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Renewable Power for Sustainable Growth

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About this book

The proceedings is a collection of papers presented at International Conference on Renewal Power (ICRP 2023), held during 28 – 29 March 2023 in Mewat Engineering College, Nuh, India. The book covers different topics of renewal energy sources in modern power systems. The volume focusses on smart grid technologies and applications, renewable power systems including solar PV, solar thermal, wind, power generation, transmission and distribution, transportation electrification and automotive technologies, power electronics and applications in renewable power system, energy management and control system, energy storage in modern power system, active distribution network, artificial intelligence in renewable power systems, and cyber physical systems and internet of things in smart grid and renewable power.

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- Hasmat Malik,
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- Presents research works in the field of renewable power sources
- Results of ICRP 2023 held in Nuh, India during 28 – 29 March 2023
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Using Linear Regression Model to Predict the Wholesale of the Electric Car in Indonesia: What Can Be Learned from the Model?

Rosyid R. Al-Hakim, Nur F. Soelaiman, Sri Riani, and Yanuar Z. Arief

Abstract We analyze wholesale datasets from Indonesian Automobile Industry Data for electric cars in Indonesia using statistical analysis to predict the electric cars used in the future. We apply a linear regression approach that adjusts the regression model according to wholesale electric cars between 2020 and 2022, as well as a statistical correlation test and the Wilcoxon test to support the regression result. We find a strong positive relationship for electric cars bought in the future, with a not significantly different population median of the total number of wholesale electric cars. It might be 210 cars estimated per year. Among the regression model, it is more effective for policymakers, as well as car industries. We estimate that there are various reasons and conditions for Indonesian people regarding buying electric cars inside conventional ones.

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Keywords Electric vehicles · Hybrid vehicles · Energy policy · Electric car consumption · Car industry

1 Introduction

Indonesian regulations related to new and renewable energy [1] would optimize the green or renewable energy used in all sectors. One of the challenges regarding its policy includes EV [2]. Besides, since 2020 Indonesia has launched electric vehicles (EVs) in the transportation industry. Migrating to EV from a conventional vehicle (CV) based on oil-fueled or gasoline-powered fuel must be concerned in the context of green energy, as well as zero-emission missions [3, 4].

The car dealership plays the leading role in supplying the EV in the vehicle market [5]. The most common EV types are fully fueled by electricity, including battery electric vehicles (BEVs). It is reported that the overall selling market of this EV must be the attention of policymakers [6, 7]. Most people would choose an alternative fuel vehicle, BEV, caused of its crucial element of sustainable development, as well as electromobility factors [8]. Car industries would encourage buyers to adopt electromobility to improve EV uptakes [9, 10]. Besides, various choice reasons influenced EV buyers [11–13]. EV ownership is adopted mainly for lower costs than other fuel vehicles [14].

We tried to analyze within providing the statistical model for predicting the total number of EV wholesale in Indonesia. Besides, Indonesia is a developing country, and the emergence of EVs in the vehicle market has given rise to fluctuating purchases. The first year intensified the massive use and legalization of EVs in Indonesia since 2020. This study was conducted to statistically model the possible number of EV wholesale in the future.

2 Research Method

2.1 Data Collection

We collected the primary wholesales electric car (car electric vehicle, CEV) dataset from Indonesian Automobile Industry Data (https://files.gaikindo.or.id/) between 2020 and 2022, as well as reported electric cars began to be marketed in Indonesia in 2020. The data was collected for all car providers that sell fully electrical-based fuel, including battery electric vehicle (BEV) and Fuel-Cell Vehicle (FCEV), as well as not included Hybrid Electric Vehicle (HEV) and Plug-in Hybrid Electric Vehicle (PHEV) that is already used oil-based fuel. We are concerned with oil free and fully electrical-based fuel for this study, according to support zero emissions and fossil-free use, especially in the vehicle industries [15].

2.2 Data Analysis

The collected dataset was analyzed using linear regression to predict future electric vehicles (EVs), especially car electric vehicles (CEVs). The regression equation was obtained by regression analysis for the proposed mathematical prediction modeling. To support the regression result, we also used statistical correlation Kendall-Tau for analyzing the correlation between month wholesale quantity and the year of product sale. Besides, the Wilcoxon test was used to determine the future probability of total CEV sales in Indonesia obtained from the population median from the dataset.

3 Results and Discussion

3.1 Statistical Analysis Results

Tables 1 and 2 show the regression analysis results to predict the future wholesale total of car electric vehicle (CEV) (Fig. 1) based on the wholesale data from 2020 and 2022 in Indonesia. The regression analysis shows a significant (p-value < 0.050, one-tailed) difference between wholesale and year of sales in Indonesia. The future CEV industry in Indonesia would be proposed from the regression model as shown in Fig. 1, such as market optimization.

Meanwhile, the Kendall-Tau statistical correlation test shows the value of r-correl = 1.00, indicating that wholesale total CEV and year of sale have strong positive relationships. Besides, the regression model can be predictable for future wholesale total CEV in Indonesia, as well as supported by strong positive relationships. In addition, the Wilcoxon test shows that the number of CEV sales in the future is not significantly different from the population median of 201 cars estimated per year (p-value 0.054 > 0.050, one-tailed) in Indonesia.

