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A Mathematical Model of Factors Driving Product Success in an Indonesian Market using Design of Experiment

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Abstract. Previous studies have not agreed on factors that affect the success of different kinds of products. These studies have used independent variables with a different number of success factors to examine several products, and some of these variables have been redundant. No standardized factor predicts the success of various products; thus, no generalizable result has provided a reference for further studies or use recommendations for practices. Therefore, this study produced a model that not only examined specific products and scope but also used a number of standardized success factors by building a mathematical model of the success factors that affect the success of various products. The study utilized 304 products from the Indonesian market as well as design of experiment to build the mathematical model. The results suggested that six standardized success factors affected the success of various products: (1) price, (2) product performance, (3) brands, (4) aesthetic design, (5) services and (6) marketing. Services and marketing (i.e., appropriately timed marketing) were positively correlated and proportional to the increase of market share. Therefore, focusing on the services and marketing factors that will drive the success of a product is important for many companies. The factors that positively drive success can be determined by characteristic sales in the Indonesian market.

Keywords: Design of experiment; Indonesian market; Mathematical models; Success factors

1. Introduction

Predicting the potential factors that drive product success is important for companies. Besides being very costly, product development activities are also critical to the company to know which potential factors will drive success. Its means that product development activities must be based on the potential factors that will drive success. In addition, companies must minimize potential investment failures in product development. Therefore, this study investigated potential factors that drive success in the Indonesian market.

Previous research has identified success factors in the market. For example, Montoya-Weiss and Calantone (1994), Cooper (1979a), Cooper et al. (2014) and Henard and Szymanski (2001) examined key factors that affect product success. These factors include product quality (Cantner et al., 2012), branding and marketing (Gao et al., 2006), product services (Jiang and Liu, 2012), price promotion (Lee and Zhou, 2012), product

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performance and marketing (Ernst, 2002). Several literature reviews and a meta-analysis also investigated the factors of product success (Griffin and Page, 1993; Ernst, 2002; Kleinknecht and Panne, 2012; Setyaningrum et al., 2016) then the product success factor become research trend. Previous research identified success factors in business incubators (Gozali et al, 2020) and multi factors productivity that a priori insights in capital project (Woodhead and Berawi, 2020).

According to previous research, models that examined the factors of product success had some weaknesses. They used independent variables with a different number of success factors for several products, and some variables were redundant. This was because no standardized factor effecting a product's success exists (Cooper, 1979b; Henard and Szymanski, 2001; Wijaya, 2011; Handaru, 2012; Mutjaba, 2013; Cooper et al., 2014; Nugroho, 2014; Armunifah, 2014; Susilowati, 2016; Lenggono, 2016).

The studies by Wijaya (2011), Handaru (2012), Mutjaba (2013),vNugroho (2014), Armunifah (2014), Susilowati (2016) and Lenggono (2016) used various factors for different kinds of products. The most common factors used to predict product success are shown in Figure 1. The number of factors used to predict product success varied for different products. Electronic products used 12 success factors,14 smartphone products used 5–14 success factors (Wijaya, 2011; Armunifah, 2014), automotive products used 12–14 success factors (Wijaya, 2011; Lenggono, 2016), wood products used 11 success factors (Mutjaba, 2013; Nugroho, 2014; Susilowati, 2016), and service products used 7–12 success factors (Nugroho, 2014) and product success analysis (Suharyanti et al., 2017). No agreement was found on the factors determining success for various products. Additionally, some factors were redundant and could be grouped together.

