Journal of Open Innovation: Technology, Market, and Complexity

Article

Open Innovation in Developing an Early Standardization of Battery Swapping According to the Indonesian National Standard for Electric Motorcycle Applications

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Abstract: This research aims to achieve early standardization for battery swapping in line with domestic capabilities and global standards, and to protect Indonesian battery swap stakeholders. By distributing questionnaires to 190 respondents, the Framework for Analysis, Comparison, and Testing of Standards (FACTS) approach was used to analyze stakeholder needs, compare global standards regarding battery swaps, and validate the Indonesian National Standard (SNI) framework. An open innovation approach was considered to integrate a FACTS approach with open participation, mutual understanding, and consensus to generate parameters. Therefore, characteristics of open participation, mutual understanding, and consensus were identified using FACTS to catalyze market needs as well as stakeholder needs. The relationship between SNI implementation variables, national uniqueness, and stakeholder needs was predicted using structural equation modeling (SEM). We found that the proposed constructs—i.e., electromagnetic compatibility, equipment construction requirements, marking and instruction, and protection against electric shock—positively affect SNI implementation. Meanwhile, the SNI implementation, national uniqueness, and stakeholder protection positively affect SNI acceptance. Therefore, SNI acceptance can be obtained by considering SNI implementation, national uniqueness, and stakeholder protection. The findings of this study can be used to develop an SNI battery swap test that is globally competitive, has national characteristics, and considers domestic capabilities when developing the SNI documentation.

Keywords: battery swap; early standardization; FACTS; global competitiveness; open innovation; SEM

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Citation: Sutopo, W.; Prianjani, D.; Fahma, F.; Pujiyanto, E.; Rasli, A.; Kowang, T.O. Open Innovation in Developing an Early Standardization of Battery Swapping According to the Indonesian National Standard for Electric Motorcycle Applications. *J. Open Innov. Technol. Mark. Complex.* **2022**, *8*, 219. https://doi.org/10.3390/joitmc8040219

Received: 6 November 2022
Accepted: 13 December 2022
Published: 15 December 2022

1. Introduction

Motorcycles are oil-fueled motor vehicles with the highest use percentage among Indonesian citizens from an economic standpoint [1]. There is a sufficiently strong potential to convert from oil-fueled motorcycles to electric motorcycles in Indonesia because of the high number of motorcycle enthusiasts. Activities to immediately implement electric vehicle programs in Indonesia are supported by political, economic, technological, and social factors [2]. The Indonesian government has issued regulations for accelerating battery-based electric motor vehicle programs for road transportation. The government attempts to provide a foundation, direction, and legal certainty to encourage energy conservation in the transportation sector. As a result, this demonstrates the country's readiness to accelerate the transition from fossil-fueled to electric vehicles [3].

Battery swapping, also known as battery-as-a-service, allows electric vehicles' owners to exchange discharged batteries for charged ones at swapping stations. Battery swapping, like most commodities, has its own supply chain system, from suppliers, orders, mass production, distribution, marketing, and service, to consumers [2]. However, battery swap testing standards must be developed before the technology can be mass-produced and used as a driving force for electric motorcycles. The early supply chain of the battery swap—i.e., the product development stage, which includes planning, design, development, and pre-production—must be considered in the development of standardization [4]. As the supervisor, developer, and coordinator of activities in the field of standardization, the national standardization body has authority over the process of developing these standards [5]. Each process of developing battery swap products—including planning, design, development, and pre-production—must follow the standard development process, which includes the formulation and setting of standard activities.

Every use of a particular product must focus on consumer protection [6]. Consumer protection is required by the law to support the conversion of oil-fueled motorcycles to electric motorcycles. A standard can be used to provide such protection. Due to the unavailability of an Indonesian National Standard for battery swap product safety and performance, battery swap research for national electric motorcycles may lack a minimum level of quality and reference. As a result, product test standards must be used as a reference. Consumers can be assured that their products are appropriate in terms of performance, safety, and production by using product test standard processes in certifications or product standard labels [6]. Furthermore, Indonesia's diverse natural conditions and its citizens' distinct habits necessitate national uniqueness.

In Indonesia, battery swapping is a new technology with broad applicability. Over time, the lifecycle of a new technology may be more or less similar to that of other innovations. Depending on the technology's market adoption, it may or may not follow the diffusion of innovation [7]. In this case, knowing when and how to apply standards successfully requires understanding of the battery swap lifecycle. A new technology's lifecycle is divided into four stages: invention, growth, maturity, and decline [8]. The invention phase is when the technology is first developed. It has a slow initial growth rate as experiments, research, and development on battery swaps and electric vehicles are carried out during this phase [9–14]. The second phase, known as the growth phase, is characterized by steady and rapid growth as the technology improves. This phenomenon occurs when the battery swap technology is widely used and developed [15–20]. At the maturity phase, the technology is mature, relatively stable, and has competitive implementations in the market. This phase is critical, as the compatibility of the technology is of high priority, and there would be a loss in market share unless compatibility is embraced [7]. The real challenge is to bring battery swap technology to market and keep it from dying in the valley of death. As a result, strategies for accelerating the commercialization of this new technology are required [21]. Therefore, it is necessary to introduce standards during the maturity phase to strengthen the technological innovation to cross the valley of death, emerge in the market, and avoid being trapped in the decline phase.

This study employed the FACTS approach, which can be applied to develop and implement standards as per the recommendations of the National Institute of Standards and Technology [22]. Various standards—such as battery cell standards, battery modules, battery management, and battery-powered wheelchairs—have been developed [23–26]. Standardization and open innovation have similar characteristics [27].

Open innovation is a topic of innovation that is increasingly being discussed. Open innovation refers to the process carried out by companies to find new technologies, innovations, research, and products externally [28]. The aim of open innovation is to tap into the R&D community, even outside the industry, in order to align the pace of internal research and innovation with external developments. Open innovation is a systematic approach to innovation management that exploits internal advantages and capabilities while integrating external opportunities and sources from industry, government, universities, and society [29].

The open innovation approach was considered to integrate a FACTS approach through the interaction of inbound and outbound processes. Thus, the knowledge, experience, and needs of stakeholders can be captured in deliverable standards. In developing standards, the FACTS approach considers all relevant stakeholders' interests that represent transparency and open participation. As a result, the consensus principle in standardization allows interested parties to express their viewpoints and be accommodated accordingly.

This paper outlines a comprehensive strategy for establishing an early standardization for battery swaps in electric motorcycle applications. This research aims to develop an SNI for battery swap testing that is globally competitive, has a national character, and is within domestic capabilities using FACTS and SEM methods. The FACTS method was employed to create a globally competitive standard framework for battery swapping, while the SEM method was applied to determine which construct models can support acceptance of standard implementation so that battery swap stakeholders in Indonesia can implement the standard.

2. Literature Review

2.1. FACTS and SEM Approach

The FACTS method has been used to develop various other standards, such as for battery cells, battery modules, battery management, and wheelchairs [23–26]. The FACTS approach considers the interests of all relevant stakeholders; this approach also provides a framework for analyzing, comparing, and testing standards by structuring information through the Zachman framework. The Zachman framework is used to obtain information using the 5W1H questions (Who? What? When? Where? Why? How?). However, the FACTS method cannot determine which indicators or constructs should be the priority to be included in the standard. As a result, the SEM approach is applied to determine the relationships between constructs and indicators to identify which construct models support the adoption of standards early in the commercialization process.

SEM is a multivariate statistical technique that combines factor analysis and regression analysis to investigate the relationships between variables in a model, either between indicators and their constructs or between the constructs themselves [30,31]. Latent variables are also known as unobserved variables, constructs, and latent constructs. Manifest variables are also known as observed, measured, and indicators. SEM combines two statistical methods: psychological factor analysis and simultaneous equation modeling developed in econometrics [32].

There have been many studies using the SEM method. SEM is a powerful tool that has been utilized to explore the public acceptance, especially towards environmental sustainability [33–35]. Previous studies have also researched the acceptance and purchase of electric vehicles using the SEM method [36,37]. Other research on the development of the TAM model as an indicator of electric taxi acceptance can also be carried out using SEM [38]. Table 1 shows the position of this research compared to the existing literature.

Table 1. State of the art of this study's field.

Authors	Study Object	Number of Constructs	Number of Indicators	FACTS	SEM
Prianjani et al. [25]	$LiFEPO_4$ battery cell standard	3	15	✓	-
Aristyawati et al. [23]	$LiFEPO_4$ battery module standard	6	-	✓	-
Rahmawatie et al. [26]	$LIFEPO_4$ battery management system standard	4	14	✓	-
Pratiwi et al. [24]	Manual wheelchair standard	7	-	✓	-
Nosi et al. [37]	The intensity of e-car purchases by millennials	6	34	-	✓
Prianjani et al. [39]	Conceptual model framework standardization and testing battery swapping in Indonesia	4	-	✓	-
Wang et al. [40]	Public acceptance of electric vehicles	12	43	-	✓
Globisch et al. [38]	Using the TAM model as an SEM indicator of electric taxi acceptance	11	-	-	✓
Zhao et al. [41]	Consumers' acceptance of electric vehicles	6	27	-	✓
Adu-Gyamfi et al. [42]	Investigating the adoption intention for battery swap technology for electric vehicles	7	27	-	✓
Gulzari et al. [43]	A young consumer electric vehicle rental behavioral model	7	27	-	✓
This study	Development of battery swap testing standards using FACTS and SEM methods	7	58	✓	✓

2.2. Open Innovation Dynamics

Innovation is one of the important elements that drive the success, sustainability, and competitive advantage of a company. Various innovation models continue to be developed to make it easier for companies to innovate, such as the open innovation model. The dynamics of open innovation continue to evolve over time. There have been many studies on models that can be applied to manage product development in the context of open innovation.

