The Relationship between Technological Capability and Manufacturing Performance

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***Abstract*— Technological capability plays an important role in achieving competitive advantages. It also increases performance of firms, industries, and as well as for the countries. Its' potential as competitive weapon has been recognized to the industry. Manufacturers are striving to outperform the competitors. They are not only competing on the profit made but also struggling to perform a high level operational performance. Traditionally, manufacturers' performance were measured based on the accounting management measures. However, the focus had shifted from solely emphasizing on financial measures to more specific multidimensional operational priorities. Hence, the purpose of this study is to investigate the relationship between two dimensions of technological capability (i.e. acquiring and upgrading) and four dimensions of manufacturing performance (i.e. quality, cost, delivery and flexibility). Stratified random sampling was employed and 302 questionnaires were distributed to the respondents ranging from small to large manufacturing firms in Malaysia. Pearson correlation analysis was employed to test the hypothesis. The study result shows that the relationship between technological capability and manufacturing performance is significant and positive. This study proved there is a connection between the variables. Further investigation is required to understand the impact of technological capability on manufacturing performance and to understand deeper the influences of differences by size of firms and industry characteristics.**

Keywords*—*Technological capability, manufacturing performance, resource-based view, manufacturing industry

1. Introduction

Technological capability (TC) has been studied for almost 40 years since 1980 from the earliest literature of model development on TC. Studies on TCs are intensely relevant up until today, in varies sector of industries [1-5]. Research has now collaborating the benefits of assessing TC in the context of fourth industrial revolution era [6]. The fundamental understanding about TC is simply where firms are originally technologically immature and incapable, where TC starts to be developed through the learning process over time when knowledge starts to accumulate and the firms are able to progressively run new activities while improving the capabilities [1, 7]. This has proof that the development of TC is not a short term commitment. For TC to be built, it must involves with a long term process instead of a short term planning [8]. Therefore, it must takes effort of every component to obtain the result of the firm performance and acquire competitive advantages while at the same time trying to sustain the commercial success in the local and global market during the long life span [9]. It is suggested the development of TC is a constant and cumulative process [6]. In a long-term view, technological interactions between firms and their environments have to be considered in manufacturing strategy formulations in both national and company levels, where firms' TCs help build technological characteristics in both internal and external contexts in an accumulating procedure [4, 8].

Szalavets [6] defines TC as the capability to change or develop products and processes more meaningfully than what routine production activities would entail. It is manifested to the capability of firm in adapting and improving the new technological components for the firm whether it is a process, product or a system. Schubert et al. [10] perceived TCs as the sum of the firms' internal competences ranging from the production, use, adaption and improvement of new technological knowledge, value chain technologies and product development technologies, competences in technology forecasting and technology assessment

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as well as the ownership of patents and licenses. To put the definition in conclusively, TC is a term that encompasses the system of activities, physical systems, skills and knowledge bases, managerial systems of education and reward, and values that create a special advantage for an organization or line of business. Basically, firms must be capable in operating, maintaining, adapting, and assimilating the transferred technology to survive the changing industrial technology. TC funtions suit the firm's technology management activities of identification, selection, acquisition, exploitation and protection [11].

Advanced high-technology large-scale firms prone to have a high degree of technological capability. However, SMEs faced another story where they often encounter more difficulties in developing TC due to the resource limitations on investments and talents and the huge risk of R&D itself [12, 13]. Thus making these companies appreciating their organizational learning and knowledge management to support the firms' abilities in exploring and utilizing various external technical resources or developing new techniques for the sake of TC accumulation over time. There are two main dimensions of TC which are activities and strategies [14]. Activities concerned with the research and development activity in term of patenting, product launching, and problem solving whereas strategy will consider on the technological sourcing. TC has been investigated dynamically in terms of its capacity utilization, the quality of TC and, the level of TC [15, 16].