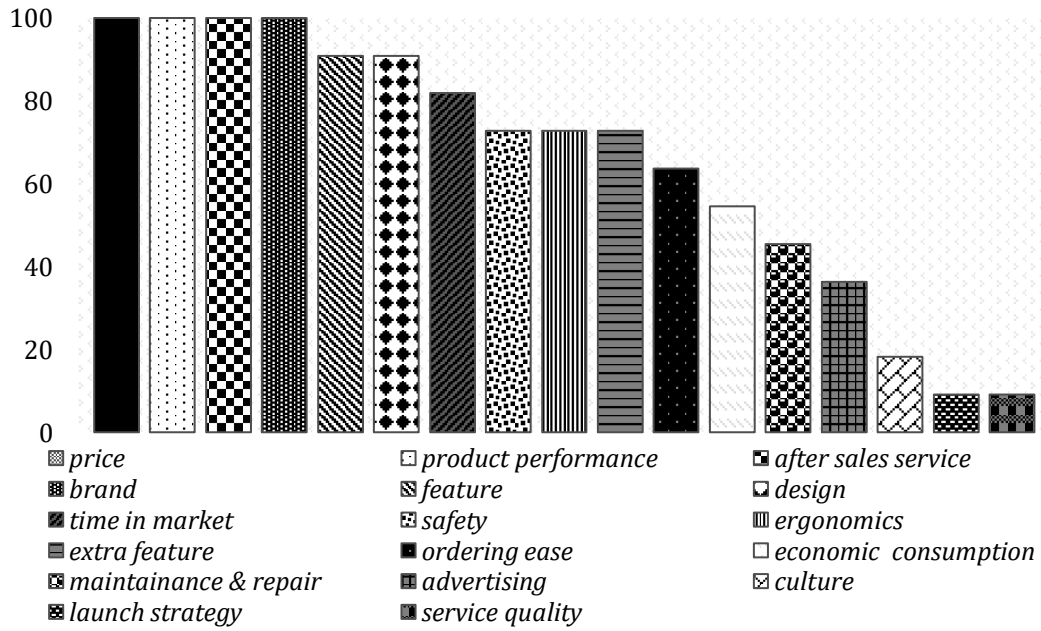


Figure 1 The utilization percentage of success factors based on 12 studies

1.1. Aims and Benefits of the Research

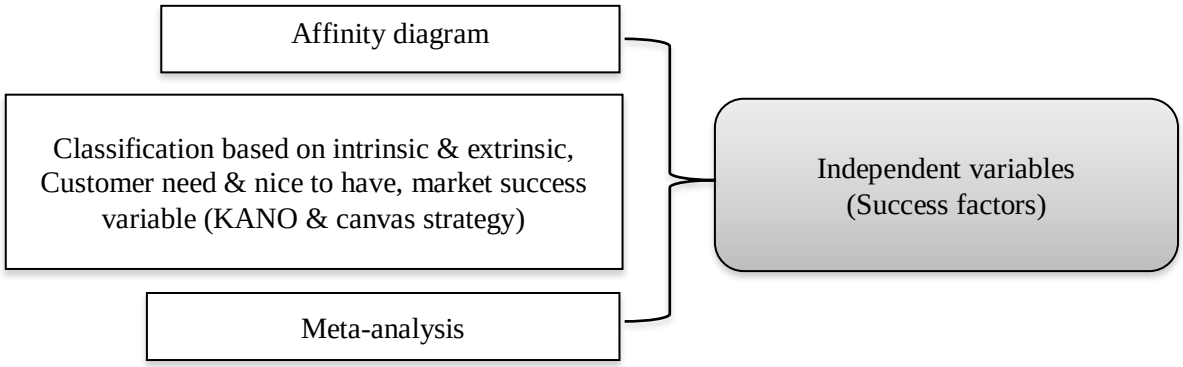
To fill the gap in previous research, this study aimed to determine the success factors of various products. Additionally, it aimed to develop a mathematical model of the relationship between market share and success factors for various products. The research established the standardized factors that affect product success. The results of the study can be used to determine product development strategies by optimizing potential success factors; investigating these factors is important for companies.

