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A Novel New Product Development Hybrid Framework

Tan Owee Kowang[a*], Lim Kim Yew[b], Ong Choon Hee[c], Goh Chin Fei[d], Choi Sang Long[e], [a,c,d]Azman Hashim International Business School, Universiti Teknologi Malaysia, Johor, Malaysia, [b]INTI International University, Nilai, Malaysia, [e]Raffles University, Iskandar, Malaysia, Email: [a*]oktan@utm.my

In the current New Product Development (NPD) literature, NPD constructs from process and management perspective are being viewed separately. This paper aims to advance the state of NPD literature and empirical understanding of the determinants for NPD success via the development of NPD process and management hybrid determinants' framework. As such, five NPD process constructs and 101 NPD process attributes are identified from the literature review. These attributes and constructs are formulated into a survey questionnaire which was answered by 186 respondents from R&D based companies within Malaysia. Exploratory Factor analysis was applied as data reduction tool to screen and group inter-correlated NPD process attributes with the ultimate aim to extract the representatives NPD Management constructs. Seven NPD Management constructs are extracted via Factor Analysis. Based on NPD Evolutionary Theory, attributes that commonly shared between NPD process and management constructs are identified and grouped together to form the NPD hybrid framework. The formation of NPD Process and NPD Management Hybrid Framework suggests that a comprehensive NPD Process and NPD Management integration theory exist with the potential to describe a large part of NPD phenomena within the context of R&D based companies in Malaysia. In term of novelty, the hybrid framework allows characterizing commonalities of attributes across the different stages of NPD process and various levels of NPD management. In addition, the hybrid framework has descriptive value in terms of studying, classifying and defining the attributes and relationships that govern process and management aspects in NPD.

Key words: *New Product Development, Hybrid Framework, Factor Analysis, Integrated Framework.*

Introduction

Competitive and hostile business environments make NPD process and NPD management as the important elements to ensure business stays ahead of present or potential competition (Michael, 2008). As such, a rich stream of academic literature had discussed the determinants for NPD success (Cornelia, Roger and Nukhet, 2008). However, in the current academic literature of NPD, the important constructs from NPD process and NPD management perspectives are frequently being viewed and discussed separately.

Study of NPD by Cooper (2008), Merle and Anthony (2006), Lioukas (2007), Dariush (2007), Roxana, Akireza and Mohammad (2009) focused on the literature of NPD constructs within the context of NPD process, such as Concept Development, Product Design and Product Testing. Whereas study by Marisa *et. al*. (2008); Azaze and Izyanti (2009); Chen and Chen (2009) dealt with NPD constructs from the holistic NPD management point of view; for instance, Technology Management, Strategy Management, Human Management etc. Hence, it is obvious that the current NPD literature has not been explored adequately; neither had it explored the importance of a specified NPD management construct at each stages of NPD process, nor do the importance of a particular NPD process construct within various areas of NPD management. As such, this study aims to close the research gap of NPD constructs and complements the current research by investigating the main constructs of NPD success from both NPD process and NPD management points of view within the context of R&D based companies in Malaysia. Building on this conceptual, the ultimate objective of the research is to develop a novel NPD hybrid framework that integrating both NPD Management and Process constructs.

Literature Review

NPD Process Constructs

Efficient new product development process is the main success factor for new product introduction (Kumar, Balasubramanian and Suresh, 2009). A typical NPD process comprised of several distinct phases, and each NPD phase accomplishes specified objectives toward the success of NPD. Hence, prior researchers (Cooper, 1993; Merle and Anthony, 2006; Kotles*et. al.,* 2006; Dariush, 2007; Roxana, Akireza and Mohammad, 2009) commonly viewed phases that formed the entire NPD processes as the important constructs for NPD success. As such, in every new product development phase it is crucial to focus on a structured and systematic approach in order to form an effective NPD process.

