A Framework for Integrating the Product-Consumer Adoption Model of Electric Motorcycle: Preliminary Research

Yuniaristanto, Wahyudi Sutopo and Muhammad Hisjam
Department of Industrial Engineering
Universitas Sebelas Maret (UNS)
Ir. Sutami St. No.36A 57126, Surakarta, Indonesia
yuniaristanto@ft.uns.ac.id, wahyudisutopo@staff.uns.ac.id, hisjam@staff.uns.ac.id

Hendro Wicaksono
Mathematics and Logistics
Jacobs University Bremen gGmbH
Campus Ring 1 28759 Bremen, Germany
h.wicaksono@jacobs-university.de

Abstract

The transportation sector is the main source of air pollution in Indonesian cities. Pollution can reduce air quality and increase carbon emissions that impact climate change. The Indonesian Government has issued regulations to accelerate the migration from internal combustion engine vehicles to electric vehicles to overcome this problem. This research is focused on electric motorcycles (EM) because motorcycles dominate more than 80% of the total vehicles in Indonesia. This paper aims to investigate consumer purchase intention in EM by considering consumer and product views in the Indonesian context. This research develops a conceptual framework by integrating the Unified Theory of Acceptance and Use of Technology (UTAUT) and the discrete choice model. This research contributes to considering brand trust factors into UTAUT and integrating consumer and product aspects in developing a hybrid choice model. This study will be conducted on motorcycle owners in Indonesia. The findings from the research will provide the EM purchase intention of Indonesian consumers by considering the analysis of consumer behavior for various EM attributes.

Keywords
Electric motorcycles, Brand trust, UTAUT, Hybrid choice model and Indonesia.

1. Introduction
The road transportation sector still contributes significantly to economic growth in many countries where this condition impacts energy security and air pollution (Li et al., 2018; Moradi and Vagnoni, 2018). Rapid economic growth will cause environmental quality to decline (Coates, 2016). The key concerns governments must solve in this century are those connected to air quality and human health, including climate change, air pollution, energy security, and energy shortages (Lopez-Arboleda et al., 2019). The primary contributor to air pollution in cities is the transportation sector. In urban areas, vehicle emissions account for 70% of the pollution caused by Nitrogen Oxide (NO_x), Carbon Monoxide (CO), Sulfur Dioxide (SO_2), and Particulate (PM) pollution in urban areas (Ministry of Environment and Forestry, 2021).

In the Indonesian context, vehicles have continued to increase in the last four years, reaching 143,797,227 units dominated by 121,209,304 motorcycles and 16,903,094 passenger cars in 2021 (Statistics Indonesia, n.d.-a). The most rapid growth was in motorcycles, with an average increase of 4.85 million units per year, where sales reached 5,057,516 units in 2021 (AISI, n.d.). The number of motorcycles in Indonesia is more than other vehicles such as cars and buses. Motorcycles have several advantages, including low prices, low operational costs, and easy adjustments to road conditions (Dorocki et al. 2021). These advantages encourage Indonesians to choose motorcycles as the main

mode of transportation. This fact has resulted in Indonesia being the top three global motorcycle markets after India and China (Eccarius and Lu, 2020b).

This condition will certainly impact increasing air pollution and greenhouse gas emissions, decreasing air quality in Indonesia. The air quality index in Indonesia is ranked 17th in the world, with an AQI of 34.3 in 2021 (IQAir, n.d.). Even in 2019, Indonesia's AQI reached its highest level, 51.7. An index of 34.3 means that the air quality in Indonesia exceeds 5 to 7 times the standard set by WHO. The Air Quality Index (AQI) is calculated based on measurements of particulate matter (PM 2.5 and PM 10), Ozone (O_3), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), and Carbon Monoxide (CO) emissions which all contribute to air pollution. Vehicle migration from fossil fuels to alternative fuels can be a solution to improve air quality.

By migrating from conventional to electric vehicles (EVs), air quality may be improved, and the negative consequences of air pollution reduced (Chen et al., 2013). Indonesia pledged at the 2015 Paris Climate Change Conference to cut its carbon dioxide emissions by 29% by 2030 (Goldenberg, 2015). To support this commitment, the Government issued Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Battery-Based Electric Vehicle (BEV) Program for Road Transportation (Indonesian Government, 2019). The Government institutions such as Bank Indonesia, the Minister of Home Affairs, the Minister of Energy and Mineral Resources, and the Minister of Transportation have also issued the regulation to support the Presidential Regulation implementation. The Indonesian Government released a plan for producing more than three million EVs, including 600,000 electric automobiles and 2.45 million electric motorcycles (Gaikindo, n.d.). This high production target must be accompanied by increased sales by the vehicle market in Indonesia. The Ministry of Energy and Mineral Resources has also set a target of ending sales of Internal Combustion Engine Vehicles (ICEV) in 2040 (Gaikindo). Because of this, the Government is encouraging the use of low-emission or even zero-emission vehicles, one of which is a hybrid electric vehicle (HEV) or electric vehicle (Gaikindo).