2. Methods

The mathematical model was developed simultaneously to resolve some of these problems, and the research was conducted in several steps. The mathematical model was built using experiment design. One of the experimental design applications using Taguchi (Khentout et al., 2019). The first step was determining success factors to build the mathematical model, which could determine what kinds of factors positively and negatively affect market share. These were selected by arranging factors into an affinity diagram. Then, the factors were classified by their intrinsic/extrinsic nature, whether they were a customer need/nice to have and by their market success variable. Meta-analyses used data from a number of previously published case studies. Structurally, the step of meta-analysis is identification of correlation value of X and Y on every study is done directly or by seeing the statistical *F* value, *t* statistic, or effect size (*d*). Furthermore, design of experiment was applied to formulate the mathematical model of the relationship between the success factors and market share. In brief, the factors that positively drive success could be determined by lifecycle characteristics of automotive and non-automotive products. These characteristics were based on the success of the product in the Indonesian market.

2.1. Success Factors Selection Process

The success factors were selected using an affinity diagram and were classified based on whether they were intrinsic/extrinsic, whether they were a customer need/nice to have and what their market success variable was. Additionally, meta-analysis was performed on the success factors. These three processes produced the selected success factors, as shown in Figure 2.



* Kano is the method of product development

Figure 2 Selection process on deciding success factors

The affinity diagram identified patterns and built related groups of variables. The results clustered the variables into major categories and developed a descriptive name for each variable. The classification of factors used a mathematical model from previous research (Suharyanti et al., 2017). Finally, a meta-analysis was performed on the output variables from the affinity diagram and variable classification. The articles used in the meta-analysis were taken from reputable publication sources published between 2000 and 2015. The article was found with the keyword product development factors offered in the span of the year.

2.2. Design of Experiment

The 2^6 fractional factors were used to determine the effect of independent variables on the dependent variable. The dependent variable (Y) was the market share. The success

factors, including price (X_1), product performance (X_2), brand (X_3), aesthetic design (X_4), service level (X_5) and marketing effort (X_6), were the independent variables. These variables were obtained based on the results of the selection process.

The data of the independent and dependent variables had a wide range and different units. Therefore, the data had to be standardized before being used to build an equation; this has a substantial impact on whether the data are representative and how they can be analysed (Hair et al, 2010) The standardization of data was in the range number of 0–100.

The equation used a linear regression model to explain the relationship between success factors and market share. In the design of experiment process (Montgomery, 2001; Box et al., 2005; Geng et al., 2016), the generators selected for every fractional factor were based on the data combination of the automotive products most fulfilled by the generator. Validation of the model was performed using ANOVA statistical tests.

The data of 304 products and services in the Indonesian market from 2011–2016 were used to build the mathematical model. The source of the data was specification and market shares of various products sold in Indonesia. The data is obtained from the company's annual report, field observations and websites that explain the observed product specifications. These products included 115 automotive products and 189 non-automotive products, such as smartphones, laptops, food, apparel, furniture, telecommunication services, flight services and hospital services. Non-automotive products included a collection of several products and services with the same lifecycle characteristics. The sample of automotive products and non-automotive products was selected to distinguish the characteristics of automotive products from other products.

The product group was categorized by finding similar characteristics, including whether the product was innovative. For example, products have a number of product series and a period of generation. Then, the product's life cycle was explained. For example, smartphone products have a short lifecycle of 12–16 months, while electronic products have a lifecycle of less than five years. Furthermore, the class of the product was identified (low product, medium product and high product) based on product price.

As a result, the study produced three mathematical models. Model 1 used automotive products more than non-automotive products (high automotive). Model 2 used a relatively equal number of automotive and non-automotive products (medium automotive). Model 3 used automotive products less than non-automotive products (low automotive).

3. Results and Discussion

3.1. Design of Experiment

The descriptive statistics and the correlation coefficients of the variables are presented in Tables 1 and 2.

Table 1 Descriptive statistics of the samples used for design of experiment

Variables	Mean	Standard deviation	Maximum	Minimum
Price (X1)	45.97	31.12	100	0
Product Performance (X2)	48.14	25.45	100	0
Brand (X3)	48.96	32.66	100	0
Aesthetics Design (X4)	52.16	24.83	100	0
Services (X5)	46.20	33.39	100	0
Marketing (X6)	35.44	31.68	100	0
Market Share (Y)	30.77	34.19	100	0

The descriptive statistics showed that the mean of the data ranged from 30.77–52.16. The standard deviation of the data ranged from 24.83–34.19. The correlation coefficients showed that all variables could be used to build the formula (Table 2).

