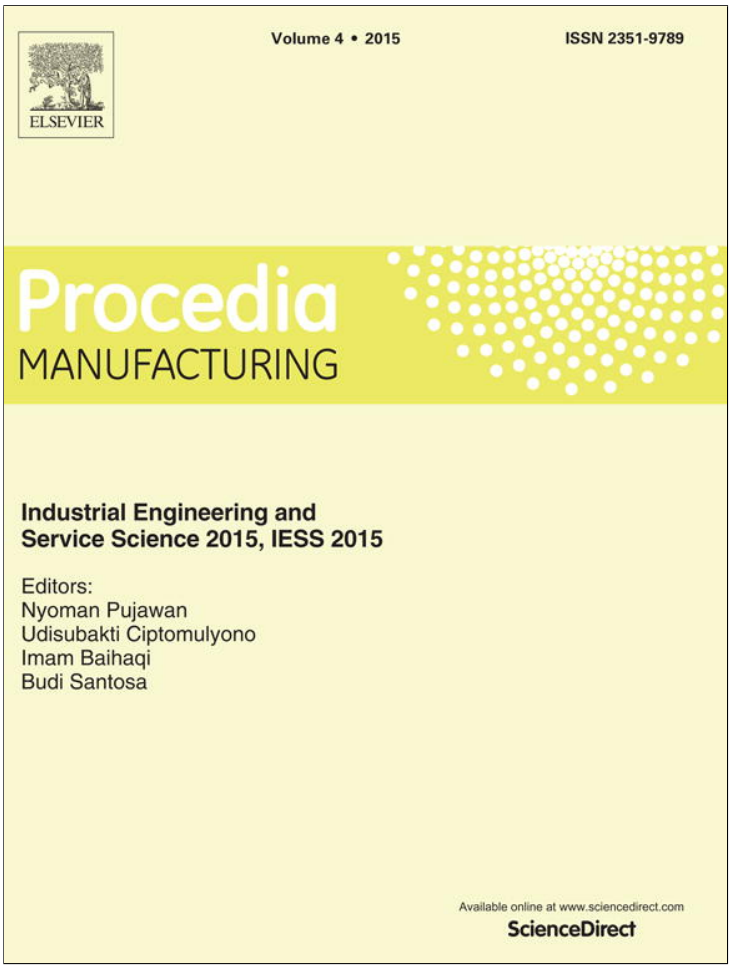

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The scheme of product development process as a trigger to product success: A theoretical framework

Yosephine Suharyanti[a*]; Subagyo[b]; Nur Aini Masruroh[c]; Indra Bastian[d]

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Abstract

Researches on product development since 1970s have discussed many aspects. However, none of them clearly describes the relationship between product development activities and product success, the final goal of a business. This paper presents the development of a theoretical framework of the way product development affects product success. The result of a meta-analysis study prior to this study shows that product development is one of the five variables proven to influence product success ($r = 0.32$). Based on this result, a theoretical framework is developed through five stages. First, relationship between product development and four other variables is evaluated. Through an evaluation on some established models of product development process and a meta-analysis study, three variables, i.e. product characteristic, technological advanced, and management, could be assumed to be inseparable from and closely related to the product development process ($0.57 \leq r \leq 0.64$), while one other variable, market environment, is externally driven and still separated. Second, product development scheme is defined to cover the three variables mentioned above. A meta-analysis study is conducted and the result shows that product development scheme significantly affects the product success ($r = 0.31$). The model then is restructured into a model of the relationship between product success and the two remaining variables. Third, five sub-variables of product development process, as the elements of product development scheme, is developed based on a mostly referred model and some cases in Indonesia. Forth, a meta-analysis study on the relationship between product success and the five sub-variables is done ($0.30 \leq r \leq 0.38$). Finally, a theoretical framework to model the relationship of product success and product development scheme is developed, as a part of further study.