Many manufacturers have started selling four-wheeled and two-wheeled EVs. However, until July 2022, Indonesia's total sales of electric motorcycles (EMs) had only reached 19,024 units (Rahayu, 2022). This condition is certainly a challenge because the adoption rate of EVs in Indonesia is still low, even though the Indonesian Government has set a target of producing more than three million EV units by 2030. In addition, the Government has issued several regulations to support the acceleration of the diffusion of EVs in Indonesia.

This fact can certainly be the main reason for exploring the factors influencing EV adoption in Indonesia. This research focuses on the object of EMs because the number of conventional motorcycles (CM) in Indonesia is far more than the number of conventional cars, reaching almost eight times (Statistics Indonesia, n.d.-b). In addition, EM prices are more affordable because they are in the same price range as CM prices.

Based on the previous description, a research question can be raised, what factors influence the adoption of EM in Indonesia? Other researchers have carried out many studies regarding EM adoption. However, many studies still look at separate consumer and product views of EM purchase intentions. Consumer views may include psychological and demographic factors, while product views include technological and cost factors. This study aims to develop a conceptual model to determine the factors influencing EM adoption in Indonesia by integrating consumer and product views. This research has the following contributions: (i) this study can enrich the study of EM adoption where there are still very few studies that take EM objects, and the Indonesian context, (ii) this study develops a hybrid choice model that integrates consumer views (latent variables) and product view (observable variable).

This research has the following benefits for stakeholders. First, this study is still applicable to Indonesia's current market conditions because EM adoption is still in its early stages, and many potential consumers are still debating whether or not to purchase EM. Second, the Government can use research results as material for consideration in drafting regulations to accelerate EM diffusion in the Indonesian market. Third, producers can find out their interest in adopting EM as a basis for consideration in marketing and improving the attributes of EM products according to the interests of Indonesian consumers.

2. Literature Review
More research was conducted on consumer adoption of EVs than on EMs. Studies on customer adoption of EMs are more ecologically beneficial than conventional motorcycles (Eccarius and Lu, 2020b). Eccarius and Lu (2020b) reviewed the literature on motorcycle adoption models. Five theoretical frameworks—planned behavior, normative,

symbols, lifestyle, self-identity, innovation diffusion, and consumer emotions—describe the research of alternative fuel motorcycles. Using the Theory of Planned Behavior (TPB), Eccarius and Lu (2020a) investigated the variables that affected students' intention to utilize electric scooter-sharing. Yuniaristanto et al. (2022) explored the important factors affecting the intention to adopt EMs in Indonesia by considering micro, cost, technology, and macro aspects.

Liu dan Lai (2020) contributed to the theory of adopting environmental technology by considering environmental policies. Guerra (2019) conducted a selection experiment in Solo, Indonesia, to assess the viability of EMs as a replacement for gas-powered motorcycles. The relationship between buying intention, image, perceived risk, value, and advantages in EM markets was examined by Wu et al. (2015), along with the factors that precede purchase intention. While evaluating prior research, it should be highlighted that several studies have sought to comprehend consumer views, such as psychological and demographic aspects (Eccarius and Lu, 2020a; Wu et al., 2015). Numerous research concentrate on objective factors, including socioeconomic (Guerra, 2019; Yuniaristanto et al., 2022), subsidy policies (Yuniaristanto et al., 2022), and environmental policies (Liu and Lai, 2020).

Many studies focus more on small electric scooter (ES) objects, but only a few focus on EM objects. ES can be divided into two, namely small ES and large ES. Large ES or EM have the same characteristics: two wheels with a maximum speed of more than 45 km/hour (Weiss et al., 2015). In addition, users of the two vehicles are required to have riding license for the territory of Indonesia. In comparison, many of the ES objects studied in previous studies focused on small ES with a maximum speed of less than 45 km/hour. In addition, this research takes case studies in Indonesia because Indonesia has a high level of motorcycle density, with the number of motorcycles reaching 121 million units in 2021. This fact makes migration from CM to EM an urgent matter for Indonesia.

In general, research can be seen from two views: consumer and product. Consumer views include psychological and demographic, while product views include technology and costs. Several studies focus on consumer perceptions by adopting technology acceptance theories such as TAM (Javadinasr et al., 2022; Ratan et al., 2021; Rejali et al., 2021), TPB (Eccarius and Lu, 2020a; Jayasingh et al., 2021), UTAUT (Popova and Zagulova, 2022), UTAUT 2 (Kopplin et al., 2021; Öztaş Karlı et al., 2022), TRA-NAM (Ho and Wu, 2021) and other theories such as BRT, BCT, TCE, *consumer lifetime value, consumer innovativeness* and *domain-specific innovative*. However, no research has adopted the technology acceptance theory in EM by combining it with brand trust. This study adopts the UTAUT model by adding the brand trust factor in developing the EM adoption model. The UTAUT model considers four determinants: performance expectancy, effort expectancy, social influence, and facilitating conditions.

Brand trust is a quality relationship that consumers feel from a product to the manufacturer's brand and reputation (Yang et al., 2020). In the Indonesian context, two brands currently dominate the motorcycle market share in Indonesia. However, the two brands have just released an EM for the upper segment and will only release the EM segment at the same price as CM in 2023. Meanwhile, for the past five years, local manufacturers have dominated EM manufacturers, such as Viar, Gesits, Volta, Smoot, Polytron, Selis, and others. This study investigates whether this brand trust can influence consumer purchase intention.