The main key to the success of open innovation is choosing the right partners so that economic performance and sustainability performance of innovation can be met simultaneously [44]. In addition, an effective open strategy can be implemented to achieve the desired competitive advantage from innovation management activities [45]. In open innovation, there are roles for government, industry, society, and universities in the innovation ecosystem to form dynamic micro-relationships that can then evolve into macro dynamics [46]. Furthermore, Yun et al. [47] explored the role of culture in driving the dynamics of open innovation, where open innovation is influenced by three-dimensional interactions, namely, entrepreneurship, intrapreneurship, and organizational entrepreneurship. There is a correlation between the types of networks that lead to collaboration and the types of innovation activities pursued and innovation outcomes realized [48].

Universities, which in this study are parties that actively carry out product research and development, have a large impact as a result of their engagement in open innovation. The administration of a university can target open innovation interactions and foster the emergence of specific university–industry relationships by providing professional assistance [49]. Universities can serve as a reliable intermediary to facilitate collaboration between multiple parties in a secure environment [50,51].

Innovation capabilities and market outcomes from open innovation depend on the strategy implemented. This can affect changes in the innovation efficiency curves resulting from the use of open innovation business models. Open innovation strategies appear in a variety of ways; hence, their effects are similarly diverse [52]. Therefore, strategic management of open innovation is vital for addressing dynamic capabilities as they relate to the right time to use open innovation. Thus, the positive and constraining aspects of open innovation in various circumstances can be identified [53].

3. Research Methodology

This study began with data collected from various sources and direct observation. We reviewed international battery swap standards for electric motorcycle applications, stakeholder requirements, standard technique adoption procedures, and SNI writing procedures. The interaction between standardization and open innovation was considered in the form of interactions between inbound and outbound processes. Inbound processes, which consider knowledge, experience, and stakeholders' needs, were utilized with the FACTS steps. Meanwhile, outbound processes, which consider deliverable standards that meet the current and future needs of stakeholders, were utilized for the SEM approach. The experiment was carried out at the battery swap mini-plant of the university, where battery swap components, battery cells, and battery modules are available to be installed on electric motorcycles.

This study uses variance-based SEM to develop exploratory SNI design models for electric motorcycle battery swap tests based on first-generation TAM theory [54]. The SNI battery test framework, which is the output of the FACTS approach, is the latent construct in developing the dependent variable of this study, i.e., perceived ease of use. This study is a continuation of previous research, where we developed the initial framework [39]. The initial framework used sequential mixed methods [55] and is illustrated in Figure 1.

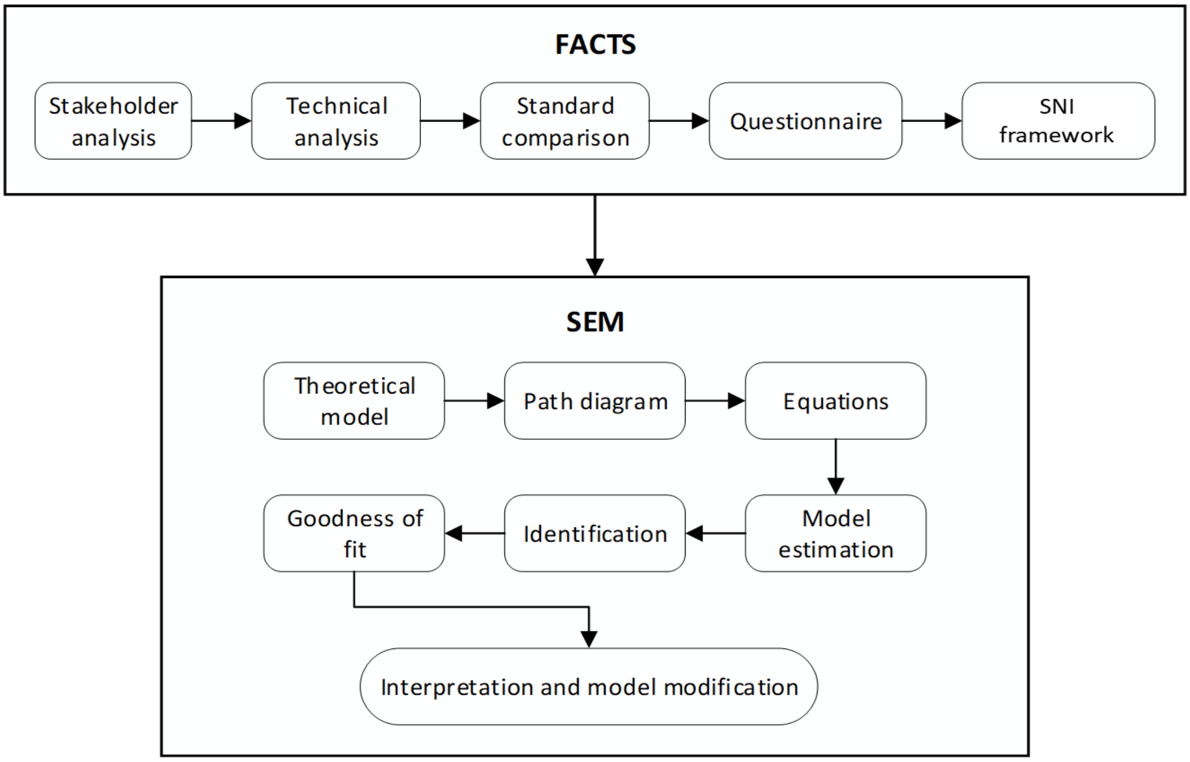

Figure 1. Sequential mixed methodology of the study.

3.1. FACTS Approach

The SNI framework was built using the FACTS approach, implemented in four stages. Stakeholders' requirements were analyzed based on the perspectives and opinions of the stakeholders, such as the government, battery swap R&D, battery swap laboratories, battery swap factories, electric motorcycle factories, and electric motorcycle users (i.e., people who have ridden an electric motorcycle). In the second stage, technical analysis was performed by converting stakeholders' opinions into technical language.

A comparison of standards was made in the third stage by analyzing the similarities and differences in the reference standard. The Zachman framework was used to identify gaps and overlaps between the reference standard and the technical specifications of stakeholder requirements at this stage. The reference standard was IEC 62840-2:2016, containing the standard battery swap requirements for electric vehicles [56]. This standard was chosen because no international standards for the battery swap test were available. The comparison of stakeholder requirements and reference standards is shown in Table 2.

Table 2. Standard comparison.

Stakeholder Requirements	Standard Reference (Adopted from IEC 62840-2:2016)
Protection against electric shock	Chapter 7
Equipment constructional requirements	Chapter 8
Electromagnetic compatibility	Chapter 9
Marking and instruction	Chapter 10

Based on an analysis of the similarities and differences in the reference standards, we subsequently conducted standard testing and verification of any testing standards that could meet the requirements of battery swap stakeholders for electric motorcycle applications in the final stage. The output of the FACTS approach was used to develop a questionnaire to create the SNI framework from the SEM analysis.

3.2. SEM Approach

SEM was used for the second stage of data processing. Domestic capacity was recapitulated based on the FACTS output to implement the proposed SNI for battery swap testing. This information was then used as the input for SEM. First, based on the problem or research hypothesis, a structural model (i.e., outer model) of the relationships between latent variables in the partial least squares was created. Then, a measurement model (i.e., inner model) was created to determine whether the indicator was reflective or formative. The path diagram was then created based on the outcomes of the external and internal model designs. Subsequently, estimation of parameters was carried out by iteration. The goodness of fit was measured to ensure the validity of the model. Finally, hypothesis testing was performed.

3.2.1. Structural Model

Four latent variables (i.e., constructs) were used in the model, namely, SNI implementation, stakeholder protection, national uniqueness, and SNI acceptance. The SNI implementation variable was obtained from data processing using the FACTS method, resulting in a non-equivalent adopted SNI based on IEC 62840-2: 2016. The stakeholder protection variable was generated from a literature review conducted previously. In addition, the national uniqueness variable was based on 10 goals of standardization [57]. Finally, the SNI acceptance variable was the outcome of this study. The exogenous latent variables identified were national uniqueness, stakeholder protection, electric shock protection, equipment constructional requirements, electromagnetic compatibility, and marking and instruction. Meanwhile, the endogenous latent variables were the SNI implementation and its success. Figure 2 depicts the structural model and variable direction based on TAM [54].