Table 1 Regression summary of this study

Regression statistics	
R square	0.8852
Adjusted *R* square	0.7703

Table 2 Regression test results of this study

Regression analysis	Std. error	*t* stat	*F*	Sig. *F*	*p*-value	Lower 95%	Upper 95%
Wholesale (2020–2022)	0.392	5150.868	7.7087	0.220	0.000*	2015.245	2025.212

* p-value < 0.050, one-tailed

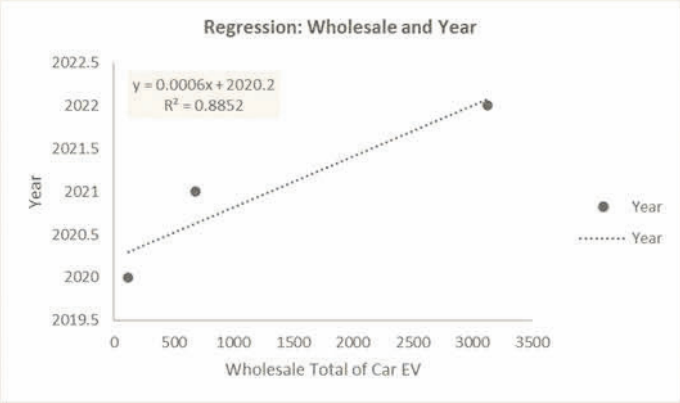

Fig. 1 Regression equation of the total wholesale EV car in Indonesia against the year of sales

3.2 Discussion

The regression model shown in Eq. (1) indicates that the prediction of wholesale total CEV in the future in Indonesia is optimistic when the constant value of 2020.2 is affected (increased) by wholesale total car electric vehicle (WTCEV). The increase in the year also affected the number of wholesale CEV products in Indonesia. The Kendall-Tau correlation test also supports strong positive relationships between them.

$$y = 0.0006 \times \text{WTCEV} + 2020.2, \tag{1}$$

where

y prediction of wholesale total CEV in the future in Indonesia;
WTCEV number of wholesale total car electrical vehicle (CEV).

Based on the prediction model, the estimated wholesale total number of CEVs in the future is about 210 cars per year in Indonesia's population median. It might be fluctuating conditions, such as pandemic policy [16]. This model would be influenced by infrastructure development and government policy conditions according to Mali et al. [3] stated that in Nepal as a developed country, there are various influences, such as several accomplished initiatives, problems, tried-and-true regulations, and infrastructure development are all examples of this. Indonesia is also a developed country, so those factors probably influenced our study model, especially in the availability of charging station infrastructure [15] and policy implications [17], as well as techno-economic study [18]. Regarding the EV policy, we can learn from a previous study by Lebrouhi et al. [6]. Lemme et al. [19] proposed a model for evaluating electric vehicles as a fleet composition option in station-based car-sharing systems, and it can be applied in infrastructure development. Besides, Jakarta used photovoltaic (PV) integrated with electric vehicles (EVs) as the battery to reduce

energy costs by 33–34% in 2030 [20], so if this concept plan to be spreading to other cities in Indonesia, it is an alternative to make efficient use of green energy sources. In addition, the Indonesian government must provide a new policy regarding energy sources for EVs; like China [21], as well as the development of a vehicle-to-grid operations policy [22, 23], it is crucial to regulate gasoline-powered vehicles (conventional cars), so they can be used for the reason of migrating conventional vehicle to electric vehicle (EV) [24].

The trend in Istanbul–Turkey stated that subsidizing electric vehicle parking and hybrid car bridge and tunnel crossing tolls is more efficacious [11]. Based on the dataset obtained, non-fully electric batteries, including hybrid cars and oil-fueled cars (conventional cars), are the most consumed in Indonesia. Besides, Brazil reported that factors influencing EV usage intention include charging infrastructure, charging time, car autonomy, and purchasing price [12]. If these factors concern the Indonesian government, it would be an excellent way to educate about using the EV inside the conventional car.

The study shows that many unidentified factors in the statistical analysis influenced the regression model. It would probably be the factors of family decisions to buy the EV [25], economic and safety opinions [26], EV subsidy [27], EV buyer willingness regarding solar energy aspects [28], three together aspects: electrification, shared mobility, and automation [4], driver's preferences [7], transport actors and behavior [29], electrification level optimization for the passenger [30], total cost ownership [31], incentives for buying an EV [32], and technology-based as well as industrialization aspects [33].

4 Conclusion

We proposed the prediction model based on the statistical analysis for the number of total wholesale of car electric vehicles (CEVs) in Indonesia for the future. This study reported the preliminary report regarding the factors that probably influence the Indonesian people to buy an EV. Our model predicted that increased years would increase the number of buying an EV. The predicted total number of wholesale CEVs in the future might fluctuate, based on various factors, including economics, policy, willingness, and behavior of Indonesian people. Hopefully, this study can be used to determine the next new energy vehicle as well as the electric vehicle (EV) strategy. This study is limited to analyzing the wholesale number of EVs in Indonesia and predicting the future. We were also grateful for any feedback on this study. It is suggested for future works to extend the duration of wholesale year as well as the manufacturers to give comprehensive results.

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