Jurnal
Teknologi

Full Paper

ANALYSIS OF INNOVATION CAPABILITIES AND COMPANY PERFORMANCE: AN EMPIRICAL EVIDENCE OF MALAYSIAN LARGE COMPANIES USING PLS-SEM.

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Article history
Received
25 October 2015
Received in revised form
14 December 2015
Accepted
9 February 2016

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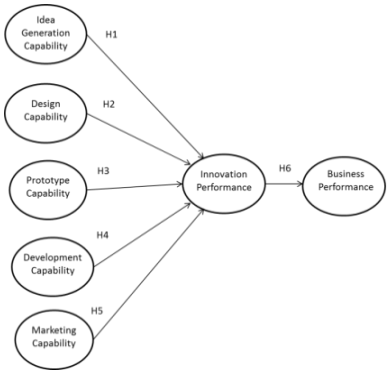
Graphical abstract



Abstract

Although numerous studies have been conducted to gauge the innovativeness of the Malaysian companies, the understanding on the Malaysian companies' innovation capabilities are still low and unclear. This study employed a structured framework to gauge the innovation capabilities of the Malaysian large companies. This framework is significant in such a way that it clearly distinguished the innovation factors, innovation process, innovation output and innovation outcome of the company. Next, the PLS-SEM was used to validate the innovation capabilities framework and later used to examine the hypothesized relationships that linked all the innovation capabilities constructs with the company performance constructs. A total of 124 responses from the managers were received but only 98 valid responses were used to validate the structural model of this study. The findings confirmed that the framework has the ability to predict the innovation capabilities of the Malaysian large companies. It was also found that design capability; develop capability and prototype capability is significantly related to innovation performance. In addition, the innovation performance was also found to be significantly related to the business performance. Results of this study shall guide the companies in focusing on the innovation processes that needed to be improved in order to expedite their innovation capabilities.

Keywords: Innovation capabilities, large companies, performance, PLS-SEM

1.0 I NTRODUCTION

Malaysia has embraced innovation as a key strategy to be the Developed and High-Income Nation by the year 2020. There are only a few years left for Malaysia to achieve this vision, therefore, various studies to measure the innovativeness of individuals, organizations, companies and the country have been carried out to support this vision. The first initiative of the Malaysian innovation studies was conducted by Malaysian Science and Technology Information Centre (MASTIC) under Ministry of Science, Technology and Innovation (MOSTI) whom carried out the first National Survey of innovation (NSI-1) in 1995. To date MASTIC had conducted 6 NSI surveys which include: NSI-1(1990-1994), NSI-2 (1997-2000), NS-3 (2000-2001), NSI-4(2002-2004), NSI-5(2005-2008) and NSI-6 (2009-2001). The NSI survey adopted a questionnaire based on Oslo Manual guidelines and CIS-4 harmonized questionnaire [1]. The Productivity Investment Climate Survey (PICS) was conducted with the collaboration of Economic Planning Unit, Prime Minister's Dept. and World Bank. PICS conducted an assessment of a country's business environment on

firm performance in an internationally comparable manner. Questions related to innovation is covered under capacity, innovation, and learning section. To date, two PICS surveys has been conducted; PICS-1 in 2002 and PICS-II in 2007 [2]. MyKe (Knowledge Content in Key Economic Sectors in Malaysia was conducted in 2003 (MyKe 1) and 2007 (MyKe 2) by Georgia Tech and IISC in collaboration with EPU and DOSM using Knowledge Content Measurement Model. Its objectives are to identify and analyze leading and lagging sectors in terms of knowledge content[3]. Technological Innovation Capabilities of Malaysian-owned companies Survey (MyTIC) conducted in 2012 was a collaboration work of MITI, MPC and Centre of Modelling and Data Analysis (DELTA) UKM aims to gauge the level of Technological Innovation Capabilities (TIC) of the Malaysian-owned companies [4]. The Innovation Certification For Enterprise rating and Transformation (1-InnoCERT) is a yearly certification assessment scheme under SMECORP. The 1-InnoCERT assessment consists of two phase evaluation which based on innovation ability, commercialization of innovation ability, management of innovation ability and the innovation outcome [5]. Due to its emerging concern, many individual researchers also have shown much interest on innovation study. Researcher use various models and frameworks to identify the factors of innovation [6] and its role in the organizational performance [7]. Other researcher examines the relationships of innovation with the firm's performance [8][9] and the innovation level of the company [10][4].