3.2.2. Measurement Model

The measurement model emphasizes the relationships among measured (i.e., observed) variables underlying the latent variables. In this study, all constructs have reflective indicators, which measure each construct. For each construct, a measurement model was developed and consisted of the following aspects:

- Manifest variable (indicator), which is denoted by X for indicators related to exogenous constructs or Y for indicators related to endogenous constructs;
- Loading factor (λ), which represents the direct correlation between construct and indicator;

- Latent variable or construct (ξ);
- Measurement error, which is denoted by δ for error related to exogenous constructs or ε for error related to endogenous constructs.

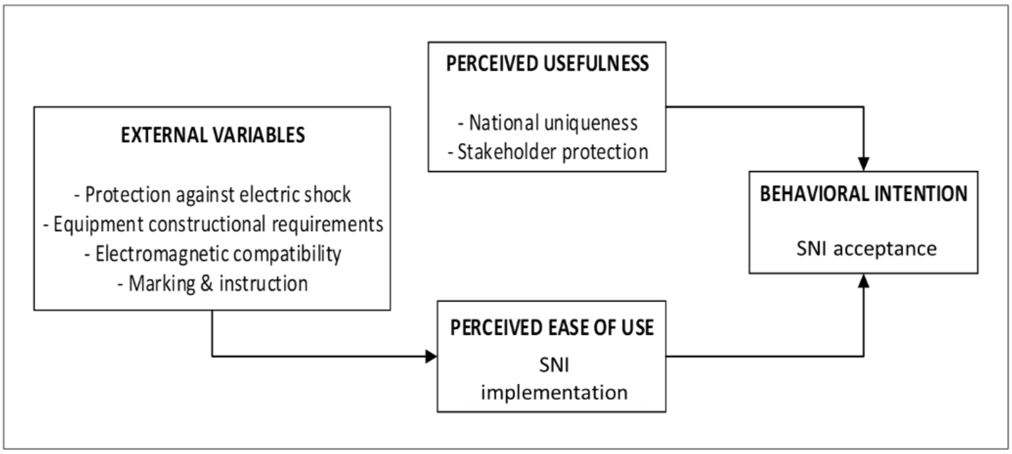

Figure 2. Structural model.

The residual regression value on endogenous latent variables denoted by ζ also contributes to the model. The regression coefficient between exogenous latent variables and endogenous latent variables is denoted by γ, while the relationship between two endogenous variables is denoted by β. Table 3 presents the proposed constructs and indicators in the SEM model, while Table 4 shows the measurement model for each construct. On the other hand, Figure 3 shows the path diagram of the SEM model.

Table 3. The construct and indicators in the SEM model.

Construct	Indicators	Code
National uniqueness	Conformity to standardization goals	A1
	Exchangeability	A2
	Diversity control	A3
	Compatibility	A4
	Increased empowerment of resources	A5
	Communication	A6
	Security, safety, and health	A7
	Environmental conservation	A8
	Technology transfer	A9
	Reducing trade barriers	A10
Protection of stakeholders	Protecting the government	B1
	Protecting battery swap R&D	B2
	Protecting battery swap laboratories	B3
	Protecting the battery swap industry	B4
	Protecting the electric motor industry	B5
	Protecting electric vehicle users	B6

Table 3. *Cont.*

Construct	Indicators	Code
Protection against electric shock	Standard contains protection against electric shock	C1
	Standard contains constructional equipment requirements	C2
	Standard contains electromagnetic compatibility	C3
	Standard contains marking and instruction	C4
	Protection against direct and indirect contact	C5
	Protection for power supply equipment	C6
	SBS charging equipment protection	C7
	Direct contact	C8
	Protection in battery enclosure	C9
	Protection regulations on coupler	C10
	Protective measures on energy with high voltage	C11
	Protective measures for unexpected events	C12
	Control signals on the shielding conductors	C13
	Additional protection	C14
	Manual reset of circuit breakers, residual current devices, and other equipment	C15
	Protection of persons in accordance with standard	C16
	Compliance of telecommunications network with standard	C17
Equipment constructional requirements	Compliance with standard	C18
	Switch	C19
	Contactor	C20
	Circuit breakers	C21
	Relay	C22
	Electrical measurements	C23
	Clearances and creepage distance	C24
	Resistance against mechanical, electrical, thermal, and environmental stresses	C25
	Minimum level of protection against mechanical impact	C26
	Material flammability and resistance against effects of solvents or liquids, vibration, and shock	C27
	Protective coating on the exposed surface in corrosion test	C28
	Enclosure stability in dry heat test	C29
	External parts of insulating material and parts are subject to heat and fire tests.	C30
	Ball pressure test	C31
	Resistance to tracking	C32
	Resistance to solar radiation	C33

Table 3. *Cont.*

Construct	Indicators	Code
Electromagnetic compatibility (EMC)	Compliance with EMC requirements of residential location	C34
	Compliance with industrial sites' EMC requirements	C35
Marking and instruction	Marked with complete information	C36
	Legible, durable, and visible marks	C37
	Prohibition of plastic usage for markings	C38
	Indication of dangerous occurrence using visual signals	C39
Conclusion	Consideration of national uniqueness and stakeholder protection	C40
	Stakeholder confidence when implementing standard	C41
	Sustainability of standard	C42

Table 4. Measurement model for each construct.

Construct	Number of Indicators	Measurement Model
National uniqueness (ξ_1)	10 ($X_1, \ldots, X_{10}$)	$X_1 = \lambda_{X1}\ \xi_{X1} + \delta_1$ (1) $X_2 = \lambda_{X2}\ \xi_{X2} + \delta_2$ (2) . . $X_9 = \lambda_{X9}\ \xi_{X9} + \delta_9$ (9) $X_{10} = \lambda_{X10}\ \xi_{X10} + \delta_{10}$ (10)
Stakeholder protection (ξ_2)	6 (($X_{11}, \ldots, X_{16}$)	$X_{11} = \lambda_{X11}\ \xi_{11} + \delta_{11}$ (11) . . $X_{16} = \lambda_{X16}\ \xi_{16} + \delta_{16}$ (16)
Protection against electric shock (ξ_3)	12 ($X_{17}, \ldots, X_{28}$)	$X_{17} = \lambda_{X17}\ \xi_{17} + \delta_{17}$ (17) . . $X_{28} = \lambda_{X28}\ \xi_{28} + \delta_{28}$ (28)
Equipment constructional requirements (ξ_4)	16 ($X_{29}, \ldots, X_{44}$)	$X_{29} = \lambda_{X29}\ \xi_{29} + \delta_{29}$ (29) .. $X_{44} = \lambda_{X44}\ \xi_{44} + \delta_{44}$ (44)
Electromagnetic compatibility (ξ_5)	2 (X_{45}, X_{46})	$X_{45} = \lambda_{X45}\ \xi_{45} + \delta_{45}$ (45) $X_{46} = \lambda_{X46}\ \xi_{46} + \delta_{46}$ (46)
Marking and instruction (ξ_6)	4 ($X_{47}, \ldots, X_{50}$)	$X_{47} = \lambda_{X47}\ \xi_{47} + \delta_{47}$ (47) .. $X_{50} = \lambda_{X50}\ \xi_{50} + \delta_{50}$ (50)
SNI implementation (η_1)	4 ($Y_1, \ldots, Y_4$)	$Y_1 = \lambda_{y1} + \varepsilon_1$ (51) . . $Y_4 = \lambda_{y4} + \varepsilon_4$ (54)
SNI acceptance (η_2)	3 (Y_5, Y_6, Y_7)	$Y_5 = \lambda_{y5} + \varepsilon_5$ (55) $Y_6 = \lambda_{y6} + \varepsilon_6$ (56) $Y_7 = \lambda_{y7} + \varepsilon_7$ (57)