Table 2 The correlation matrix

Variables	X1	X2	X3	X4	X5	X6
X1	1					
X2	-0.144	1				
X3	0.007	-0.042	1			
X4	-0.009	-0.131	0.009	1		
X5	-0.039	-0.157	-0.053	-0.036	1	
X6	0.111	-0.007	-0.150	-0.092	-0.124	1

The combination of automotive and non-automotive product data was involved in every model. The fulfilment priority of the data combination for every fractional factor was the automotive products. The remaining capacity was filled by the non-automotive products. The coefficients of the mathematical equations, the contribution of the success factors and the validation results of the first, second and third models are presented in Table 2. In the first model, price (X_1), brand (X_3) and service level (X_5) were positively correlated and proportional to market share increase. Therefore, the increase of those factors improved market share (Wijaya, 2011; Torres and Tribo, 2011; Kuruzovich et al., 2013; Mitra and Patankar, 1997). Based on the results of this study indicate that a research study on services, product price and market share found that the three variables are correlated. Based on the first model, the variables that contributed to market share, from the highest to the lowest, were services, brand and price.

In the second model, the price (X_1), product performance (X_2), brands (X_3), aesthetic design (X_5) and marketing/launching time (X_6) were positively correlated and proportional to market share. This finding was consistent with the results of previous research studies (Wind and Rangaswamy, 2001; Moon et al., 2008) that showed that price is an important factor (Cantner et al., 2012). A study on aesthetics provided useful insight: designing a mobile phone with optimal attributes will enhance the aesthetics as well as the overall customer satisfaction (Chuang and Chen, 2008). Another study concluded that marketing capability positively affects market performance (Mutjaba, 2013). The sequence of the variables' contribution to market share in the second model from highest to lowest was marketing, brands, price, product performance and aesthetic.

In the third model, price (X_1), product performance (X_2), aesthetic design (X_4) and services (X_5) were positively correlated and proportional to market share. Therefore, an increase in the four variables increased market share (Postel, 2001; Kuruzovich et al., 2013). A study on services concluded that product services influence the level of customer satisfaction and loyalty. The increase of product services improved market share and customer satisfaction (Wijaya, 2011; Kuruzovich et al., 2013). Based on the third model, the influencing variables on market share from highest to lowest were culture, marketing, services, aesthetic design, brand, product performance and price.

In all three models, price (X_1) was positively correlated and inversely proportional to market share. The facts in the Indonesian automotive market indicate that purchasing automotive products will be considered by the brand. This result was in agreement with the findings of another study that showed that specific brand factors impact the market success of car models (Wijaya, 2011). Additionally, other studies (Moon et al., 2008; Wind and Rangaswamy, 2001) found that price is an important factor and that exceeded price will reduce sales. As shown in Table 3, the statistical test using ANOVA concluded that, in

the three models, market share had a linear relationship with the success factors (significant at α = 0.05). The computation time to develop the three models was between 20 and 30 minutes.

Table 3 Coefficients of the mathematical equation, variable contribution, and validation test

Coefficients, contributions and validation test		Model 1 (High)	Model 3 (Low)	Model 2 (Medium)
Coefficients of mathematical equation:				
	a	0.20	0.11	0.02
	b	-0.06	0.05	0.20
	c	0.10	0.18	-0.02
	d	-0.20	0.002	0.21
	e	0.17	-0.05	0.40
	f	-0.07	0.23	-0.33
Contribution of success factors to market share:				
	X1	26.8 %	6.2 %	23.8 %
	X2	14.4 %	15.3 %	15.6 %
	X3	4.1 %	1.9 %	3.7 %
	X4	2.9 %	46.5 %	5.2 %
	X5	17.3 %	20.6 %	21.9 %
	X6	34.6 %	9.5 %	29.7%
Validation test:				
	R^2 (model summary)	60.1 %	41.7 %	40.4%
	Significance	0.0013*	0.0015*	0.00000002*

