesian palm oil export to India for 8 years, from 2011 – 2018 in net weight (tonnes) was obtained from the Central Bureau of Statistics (BPS) Indonesia. Data from 2011 – 2016 was used for forecasting and data from 2017 – 2018 was used for out-of-sample testing.

3.2 Forecasting techniques

Forecasting cannot be separated from the business world. Forecasting is needed to determine the number of products to be produced in an organization or economy. Without forecasting, there can difficulty in determining how many raw materials are needed and which must be made annually. If the amount of production is too much, the company will experience a loss if the demand is small, while if the amount of output is too little and it turns out that market demand is very high, the company will lose a large profit. In full, forecasting is an essential input in the process of making operations management decisions in providing information about future demand to determine how much capacity or supply is needed to make staffing decisions, budgets that must be prepared, ordering goods from suppliers and partners in the chain. Supply and demand information is required in making realistic plans and forecasting play important role in it (Stevenson, 2009).

In recent years, Indonesian palm oil exports to several countries have experienced an increase and a decrease, one of which is to India. But the rise and fall are still in a stable state. This paper aims to look at the forecasting of Indonesian palm oil exports to India in the next 7 years, namely from 2019-2025 using secondary data on Indonesian Palm Oil Exports to India for 8 years, from 2011-2018 obtained from the Central Statistics Agency (BPS) Indonesia. The goal is to see whether Indonesia's palm oil exports to India will continue to be stable or not for the next few years, especially with the COVID-19 pandemic this year.

3.2.1 Even grey forecasting model EGM (1,1, α, θ). Grey System Theory was first developed by Deng (1982). After more than four decades of development, it has shaped a somewhat broad theoretical system and solved numerous practical problems in a lot fields (Du *et al.*, 2021). Grey Forecasting Model or commonly called GM (1,1) is a forecasting model for limited data. The model uses a first-order differential equation with one variable. There is ample of evidence that suggests even with limited data or data containing uncertainty, GM (1,1) can provide an effective method for short-term forecasting (Xie *et al.*, 2021; Ikram *et al.*, 2019; Widyaningsih & Utami, 2015). Forecasting with GM (1,1) can be used for sequence forecasting, interval prediction, natural disaster forecasting, season forecasting and capital market forecasting. However, there should be at least four data values for forecasting (Javed *et al.*, 2020a).

Even Grey Model (1,1) (EGM) was proposed by Javed *et al.* (2020a) as a special case of the proposed model EGM(1,1,α,θ). The EGM with first-order differential equation containing one variable EGM (1,1) and Discrete Form of Grey Model with first-order differential equation containing one variable DGM (1,1) are two of the four basic models of grey forecasting theory. EGM is suitable for making predictions through non-exponential increasing data sequence and DGM is suitable for making predictions through a homogenous exponential data sequence (Liu *et al.*, 2017). below are some of the equations that can be used from EGM(1,1,α,θ) (Javed *et al.*, 2020a):

$$x^{(\alpha)} = \left(x^{(\alpha)}(1), x^{(\alpha)}(2), \dots\ x^{(\alpha)}(n)\right)$$

where, $x^{(\alpha)}(k) = \sum_{i=1}^{k}(\frac{x^{(0)}(i)}{i^{1-\alpha}})$, k = 1, 2, …, n. In the classical even grey model, α = 1, however, in EGM(1,1,α,θ), α ∈ (0,1].

The adjacent neighbor average sequence of $x^{(1)}$ will be

$$Z^{(1)} = \left(Z^{(1)}(1), Z^{(1)}(2), \dots\ Z^{(1)}(n)\right)$$

where the background value $Z^{(1)}(k) = \theta.x^{(\alpha)}(k) + (1 - \theta).x^{(\alpha)}(k-1)$. In the classical even grey model, the background coefficient α = 0.5, however, in EGM(1,1,α,θ), θ ∈ (0,1].