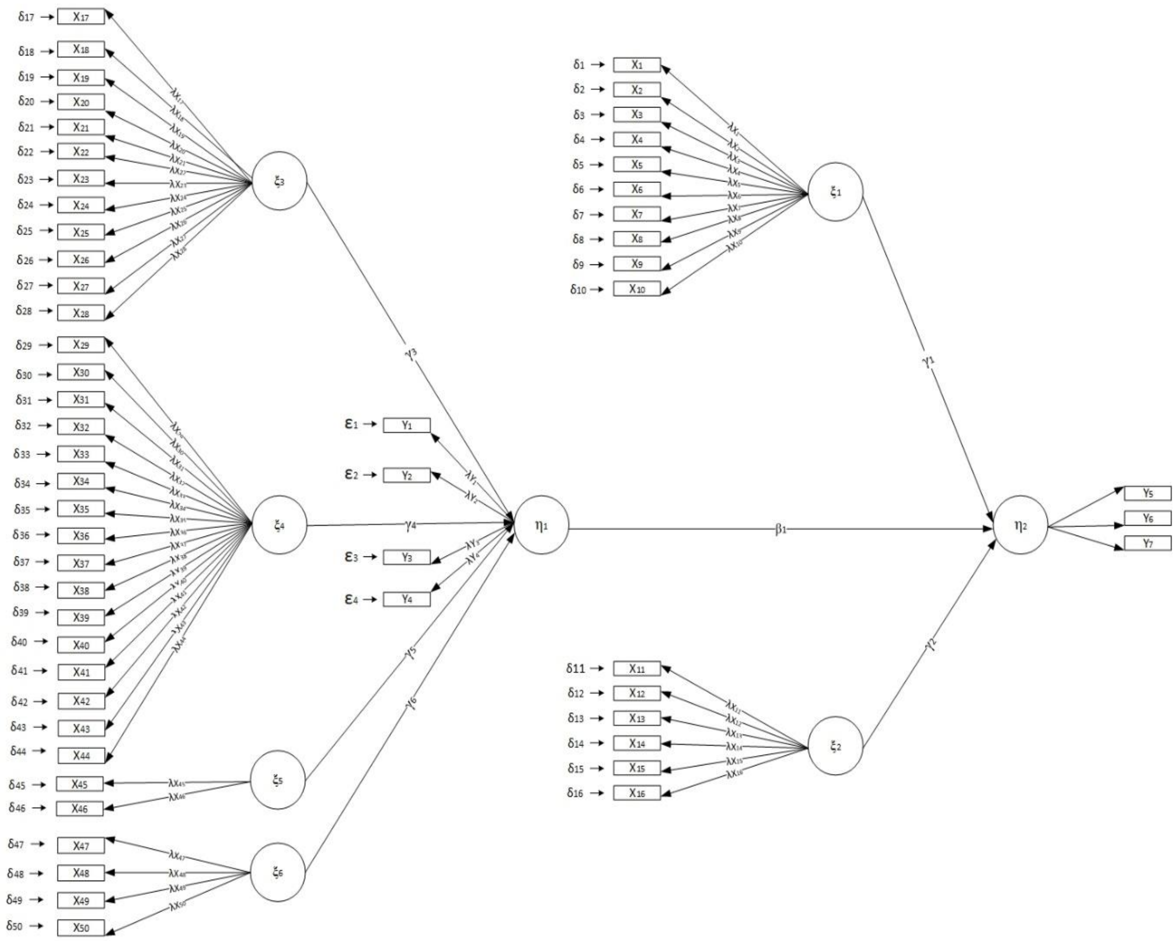

Figure 3. Path diagram of the SEM model.

This study was conducted using SmartPLS version 3.2.8. In this study, the variant-based SEM model was used. The parameter estimation method was partial least squares (PLS), which does not require the data to be normally distributed and can be performed simultaneously during data processing.

3.2.3. Model Evaluation

This stage was used to determine whether the overall model was appropriately fitted. We used goodness of fit as a metric to determine the model's validity. Table 5 shows the criteria for determining model validity and the values used in this study.

We integrated the FACTS and SEM approaches to analyze the dynamics of open innovation in the development of battery swap standards. In open innovation, there is interaction between inbound and outbound processes. The inbound processes allow us to explore external knowledge and the needs of various stakeholders with regard to battery swap standards. Meanwhile, the outbound processes entail the dissemination of the results of standard development to stakeholders. In developing standards, the FACTS approach considers all relevant stakeholders' interests that represent transparency and open participation. In addition, the SEM approach is used to validate stakeholder needs that have been processed through the FACTS approach. Therefore, the consensus principle in standardization allows interested parties to express their viewpoints and be accommodated accordingly.

Table 5. Goodness of fit.

Criteria	Description	Reference
Convergent validity of indicators	Loading factor $\geq$ 0.5	[58]
Convergent validity of constructs	Cronbach's alpha $\geq$ 0.5	[58]
Discriminant validity	Cross-loading with the $\sqrt{AVE}$ (average variance extracted) value of a construct and the correlation of that construct with other constructs. The $\sqrt{AVE}$ value for each construct must be greater than the correlation value between constructs and other constructs	[58]
Collinearity assessment	$VIF \geq 0.2$ or $VIF \leq 5$	[59]
Path coefficient	The path coefficient values range from −1 to +1.The minimum path coefficient value is 0.2, and the ideal is more significant than 0.3 to express a meaningful relationship	[60]
Coefficient of determination (R^2)	Square adjusted value $\geq$ 0.25	[61]
Effect size f^2	Large (f^2 = 0.35), medium (f^2 = 0.15), small (f^2 = 0.02)	[61]
Predictive relevance Q^2	Certain endogenous constructs have predictive relevance if Q^2 = 0	[60]
Effect size q^2	Large (q^2 = 0.35), medium (q^2 = 0.15), small (f^2 = 0.002)	[60]
Hypothesis test	t-Value $\geq$ t-table	Hypothesis acceptance rules

4. Results

In this section, we evaluate items about outer model analysis, inner model analysis, and hypothesis testing.

4.1. Outer Model Analysis

In this section, the items evaluated include the convergent validity of indicators, the convergent validity of constructs, and discriminant validity. Convergent validity is used to show the correlation between indicators of the same construct. Table 6 presents the results of the calculation of outer loading for the convergent validity of indicators. At the same time, Figure 4 shows the model in which the outer loading passes the convergent validity of indicators. Next, we also evaluated the convergent validity for each construct (latent variable). This is a combination of all reliability indicators for the corresponding construct. Table 7 presents the Cronbach's alpha for each construct. We then evaluated the discriminant validity using the cross-loading method (or $\sqrt{AVE}$ value). Table 8 shows the results of cross-loading of the latent variable.

Table 6. Convergent validity of indicators.

Construct	Indicators	Loading Factor	Decision	
			Valid	Not Valid
National uniqueness	A1	0.288		✓
	A2	−0.022		✓
	A3	0.787	✓	
	A4	−0.359		✓
	A5	0.662	✓	
	A6	0.650	✓	
	A7	0.513	✓	
	A8	0.621	✓	
	A9	−0.186		✓
	A10	0.366		✓

Table 6. *Cont.*

Construct	Indicators	Loading Factor	Decision	
			Valid	Not Valid
Stakeholder protection	B1	−0.076		✓
	B2	0.563	✓	
	B3	0.852		✓
	B4	0.026		✓
	B5	0.716	✓	
	B6	−0.112		✓
SNI implementation	C1.1	0.876	✓	
	C1.2	0.374		✓
	C1.3	−0.114		✓
	C1.4	0.890	✓	
Protection against electric shock	C2.1	0.135		✓
	C2.2	0.609	✓	
	C2.3	−0.132		✓
	C2.4	0.647	✓	
	C2.5	0.116		✓
	C2.6	0.327		✓
	C2.7	0.028		✓
	C2.8	0.439		✓
	C2.9	0.599	✓	
	C2.10	0.734	✓	
	C2.11	0.450		✓
	C2.12	0.469		✓
Equipment constructional requirements	C3.1	−0.353		✓
	C3.2	−0.005		✓
	C3.3	0.377		✓
	C3.4	0.611	✓	
	C3.5	0.589	✓	
	C3.6	0.701	✓	
	C3.7	0.511	✓	
	C3.8	0.214		✓
	C3.9	0.245		✓
	C3.10	−0.233		✓
	C3.11	0.533	✓	
	C3.12	0.114		✓
	C3.13	0.102		✓
	C3.14	0.172		✓
	C3.15	−0.253		✓
	C3.16	−0.238		✓
Electromagnetic compatibility	C4.1	−0.765		✓
	C4.2	0.977	✓	
Marking and instruction	C5.1	−0.655		✓
	C5.2	0.361		✓
	C5.3	0.449	✓	
	C5.4	−0.197		✓
SNI acceptance	C6.1	0.003		✓
	C6.2	0.640	✓	
	C6.3	0.934	✓	