*Significance at α =0.05

3.2. Independent Character in Automotive Products

The mathematical equations developed in the three models were used to identify the relationship between success factors and market share (dependent variable). The contribution of success factors to market share is illustrated in Figure 3. The characteristics of the success factors are shown in Figures 4, 5 and 6; these were supported by the significance test (*p* value of 10%; Table 4).

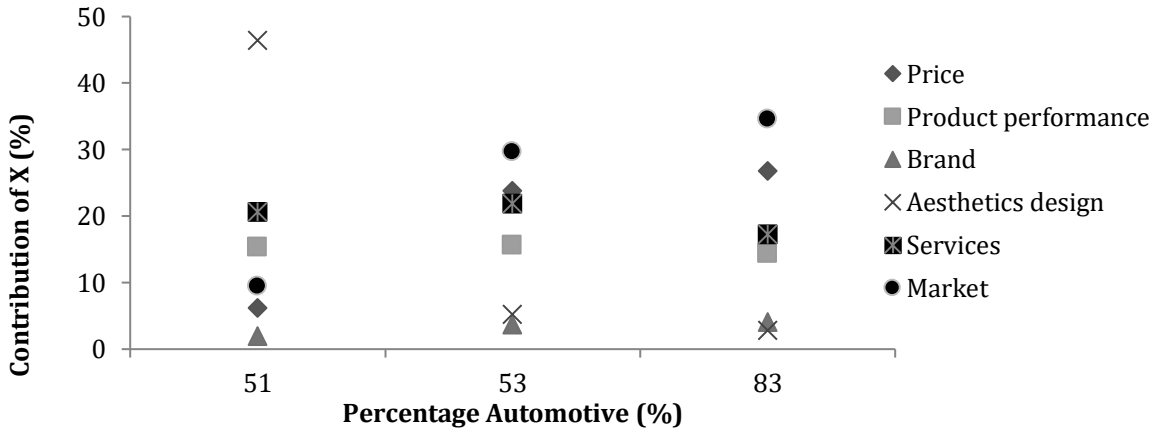


Figure 3 The contribution of success factors to market share

The contribution of price to market share fluctuated from 6.2–26.8%. The contribution of price to market share is supported by the conclusion of some studies (Wind and

Rangaswamy, 2001; Moon et al., 2008) that showed that price is an important factor and that exceeded price will reduce sales (Cantner et al, 2012). Product performance contributed to market share from 14.4–15.6%. Brand contribution to the market share was 1.9–4.1%, which agreed with another study that showed that brand affects the market success of automotive products (Wijaya, 2011). Aesthetic contribution to market share fluctuated from 2.9–46.6%. The contribution of services to market share ranged from 17.3–21.9%. A study on services stated that a product service management portfolio positively influences customer satisfaction (Moon et al., 2008). The contribution of marketing to market share ranged from 9.5–34.6%. As mentioned in another study, firm marketing capability positively influences market performance (Mutjaba, 2013).

Based on the significance test presented in Table 3, services (X5) significantly influenced market share in the three models. The variables of price (X1) and marketing/launching (X6) significantly influenced market share in the first model and in the third model, which were the high-automotive and low-automotive data, respectively. Aesthetic design (X4) significantly influenced market share in the third model (medium-automotive data).

Table 4 Significance test of the linear regression

Variables	Model 1 (High)	Model 3 (Low)	Model 2 (Medium)
Price (X1)	0.03*	0.044	0.002*
Product performance (X2)	0.54	0.11	0.09*
Brand (X3)	0.74	0.8	0.61
Aesthetics design (X4)	0.86	0.0001*	0.60
Services (X5)	0.10*	0.03*	0.005*
Marketing (X6)	0.001*	0.22	0.00005*

**Significance at α =0.05

As seen in Tables 3 and 4 and Figure 4, the variables of price and services were generally positively correlated and proportional to market share in the models, including those with automotive product dominance, while the variables of product performance, brand, aesthetic design and marketing/launching could still not be generalized.