The even form of GM(1,1), a first-order, single-variable grey forecasting model with parameters α and θ, is a continuous-time grey differential equation, defined as

$$\frac{dx^{(1)}(k)}{dk} + ax^{(1)}(k) = b, k \geq 1$$

The inverse conformable fractional accumulation, which is needed to extract simulation of the actual data sequence $\hat{x}^{(0)}(k)$ from the simulation of the accumulated data sequence $\hat{x}^{(\alpha)}(k)$, is executed through the following approximate regressive reduction formula

$$\hat{x}^{(0)}(k) = k^{1-\alpha}\left(\hat{x}^{(\alpha)}(k) - \hat{x}^{(\alpha)}(k-1)\right), k = 1,2,\dots,n$$

And the time-response function of $x^{(0)}$, which is an exponential function of time, is given by

$$\hat{x}^{(0)}(k) = k^{1-\alpha}(1-e^{a})\left(x^{(0)}(1) - \frac{b}{a}\right)e^{-a(k-1)}, k = 1,2,\dots,n$$

The model's complete algorithm and properties are available in Javed *et al.* (2020a). Later, Linear Regression and Exponential Regression models will be used for the comparative evaluation of Even Grey Model EGM (1,1, α, θ).

3.2.2 Linear regression. Linear regression is a statistical tool used to determine the effect of one or more variables on one other variable. Variables that influence are referred to as independent variables, independent variables, or explanatory variables. The general form of Linear Regression model is

$$Y = \alpha + \beta X$$

where, α and β are two parameters, and *Y* and *X* represent dependent and independent variables, respectively. To calculate linear regression in Microsoft Excel, in the current study, the formula below, *Y* =-87.371**periods*+5849.5, was used.

3.2.3 Exponential regression. Exponential regression is the process of getting the exponential function equation that best fits a set of data. This general form of Exponential Regression model is

$$Y = ae^{bX}, a \neq 0$$

where, *a* and *b* are two parameters, and *Y* and *X* represent dependent and independent variables, respectively. To calculate exponential regression in Microsoft Excel, the formula, Y=5828.7*EXP(-0.015**periods*), was used.

3.3 Forecast error measurement technique

For forecast error measurement, Mean Absolute Percentage Error (MAPE) was used as (Javed & Cudjoe, 2021; Javed et al., 2020b),

$$MAPE(\%) = \frac{1}{n} \times \sum_{k=1}^{n} \left| \frac{x(k) - \hat{x}(k)}{x(k)} \right| \times 100$$

where, $x(k)$ and $\hat{x}(k)$ are actual and forecasted data, respectively.

4. Results and discussion

This section will explain the results of Forecasting the Export of Indonesian Palm Oil to India from 2019-2025 using the Grey Forecasting Method and the Formula of Linear Regression Formula, Exponential Regression, Even Grey Model. Following Javed and Liu (2018), analyses of Relative Growth Rate and Doubling Time was also performed.

In Table 1 one can see the forecasting result on Indonesian palm oil exports to India using Linear Regression, Exponential Regression, and the grey forecasting model EGM (1,1, α, θ). According to the results of MAPE, one can conclude that: the in-sample error of the Linear Regression is 6.14%, Exponential Regression is 6.15%, and the even grey forecasting model is 4.84%, and the out-of-sample error of the Linear Regression is 23.67%, Exponential Regression

Table 1. Forecasting of exports of Indonesia palm oil to India (Tonne)

Years	Net Weight	LR	ER	EGM (1,1,α,θ)	Cumulative	RGR	$\overline{RGR}$	D_t	$\overline{D_t}$
2011	6165	5762	5742	6165	6165		0.34		1.88
2012	5254	5675	5656	5325	11419	0.62		1.18	
2013	5752.4	5587	5572	5362	17171	0.41		1.59	
2014	4920.4	5500	5489	5400	22092	0.25		2.07	
2015	5746	5413	5408	5438	27838	0.23		2.16	
2016	5424.6	5325	5327	5476	33262	0.18		2.42	
2017	7325.1	5238	5248	5514	5514	-	0.28		2.14
2018	6346.2	5151	5170	5553	11067	0.7		1.05	
2019		5063	5093	5592	16658	0.41		1.59	
2020		4976	5017	5631	22289	0.29		1.93	
2021		4888	4942	5670	27959	0.23		2.18	
2022		4801	4869	5710	33669	0.19		2.38	
2023		4714	4796	5750	39418	0.16		2.54	
2024		4626	4725	5790	45208	0.14		2.68	
2025		4539	4654	5954	51162	0.12		2.78	
MAPE% (In-sample)		6.14	6.15	4.03					
MAPE% (Out-of-sample)		23.67	23.45	18.61					