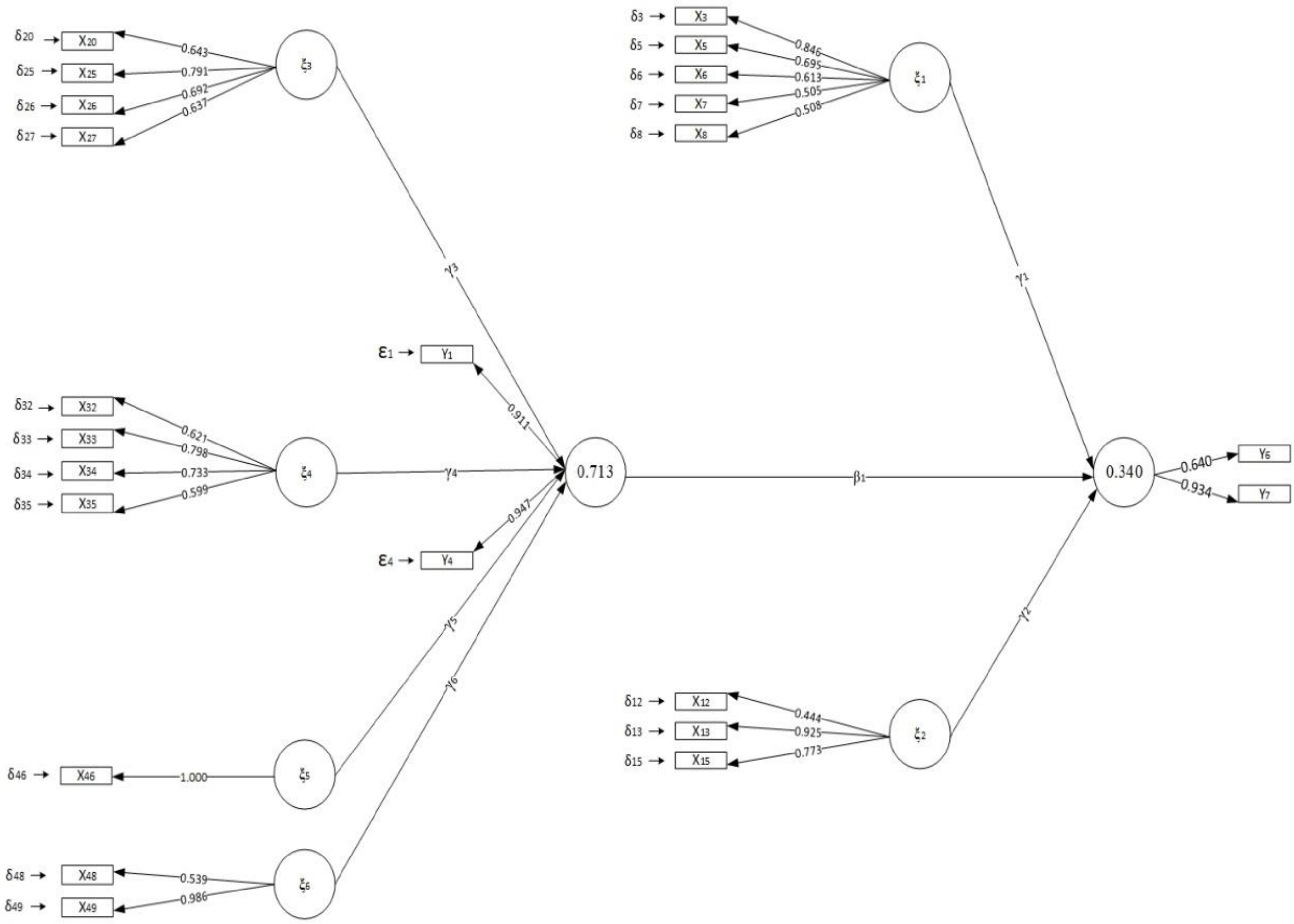

Figure 4. Indicators of outer loading that passed the convergent validity.

Table 7. Convergent validity of constructs.

Construct	Cronbach's Alpha	Decision	
		Valid	Not Valid
National uniqueness	0.678	✓	
Stakeholder protection	0.586	✓	
SNI implementation	0.844	✓	
Protection against electric shock	0.648	✓	
Equipment constructional requirements	0.628	✓	
Electromagnetic compatibility	1.000	✓	
Marking and instruction	0.564	✓	
SNI acceptance	0.516	✓	

Table 8. Discriminant validity.

Construct (Latent Variable)	Electromagnetic Compatibility	Equipment Constructional Requirements	SNI Implementation	SNI Acceptance	National Uniqueness	Marking and Instruction	Stakeholder Protection	Protection against Electric Shock
Electromagnetic compatibility	1.000							
Equipment constructional requirements		0.832						
SNI implementation		0.831	0.964					
SNI acceptance		0.542	0.561	0.886				
National uniqueness	0.528	0.661	0.469	0.736	0.810			
Marking and instruction	0.167		0.405			0.892		
Stakeholder protection	0.342	0.650	0.789	0.597	0.577		0.861	
Protection against electric shock	0.486	0.706	0.772	0.594	0.643	0.187	0.696	0.832

4.2. Inner Model Analysis

Inner model analysis can be performed when the outer model analysis shows valid results. Inner model analysis was carried out by assessing several items: the constructs' collinearity, the value and significance of the path coefficients, the coefficient of determination R^2, the effect size f^2, the predictive relevance Q^2, and the size effect q^2.

Collinearity assessment is used to see whether there is high collinearity or correlation in the path-building model. If the generated *VIF* value is >5, it indicates a collinearity problem. Table 9 presents the collinearity assessment for the model used in this study.

Table 9. Collinearity assessment.

Construct	Indicators	VIF	Decision
National uniqueness	A3	1.700	Valid
	A5	1.184	Valid
	A6	1.421	Valid
	A7	1.226	Valid
	A8	1.241	Valid
Stakeholder protection	B2	1.048	Valid
	B3	1.526	Valid
	B5	1.532	Valid
SNI implementation	C1.1	2.140	Valid
	C1.4	2.140	Valid
Protection against electric shock	C2.4	1.168	Valid
	C2.9	2.080	Valid
	C2.10	1.203	Valid
	C2.11	1.972	Valid
Equipment constructional requirements	C3.4	2.505	Valid
	C3.5	2.401	Valid
	C3.6	1.582	Valid
	C3.7	2.217	Valid
Electromagnetic compatibility	C4.2	1.000	Valid
Marking and instruction	C5.2	1.182	Valid
	C5.3	1.182	Valid
SNI acceptance	C6.2	1.137	Valid
	C6.3	1.137	Valid

Table 10 shows the relationship between the variables stated in the hypothesis. The path coefficient values range from −1 to +1. A path coefficient value close to +1 indicates a strong positive relationship between the variables, while a path coefficient value close to −1 indicates a strong negative relationship. The generated path coefficients are presented in Table 8.

Table 10. Path coefficients.

Hypothesis	Path	Path Coefficient
H1	Electromagnetic compatibility → SNI implementation	−0.218
H2	Equipment constructional requirements → SNI implementation	0.513
H3	Marking and instruction → SNI implementation	0.244
H4	Protection against electric shock → SNI implementation	0.384
H5	SNI implementation → SNI acceptance	0.143
H6	National uniqueness → SNI acceptance	0.473
H7	Stakeholder protection → SNI acceptance	0.109

The coefficient of determination (R^2) is used to show the predictive power of the path model. The value of R^2 ranges from 0 to 1. The value of R^2, which is close to 1, indicates that the prediction accuracy is getting stronger. Table 11 shows the coefficients of determination for the inner model in this study.

Table 11. Coefficients of determination.

	R^2	R^2 Adjusted	Accuracy
SNI implementation	0.664	0.657	Strong
SNI acceptance	0.340	0.329	Medium

The effect size f^2 can be used to determine the effect of an exogenous variable on the related endogenous variable. Table 12 presents the f^2 values for each path.

Table 12. Path coefficients.

Hypothesis	Path	f^2	Effect Size
H1	Electromagnetic compatibility → SNI implementation	0.121	Medium
H2	Equipment constructional requirements → SNI implementation	0.513	Large
H3	Marking and instruction → SNI implementation	0.168	Medium
H4	Protection against electric shock → SNI implementation	0.283	Large
H5	SNI implementation → SNI acceptance	0.019	Small
H6	National uniqueness → SNI implementation	0.301	Large
H7	Stakeholder protection → SNI acceptance	0.010	Small

The predictive relevance Q^2 aims to see how well the path model can predict the original observed value. The assessment Q^2 value is determined using the stipulation that if the value of Q^2 is more significant than zero, then a particular endogenous construct has predictive relevance. The predictive relevance values for the model are presented in Table 13.

Table 13. Predictive relevance.

Latent Variable	SSO	SSE	Q^2 = (1 − SSE/SSO)
Electromagnetic compatibility	190,000	190,000	0
Equipment constructional requirements	760,000	760,000	0
SNI implementation	380,000	174,968	0.540
SNI acceptance	380,000	317,710	0.164
National uniqueness	950,000	950,000	0
Marking and instruction	380,000	380,000	0
Stakeholder protection	570,000	570,000	0
Protection against electric shock	760,000	760,000	0

The value effect size q^2 is obtained by comparing the Q^2 value when all exogenous variables are involved in the path model analysis with the Q^2 value when one of the exogenous variables is omitted in the path model analysis. The q^2 value in this study is determined as follows:

$$q^2 = \frac{Q^2_{complete} - Q^2_{ommited}}{1 - Q^2_{complete}} = \frac{0.719 - 0.180}{1 - 0.719} = 1.922$$

4.3. Hypothesis Test

Hypothesis testing in this study uses a significance level of 0.15. The proposed hypothesis has a positive direction. Therefore, the test conducted is a one-tailed test with the number of variables (k) = 8 and the number of respondents (n) = 190 [62]. A hypothesis is accepted if the following conditions are met:

- The path coefficient is in the same direction as the proposed hypothesis, which is positive for a hypothesis that says "has a positive influence" or negative for a hypothesis that says "has a negative influence".
- t-Value $\geq$ t-table.

The results of the hypothesis testing are presented in Table 14.

Table 14. Hypothesis test.