In the product view, several studies apply the choice model to determine the adoption behavior of electric scooters (ES) and EM (Brezovec and Hampl, 2021; Guerra, 2019; Lee et al., 2021; Reck and Axhausen, 2021; Zhu et al., 2019). Meanwhile, other studies have developed their conceptual model by considering technological, cost, and contextual factors (Almannaa et al., 2021; Bieliński and Ważna, 2020; Glavić et al., 2021; Liu and Lai, 2020; Yuniaristanto et al., 2022). The choice model has several advantages, namely, finding out what attributes influence the desire to buy a product from respondents, providing several alternative product choices that respondents can choose from, and estimating the chances of respondents choosing an alternative choice. Many studies still focus on consumer views (Almannaa et al., 2021; Chen et al., 2018; Eccarius and Lu, 2020a; Ho and Wu, 2021; Ho and Chung, 2020; Javadinasr et al., 2022; Jayasingh et al., 2021; Öztaş Karlı et al., 2022; Popova and Zagulova, 2022). Meanwhile, other studies focus on product views without considering psychological factors (Guerra, 2019; Yuniaristanto et al., 2022; Zhu et al., 2019). Based on this state of the art, there are research opportunities in studying EM adoption in Indonesia by integrating consumer and product views. This study aims to develop a conceptual model for predicting consumer purchase intentions toward EMs by considering consumer and product views.

3. Model Development
The consumer view model adopts the UTAUT model, which has four determinants: performance expectancy (PE), effort expectancy (EE), social influence (SI), and facilitating condition (FC), by adding a new determinant, namely

brand trust. PE denotes personal perceptions regarding specific gains and increased performance using certain technologies (Venkatesh et al., 2012). PE argues that using technology increases productivity. PE has been shown by Kopplin et al. (2021) to be a predictor of behavioral intention to share e-scooters. So this study presupposes that the purchase intention of an EM depends on the user's understanding of the benefits that may arise from user involvement with technology.

H1: PE influences the EM purchase intention favorably.
EE stands for the amount of effort needed by users to interact with a specific technology (Venkatesh et al., 2003). It has been demonstrated that potential challenges in completing requirements have a negative impact on behavioral intention (Rahman et al., 2020; Trivedi et al., 2019). Thus, it is assumed in this study that EM purchase intention depends on personal perceptions of the effort required to use EM.

H2: EE influences the EM purchase intention favorably.
SI is defined as the degree to which a person values the beliefs of others (Venkatesh et al., 2003). It has been demonstrated that SI affects people's behavioral intentions when they are introduced to new technologies (Venkatesh et al., 2003). In general, it is simpler for people to adopt new technologies already widely utilized in our social milieu (Illia et al., 2015). Nordhoff et al. (2020) showed that SI drives behavioral intention, so this study assumes that general social perceptions of this technology will influence EM purchase intention.

H3: SI positively influences EM purchase intention.
Facilities and technical elements that facilitate the effective application of technology are referred to as FC (Venkatesh et al., 2003). Users are more ready to engage actively when they have the support they need to use a particular technology (Ajzen, 1991). Numerous research has demonstrated that FC positively impacts behavioral intention (Nordhoff et al., 2020). Thus, this study assumes that the facility support provided to EM users will significantly affect EM purchase intention.

H4: FC positively influences EM purchase intention.
Brand trust describes the relationship between a product or service's perceived quality by customers and the reputation and brand of the manufacturer (Xie et al., 2015). If consumers have a higher quality perception of the desired product brand, they will trust the brand more to reduce perceived uncertainty and risk. Since EM is a growing industry, most EM manufacturers and models in Indonesia are also less popular. However, this study believes that brand trust will influence consumers and eliminate the uncertainty and risk they feel.

H5. Brand trust positively influences EM purchase intention.
The Discrete Choice Model in this research uses the Discrete Choice Experiment (DCE) and Stated Preference (SP) approaches. DCE is designed in seven attributes: range, speed, filling time, acceleration, filling technology, EM price, and filling cost. Attributes, levels, and sources can be seen in Table 1. The first five attributes describe technical variables and refer to research (Beak et al., 2020; Burs et al., 2020; Jones et al., 2013). Meanwhile, the subsequent two attributes reflect the cost variable and refer to research (Guerra, 2019; Jones et al., 2013).