NPD process that revealed by prior researchers (Cooper, 1993; Merle and Anthony, 2006; Kotles*et. al.,* 2006; Dariush, 2007; Roxana, Akireza and Mohammad, 2009) could be generally categorized into five main phases; which are Opportunity Identification (OI),

Concept Development (CD), Design and Development (D&D), Product Testing (PT) and Product Commercialization (PC). The five main NPD process phases are adapted in this study as the five main NPD process constructs in conjunction with 101 NPD process attributes.

NPD Management Constructs

Marisa *et. al.* (2008) applied a systematic literature review approach to identify key constructs for NPD management. The research carried out by Marisa *et. al.* (2008) encompasses 100 published papers from different academic fields and organizational contexts. The research drew together nine key constructs on an organizations ability to manage NPD process effectively. The nine key constructs are technology, strategy, NPD process, organization culture, organizational structure, employees, resources, knowledge management and management style & leadership.

Michael (2008) conducted a Meta-analysis by using Pearson correlations to analyze the findings of 31 studies on NPD success factors for New Technology Ventures (NTVs). The study identified 3 main factors and 24 most widely researched NPD success elements or sub-factors for NTVs, The 3 main factors are Market and Opportunity, Entrepreneurial Team and Resources. In summary, there is a rich stream of literature discusses the determinants of new product success from NPD management points of views (Cooper and Kleinschmitdt, 1986; Marisa *et., at,* 2008; Cooper, 2008; Cornelia, Roger and Nukhet, 2008; Chen and Chen, 2009) which could be regrouped into 6 categories, which are Technology Management, Strategy Management, Financial Management, Societal and Cultural Management; Human Resource Management and Market & Competitor Management. These management constructs are adapted in this research as reference for factor extraction during factor analysis.

Conceptual Framework

According to Loch and Kavadias (2008), NPD encompasses a great number of areas, for instance formulation and deployment of NPD strategy, allocation of NPD resource, planning, monitoring and control of NPD activities. Loch and Kavadias (2008) argued that no "theory of NPD exist" and there is no consensus on whether one can and should exist. However, Loch and Kavadias (2008) suggested that multi-level evolutionary theory (Sobel and Wilson, 1999) could potentially explain the *large part of NPD phenomena in a comprehensive causal framework*. Hence, Loch and Kavadias (2008) proposed a NPD evolutionary framework based on multi-level evolutionary theory that consists of three levels aggregation, which are:
Level 1: NPD process level with a population of NPD process phases;
Level 2: Firm level with a population of procedures, rules and process;
Level 3: Industry level with a population of firms.

The core concept of the NPD evolutionary framework is the framework *allows characterizing commonalities across the different levels of aggregation* (Loch and Kavadias, 2008)*, and at the same time provides enough flexibility to accommodate the differences between the aggregations*.

The conceptual framework for this research is developed base on NPD Evolutionary Framework (Loch and Kavadias, 2008) however focuses on two levels of aggregations (instead of three) with NPD Process as level one, and combine firm-industry levels to as "holistic NPD Management" as level two. The uniqueness of the framework is it based on a concept where holistic NPD Management constructs at firm level (higher aggregation level) influence NPD Process framework and practices (at lower aggregation level). Meantime, both NPD Management and NPD Process have a direct impact on NPD Performance. As such, this research focuses the development of NPD hybrid framework (i.e. NPD process and NPD management integration framework) based on Loch NPD Evolutionary framework.

Research Methodology

Research Design

The research is deductive based. Deductive approach gives tangible empirical evidence through evaluation of rational relationship among concepts (Neuman, 2007). The research began with literature review on important NPD process constructs and attributes. Subsequently, survey questionnaires were used as research instrument to check the degree of importance placed by the respondents on the 101 NPD process attributes derived from the literature review. Next, exploratory Factor analysis was applied as data reduction tool to screen and group inter-correlated NPD process attributes with the ultimate aim to extract the representatives NPD Management constructs. Aligned with the hybrid framework concept, attributes that commonly shared between NPD process and management constructs are identified and grouped together to form the NPD hybrid framework.