Hypothesis	Path	Path Coefficient	*t*-Value	*t*-Table	Decision
H1	Electromagnetic compatibility has a positive effect on SNI implementation	−0.218	4.237	1.042	Accepted
H2	Equipment constructional requirements have a positive effect on SNI implementation	0.513	9.315	1.042	Accepted
H3	Marking and instruction have a positive effect on SNI implementation	0.244	3.097	1.042	Accepted
H4	Protection against electric shock has a positive effect on SNI implementation	0.384	7.479	1.042	Accepted
H5	SNI implementation has a positive effect on SNI acceptance	0.143	1.636	1.042	Accepted
H6	National uniqueness has a positive effect on SNI acceptance	0.473	5.755	1.042	Accepted
H7	Stakeholder protection has a positive effect on SNI acceptance	0.109	1.123	1.042	Accepted

5. Discussions

5.1. SEM outer Model Analysis

5.1.1. Convergent Validity of Indicators

Convergent validity is a measure that shows how much the indicator has a positive correlation with other indicators of the same construct. For research indicators that are still newly developed and have not been tested, the minimum value of outer loading is 0.5 or more [58], so that indicators with an outer loading of less than 0.5 will be removed. Removal of indicators with an extreme loading value of less than 0.5 is carried out gradually, starting from the smallest outer loading value. Every time an indicator is removed, the outer loading value is rechecked until the outer loading indicator is more than 0.5. In the SEM model with reflective indicators, the direction of the causality is from the latent variable to the indicator, which means that the latent variable determines the indicators, so all reflective indicators must have a high correlation with the latent variables. Because all indicators must have a high correlation, reducing the indicator should not change the meaning of the latent variable. An outer loading value of 0.5 or more means that the indicator has a 50% contribution to building its latent variable's constructor [59].

In the latent construct of national uniqueness, five indicators were removed: A1, A2, A4, A9, and A10.

- A1 (Battery swap components, such as battery cells, modules, and packs, must have passed the safety test)

A1 has the purpose represented by A7, which contains "test standards for swap battery products which aim to ensure safety and health for users of swap battery products". Therefore, if A1 is removed, it does not change the meaning of the construct of national uniqueness.

- A2 (Standard dimensions of swapped batteries' size, voltage, and electric current are required at all battery swap charging stations throughout Indonesia to produce equivalent performance and power without making changes or adjustments.)

The A2 indicator has the intent and purpose represented by the A5 indicator, which contains "the use of swap batteries to reduce the waste of resources (time, people, and capital)". Reduced waste of resources when using swapped batteries can be obtained if the minimum standard is implemented; hence, there are no significant differences between battery swap brands. The differences between battery swap brands can directly affect consumers and disrupt the supply chain's flow [2]. Therefore, if A2 is removed, it does not change the meaning of the construct of national uniqueness.

- A4 (Process suitability of swapped batteries for concurrent use with other relevant products without creating unnecessary interactions)

The purpose of the A4 indicator can be represented by A3, which contains the "application of standard dimensions of size, voltage and electric current of swap batteries to all battery swap stations to minimize unnecessary differences". Applying the minimum specifications for swapped batteries can minimize the differences that can harm consumers if there is more than one battery swap brand that consumers can use [63].

Three indicators were removed in the latent construct of stakeholder protection because B2, B3, and B5 can represent them, and each stakeholder can represent more than one perspective [22]. The removed indicators were as follows:

- B1 (The application of the battery swap test standard is expected to protect the interests of the government)
- B4 (The application of the battery swap test standard is expected to protect the interests of battery swap manufacturers)
- B6 (The application of the battery swap test standard is expected to protect the interests of electric motorcycle users)

Meanwhile, two indicators were removed in the latent construct of SNI implementation. These indicators included C1.2 (Battery test standards contain equipment constructional requirements) and C1.3 (Battery test standards contain electromagnetic compatibility). The question for C1.2 and C1.3 is a question of redundancy that contains the effects of the equipment constructional requirements and electromagnetic compatibility constructs on the SNI implementation construct, which can be calculated during model analysis in SEM. Therefore, the elimination of C1.2 and C1.3 does not affect the meaning of the SNI implementation construct.

Furthermore, we removed several indicators from the remaining constructs. The elimination of these indicators was based on the survey conducted at the lithium battery R&D center in Indonesia. This elimination indicates that battery swap stakeholders in Indonesia have not completely fulfilled the requirements stated in these indicators. However, several requirements can be fulfilled, but the stakeholders have not followed the reference standard rules. For example, C2.1 was removed because stakeholders in Indonesia have developed a battery that is safe against electric shock but is not compliant with IEC 60204-1:2016. C2.3 was removed because stakeholders have developed a battery that protects SBS charging equipment but is not compliant with IEC 61851-23:2014. Table 15 shows the reference standards that stakeholders have not fulfilled for each removed indicator.

Table 15. Unfulfilled reference standards.

Construct	Removed Indicators	Standards
Protection against electric shock	C2.1	IEC 60204-1:2016
	C2.3	IEC 61851-23:2014
	C2.5	IPXXB
	C2.6	IPXXB
	C2.7	IEC 60364-4-41: 2005+AMD: 2017 CSV
	C2.8	IEC 60364-4-41:2005
	C2.11, C2.12	IEC 60364 series, IEC 60479 series, IEC TR 60755:2017, IEC 61008 series, IEC 61009 series, IEC 60947-2
Equipment constructional requirements	C3.1	IEC 61439-1:2011
	C3.2	IEC 60947-3:2008+AMD1:2012+AMD2:2015 CSV
	C3.3	IEC 60947-4-1:2018
	C3.9	IEC 62262:2002
	C3.12	IEC 61439-1:2011
	C3.13	IEC 60695-2-11
	C3.14	IEC 60695-10-2
	C3.15	IEC 60112:2003+AMD1:2009 CSV
	C3.16	IEC 61439-1:2011
Electromagnetic compatibility	C4.1	IEC 61000 series, IEC 61851-21-2:2018

5.1.2. Convergent Validity of Constructs

A construct is valid if its Cronbach's alpha value is above 0.5 for new untested instruments [58]. In this study, all constructs had values above 0.5. Therefore, it can be said that all constructs are valid.

5.1.3. Discriminant Validity

Discriminant validity shows that a construct is different from other constructs, is unique, and captures phenomena not captured by other constructs. Discriminant validity at the construct level was determined by comparing the $\sqrt{AVE}$ value of a construct with the construct's correlation with other constructs. The $\sqrt{AVE}$ value for each construct must be greater than the correlation value between constructs and other constructs. This assessment is based on the Fornell–Larcker criteria [58]. In this study, the $\sqrt{AVE}$ value of a construct had the most significant value compared to the correlation values between constructs and other constructs. Thus, this research can be considered valid.

5.2. SEM inner Model Analysis

5.2.1. Collinearity Assessment

Collinearity assessment uses the provision that if the *VIF* value is more than five, then latent variable collinearity occurs. This study found no collinearity assessment with a VIF value below five.

5.2.2. Path Value and Significance

The path value and significance test the significance level of a path coefficient via the bootstrap procedure. The minimum path coefficient value is 0.2, and it is ideally greater than 0.3 to indicate a meaningful relationship [60]. In this study, the path coefficient value for the electromagnetic compatibility towards SNI implementation was negative.

5.2.3. Coefficient of Determination

The coefficient of determination is a value indicating the variance of the endogenous product caused by all of the exogenous variables connected to it. Chin [60] stated that the value of R^2 is high, medium, and small if it is 0.67, 0.33, and 0.19, respectively. The R^2 value used is the adjusted R^2 value for the model's number of predictors. The R^2 value of SNI implementation was 0.657, categorized as vital, while the R^2 value of the SNI acceptance variable was 0.329, categorized as moderate.

5.2.4. Effect Size f^2

The effect size f^2 was used to evaluate the SEM structural model. In this research, the relationships with a significant influence when an exogenous variable is removed were the relationships of equipment constructional requirements with SNI implementation and of protection against electric shock with SNI implementation. The relationships with moderate influence were the relationships of electromagnetic compatibility with SNI implementation and of marking and instruction with SNI implementation. The relationships with little influence were those of SNI implementation with SNI acceptance and of stakeholder protection with SNI acceptance.

5.2.5. Predictive Relevance

When the SEM path model shows predictive relevance, the path model can accurately predict data that are not used in evaluating the model. This study has a predictive relevance of 0.540 to the SNI implementation variable and of 0.180 to the SNI acceptance.

5.2.6. Effect Size q^2

Effect size q^2 was used to determine the exogenous effect on the Q^2 value of endogenous variables. In this study, the q^2 value was 0.1922, meaning that removing one of the exogenous variables in the pathway model has moderate predictive relevance for certain endogenous constructs.

5.2.7. Hypothesis Test

A hypothesis test was conducted by comparing the *t*-table and *t*-value. The research hypothesis is accepted if the *t*-value is greater than the *t*-table. In this study, all hypotheses were accepted.

5.3. Policy Implications

The findings and outputs obtained from this research can be used as a policy brief for the development of standards and to support the provision of recommendations and options in formulating policies related to the charging and exchange infrastructure for electric vehicle batteries. The results of this study can provide input for the draft SNI battery swap concept to the technical committee in charge of developing the SNI. Thus, this study can be used as a basis for considering the selection of standard parameters and is expected to support the effectiveness of standard development until the SNI is officially formulated.