Table 1. Attribute and level of *discrete choice experiment*

Variable	Attribute	Levels	Source
Technical	Range (km)	50-70, 100-140	(Burs et al., 2020; Jones et al., 2013)
	Speed (km/hour)	50, 70, 90	(Burs et al., 2020; Jones et al., 2013)
	Filling time (minutes)	1, 5-10, 120-240	(Burs et al., 2020; Jones et al., 2013)
	Acceleration (seconds)	0-40km/h: 10, 5, 2.5	(Jones et al., 2013)
	Filling technology	Wired charging, battery swap	(Beak et al., 2020)
Cost	EM price (Million Rp)	10-20, 20-30, >30	(Jones et al., 2013)
	Filling cost (Rp)	2500; 4000; 10,000	(Guerra, 2019)

In the choice experiment, respondents are given three choices: EM alternative 1, EM alternative 2, or they did not choose both. This research develops a Hybrid Choice Model (HCM) using the SEM-Logit model approach. HCM integrates UTAUT theory and logit models to predict EM's purchase intention by considering consumer and product views for the Indonesian market (Figure 1).
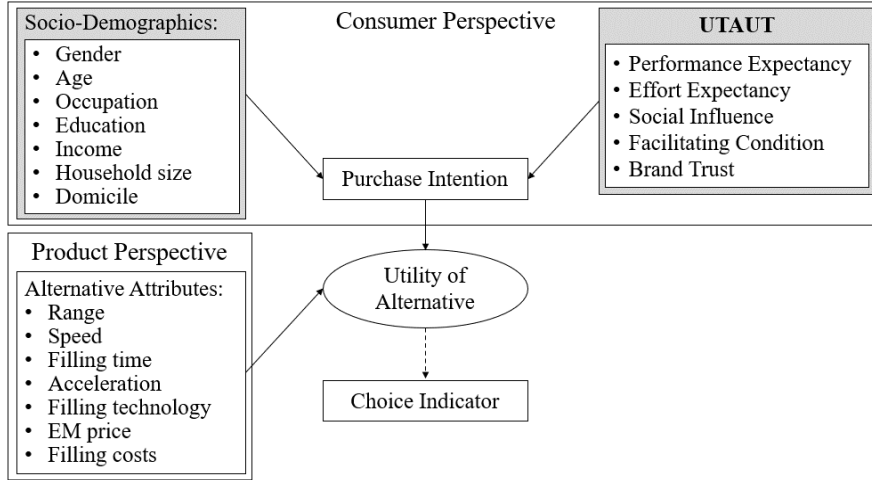
Figure 1. The framework of the integrated consumer and product views

The SEM-Logit model, which considers latent variables, is designed to characterize the impact of subjective elements on the purchase decision-making process. The model is divided into two components. The first component is the SEM model, which is used to explain the causal relationship between the latent variables of the UTAUT model and EM's purchase intention. The Logit model's second component expresses the nonlinear function relationship between the probabilities of choosing one of three options: two EM alternatives or not choosing either. The specific description of the model refers to Si et al. (2019):

1. Improvements to Utility Functions
Explicit variables like motorcycle attributes and the respondent's socioeconomic characteristics are combined with latent variables like perceptions, attitudes, and other factors to create the utility function. The utility function is formulated as:
$$V_{in} = \sum_l a_{il}s_{iln} + \sum_q b_{iq}z_{iqn} + \sum_m c_{im}\eta_{imn} \qquad (1)$$
where i refers to alternatives, n is the number of respondents, l is the number of respondent characteristics that can be directly observed, q is the number of EM attributes that can be directly observed, the number of latent variables is m. s_{iln} is a manifest variable of personal attributes, z_{iqn} is a manifest variable of EM attributes, η_{imn} is a latent variable, while a_{il}, b_{iq} and c_{im} are the parameters to be estimated.

2. Calculating the latent variable's adaptation coefficient η_{imn}
In order to calculate the adaption coefficient of latent variables, SEM is required to characterize the relationship between latent variables and their measurement variables. A set of acceptable measurement variables (x_{irn}) can adequately characterize the latent variable (η_{imn}). The structural equation model's observation model for attitudes, perceptions, and qualities in motorcycle selection, the vector form can be stated as follows:
$$\begin{bmatrix} x_{11} \\ x_{12} \\ \dots \\ x_{1n} \end{bmatrix} = \begin{bmatrix} \lambda_{x1} \\ \lambda_{x2} \\ \dots \\ \lambda_{xn} \end{bmatrix} \eta_1 \qquad (2)$$
The loading factors $\lambda_{x1}, \lambda_{x2}, \dots, \lambda_{xn}$ explained by potential exogenous variables η_1 are considered as the weights of each observed variable (index variables), and then the loading factors are standardized, using $\alpha_{x1}, \alpha_{x2}, \dots, \alpha_{xn}$ to represent the specified weights.
$$\begin{cases} \alpha_{x1} = \frac{\lambda_{x1}}{\lambda_{x1}+\lambda_{x2}+ \dots + \lambda_{xn}} \\ \alpha_{x2} = \frac{\lambda_{x2}}{\lambda_{x1}+\lambda_{x2}+ \dots + \lambda_{xn}} \\ \alpha_{xn} = \frac{\lambda_{xn}}{\lambda_{x1}+\lambda_{x2}+ \dots + \lambda_{xn}} \end{cases} \qquad (3)$$
Finally, the observed variable survey values are entered into the formula, and the adaptation values of the possible characteristic variables in the attitude perception attributes for the respondents are obtained as follows:
$$\eta_1 = \alpha_{x1}x_{11} + \alpha_{x2}x_{12} + \dots + \alpha_{xn}x_{1n} \qquad (4)$$

3. Discrete Choice Model

The binomial variable is employed to characterize the respondent's behavior (its value can only be 0 or 1). If $d_{in} = 0$, option i is not picked; if $d_{in} = 1$, option i is selected. The formula is shown as follows:

$$d_{in} = \begin{cases} 1 \text{ if } U_{in} \geq U_{jn} \\ 0 \text{ otherwise} \end{cases} \tag{5}.$$

4. Research Methodology

A questionnaire is developed based on the consumer view model to capture respondents' preferences for EM adoption in Indonesia. The questionnaire preparation begins with operationalizing the definitions of the existing latent variables so that they can be observed and measured. The questionnaire is arranged into three sections.