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Keywords: Product success; product development; scheme; theoretical framework; meta-analysis

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1. Introduction

1.1. Background

The growth of industries in a country, especially manufacturing industries, will drive its economic growth. As the engine for industry chain, manufacturing industries take the strongest role in stimulating other industry sectors. The following data shows that level of manufacturing output is relatively in line with level of gross domestic product (GDP). Manufacturing output of Unites States of America (USA), China, Germany, and Indonesia in 2012 for example, are 1.912; 1.623; 632; and 107 billions of US$ respectively [1], in line with their GDP in 2013 which are 16.768; 9.240; 3.730; and 868 billions of US$ respectively [2].

The performance of a manufacturing company relies on the success of its products, which could be achieved through the development of its market. Two of nowadays issues in market development, i.e. customization and rapid change, raise the need of product variation and shorten the life cycle of products [3, 4, 5, 6]. In this condition, product development becomes the most important function. Another industry issue, supply chain management (SCM), also places product development as the first function which drives all other subsequent functions along supply chain (SC) [7, 8].Success stories of some local companies in Indonesia say that those companies can survive and successfully develop their market through a sustainable process of product development [9, 10, 11]. In other words, product development is one the key success factor in company growth and survival [3, 8].

The belief on the importance of product development role, however, in many cases, is not related with the way the product development managed. The structure of companies' financial reports places product development costs as just a part of operating expenses and/or indirect costs. Interviews with some manufacturing companies in Indonesia show that product development activities are not well recorded and measured [12, 13]. Thus, the effectiveness of the product development process in creating values for product success is difficult to be evaluated.

1.2. Previous studies

Researches on product development begin in 1970s, go up around 1990, and still become one of the interesting topics until now [14]. From SCM viewpoint, product development (PD) researches can be seen in the context of the way a company realizing the product success (PS). PD is related to product realization (PR), product delivery (PDv), and PS.

Major researches related to PD cover frameworks, strategies, processes, product data management, product design, product platforms, and product selections. Researches on PS cover product success factors and brand management. Relationship between PD and PR is dominated by researches on design-for-manufacture and concurrent engineering, while relationship between PD and PDv encourages the researches on design-for-SC [4, 5, 6, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55]. Specific researches related to relationship between PD and PS was rarely found. Up to this time, most of those are parts of researches on the product success factors and product life-cycle management [5, 22, 23, 30, 32, 33, 34, 37, 38, 40, 45, 56, 57, 58, 59, 60, 61, 62, 63]. Therefore, the way the product development affecting the product success becomes an opportunity to study further.

2. The study

2.1. Context, goal, and approaches

This paper presents a study that is a part of a research concerning with the relationship between product success and the scheme of product development cost. The study presented here aims to (1) construct the variables relationship model, and (2) develop a framework to model the relationship between product success and product development scheme.

2.2. Previous work

A study prior to this study discusses the aspects affecting the product success [64]. Through a review on a number of previous researches, six variables affecting product success (*S*) are developed, i.e. product characteristic (*P*), technology advanced (*T*), management (*M*), market environment (*E*), product development (*D*), and product development cost (*C*). A meta-analysis study was conducted based on a number of studies published from 1979 to 2014, consists of 166 studies with total number of sample (*N*) of 30,759. The result shows that *P*, *T*, *M*, *E*, and *D* are significantly correlated to *S*, while *C* is not proven to be correlated to *S*. Some studies (31%) say that *C* has low, even negative, correlation to S ($-0.15 \leq r \leq 0.26$), while the others (69%) say that the *C* is highly correlated to *S* ($0.437 \leq r \leq 0.843$). The relationship model resulted still has to be improved to get more reasonable scheme of relationship.

2.3. Method

In order to accomplish the aim of this study, five stages described as follows are conducted. First, in order to obtain a reasonable relationship model, a review on some established models is conducted and the correlations between *D* and other independent variables are analyzed. Second, the model is reconstructed based on the result of the first stage. Third, the sub-variables of *D* are defined based on some established models by considering the some actual cases. Forth, relationships between product success and the sub-variables of *D* are evaluated through a meta-analysis study to ensure the existence of the relationships. Finally, a theoretical framework is developed based on the four preceding stages.