Research Instruments

The research used quantitative tool via survey questionnaires. A questionnaire is designed based on the 101 important NPD process attributes that identified from the extensive literature review. The questionnaire attempts to check the degree of importance placed by the respondents of R&D based organizations in Malaysia on the 101 important NPD attributes derived from the literature review. Respondents are asked to rate the level of importance they placed on each attributes based on the five point scale of (1) `Not important to (5) `Extreme important'.

Analysis Tools

Kaiser-Meyer-Olkin (KMO) analysis is used to measure sampling adequacy. The KMO measure is within 0 to 1. A "0" value of KMO represents sum of partial correlation is greater than sum of overall correlation, therefore factor analysis is unacceptable. Value of "1" indicates that correlations trend is relatively compact and application of Factor Analysis is appropriate (Kaiser, 1974). Field (2005) suggested a KMO value of more than 0.5 is acceptable.

Factor analysis attempts to identify small number of underlying attributes that explain most of the variance observed in a much larger number of manifest variables (Eelko, 2007). Exploratory Factor analysis with principal component analysis extraction method and Varimax rotation is applied in this research as a data reduction tool to screen and group inter-correlated pf NPD process attributes to form the representative NPD management constructs. Through Factor analysis, redundant items from the quantitative data were deleted prior to subsequent analysis.

Population and Sampling Size

Population of this research were R&D Manager or Director from 4 R&D groups defined by The Malaysia Research and Development Classification System (MRDSS). Which are (a) Computer Hardware and Electronic Equipment R&D, (b) Communication Equipment R&D, (c) Instrumentation R&D, (d) Machinery and Equipment R&D. Base on the list of Multimedia Super Corridor (MSC) status companies given by the authority of MSC, there are 186 companies in the list. Based on Krejcie and Morgan sampling size table, the targeted sample size for this study is 127 companies randomly selected from the list of MSC.

Result and Discussion

Return survey questionnaires were verified via data screening process to ensure data in the questionnaires are all in place, and accounted for. As the result, the total population for the quantitative survey was 28 companies. The total useable respondents are 89 companies, this made up the total company's response rate of 69.5%. In addition, the value of 0.614 for Kaiser-Meyer-Olkin Measure of Sampling Adequacy and the low p-value of 0 for Bartlett's Test of Sphericity indicate that the quantitative field data is significant for subsequent factor analysis.

Development of NPD Management Constructs

Scree Plot criterion is used to determine the number of un-rotated factors (i.e. NPD management constructs) to be extracted. Result of Scree plot illustrates that the 7 factors model contributes the highest "rotated sum of loading" of 39.4%. Hence, factor analysis is rerun with Scree Plot extraction method of 7 factors, and factor loading of 0.33. The extraction was done via Principle Component Extraction method and rotation of Varimax with Kaizer Normalization.

Bases on analysis of Rotated Component Matrix of factor analysis, 73 out of the original 101 attributes are loaded into 7 factors to from the main NPD Management constructs. 28 attributes are excluded. The NPD management constructs extracted from factor analysis are composed of two main categories:

a) Management of general organization functional competencies such as Customer and Project Development management, Technology management and Human & Operations Management.
b) Management of specific organization decision outcomes such as Strategic management, Competitor management, financial management.
The 7 factors or constructs with the respective Cronbach Alpha reliability coefficient are summarized in Table 1. Cronbach Alpha reliability values for all constructs are found to be above 0.7971. This implies that the data is statistically significant to proceed for further analysis.

Table 1: Reliability Analysis (NPD Management Constructs)

NPD Management Constructs	Cronbach's Alpha
Customer & Project Development Management (C&PDevM)	0.9034
Strategic Management (StraM)	0.8970
Financial Management (FinM)	0.9217
Business Development Management (BusDevM)	0.9017
Human, Competitor & Operations Management (HC&OM)	0.8066
Technology Management (TechM)	0.8687
Product Risk Assessment Management (PRiskM)	0.7971

Development of novel NPD Hybrid Framework

Aligned with the hybrid framework concept of this research, the average score of attributes commonly shared by each set of NPD Process and Management constructs are calculated to

determine a mean score of NPD Process-Management hybrid construct based on following formula.