The first section gives background information on this study and describes some ethical commitments. Age, gender, income, occupation, education level, and domicile are the demographic factors included in the second section on a nominal scale. One question in this section asks respondents if they have used EM at least once. The measurement items are described in the final part, which is adapted from Venkatesh et al. (2003) and Oztas Karli et al. (2022). A five-point Likert scale is used for each construct to provide a score (from strongly disagree to strongly agree). In order to increase the validity of the questionnaire, 30 people are chosen for pretesting.

In the product overview, attributes and levels are determined based on the results of a literature study. The next stage is the design of a discrete choice experiment (DCE) involving a combination of attributes and levels of EM. DCE is designed in SPSS version 29 using an orthogonal design which will produce several choice sets where each set contains seven attributes based on the potential cognitive load of increasing the number of attribute sets. Each set of choices will display two alternative choices, namely EM alternative 1 and EM alternative 2, and one option, "choose neither" as the respondent's choice. Then a questionnaire is prepared based on this choice set to capture the respondents' preferences.

The two questionnaires are distributed online to respondents throughout Indonesia. The survey will be carried out following the convenience sampling method (non-random) and distributed over provinces with the highest levels of motorcycle sales in Indonesia. The selection of this province follows the Pareto law: around 80% or more of total motorcycle sales in Indonesia will be represented by around 20% of the provinces in Indonesia. The characteristics of the selected respondents include age 17 and over, having a riding license (SIM C), and owning a motorcycle. According to Cochran, the sample size is sufficient to represent the target population within the 95% confidence interval (Cochran, 1977).

The next stage is to analyze data from respondents using the SEM-Logit model approach to estimate the intention to buy EM from respondents in Indonesia. This SEM-Logit model has considered two existing views to estimate the choice behavior of respondents towards EM. Processing of the SEM-Logit model is carried out in two stages, namely the first stage of SEM analysis with SmartPLS version 4, then the second stage of logit model analysis with Nlogit version 6.

The SEM model tries to represent the causal relationship between latent factors and the corresponding observable variables in the EM decision and the relationship between latent variables and explicit variables. The Logit model represents the functional relationship between the likelihood of choosing an EM, latent factors, and explicit variables influencing decision-making. It should be highlighted that the observable variables can only be used to quantify latent variables and have no impact on a person's chosen behavior.

The results of the analysis of the SEM-logit model are synthesized into four discussions, namely similar research with contexts in other countries, the possibility of using research results for other developing countries, recommendations for the Government, and recommendations for business actors. The final stage is concluding research results, limitations, and potential for further research.

5. Conclusion

This study aims to develop a conceptual model to determine the factors influencing EM adoption in Indonesia by integrating consumer and product views. The conceptual model developed adopts the UTAUT model by adding the

brand trust factor. Based on a review of relevant literature, it is known that the UTAUT model is a pragmatic approach that is able to explain better behavioral intentions than TPB and TAM. In addition, no research combines technology acceptance theory on EM objects with brand trust. This research focuses on large ES or EM because most research focuses more on small ES objects. This focus is in line with the CM to EM migration acceleration program because the number of motorcycles in Indonesia is enormous, resulting in high pollution and GHG emissions.

This study also integrates consumer and product views because many EM adoption studies still consider consumer and product views separately. The SEM-Logit model is developed to accommodate the effect of latent and observable variables on the purchasing decision-making process.

This model has two components: the first is the SEM model, which is used to explain the causal relationship between the latent variables of the UTAUT model and EM's purchase intention. The Logit model's second component represents the nonlinear function relationship between the probabilities of choosing one of three options: two EM alternatives and not choosing either. The research results are expected to provide input for manufacturers and the Government to accelerate the migration from fossil-fuel vehicles to EVs. EM producers can find out the factors that need to be considered in designing and marketing EM according to the interests of Indonesian consumers. The Government can use research results for consideration in drafting regulations to accelerate EM diffusion in the Indonesian market.

Acknowledgment

References

AISI., *Statistic Distribution* -. Retrieved April 16, , from https://www.aisi.or.id/statistic/, 2022.