This research is consistent with the principles of SNI formulation, namely, openness and consensus. It involves interested parties in the standardization of electric vehicles, including the government, battery swap R&D, battery swap laboratories, battery swap manufacturers, electric motorcycle manufacturers, and electric motorcycle users. We are open to these stakeholders so that they know about the SNI development program, and we provide equal opportunities for them to participate in the formulation of this SNI by exploring their opinions and needs related to battery swap standards and accommodating their needs in determining standard parameters. With this participation, the parties involved become aware of the importance of the current problem, so it is expected that in the future they would be willing to adopt the SNI that has been formulated and participate in the success of the electric vehicle acceleration program in Indonesia. Thus, this research supports the climate for developing electric vehicle policies and encourages the acceptance of the SNI in the community.

The dynamics of open innovation are an important aspect to pay attention to in early standardization. The engagement of various parties—such as industry, government, society, academics, and developers—comprises the interaction required in developing a standard battery swap. The engagement of stakeholders can enhance the effectiveness and capability of the early standardization process. Therefore, it can better facilitate the product development process of battery swaps.

6. Conclusions

An SNI for battery testing that is globally competitive was designed through data processing with the FACTS method, referring to international standards, namely, the IEC 62840-2: 2016 standard regarding Electric Vehicle Battery Swap Systems–Part 2: Safety Requirements. Test variables in the SNI battery test include protection against electric shock, equipment constructional requirements, electromagnetic compatibility, and marking and instruction. The SNI for battery swap testing was designed through data processing validation using SEM.

The proposed constructs—i.e., electromagnetic compatibility, equipment construction requirements, marking and instruction, and protection against electric shock—positively affect SNI implementation. Meanwhile, the SNI implementation, national uniqueness, and stakeholder protection positively affect SNI acceptance. Therefore, it can be said that SNI acceptance can be obtained by considering SNI implementation, national identity, and stakeholder protection. An SEM model was designed for formal acceptance through the development of the technology acceptance model (TAM), which considers the variables of perceived ease of use, perceived usefulness, and attitudes towards use.

The validation results using SEM indicate that all hypotheses were accepted. Because all of the hypotheses were proven correct, the research framework that was developed by applying FACTS and SEM can be used for early standardization. This means that the standardization of each process should accompany the development of battery swap products.

Standardization as a catalyst of open innovation has shown through analysis that implementation, national uniqueness, and stakeholder protection positively affect SNI acceptance. The open innovation approach was considered to integrate a FACTS and SEM approach to generate significant parameters of swappable battery standards. Further research of open innovation and standardization will be more complex not only for swappable batteries, but also for smart connected products. Thus, interoperability of standardization is a crucial area for further study.

Author Contributions: Conceptualization, W.S. and F.F.; methodology, W.S., D.P. and E.P.; software, D.P.; validation, W.S., D.P. and F.F.; formal analysis, D.P.; data curation, D.P.; writing—original draft preparation, W.S., D.P., A.R. and T.O.K.; writing—review and editing, W.S., D.P., A.R. and T.O.K.; supervision, W.S. and E.P.; project administration, W.S. and F.F.; funding acquisition, W.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partially supported by the LPPM (Institute for Research and Community Service) Universitas Sebelas Maret under the "*Program Flagship Prioritas Riset Nasional Untuk Perguruan Tinggi*" Program FY 2021 (Contract no.: 2883/UN27.22/PT.01.03/2021).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to thank Universitas Sebelas Maret for supporting this research.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Statistics Indonesia Number of Motor Vehicle by Type (Unit), 2018–2020. Available online: https://www.bps.go.id/indicator/17/57/1/jumlah-kendaraan-bermotor.html (accessed on 18 June 2020).
2. Prianjani, D.; Sutopo, W.; Hisjam, M.; Pujiyanto, E. Sustainable supply chain planning for swap battery system: Case study electric motorcycle applications in Indonesia. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *495*, 12081. [CrossRef]
3. Government of the Republic of Indonesia. *Acceleration of Battery-Based Electric Motorized Vehicles for Battery Electric Vehicle for Road Transportation*; Government of the Republic of Indonesia: Jakarta, Indonesia, 2019.
4. Sutopo, W.; Aqidawati, E.F. Learning a Supply Chain Management Course by Problem Based Learning: Case Studies in the Newspaper Industry. In Proceedings of the International Conference on Industrial Engineering and Operations Management, Bangkok, Thailand, 5–7 March 2019; pp. 5–7.
5. Government of the Republic of Indonesia Laws of the Republic Indonesia Number 20 of 2014 about Standardization and Assessment of Compatibility. Available online: https://www.bsn.go.id/uploads/download/UU-20_TAHUN_2014_TENTANG_SPK1.pdf (accessed on 10 March 2019).
6. Ministry of Trade of the Republic of Indonesia. *Final Report of the Standard Needs Assessment in the Dimensions of Competitiveness and Consumer Protection*; Ministry of Trade of the Republic of Indonesia: Jakarta, Indonesia, 2013.
7. Stella, J. The Problem with Early Standardization. Available online: https://bit.ly/31pNznM (accessed on 17 June 2020).
8. Riitta, S. Managing Change towards Lean Enterprises. *Int. J. Oper. Prod. Manag.* **1994**, *14*, 66–82. [CrossRef]
9. Fadillah, H.; Jusuf, A.; Santosa, S.P.; Dirgantara, T. Li-ion NCA Battery Safety Assessment for Electric Vehicle Applications. In Proceedings of the 2018 5th International Conference on Electric Vehicular Technology (ICEVT), Surakarta, Indonesia, 30–31 October 2018; pp. 172–178.
10. McNerney, J.; Needell, Z.A.; Chang, M.T.; Miotti, M.; Trancik, J.E. TripEnergy: Estimating Personal Vehicle Energy Consumption Given Limited Travel Survey Data. *Transp. Res. Rec. J. Transp. Res. Board* **2017**, *2628*, 58–66. [CrossRef]
11. Needell, Z.A.; Trancik, J.E. Efficiently Simulating Personal Vehicle Energy Consumption in Mesoscopic Transport Models. *Transp. Res. Rec. J. Transp. Res. Board* **2018**, *2672*, 163–173. [CrossRef]
12. Sutopo, W.; Rahmawatie, B.; Fahma, F.; Nizam, M.; Purwanto, A.; Louhenapessy, B.B.; Kadir, E.A. A technical review of BMS performance standard for electric vehicle applications in Indonesia. *Telkomnika* **2018**, *16*, 544–549. [CrossRef]
13. Sutopo, W.; Kadir, E.A. Designing framework for standardization case study: Lithium-ion battery module in electric vehicle application. *Int. J. Electr. Comput. Eng.* **2018**, *8*, 220. [CrossRef]
14. Trancik, J.E. Renewable energy: Back the renewables boom. *Nature* **2014**, *507*, 300–302. [CrossRef]
15. Ahmed, M.; Kim, Y.-C. Energy Trading with Electric Vehicles in Smart Campus Parking Lots. *Appl. Sci.* **2018**, *8*, 1749. [CrossRef]
16. Chen, P.-T.; Shen, D.-J.; Yang, C.-J.; Huang, K.D. Development of a Hybrid Electric Motorcycle that Accords Energy Efficiency and Controllability via an Inverse Differential Gear and Power Mode Switching Control. *Appl. Sci.* **2019**, *9*, 1787. [CrossRef]
17. Hu, J.; Jiang, X.; Jia, M.; Zheng, Y. Energy Management Strategy for the Hybrid Energy Storage System of Pure Electric Vehicle Considering Traffic Information. *Appl. Sci.* **2018**, *8*, 1266. [CrossRef]
18. Lee, H.-J.; Cha, H.-J.; Won, D. Economic Routing of Electric Vehicles using Dynamic Pricing in Consideration of System Voltage. *Appl. Sci.* **2019**, *9*, 4337. [CrossRef]
19. Long, Y.; Zhang, Y.; Sun, H.; Hou, X.; Xiao, J. A Developed Vehicle Terminal of Time-Sharing Rental Electric Vehicle Using Acoustic Communication Technology. *Appl. Sci.* **2019**, *9*, 5408. [CrossRef]
20. Oldenbroek, V.; Smink, G.; Salet, T.; van Wijk, A.J.M. Fuel Cell Electric Vehicle as a Power Plant: Techno-Economic Scenario Analysis of a Renewable Integrated Transportation and Energy System for Smart Cities in Two Climates. *Appl. Sci.* **2019**, *10*, 143. [CrossRef]