$p \cap m = \{x \mid x \in p \text{ and } x \in m\}$	(1)
$Important\ level\ of\ P \cap M = \frac{\sum_{i=1}^{n} x_i}{n}$	(2)

P = NPD Process construct p = Attributes for NPD Process construct P.
M = NPD Management construct m = Attributes for NPD Management construct M
$P \cap M$ = NPD Process-Management hybrid construct.
$p \cap m$ = NPD Process and Management hybrid attributes

As example, there are nine common attributes shared by NPD process construct "Design and Development" and NPD Management construct "Technology Management". The nine commonly shared attributes and their individual average rating from quantitative survey is summarized in Table 2.

Table 2: Important Level of Technology Management in Design and Development Phase

	NPD Process construct: Design & Development (D&D)	Important level
NPD Management construct: Technology Management (TechM)	Attribute 1: Application of CAD	4.63
	Attribute 2: Application of DFM	4.68
	Attribute 3: Application of DFMEA	4.61
	Attribute 4: Application of Robust Design	4.69
	Attribute 5: Optimization of design through DOE	4.58
	Attribute 6: Product Component Trade-off	4.58
	Attribute 7: Modelling and simulation	4.58
	Attribute 8: Concurrent Engineering	4.67
	Attribute 9: Prototype development	4.67
	Average of TechM in D&D Hybrid Construct	*4.63*

The average rating for the nine attributes is calculated as 4.63, this number representing the important level score for hybrid construct "Technology Management in Design and Development phase". The formation of hybrid framework streamlines the NPD important level into a matrix form; the score for the rest of NPD hybrid constructs are generated and summarized in Table 3.

Table 3: NPD Hybrid Framework

		NPD Process				
		D&D	PC	OI	PT	CD
NPD Management	TechM	4.63				
	StraM	4.68	4.58	4.5		
	BusDevM	4.49	4.52	4.3		
	FinM		4.49		4.20	
	C&PDevM		4.14		4.18	4.16
	PRiskM				4.27	4.00
	HC&OM			4.15		3.89

As shown in Table 3, the aspects of Strategy management in Design Development phase (StraM in D&D) and Technology management during Design and Development phase (TechM in D&D) are regarded as the most important hybrid constructs for NPD within R&D based companies in Malaysia. While, the management of Human, Competitor and Operation during concept development stage (HC&OM in CD) is rated as the least important hybrid construct.

The importance of Strategy Management in Design and Development phase is also confirmed in the study by Porter (1980). According to Porter (1980), competitive strategy in design and development phase frames-up the organization targeted market segment and the desired market position, outlines product development framework and development plan to defend competition from other market players, with the ultimate aim to reach and secure the company's desired position.

The finding from the NPD hybrid framework is also consistent with research done by Tatikonda and Stock (2003). Tatikonda and Stock (2003) developed a NPD conceptual model that integrates NPD with supply chain management and technology management. The research identified that management of technology is the key activity in the Design and Development process. The same observation was made by Love and Roper (1999), where they revealed that technology management; in particular management of technology transfer is the most important constructs at design and development stage.

Conclusion

Based on the findings of this research, the formation of NPD Process and NPD Management Hybrid Framework suggests that a comprehensive NPD Process and NPD Management integration theory exist with the potential to describe a large part of NPD phenomena within the context of R&D based companies in Malaysia. The hybrid framework allows characterizing commonalities of attributes across the different stages of NPD process and

various levels of NPD management. In addition, the hybrid framework has descriptive value in terms of studying, classifying and defining the attributes and relationships that govern process and management aspects in NPD, which is significant to the literature and study of NPD. A potential extension of this research is to assess the NPD Process and Management hybrid constructs framework on a single industry sector basis. This would contribute to the knowledge of NPD via determination of how the research output differs between types of industries.

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