Ajzen, I., The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 1991. https://doi.org/10.1016/0749-5978(91)90020-T

Almannaa, M. H., Alsahhaf, F. A., Ashqar, H. I., Elhenawy, M., Masoud, M., and Rakotonirainy, A., Perception analysis of E-scooter riders and non-riders in Riyadh, Saudi Arabia: Survey outputs. *Sustainability,* 2021. *(Switzerland)*. https://doi.org/10.3390/su13020863

Beak, Y., Kim, K., Maeng, K., and Cho, Y., Is the environment-friendly factor attractive to customers when purchasing electric vehicles? Evidence from South Korea. *Business Strategy and the Environment*, *29*(3), 996–1006, 2020. https://doi.org/10.1002/bse.2412

Bieliński, T., and Ważna, A., Electric scooter sharing and bike sharing user behaviour and characteristics. *Sustainability (Switzerland)*, 2020. https://doi.org/10.3390/su12229640

Brezovec, P., and Hampl, N., Electric vehicles ready for breakthrough in MaaS? Consumer adoption of E-car sharing and E-scooter sharing as a part of mobility-as-a-service (MaaS). *Energies*, *14*(4), 2020. https://doi.org/10.3390/en14041088

Burs, L., Roemer, E., Worm, S., and Masini, A., Are they all equal? Uncovering adopter groups of battery electric vehicles. *Sustainability (Switzerland)*, *12*(7), 2020. https://doi.org/10.3390/su12072815

Chen, H.-S., Tsai, B.-K., and Hsieh, C.-M., The effects of perceived barriers on innovation resistance of hydrogen-electric motorcycles. *Sustainability (Switzerland)*, 2018. https://doi.org/10.3390/su10061933

Chen, Y., Ebenstein, A., Greenstone, M., and Li, H., Evidence on the impact of sustained exposure to air pollution on life expectancy from China's Huai River policy. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(32), 12936–12941, 2013. https://doi.org/10.1073/pnas.1300018110

Coates, J. F., The sixteen sources of environmental problems in the 21st century. *Technological Forecasting and Social Change*, *113*, 23–25, 2016. https://doi.org/10.1016/J.TECHFORE.2016.10.053

Cochran, W. G., *Sampling techniques*. John Wiley and Sons, 1977.

Dorocki, S., and Wantuch-Matla, D., Power Two-Wheelers as an Element of Sustainable Urban Mobility in Europe. *Land 2021, Vol. 10, Page 618*, *10*(6), 618, 2021. https://doi.org/10.3390/LAND10060618

Eccarius, T., and Lu, C. C.. Adoption intentions for micro-mobility – Insights from electric scooter sharing in Taiwan. *Transportation Research Part D: Transport and Environment*, *84*, 2020a. https://doi.org/10.1016/j.trd.2020.102327

Eccarius, T., and Lu, C. C., Powered two-wheelers for sustainable mobility: A review of consumer adoption of electric motorcycles. *International Journal of Sustainable Transportation*, *14*(3), 215–231, 2020b. https://doi.org/10.1080/15568318.2018.1540735

Gaikindo, *Pemerintah Targetkan 600 Ribu Unit Produksi Mobil Listrik 2030*. Retrieved April 12, 2022, from https://www.gaikindo.or.id/pemerintah-targetkan-600-ribu-unit-produksi-mobil-listrik-2030/

Glavić, D., Trpković, A., Milenković, M., and Jevremović, S., The e-scooter potential to change urban mobility—belgrade case study. *Sustainability (Switzerland)*, 2021. https://doi.org/10.3390/su13115948

Goldenberg, S., Indonesia to cut carbon emissions by 29% by 2030. In *The Guardian*. , 2015. https://www.theguardian.com/environment/2015/sep/21/indonesia-promises-to-cut-carbon-emissions-by-29-by-2030

Guerra, E. , Electric vehicles, air pollution, and the motorcycle city: A stated preference survey of consumers' willingness to adopt electric motorcycles in Solo, Indonesia. *Transportation Research Part D: Transport and Environment*, *68*, 52–64, 2019. https://doi.org/10.1016/j.trd.2017.07.027

Ho, C.-W., and Wu, C.-C., Exploring intention toward using an electric scooter: Integrating the technology readiness and acceptance into norm activation model (tra-nam), 2021. *Energies*. https://doi.org/10.3390/en14216895

Ho, M. H.-W., and Chung, H. F. L., Customer engagement, customer equity and repurchase intention in mobile apps. *Journal of Business Research*, 2020. https://doi.org/10.1016/j.jbusres.2020.07.046

Illia, A., Ngniatedema, T., and Huang, Z., A conceptual model for mobile banking adoption. *Journal of Management Information and Decision Sciences*, *18*(1), 111–122, 2015.

Indonesian Government., *Presidential Regulation Number 55 of 2019: Acceleration of the Battery Electric Vehicle Program for Road Transportation.* , 2019. https://peraturan.go.id/peraturan/view.html?id=3e227ec8ad446de9a348afdf7de4b0cb

IQAir., *Negara and wilayah paling berpolusi di dunia (data historis 2018-2021)*. Retrieved April 12, 2022, from https://www.iqair.com/id/world-most-polluted-countries

Javadinasr, M., Asgharpour, S., Rahimi, E., Choobchian, P., Mohammadian, A. K., and Auld, J., Eliciting attitudinal factors affecting the continuance use of E-scooters: An empirical study in Chicago. *Transportation Research Part F: Traffic Psychology and Behaviour*, 2022. https://doi.org/10.1016/j.trf.2022.03.019

Jayasingh, S., Girija, T., and Arunkumar, S., Factors influencing consumers' purchase intention towards electric two-wheelers. *Sustainability (Switzerland)*, 2013. https://doi.org/10.3390/su132212851