Despite of numerous studies being conducted to gauge the innovativeness of the companies in Malaysia, the application of the structured innovation framework and the understanding on the Malaysian companies' innovation is still unknown and unclear. The mix use of definition, indicators, factors, parameter and approaches in the previous study of innovation made it difficult to gauge and understand the Malaysian company innovativeness [11]. Framework from other countries could be used but different country has different culture and innovation landscape. Furthermore, studies who applied the empirical data on the Malaysia innovation studies are still limited. Therefore, this study uses a structured and holistic framework by clearly distinguished the difference among the innovation factors, innovation process, innovation output (Innovation Performance) and innovation outcome (Business Performance) to measure the innovation capabilities of the Malaysian large companies. Then, the Structural Equation Modelling–Partial Least Square methodology (herein after called as PLS-SEM) was used to validate the innovation capability framework and used to assess the hypothesized relationships that linked all the innovation capability constructs with the company performance constructs. Result from this study shall contributes to the growing empirical literature on Malaysia innovation and shall guide the Malaysian companies in focusing on the innovation processes that needed to be improved in order to expedite their innovation processes.

2.0 EXPERIMENTAL

2.1 Data Collection

The sampling frame of this study was based on the database provided by Department of Statistic Malaysia (DOSM). It includes companies established under the IMP3 sectors, owned by Malaysian with equity of more than 50 percent and established under the large company category. A total of 124 responses from the owner or top management of the Malaysian Large companies were received but only 98 valid responses were employed to validate the structural model in this study.

2.2 Theoretical Framework

In this study, PLS-SEM is used to predict the innovation capabilities of the Malaysian large companies. Hypotheses were developed and used to explained and predict outcomes of the study. Innovation Capabilities constructs consist of 1) Idea Generation capability 2) Design capability 3) Prototype capability 4)Development capability and 5)Marketing capability whereas the company performance constructs consist of 1)Innovation Performance and 2) Business Performance. They were all the reflective constructs with 3, 4, 4,4,4,4 and 5 indicators respectively. Figure 1 depicted the framework for innovation capabilities in the Malaysian Large companies.

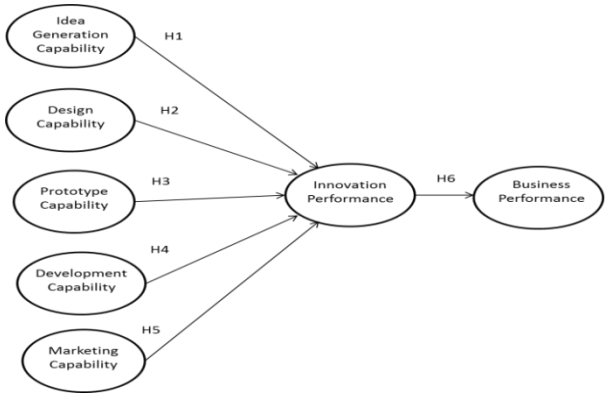


Figure 1 Framework for innovation capabilities of the Malaysian large companies

The foundation model of this study were developed during the Technological Innovation Capabilities (TIC) of Malaysian-Owned Companies Survey 2012 [11][4]. Based on the past literatures below hypotheses were proposed:

H1: Idea Generation capability is related to Innovation Performance.

H2: Design capability is related to Innovation Performance.

H3: Prototype capability is related to Innovation Performance.

H4: Development capability is related to Innovation Performance.

H5: Marketing capability is related to Innovation Performance.

H6: The Innovation Performance is related to the Business Performance. The summary of respective Innovation Capabilities indicators, Innovation Performance Indicators and Business Performance indicators and the descriptions of each indicator were presented in Table 1.

Table 1 Indicator for innovations capabilities, innovation performance and business performance constructs