3. Stage 1: defining of the relationship among *P*, *T*, *M*, *E*, and *D*

SCM viewpoint says that product development is the first function which drives all the other subsequent functions [7, 8]. It means that the results of SC process including product characteristic, technology used, and management process, are defined in product development phase. Cooper and Kleinschmidt model of product development process [15] defines the activities included in product development: (1) initial screening, (2) preliminary market assessment, (3) preliminary technical assessment, (4) detail market study, (5) business/financial analysis, (6) product design, (7) in-house product testing, (8) customer tests of product, (9) test market, (10) trial production, (11) pre-commercialization business analysis, (12) production start-up, and (13) market launch. Activity (1) to (8) are closely related to *P* ; *T* is closely related with activity (3), (6), (7), (10), and (12); and *M* could be defined through (2), (4), (5), and (10) to (13). Other models like Stage-gate [3, 16, 30], Basic Concurrent Engineering (BCE), Product and Cycle-time Excellence (PACE), Concept-Development-Optimize-Verify (CDOV) [28] also define similar activities related to *P*, *T*, and *M*.

To ensure the integration of *P*, *T*, and *M* into D, a meta-analysis is conducted. Itincludes case studies published during 1986 to 2014, cover manufacturing industries and services, large scale industries and SMEs, profit oriented companies and non-profit organizations [15, 56, 62, 63, 65, 66, 67, 68, 69, 70, 71]. Total number of studies (*K*) observed is 67 and the *N* is 13,311. Reliability (α) of all the variables is ranged from 0.52 to 0.95, exceeds the minimum α of 0.5. For every variable, the number of sample is ranged from 3019 to 6064, exceeds 3000, the minimum number of sample required [72].Table 1 shows the summary of this analysis. The *r* represents observed correlation value, ρ is the correlation value resulted from the analysis,σ_ρ denotes standard deviation of ρ, σ_r stands for standard deviation of *r*, andρ/σ_ρ represents the significant level of the result. Under 5% confidence interval, the minimum value of ρ/σ_ρ is $1.96 \cong 2$ [72].

Table 1. Data summary and result of meta-analysis on the correlation between *P*, *T*, *M* and *D*.

Relationship	Data						Meta-analysis result		
	K	*N*	N_K	*r*	σ_r	α	ρ	ρ/σ_ρ	*Conclusion*
P and *D*	25	4228	30-800	0.17-0.70	0.15	0.52-0.86	0.64	3.59	Significant
T and *D*	11	3019	61-800	0.14-0.68	0.21	0.67-0.83	0.61	2.22	Significant
M and *D*	31	6064	30-800	0.10-0.74	0.21	0.70-0.95	0.57	2.17	Significant

The values of ρresulted from this analysis prove that the integration of *P*, *T*, and *M* into *D* is reasonable. The variables affecting *S* then is reduced into two variables, *E* and *D*. *D*, however, is not precisely as the previous *D*. Integration of *P*, *T*, and *M* into *D* redefines *D* as a scheme of activities related to the creation of *P*, the design and use of *T*, and the planning and implementation of *M*. Hence, *D* is redefined and the relationship between *S* and *D* is re-evaluated.

Suppose that the new *D* is called D_S, the scheme of product development, a meta-analysis then is done on the correlation between *S* and D_S. The analysis uses $K = 28$ with $N = 3760$ from a number of case studies published during 1979 to 2014, cover manufacturing industries and services [15, 32, 56, 61, 66, 67, 68, 69, 73]. Based on the observed *r* ranged from 0.03 to 0.70, the ρ value resulted from the analysis is 0.31 withαranged from0.59 to 0.93.

4. Stage 2: restructuring of the relationship

According to the last analyzes, the relationship model is restructured into a simpler model: *S* is affected by *E* and D_S (Fig. 1). *D* is internally driven variable which covers all the internally driven aspects affecting *S*.