2. Technological Capability and Firm Performance

It is known that the development of technological capability (TC) helps a company gain competitive advantage [17-19] and stretch the competitive capabilities [3, 20]. Basically, three areas of manufacturing that affected by technological changes are information technology, materials technology, and manufacturing process technology. A bunch of studies have been carried out on the effect of TC towards manufacturing, high-technology, or technology-based firms' performance specifically. TC has also been proven to play an important roles in the establishment from ordinary technology-based firms to become highly innovative firms besides the knowledge and managerial capabilities [21]. The performance indicators differed within different studies' focus. It is acknowledged that TC is one most essential capabilities that has the impact on firm performances [22].

TC has been tested on its impact towards operational performance aspects namely; innovative output and technological impact [23], competitive priorities [19], customer satisfaction [3, 24], innovativeness [25], strategic decisions [4, 26], system efficiency [6, 27], main technology performance [28], innovation performance [20, 29-32], manufacturing or operational performance [8, 33-35], and new product development (NPD) performance [36-40].

TC is recognized to have a direct effect on the NPD and overall business performance [38]. Both performances are also indirectly affected when the customer value participates as mediator. Customer value in its own has an important impact on NPD performance and overall business performance. As such, it mediates the impact on TC. Nonetheless, the finding on the impact of TC on learning orientation and environmental turbulence is provisional, while the market turbulence has a negative moderating in the correlation between customer value and TC as well as the correlation between new product development performance and TC. There is another research that examined TC and its correlation with operational performance in manufacturing cost and quality of final product. The results indicated that TC, considered as technology absorption capability, however it was found not directly correlated to the performances [33].

Guifu and Hongjia [32] established three TC levels; technological shifting capability, technological acquiring capability, and technological operating capability and the impact on innovation performance. The findings revealed that technological shifting capability is significantly positively associated with product upgrading. Neither technological acquiring capability nor technological operating capability is notably related with product upgrading. Technological shifting capability and technological operating capability significantly pose a positive relation with process upgrading but not for technological acquiring capability. The magnitudes and effects of capabilities to firm transformation might be more complicated than anticipated, explaining the existence of non-related interactions between some particular TCs toward product and process upgrading.

Overall, previous studies in the field of TC have proved the significant roles played by TCs on various organizations performance measures even though the results are happened to be mix. Developing and improving TC of an organization is a long-term commitment and therefore its implementation plays important characters to ensure companies survival in the market for future accomplishments [6, 20], and sustainable industrial development [41]. In a nutshell, TC is labeled as crucial determinant together with other firm capabilities that promote competitive advantage and advance firm performance.

3. Resource Based View

A long-term sustainable competitive advantage will be generated if only a company develops its strategy based on the firm's resources and capabilities. This study provides a support for the argument that resources and capabilities are greatly important in relation to TC and manufacturing performance. Hayes and Wheelwright [42] manifested the relation between manufacturing strategy and resource-based view (RBV), where manufacturing strategy leads to the formation of a set of specific capabilities. Capabilities are referred as the complex forms of skills and accumulated knowledge that over time come to be embedded as firm's routines and practices [43]. Wernerfelt [44] stressed out that strategies which are not resource-based are doubtful to succeed in business environment.

As in the case of this research, TC acts as the resource needed by an organization to generate and manage technical changes [45], and technological changes [46] which promote firm performance. TC works as a set of functional abilities that reflected an organization's performance through various technological activities and whose ultimate purpose is firm-level value management by developing inimitable organizational abilities [47, 48]. Equally important, Wang, et al. [38] suggested that TC aids to escalate a firm's capacity to recognize and apply new exterior knowledge to continue the competence enlargement, which may result in superior performance.

It is argued that firm growth is drives by the development of new technology of products or processes which make the focus will be mainly to the firm TCs [38, 49, 50]. The aim to clarify the position of where TC fit in the resource base in both theoretical and empirical is by acknowledging the relationship between firm-specific capabilities and competitive advantage. For instance, a case study by Rangone [51] on fourteen SMEs had revealed an interesting point of view of RBV where companies will developed a sustainable competitive advantage through three basic capabilities of innovative capability, production capability and market management capability.