Constructs	Indicators	Items
Idea Generation Capability	CP1_FC2	Are the Facility factors effectively implemented in the Idea Generation Stage?
	CP1_FF2	Are the Funding factors effectively implemented in the Idea Generation Stage?
	CP1_HR2	Are the Human Resource factors effectively implemented in the Idea Generation Stage?
Design Capability	CP2_FC2	Are the Facility factors effectively implemented in the Design stage?
	CP2_FF2	Are the Funding factors effectively implemented in the Design stage?
	CP2_HR2	Are the Human Resource factors effectively implemented in the Design stage?
	CP2_PO2	Are the Policy factors effectively implemented in the Design stage?
Prototype Capability	CP3_FC2	Are the Facility factors effectively implemented in the Prototype stage?
	CP3_FF2	Are the Funding factors effectively implemented in the Prototype stage?
	CP3_HR2	Are the Human Resource factors effectively implemented in the Prototype stage?
	CP3_PO2	Are the Policy factors effectively implemented in the Prototype stage?
Development Capability	CP4_FC2	Are the Facility factors effectively implemented in the Development stage?
	CP4_FF2	Are the Funding factors effectively implemented in the Development stage?
	CP4_HR2	Are the Human Resource factors effectively implemented in the Development stage?
	CP4_PO2	Are the Policy factors effectively implemented in the Development stage?
Marketing Capability	CP5_FC2	Are the Facility factors effectively implemented in the Marketing stage?
	CP5_FF2	Are the Funding factors effectively implemented in the Marketing?
	CP5_HR2	Are the Human Resource factors effectively implemented in the Marketing stage?
	CP5_PO2	Are the Policy factors effectively implemented in the Marketing stage?
Innovation Performance	IPI_PDT1	Level of Product innovation based on number of improvements to existing products/services.
	IPI_PDT2	Level of Product innovation based on number of new product/services produced.
	IPI_PR1	Level of Process Innovation based on number of improvements to existing process.
	IPI_PR2	Level of Process Innovation based on number of new product/services produced.
Business Performance	NewMKT	Impact of innovation activities on the establishment of new market segment
	Prodvity	Impact of innovation activities on productivity
	Profit	Impact of innovation activities on profit
	Sales	Impact of innovation activities on sales
	ExistMKT	Impact of innovation activities on existing market segment

3.0 RESULTS AND DISCUSSION

3.1 Characteristics of the Companies

Out of 124 questionnaires received from the Malaysia large companies, only 98 questionnaires were valid to be employed in this study, representing a usable rate of 79%. Out of 98 companies, 67.3 percent was from the Service sector and 32.7 percent was from the Manufacturing sector. Majority of the companies were from the Business and Professional industry (23.5%), followed by Logistic industry (20.4%), ICT and Food Processing industry (both hold 12.2%) and Healthcare industry (11.2%). 44.9 percent of the companies have been operated between 11 to 20 years, 42.9 percent have been operated more than 20 years, 10.2 percent have been operated between six to ten years and only 2 percent of the companies have been operated between two to five years.

Annual Sales turnover of the companies ranged between RM250 thousands to more than RM 25 Million with 55.7 percent companies have more than 25 Million Annual Sales Turnover followed by 16.5 percent (10 Million to 25 Million), 12.4 percent (more than 5 Million and less than 10 Million), 11.3 percent (more than 1 Million to 5 Million) and 4.1 percent (more than 250 thousands to 1 Million) respectively.

3.2 Assessment of the Reflective Measurement Models.

The innovation capability of the Malaysian Large Companies Model has seven constructs with reflective measurement models. The reflective measurement models include Idea Generation capability (3 indicators), Design Capability (4 indicators), Prototype Capability (4 indicators), Development Capability with (4 indicators), Marketing Capability (4 indicators), Innovation Performance (4 indicators) and Business Performance (5 indicators). The objectives of the reflective measurement models assessment is to estimates the relationships between the construct and their indicators. [12] suggested four criteria of the reflective measurement model assessment. These criteria include evaluation of indicator reliability, internal consistency (composite reliability), convergent validity and discriminant validity at indicator and construct level. The measurement models results are summarized in Table 2.

Table 2 Results summary for the reflective measurement model

Construct	Indicators	Loadings	Indicator Reliability (loadings2)	Composite Reliability	AVE
Idea Generation Capability	CP1_FC2	0.727	0.528	0.908	0.769
	CP1_FF2	0.949	0.901		
	CP1_HR2	0.936	0.877		
Design Capability	CP2_FC2	0.828	0.686	0.904	0.703
	CP2_FF2	0.851	0.723		
	CP2_HR2	0.861	0.742		
	CP2_PO2	0.812	0.659		
Prototype Capability	CP3_FC2	0.863	0.744	0.919	0.738
	CP3_FF2	0.842	0.709		
	CP3_HR2	0.886	0.785		
	CP3_PO2	0.845	0.715		
Development Capability	CP4_FC2	0.932	0.869	0.952	0.834
	CP4_FF2	0.928	0.862		
	CP4_HR2	0.895	0.801		
	CP4_PO2	0.896	0.802		
Marketing Capability	CP5_FC2	0.860	0.740	0.929	0.767
	CP5_FF2	0.951	0.904		
	CP5_HR2	0.932	0.868		
	CP5_PO2	0.746	0.556		
Innovation Performance	IPI_PDT1	0.908	0.824	0.940	0.797
	IPI_PDT2	0.915	0.837		
	IPI_PR1	0.853	0.728		
	IPI_PR2	0.894	0.799		
Business Performance	NewMKT	0.853	0.728	0.896	0.634
	Prodvity	0.703	0.494		
	Profit	0.773	0.598		
	Sales	0.901	0.811		
	ExistMKT	0.734	0.539		

Indicator reliability shows the reliability of each manifest variable [12]. The indicators reliability of the reflective constructs: Idea Generation Capability, Design Capability, Prototype Capability, Development Capability, Marketing Capability, Innovation Performance and Business Performance are between 0.494 and 0.901. The threshold for indicators reliability of 0.70 is preferred, however for an exploratory research, indicator reliability of 0.40 or higher is acceptable [13]. Therefore, it can be said that all of the indicators for the seven reflective constructs are well above the minimum acceptable levels for outer loading.