**In the cumulative column, the actual data is used for the years 2011–2018, and for the years 2019–2025, the simulation data are used.*
***LR and ER denotes Linear Regression and Exponential Regression.*
****$\overline{RGR}$ and $\overline{D_t}$ denotes Mean RGR and Mean D_t respectively.*

is 23.45%, and the even grey forecasting model is 18.61%. The parameter a = -0.006974422 and b = 5263.556472 for EGM (1,1, α, θ).

From the result, one can see that the performance of the three models is different. Only the results of all the MAPE-in samples averaged below 10%. But we can conclude that the results of the MAPE-in sample and MAPE-out sample Even Grey Model are the smallest than others, in sample is 4.84% and out sample is 18.81%. So the Even Grey Model is more accurate than others. And the result of forecasting of export Indonesia palm oil to India from 2019-2025 using Even Grey Model are continuing to increase. The accuracy of the models is evaluated in Figure 3. Unlike, Linear and Exponential Regression models, the Even Grey Model is revealing increasing exports, while the other two models are revealing decreasing trend. Despite uncertainty in data, the results of the Even Grey Model are more realistic.

5. Conclusion

Both organizations and economies need to know the demand for their products. Demand forecasting is important to develop aggregate plans so maximum demand can be met. The current study is intended to determine the accuracy of the EGM (1,1, α, θ) method for forecasting the export of Indonesia palm oil to India 2019-2025 by comparing the EGM (1,1, α, θ) method with two other forecasting methods: Linear Regression and Exponential Regression. Not all types of forecasting methods can be used for all data because many factors must be considered in choosing a forecasting method, such as the data pattern that is owned and the amount of data. The grey forecasting method is one of the forecasting methods used to determine short-term decisions and the grey forecasting model has a smaller error value. The grey forecasting model can be used in uncertainty, for example, for remote data and incomplete data information. And this study shows that The grey forecasting model can be used on fewer data and the results are more precise than

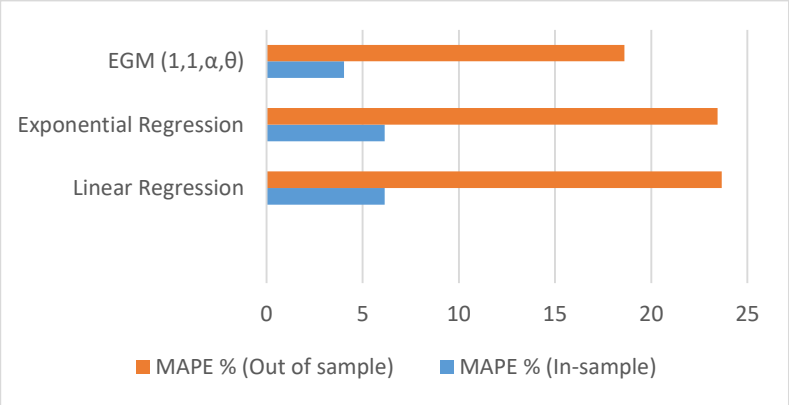

Figure 3. Forecast error evaluation

some of the statistical methods. The results showed increasing trend in Indonesian palm oil exports to India thus policy-makers should develop policies to sustain this trend, especially to minimize the effect of pandemic-induced disruptions. In future more accurate forecasting model should be developed to forecast palm oil exports that can incorporate the zigzag trend in data more effectively.

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