Being equivalent, this study is attempted to examine on the firm's ability to acquire and upgrade technology on new products and processes while exploiting these knowledge in order to assimilate, use, adapt and change existing technologies. These abilities will be evaluated in response to the changing economic environment of manufacturing industries. Capabilities are defined not by resource type, but in term of resource functionality to deploy its available resources as its main assets and the argument is that resource functionality is a true source of competitive advantage in a sense of its rareness [52, 53]. In other words, capabilities are a complex bundle of skills and accumulated knowledge that enable firms to coordinate activities and make use of their assets [54, 55]. As supported by Barney et al. [56], where they have suggested what are likely to be the most important capabilities that a firm can possess are the learning ability and the changing ability. The idea is, it is not only to proficiency in the TCs, but to also comprehend in deploying and expanding the full implications of core competencies, combine various stream of technologies and mobilize technological resources efficiently across organization [12, 38, 57].

4. Theoretical Framework

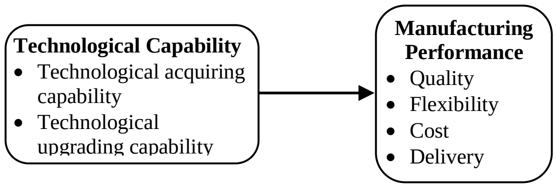

Figure 1. Theoretical framework

Previously, multiple theoretical perspectives have been covered to evaluate the relationship between TC and performance measures. We however, intentionally investigated the relationship between TC constructs (acquiring capability and upgrading capability) and manufacturing performance constructs (quality, flexibility, cost and delivery) as depicted in **Figure 1**. Thus in this research, we hypothesize the relationship between the two variables as:

***H1**: There is a significant relationship between technological capability and manufacturing performance*

5. Methodology

Respondents were asked to answer a set of close-ended questionnaires adapted from several related sources. This study emphasizes in measuring TC with ten measures while fourteen measures for manufacturing performance are shown in **Table 1**. Manufacturing performance were measured based on the attainment during the past three years to reduce the possibility of momentary changeability in the variables [58]. All the instruments were measured as perceptual data with a six-point Likert scale: strongly disagree (1); disagree (2); slightly disagree (3); agree (4); slightly agree (5); and strongly agree (6). The population is obtained from the Federation of Malaysian Manufacturers (FMM) Directory 2014. There are about 2,500 manufacturing companies registered under the Federation. A proportionate stratified random sampling technique was employed in this research to identify the proportion of sampled respondents. The unit of analysis is the organization. Statistical Package for Science Social (SPSS) version 22.0 was used to analyze the data being collected. Descriptive and correlation analyses have been carried out to achieve the research aim. Pearson correlation analysis was employed to test the hypothesis.

Table 1. Measurement Instrument and Related Research

Code	Items	Source
	Technological Capability	
TC1	We intensely cooperate with scientific research institutions to develop technologies	[58]
TC2	We cooperate with others (suppliers/customer) to develop technologies	
TC3	We tie with the technology suppliers in the market	
TC4	We manufacture with advanced technologies	
TC5	We have more skilful technical workers and operational workers	
TC6	We have less operation discontinuity	
TC7	We frequently upgrade our production process	
TC8	We strongly upgrade our products according to market demand	
TC9	We improve greatly on production process based on our own ideas	
TC10	We develop and test our own new product design	
	Quality	
PQ1	Improve high performance product features	[59]
PQ2	Offer consistence and reliable product quality	
PQ3	Improve conformance to product specification	
	Cost	
PC1	Reduce inventory	[60]
PC2	Increase capacity utilization	
PC3	Reduce production costs	
PC4	Increase labor productivity	
	Delivery	
PD1	Improve fast delivery	[59]
PD2	Improve delivery on time.	
PD3	Reduce production lead time	
	Flexibility	
PF1	Make rapid volume changes	[59]
PF2	Adjust capacity quickly	
PF3	Adjust product mix quickly	
PF4	Improve rapid equipment changeover	

6. Empirical Analysis

6.1 Descriptive Statistics

The hypothesis is tested on survey data collected from 175 firms ranging from small, medium, and large size manufacturing firms located in Johor, Melaka, Selangor, Kuala Lumpur, Perak, Pulau Pinang and Kedah, Malaysia. Only four industries involved in the survey due to their most contribution to the national manufacturing sector's gross domestic product for three consecutive years starting 2011. The survey was conducted in about four months from June 2015 until September 2015. 302 questionnaires were distributed and only 175 usable questionnaires were returned which represent 58 percent of response rate. Descriptive statistics of collected data are presented in **Table 2**.