The composite reliability measures the reliability of a block of manifest variable [12]. The composite reliability values of 0.908 (Idea Generation Capability), 0.904 (Design Capability), 0.919 (Prototype Capability), 0.952 (Development Capability), 0.929 (Marketing Capability), 0.940 (Innovation Performance) and 0.896 (Business Performance) demonstrate that all seven reflective constructs have high levels of internal consistency reliability. In order to measure the validity of the measurement model, assessment of convergent validity and discriminant validity were conducted. Convergent validity is the extent to which a measure correlates positively with the alternatives measures of the same constructs [12]. Results showed that the AVE values of Idea Generation Capability (0.769), Design Capability (0.703), Prototype Capability (0.738), Development Capability (0.834), Marketing Capability (0.767), Innovation Performance (0.797) and Business Performance (0.634) are well above the required minimum level of 0.50. Therefore, the measures of the seven reflective constructs have high levels of convergent validity. Fornell-Larcker criterion and the cross loadings allow checking for discriminant validity [14]. The Fornell-Larcker criterion result is shown in Table 3. Overall, the square roots of the AVEs for the reflective constructs: Idea Generation Capability (0.877), Design Capability (0.838), Prototype Capability (0.859), Development Capability (0.913), Marketing Capability (0.876), Innovation Performance (0.893) and Business Performance (0.796) are all higher than the correlations of these constructs with other constructs in the path model.

Table 3 Fornell-Larcker criterion analysis for checking discriminant validity (at construct level).

	1	2	3	4	5	6	7
1. Business Performance	**0.796**						
2. Design Capability	0.134	**0.838**					
3. Development Capability	0.204	0.515	**0.913**				
4. Idea Generation Capability	0.080	0.460	0.287	**0.877**			
5. Innovation Performance	0.136	0.359	0.268	0.259	**0.893**		
6. Marketing Capability	0.239	0.498	0.264	0.251	0.137	**0.876**	
7.Prototype Capability	-0.102	0.481	0.685	0.398	0.521	0.249	**0.859**

Discriminant validity is established when an indicator's loading on a construct is higher than all of its cross loading with other construct [14]. Table 4 exhibits the loadings and cross loadings for every reflective constructs indicator.

Table 4 Loadings and cross- loadings analysis for checking discriminant validity (at indicators level)

	Idea Capability	Design Capability	Prototype Capability	Development Capability	Marketing Capability.	Innovation Performance	Business Performance
CP1_FC2	**0.727**	0.394	0.274	0.272	0.162	0.154	0.101
CP1_FF2	**0.949**	0.462	0.402	0.275	0.312	0.274	0.074
CP1_HR2	**0.936**	0.356	0.354	0.221	0.164	0.236	0.045
CP2_FC2	0.344	**0.828**	0.464	0.461	0.307	0.359	0.047
CP2_FF2	0.487	**0.851**	0.416	0.445	0.548	0.278	0.023
CP2_HR2	0.478	**0.861**	0.359	0.344	0.478	0.288	0.066
CP2_PO2	0.269	**0.812**	0.365	0.463	0.375	0.268	0.286
CP3_FC2	0.298	0.408	**0.863**	0.502	0.173	0.531	-0.096
CP3_FF2	0.372	0.419	**0.842**	0.718	0.276	0.377	-0.021
CP3_HR2	0.446	0.478	**0.886**	0.629	0.231	0.418	0.006
CP3_PO2	0.277	0.358	**0.845**	0.549	0.196	0.433	-0.213
CP4_FC2	0.266	0.514	0.647	**0.932**	0.231	0.275	0.179
CP4_FF2	0.293	0.470	0.662	**0.928**	0.251	0.272	0.057
CP4_HR2	0.361	0.473	0.586	**0.895**	0.244	0.178	0.269
CP4_PO2	0.145	0.423	0.609	**0.896**	0.241	0.255	0.214
CP5_FC2	0.200	0.455	0.309	0.256	**0.860**	0.172	0.157
CP5_FF2	0.227	0.418	0.190	0.237	**0.951**	0.140	0.311
CP5_HR2	0.345	0.494	0.254	0.216	**0.932**	0.096	0.162
CP5_PO2	0.084	0.432	0.111	0.231	**0.746**	0.028	0.131
IPI_PDT1	0.239	0.292	0.489	0.274	0.006	**0.908**	0.198
IPI_PDT2	0.297	0.296	0.533	0.163	0.191	**0.915**	0.109
IPI_PR1	0.110	0.380	0.392	0.273	0.093	**0.853**	-0.011
IPI_PR2	0.252	0.333	0.420	0.270	0.197	**0.894**	0.167
NewMKT	0.152	0.125	-0.099	0.158	0.278	0.170	**0.853**
Prodvity	-0.073	0.023	0.009	0.225	0.126	0.004	**0.703**
Profit	-0.064	0.028	-0.234	0.111	0.011	-0.077	**0.773**
Sales	0.048	0.088	-0.132	0.150	0.112	0.046	**0.901**
ExistMKT	0.156	0.218	0.053	0.188	0.343	0.301	**0.734**