3.3. Price and Product Performance

In the models, the effects of price and product performance based on market share fluctuated. The price positively or negatively affected the market share (the range of the coefficients was -0.13–0.37; Figure 4a). The coefficient of product performance was -0.33–0.22 (Figure 4b). The variable of price significantly affected the market share, as shown in Table 4.

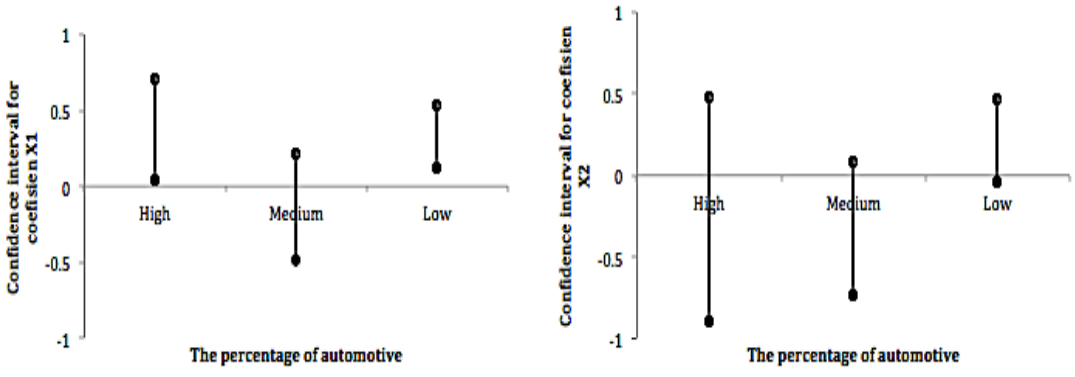
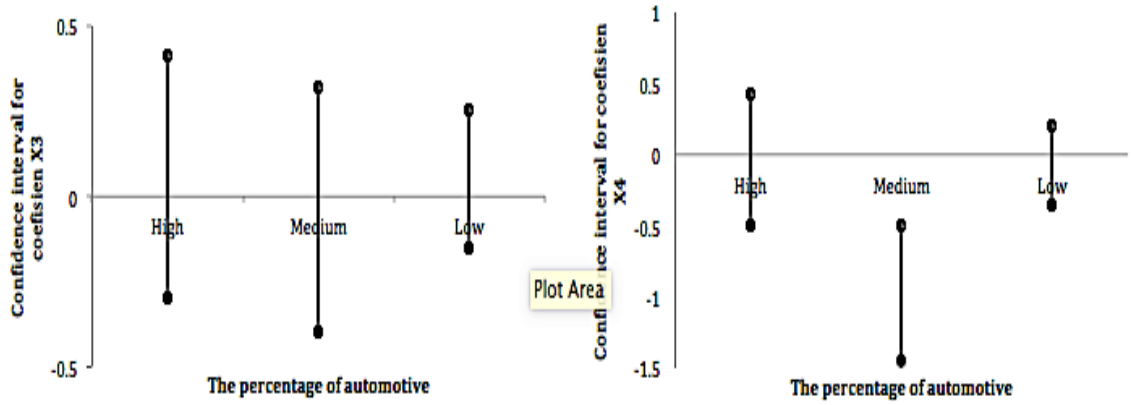


Figure 4 The coefficients of success factor equations: (a) price; and (b) product performance

3.4. Brand and Aesthetic Design

The coefficients of brand and aesthetic design fluctuated. The coefficient of brand was -0.04–0.06 (Figure 5a). The coefficient of aesthetic design was -0.97–-0.07 (Figure 5b). Therefore, the variables of brand and aesthetic design did not significantly affect the market share, as shown in Table 4.