Jones, L. R., Cherry, C. R., Vu, T. A., and Nguyen, Q. N., The effect of incentives and technology on the adoption of electric motorcycles: A stated choice experiment in Vietnam. *Transportation Research Part A: Policy and Practice*, *57*, 1–11, 2013. https://doi.org/10.1016/j.tra.2013.09.003

Kopplin, C. S., Brand, B. M., and Reichenberger, Y. , Consumer acceptance of shared e-scooters for urban and short-distance mobility. *Transportation Research Part D: Transport and Environment*. , 2021. https://doi.org/10.1016/j.trd.2020.102680

Lee, H., Baek, K., Chung, J.-H., and Kim, J., Factors affecting heterogeneity in willingness to use e-scooter sharing services. *Transportation Research Part D: Transport and Environment*, *92*, 2021. https://doi.org/10.1016/j.trd.2021.102751

Li, W., Long, R., Chen, H., Yang, T., Geng, J., and Yang, M., Effects of personal carbon trading on the decision to adopt battery electric vehicles: Analysis based on a choice experiment in Jiangsu, China. *Applied Energy*, *209*, 478–488, 2018. https://doi.org/10.1016/J.APENERGY.2017.10.119

Liu, Y., and Lai, I. K. W., The Effects of Environmental Policy and the Perception of Electric Motorcycles on the Acceptance of Electric Motorcycles: An Empirical Study in Macau. *SAGE Open*, *10*(1), 2020. https://doi.org/0.1177/2158244019899091

Lopez-Arboleda, E., Sarmiento, A. T., and Cardenas, L. M., Systematic Review of Integrated Sustainable Transportation Models for Electric Passenger Vehicle Diffusion. *Sustainability, Vol. 11, Page 2513,* 2019, https://doi.org/10.3390/SU11092513

Ministry of Environment and Forestry, *Uji Emisi Kendaraan Sebagai Bentuk Kontribusi Masyarakat Terhadap Pengendalian Pencemaran Udara -.*, 2021. https://www.menlhk.go.id/site/single_post/4078

Moradi, A., and Vagnoni, E., A multi-level perspective analysis of urban mobility system dynamics: What are the future transition pathways? *Technological Forecasting and Social Change*, *126*, 231–243, 2018. https://doi.org/10.1016/J.TECHFORE.2017.09.002

Nordhoff, S., Louw, T., Innamaa, S., Lehtonen, E., Beuster, A., Torrao, G., Bjorvatn, A., Kessel, T., Malin, F., Happee, R., and Merat, N., Using the UTAUT2 model to explain public acceptance of conditionally automated (L3) cars: A questionnaire study among 9,118 car drivers from eight European countries. *Transportation Research Part F: Traffic Psychology and Behaviour*, *74*, 280–297, 2020. https://doi.org/10.1016/J.TRF.2020.07.015

Öztaş Karlı, R. G., Karlı, H., and Çelikyay, H. S., Investigating the acceptance of shared e-scooters: Empirical evidence from Turkey. *Case Studies on Transport Policy*, 2022. https://doi.org/10.1016/j.cstp.2022.03.018

Popova, Y., and Zagulova, D., Aspects of E-Scooter Sharing in the Smart City. *Informatics*. https://doi.org/10.3390/informatics9020036, 2020.

Rahayu, I. R. S., *Jumlah Kendaraan Listrik di Indonesia Capai 16.060 Unit*. Kompas. https://money.kompas.com/read/2022/03/21/143726326/jumlah-kendaraan-listrik-di-indonesia-capai-16060-unit, 2020.

RAHMAN, A., FAUZIA, R. N., and PAMUNGKAS, S., Factors Influencing Use of Social Commerce: An Empirical Study from Indonesia. *The Journal of Asian Finance, Economics and Business*, 7(12), 711–720, 2020. https://doi.org/10.13106/JAFEB.2020.VOL7.NO12.711

Ratan, R., Earle, K., Rosenthal, S., Hua Chen, V. H., Gambino, A., Goggin, G., Stevens, H., Li, B., and Lee, K. M., The (digital) medium of mobility is the message: Examining the influence of e-scooter mobile app perceptions on e-scooter use intent. *Computers in Human Behavior Reports*, 2021. https://doi.org/10.1016/j.chbr.2021.100076

Reck, D. J., and Axhausen, K. W., Who uses shared micro-mobility services? Empirical evidence from Zurich, Switzerland. *Transportation Research Part D: Transport and Environment*, 2021. https://doi.org/10.1016/j.trd.2021.102803

Rejali, S., Aghabayk, K., Mohammadi, A., and Shiwakoti, N., Assessing a priori acceptance of shared dockless e-scooters in Iran. *Transportation Research Part D: Transport and Environment*, 2021. https://doi.org/10.1016/j.trd.2021.103042

Si, Y., Guan, H., and Cui, Y., Research on the choice behavior of taxis and express services based on the SEM-logit model. *Sustainability (Switzerland)*, 11(10), 2019. https://doi.org/10.3390/su11102974

Statistics Indonesia., *Jumlah Kendaraan Bermotor Menurut Provinsi dan Jenis Kendaraan (unit), 2021*. Retrieved April 5, 2022, from https://www.bps.go.id/indikator/indikator/view_data_pub/0000/api_pub/V2w4dFkwdFNLNU5mSE95Und2U DRMQT09/da_10/1, n.d.