21. Sutopo, W.; Astuti, R.W.; Suryandari, R.T. Accelerating a Technology Commercialization; with a Discussion on the Relation between Technology Transfer Efficiency and Open Innovation. *J. Open Innov. Technol. Mark. Complex.* **2019**, *5*, 95. [CrossRef]
22. Witherell, P.; Rachuri, S.; Narayanan, A.; Lee, J.H. *FACTS: A Framework for Analysis, Comparison, and Testing of Standards*; Systems Integration Division Engineering Laboratory, US Department of Commerce: Washington, DC, USA, 2013.
23. Aristyawati, N.; Fahma, F.; Sutopo, W.; Purwanto, A.; Nizam, M.; Louhenapessy, B.B.; Mulyono, A.B. Designing framework for standardization and testing requirements for the secondary battery a case study of lithium-ion battery module in electric vehicle application. In Proceedings of the 2016 2nd International Conference of Industrial, Mechanical, Electrical, and Chemical Engineering (ICIMECE), Yogyakarta, Indonesia, 6–7 October 2016; pp. 207–212.
24. Pratiwi, R.A.; Fahma, F.; Sutopo, W.; Pujiyanto, E.; Ayundyahrini, M. Designing Parameter for Developing Standard of Manual Wheelchair. *Int. J. Appl. Sci. Eng.* **2018**, *15*, 127–134.
25. Prianjani, D.; Fahma, F.; Sutopo, W.; Nizam, M.; Purwanto, A.; Louhenapessy, B.B.; Mulyono, A.B. The standard development for the National Standard of Indonesian (SNI) of the cell traction battery Lithium-ion Ferro phospate secondarry for electric vehicles applications. In Proceedings of the 2016 2nd International Conference of Industrial, Mechanical, Electrical, and Chemical Engineering (ICIMECE), Yogyakarta, Indonesia, 6–7 October 2016; pp. 213–218.
26. Rahmawatie, B.; Sutopo, W.; Fahma, F.; Purwanto, A.; Nizam, M.; Louhenapessy, B.B.; Mulyono, A.B. Designing framework for standardization and testing requirements of battery management system for electric vehicle application. In Proceedings of the 2017 4th International Conference on Electric Vehicular Technology (ICEVT), Bali, Indonesia, 2–5 October 2017; pp. 7–12.
27. Pīlēna, A.; Mežinska, I.; Lapiņa, I. Standardization as a Catalyst for Open and Responsible Innovation. *J. Open Innov. Technol. Mark. Complex.* **2021**, *7*, 187. [CrossRef]
28. Chesbrough, H. Open innovation: A new paradigm for understanding industrial innovation. *Open Innov. Res. New Paradig.* **2006**, *400*, 1–19.
29. West, J.; Gallagher, S. Challenges of open innovation: The paradox of firm investment in open-source software. *R&D Manag.* **2006**, *36*, 319–331.
30. Kaplan, D. *Structural Equation Modeling: Foundations and Extensions*; Sage Publications: New York, NY, USA, 2008; Volume 10, ISBN 1452245126.
31. Kline, R.B. *Principles and Practice of Structural Equation Modeling*, 3rd ed.; Guilford: New York, NY, USA, 2011.
32. Ghozali, I.; Latan, H. *Partial Least Squares Konsep, Teknik dan Aplikasi Menggunakan Program Smartpls 3.0 Untuk Penelitian Empiris*; Badan Penerbit UNDIP: Semarang, Indonesia, 2015.
33. Pfoser, S.; Schauer, O.; Costa, Y. Acceptance of LNG as an alternative fuel: Determinants and policy implications. *Energy Policy* **2018**, *120*, 259–267. [CrossRef]
34. Qi, W.H.; Qi, M.L.; Ji, Y.M. The effect path of public communication on public acceptance of nuclear energy. *Energy Policy* **2020**, *144*, 111655. [CrossRef]
35. Zaman, S.; Wang, Z.; Rasool, S.F.; uz Zaman, Q.; Raza, H. Impact of critical success factors and supportive leadership on sustainable success of renewable energy projects: Empirical evidence from Pakistan. *Energy Policy* **2022**, *162*, 112793. [CrossRef]
36. Will, C.; Schuller, A. Understanding user acceptance factors of electric vehicle smart charging. *Transp. Res. Part C Emerg. Technol.* **2016**, *71*, 198–214. [CrossRef]
37. Nosi, C.; Pucci, T.; Silvestri, C.; Aquilani, B. Does Value Co-Creation Really Matter? An Investigation of Italian Millennials Intention to Buy Electric Cars. *Sustainability* **2017**, *9*, 2159. [CrossRef]
38. Globisch, J.; Dütschke, E.; Schleich, J. Acceptance of electric passenger cars in commercial fleets. *Transp. Res. Part A Policy Pract.* **2018**, *116*, 122–129. [CrossRef]
39. Prianjani, D.; Sutopo, W.; Pujiyanto, E.; Fahma, F. Designing framework for standardization and testing requirements of battery swap for electric motorcycle application in Indonesia. *Int. J. Appl. Sci. Eng.* **2018**, *15*, 141–148.
40. Wang, N.; Tang, L.; Pan, H. Analysis of public acceptance of electric vehicles: An empirical study in Shanghai. *Technol. Forecast. Soc. Chang.* **2018**, *126*, 284–291. [CrossRef]
41. Zhao, X.; Ma, Y.; Shao, S.; Ma, T. What determines consumers' acceptance of electric vehicles: A survey in Shanghai, China. *Energy Econ.* **2022**, *108*, 105805. [CrossRef]
42. Adu-Gyamfi, G.; Song, H.; Obuobi, B.; Nketiah, E.; Wang, H.; Cudjoe, D. Who will adopt? Investigating the adoption intention for battery swap technology for electric vehicles. *Renew. Sustain. Energy Rev.* **2022**, *156*, 111979. [CrossRef]
43. Gulzari, A.; Wang, Y.; Prybutok, V. A green experience with eco-friendly cars: A young consumer electric vehicle rental behavioral model. *J. Retail. Consum. Serv.* **2022**, *65*, 102877. [CrossRef]
44. Rauter, R.; Globocnik, D.; Perl-Vorbach, E.; Baumgartner, R.J. Open innovation and its effects on economic and sustainability innovation performance. *J. Innov. Knowl.* **2019**, *4*, 226–233. [CrossRef]
45. Chesbrough, H.W.; Appleyard, M.M. Open innovation and strategy. *Calif. Manage. Rev.* **2007**, *50*, 57–76. [CrossRef]
46. Yun, J.; Liu, Z. Micro-and Macro-Dynamics of Open Innovation with a Quadruple-Helix Model. *Sustainability* **2019**, *11*, 3301. [CrossRef]
47. Yun, J.J.; Zhao, X.; Jung, K.; Yigitcanlar, T. The culture for open innovation dynamics. *Sustainability* **2020**, *12*, 5076. [CrossRef]
48. Perkmann, M.; Walsh, K. University–industry relationships and open innovation: Towards a research agenda. *Int. J. Manag. Rev.* **2007**, *9*, 259–280. [CrossRef]

49. Jonsson, L.; Baraldi, E.; Larsson, L.-E.; Forsberg, P.; Severinsson, K. Targeting academic engagement in open innovation: Tools, effects and challenges for university management. *J. Knowl. Econ.* **2015**, *6*, 522–550. [CrossRef]
50. Striukova, L.; Rayna, T. University-industry knowledge exchange: An Exploratory Study of Open Innovation in UK Universities. *Eur. J. Innov. Manag.* **2015**, *18*, 471–492. [CrossRef]
51. Huggins, R.; Prokop, D.; Thompson, P. Universities and open innovation: The determinants of network centrality. *J. Technol. Transf.* **2020**, *45*, 718–757. [CrossRef]
52. Sarkar, S.; Costa, A.I.A. Dynamics of open innovation in the food industry. *Trends Food Sci. Technol.* **2008**, *19*, 574–580. [CrossRef]
53. Bogers, M.; Chesbrough, H.; Heaton, S.; Teece, D.J. Strategic management of open innovation: A dynamic capabilities perspective. *Calif. Manage. Rev.* **2019**, *62*, 77–94. [CrossRef]
54. Davis, F.D.; Venkatesh, V. A critical assessment of potential measurement biases in the technology acceptance model: Three experiments. *Int. J. Hum. Comput. Stud.* **1996**, *45*, 19–45. [CrossRef]
55. Creswell, J.W.; Creswell, J.D. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*; Sage Publications: New York, NY, USA, 2017; ISBN 1506386717.
56. *IEC 62840-2:2016*; Electric Battery Swap System—Part 2: Safety Requirement. International Electrotechnical Commission [IEC]: Geneva, Switzerland, 2016. Available online: https://webstore.iec.ch/publication/25983 (accessed on 17 March 2020).
57. National Standardization Body. *Pengantar Standardisasi, Edisi Kedua*; BSN Jakarta: Jakarta, Indonesia, 2014.
58. Fornell, C.; Larcker, D.F. Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* **1981**, *18*, 39–50. [CrossRef]
59. Hair, J.F.; Ringle, C.M.; Sarstedt, M. PLS-SEM: Indeed a Silver Bullet. *J. Mark. Theory Pract.* **2011**, *19*, 139–152. [CrossRef]
60. Chin, W.W. The partial least squares approach to structural equation modeling. In *Modern Methods for Business Research*; Psychology Press: London, UK, 1998; Volume 295, pp. 295–336, ISBN1 1135684138. ISBN2 9781135684136.
61. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*; Lawrence Erlbaum Associates: Hillsdale, NJ, USA, 1988; pp. 20–26.
62. Santosa, P.I. *Metode Penelitian Kuantitatif: Pengembangan Hipotesis dan Pengujiannya Menggunakan SmartPLS*; Andi: Yogyakarta, Indonesia, 2018.
63. Wang, W.N.; Li, B.; Wang, Y. Design of Battery Fast-Swap System for Electric Vehicle. *Appl. Mech. Mater.* **2014**, *628*, 190–194. [CrossRef]