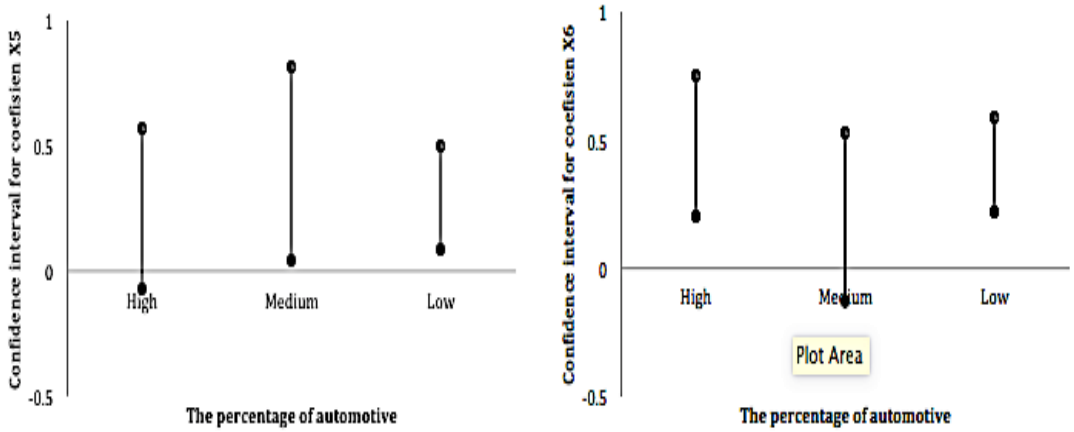


(a) (b)

Figure 5 The coefficients of success factor equations: (a) brand; and (b) aesthetic design

3.5. Services and Marketing

In all three models, services and marketing tended to positively influence market share. The coefficient of services was 0.24–0.43 (Figure 6a). The coefficient of marketing was 0.19–0.47 (Figure 6b). Both services and marketing significantly affected the market share, as shown in Table 4.



(a) (b)

Figure 6 The coefficients of success factor equations: (a) services; and (b) marketing

As seen in Figures 4, 5 and 6, the variables involved in the analysis were either proportional or inversely proportional to market share. For all products in general, an increase of services increased market share. In several models, the increase of both services and marketing/launching time increased market share. In other words, the services and marketing/launching time were proportional and highly contributed to market share. This can be used to predict product success in terms of market share. The results of these analyses will help companies develop the factors of innovation to achieve product success.

The equations constructed from some groups of products (high- to low-automotive products) were unique. The characteristics of price and services could be generally

concluded. However, the characteristics of other success factors could still not be generalized. Automotive composition varied in the product groups, and the general equations could not be retrieved. This result was in line with the findings of another study that showed that the relationship between product development and product success is unique for every case or group of cases (Suharyanti et al., 2017). Therefore, further research is needed to obtain the pattern of those factors.

4. Conclusions

This study has important implications for the research community on product development and success. The results showed that six standardized factors affect the success of various products: (1) price, (2) product performance, (3) brands, (4) aesthetic design, (5) services and (6) marketing (launching time). This study also produced some other interesting conclusions related to automotive products in the Indonesian market. For example, the relationship between market share and success factors in high-automotive, medium-automotive, and low-automotive models showed that increasing services will increase market share. The results concerning some success factors (i.e., product performance, brand, aesthetic design and marketing) varied, as these variables showed a variety of automotive compositions. The variables of price and marketing influenced the market share significantly in the high-automotive and low-automotive models. The aesthetic design significantly influenced the market share in the medium-automotive model. In the non-automotive (low-automotive) model, price, product performance, aesthetic design and services were positively correlated and proportional to market share. In the era of internet and big data storage, this study's model can be used to predict the factors that drive success. The mathematical models in this study can be conducted by building a database of the model. Then, the results can predict the level of success of a particular product. Therefore, further research is needed to profile the characteristics of all factors completely.

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