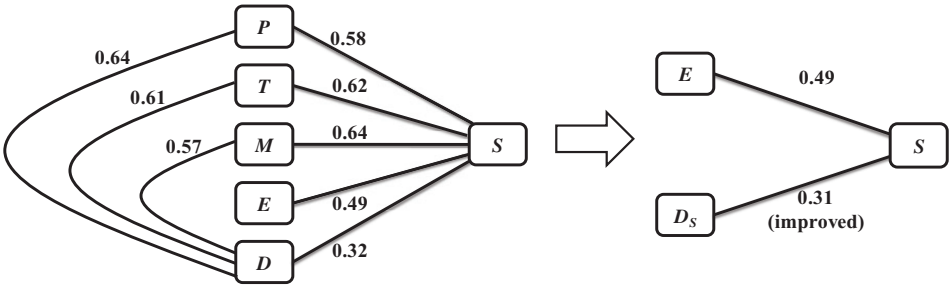

Fig. 1. Relationship model restructuring.

5. Stage 3: defining of product development activities

Several models of product development process have long been defined. Cooper and Kleinschmidt model [25], Stage-gate model [3, 16, 30], BCE model, PACE model, and CDOV model [28] are some of the mostly cited models. Based on these models and practices applied in some companies [11, 13], a general model of product development process is developed (Fig. 2). The five activities defined, i.e. development of product idea, establishment of product idea, detail design of product, test of the design of product, and launch of product, then become the sub-variables of D_S, named as D_1, D_2, D_3, D_4, and D_5 respectively.

6. Stage 4: Defining of the Relationship between *S* and D_1, D_2, D_3, D_4, D_5

Not all companies apply all of the product development activities theoretically defined. Reference [15, 16] mention that only one activity i.e. initial screening that is performed by more than 90% of 252 new product projects conducted in 123 companies, and only 1.9% of those companies performed all the activities. Hence, some studies on industry cases then observed to ensure the existence of the relationship between product success and the sub-variables constructed above.

A meta-analysis on the correlation between *S* and D_1, D_2, D_3, D_4, and D_5 is conducted based on case studies published from 1979 to 2014, cover manufacturing industries and services, profit oriented companies and non-profit organizations [15, 32, 33, 56, 61, 63, 65, 66, 68, 69, 73, 74, 75, 76, 77, 78, 79]. The *K* is 67, $N = 13{,}311$, α is 0.59-0.94, number of sample of every variable is 3016-5195. The final structure resulted is shown in Fig. 3. Significant correlations between *S* and D_S' sub-variables ($0.30 \leq \rho \leq 0.38$) means that the sub-variables developed are related to *S*.

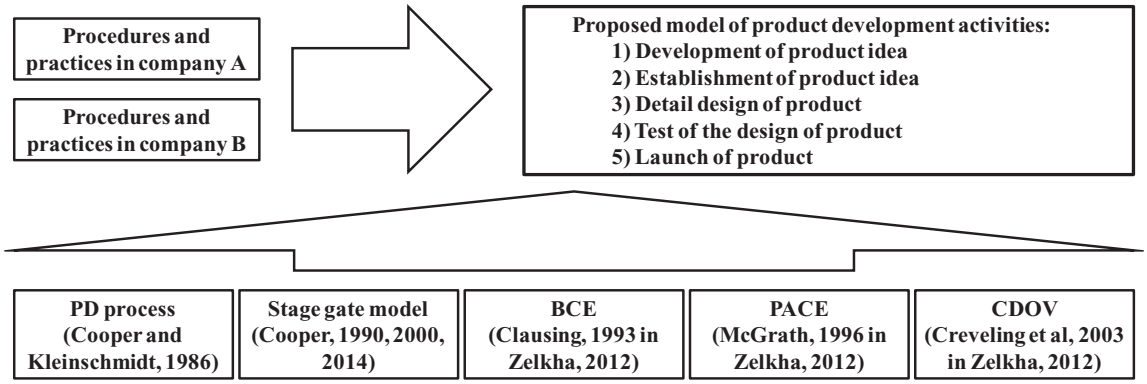

Fig. 2. Development of the sub-variables of D_S.