Statistics Indonesia., *Perkembangan Jumlah Kendaraan Bermotor Menurut Jenis (Unit)*. Retrieved April 12, 2022, n.d., from https://www.bps.go.id/indicator/17/57/1/perkembangan-jumlah-kendaraan-bermotor-menurut-jenis.html

Trivedi, T. K., Liu, C., Antonio, A. L. M., Wheaton, N., Kreger, V., Yap, A., Schriger, D., and Elmore, J. G., Injuries Associated With Standing Electric Scooter Use. *JAMA Network Open*, 2(1), e187381–e187381, 2009. https://doi.org/10.1001/JAMANETWORKOPEN.2018.7381

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D., User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 425–478, 2003. https://doi.org/10.2307/30036540

Venkatesh, V., Thong, J. Y. L., and Xu, X., Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS Quarterly*, 157–178, 2015.

Weiss, M., Dekker, P., Moro, A., Scholz, H., and Patel, M. K., On the electrification of road transportation – A review of the environmental, economic, and social performance of electric two-wheelers. *Transportation Research Part D: Transport and Environment*, 41, 348–36, 2015. https://doi.org/10.1016/J.TRD.2015.09.007

Wu, J.-H., Wu, C.-W., Lee, C.-T., and Lee, H.-J., Green purchase intentions: An exploratory study of the Taiwanese electric motorcycle market. *Journal of Business Research*, 68(4), 829–833, 2015. https://doi.org/10.1016/j.jbusres.2014.11.036

Xie, Y., Batra, R., and Peng, S., An Extended Model of Preference Formation between Global and Local Brands: The Roles of Identity Expressiveness, Trust, and Affect. *Https://Doi.Org/10.1509/Jim.14.0009*, 23(1), 50–71, 2015. https://doi.org/10.1509/JIM.14.0009

Yang, C., Tu, J.-C., and Jiang, Q., The influential factors of consumers- sustainable consumption: A case on electric vehicles in China. *Sustainability (Switzerland)*, 12(8), 2020. https://doi.org/10.3390/SU12083496

Yuniaristanto, Y., Dela Utami, M. W., Sutopo, W., and Hisjam, M., Investigating Key Factors Influencing Purchase Intention of Electric Motorcycle in Indonesia. *Transactions on Transport Sciences*, 1(1), 2022. https://doi.org/10.5507/TOTS.2022.002

Zhu, L., Song, Q., Sheng, N., and Zhou, X. ,. Exploring the determinants of consumers' WTB and WTP for electric motorcycles using CVM method in Macau. *Energy Policy*, 127, 64–72, 2019. https://doi.org/10.1016/j.enpol.2018.12.004

Biographies

Yuniaristanto is a first-year Doctoral student at the Department of Industrial Engineering, Universitas Sebelas Maret. He received his Bachelor's degree in Industrial Engineering from Institut Teknologi Sepuluh November, Indonesia, and a Master's degree in Industrial Engineering and Management from Institut Teknologi Bandung, Indonesia. He worked as a lecturer in Industrial Engineering Department at Universitas Sebelas Maret. His research interests include technology adoption and diffusion, supply chain management, performance measurement, and entrepreneurship.

Wahyudi Sutopo is a professor in industrial engineering and Head of Industrial Engineering and Techno-Economics Research Group, Department of Industrial Engineering, Faculty of Engineering, Universitas Sebelas Maret (UNS), Indonesia. His educational background is a doctorate in industrial engineering and management from Bandung Institute of Technology (ITB) in 2011. He is the president of the industrial engineering and operations management (IEOM) society for Indonesia's professional chapter. His research areas of interest are in the areas of logistics and supply chain management, engineering economy and cost analysis, and technology commercialization. He has published articles on over 180 documents indexed by Scopus with H-index 11.

Muhammad Hisjam is a lecturer at the Department of Industrial Engineering, Faculty of Engineering, Universitas Sebelas Maret since 1998. He earned Bachelor in Agroindustrial Technology from Universitas Gadjah Mada, a Master in Industrial Engineering and Management from Institut Teknologi Bandung, and Ph.D in Environmental Science from Universitas Gadjah Mada. His research interests include supply chain, logistics, business, and sustainable development. He published some papers in journals and proceeding his research area. He holds Accredited Supply Chain Analyst from the American Academy of Project Management. He is a member of IISE, AAPM and IEOM.

Hendro Wicaksono received his B.Sc. degree in informatics from Institut Teknologi Bandung, Indonesia, and M.Sc. degree in Information and Communication Engineering from the University of Karlsruhe, Germany. After gaining some experience in the industry, he completed his doctoral degree in mechanical engineering at the Karlsruhe Institute of Technology. He worked as a researcher at the FZI Research Center of Information Technologies and Institute of Information Management in Engineering (IMI) at Karlsruhe Institute of Technology. Since 2018, he has been working as a Professor of Industrial Engineering and leads the INDEED (Intelligent Data Management in Industry 4.0) Research Group at Jacobs University Bremen, Germany. His research interests include data management, knowledge management, and innovation management.