In conclusion, as can been seen in Table 2, Table 3 and Table 4, all criteria for reflective measurement model have been met, providing support for the measures' reliability and validity of the Innovation Capabilities of the Malaysian Large Company Model.

3.3 Assessment of the Structural Model

Assessment of the structural model shall determine how well the empirical data support the innovation capability of the Malaysian Large company theory. For this reason, the path coefficients and R^2 values were examined. Path coefficient represents hypothesized relationships of the constructs. Path coefficient close to +1 indicates a strong positive relationship whereas close to -1 indicate strong negative relationships [15]. The significance of the path coefficients were tested by using bootstrapping procedure. Table 5 exhibits the t-statistics for path coefficients structural model.

Table 5 T-statistics for path coefficient structural model

	Relationships	Path Coefficient	*t* value	*p* values	Decision
H1	Idea Generation Capability --> Innovation Performance	0.005	0.055	0.956	NS
H2	Design Capability --> Innovation Performance	0.226	2.067	0.041	**
H3	Development Capability --> Innovation Performance	-0.235	1.810	0.073	*
H4	Prototype Capability --> Innovation Performance	0.586	5.174	0.000	***
H5	Marketing Capability --> Innovation Performance	-0.061	0.692	0.490	NS
H6	Innovation Performance -> Business Performance	0.332	3.018	0.003	***

NS: Not supported ; *p < .10. ** p < .05. ***p <.01.

Based on the t-test statistics, Hypotheses H2, H3, H4 and H6 were supported whereas Hypotheses H1 and H5 were not supported. Design Capability, Development Capability and Prototype Capability were related to the Innovation Performance. In addition, the Innovation Performance was also found to be related to Business Performance. On the other hand, the Idea Generation Capability and Marketing Capability were not related to the Innovation Performance. R^2 value is a measure of the model's predictive accuracy[12]. R^2 value of 0.316 (Innovation Performance) were considered high in discipline such as consumer behavior and social science. Further analysis of Q^2 by means of blindfolding procedures showed that Q^2 values were larger than zero indicated the path models predictive relevance for the particular constructs. The effect size f^2 analysis was used to access the exogenous constructs contributions to its endogenous constructs [16]. Results shown that Prototype capability (0.240) have a medium effect on the Innovation performance whereas f^2 effect size for Design capability (0.032) and Development capability (0.041) shown a small effect on the Innovation performance.

4.0 CONCLUSION

The purpose of this study is to validate and assess the hypothesized relationships among the innovation capabilities (Idea Generation capability, Design capability, Prototype capability, Development capability, Marketing capability), innovation output (Innovation Performance) and the innovation outcome (Business Performance) of the Malaysian Large companies. Based on the SEM-PLS results, all model evaluation criteria have been met, thus giving evidence of the reliability and validity of the innovation capabilities of the Malaysian large companies' framework. From the six hypotheses tested, four out of six hypotheses showed that they were statistically significant. Results of this study suggest that in the Malaysian large companies' innovation eco-system, design capabilities, prototype capabilities and development capabilities were significant and related to the innovation performance. It was also found that Innovation Performance will leads to a greater Business Performance. Thus, managers should focus on the enhancing and improving the company's related innovation policies, funding, skill of the human resources and facilities in the design, development and prototyping process.

Acknowledgement

The work describe in this paper is supported by a grant from Malaysia Productivity Corporation (STGL-005-2012). The authors wish to express their grateful appreciation to the members of MyTIC 2012 study from Center of Data Modelling and Analysis Data (DELTA), FST, Universiti Kebangsaan Malaysia for their assistance in conducting the study.

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