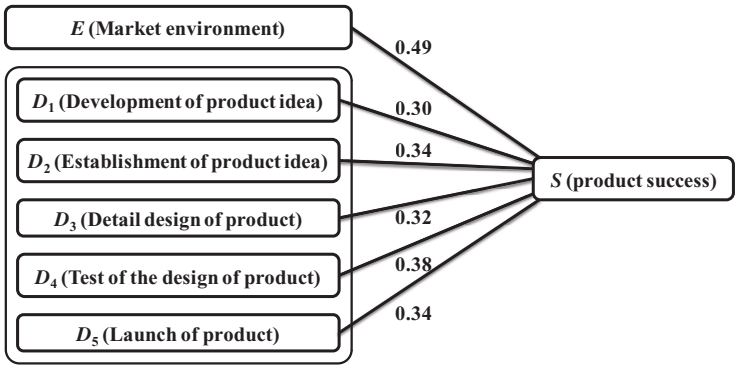

Fig. 3. Final relationship structure.

7. Stage 5: Framework Development

A framework to model the relationship between S and D_S and E is developed and consists of 6 steps (Fig. 4). The first step is preparation empirical data, which consist of scores of activities and related product success, and weights of activities. In order to get the pattern of the relationship between S and each of D_1, D_2, D_3, D_4, D_5, and E, a curve fitting work then is done (Step2). The result of the curve fitting will give information about the characteristic of D_1, D_2, D_3, D_4, D_5, and E. A diagram adapted from Kano Diagram [80, 81] will be used in Step 3 to categorize those activities. Then a set of possible structures of D_S must be arranged in Step 4, based on the result of Step 3. In Step 5, the best structure is chosen. Finally, to learn further the behavior of the system, a simulation work should be performed.

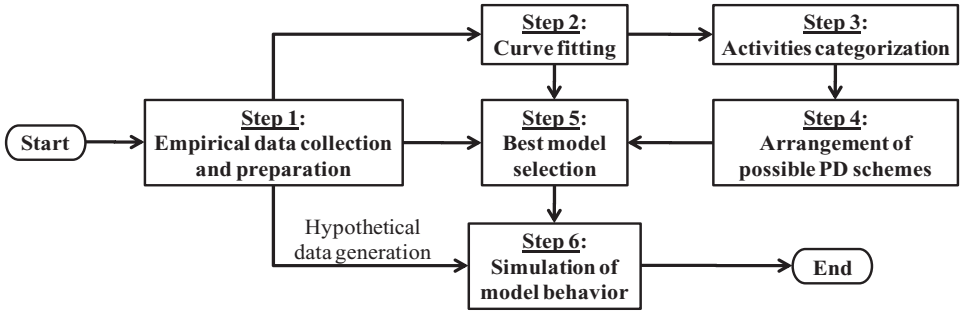

Fig. 4. Theoretical framework of construction of the relationship between S and D_S and E.

8. Conclusion and future works

Based on a series of literature reviews and meta-analysis studies, a relationship structure presenting the variables affecting product success could be established. The final structure says that product success is affected by product development scheme, in which product characteristic, technology advanced, and system management as the outcome of the product development scheme are involved. The other variable affecting product success is market environment. Further, a framework of model to model the relationship between product success and product development scheme is developed. The framework provides six steps to be performed when a case of product development process is required to be analyzed. The final output of the framework is a best fit model for a case or a group of cases.

In order to validate the framework, a lot of case studies must be analyzed further. A clustering work to classify the cases base on some categories is required to obtain the general model. Industry field, company, product type, or geographical area, are some categories could be mentioned as the basis for the clusters.

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