Table 2. Descriptive Statistics

Demographic	F (n=175)	P (%)
Company ownership		
Malaysia owned	126	72.00
Foreign owned	49	28.00
Industry		
Food products	56	32.00
Chemical and chemicals products	44	25.15
Rubber and plastic products	38	21.70
Computer, electronic and optical products	37	21.15
Company establishment in Malaysia		
Less than 5 years	17	9.70
Between 5 to 10 years	30	17.15
More than 10 years	128	73.15
Number of full-time employees		
Less than 75 workers	82	46.90
Between 75 to 200 workers	37	21.10
More than 200 workers	56	32.00
Current position in the company		
Managing director or above	16	9.15
Director	9	5.15
General manager	11	6.30
Plant manager	13	7.40
Senior manager	15	8.60
Department manager	37	21.10
Senior Executive	74	42.30
Job function		
Corporate executive or managing	19	10.90
director	119	68.00
Operation or production	15	8.60
Planning and inventory	2	1.10
Purchasing	9	5.10
Quality control	11	6.30
Supply chain management		
Years of experiences working in the industry		
Less than 5 years	48	27.40
Between 5 to 10 years	64	36.60
More than 10 years	63	36.00

Note: F = Frequency, P = Percentage
Source: Computed data analysis

6.2 Validity of Instruments

To determine the validity of TC scale, a principle component analysis (PCA) was performed. Initially, there were ten items of TC. The results of factor analysis are shown in **Table 3**. As can be seen in the tabulation, the KMO measure of sampling adequacy for TC scale is 0.811 indicating that the items are interrelated. Bartlett's Test of Sphericity shows a significant value (Approx. Chi-Square = 786.683 $p < 0.001$) indicating the significance of the correlation matrix and appropriateness for factor analysis. Moreover, the individual MSA values range from 0.789 to 0.881, indicating that the data matrix was suitable to be factor analyzed.

Results of factor analysis with varimax rotation indicated the existence of two components with initial eigenvalues greater than one that explained 71.17 percent of total variance. There are four items merged together relating to firm's acquiring capability and was named as Technological Acquiring Capability (TAC) component. This first factor accounted for 38.30 percent of the total variance with loadings ranged from 0.715 to 0.912. The second factor which is related to firm's upgrading capability consisted of four items with loadings ranging from 0.671 to 0.843 which accounted for 32.87 percent of total variance explained. The second factor was named Technological Upgrading Capability (TUC). Both names of these two factors were renamed according to the original source [58]. Meanwhile, two items which are "having more skillful technical workers and operational workers", and "having less operation discontinuity" were discarded due to low on communalities values.

Table 3. Factor Analysis for Technological Capability

Item Description	Component	
	1	2
TC2 - We cooperate with others (suppliers/customer) to develop technologies.	**0.912**	
TC3 - We tie with the technology suppliers in the market.	**0.909**	
TC1 - We intensely cooperate with scientific research institutions to develop technologies.	**0.795**	
TC4 - We manufacture with advanced technologies	**0.715**	
TC10 - We develop and test our own new product design.		**0.843**
TC8 - We strongly upgrade our products according to market demand.		**0.828**
TC9 - We improve greatly on production process based on our own ideas.		**0.799**
TC7 - We frequently upgrade our production process.		**0.671**
Initial Eigenvalues	4.028	1.665
% of Variance Explained (after rotation)	38.298	32.867
Total Variance Explained (%)	71.166	
KMO	0.811	
Bartlett's Test of Sphericity:		
Approx. Chi-Square	786.683	
df	28	
Sig.	0.000	

Source: Computed data analysis

Determining the validity of manufacturing performance scale, the PCA was carried out too. Initially, there were 14 items and four dimensions; three items for quality performance, four items for flexibility performance, four items for cost performance and three items for delivery performance. The result of factor analysis is presented in **Table 4**, which revealed that each dimension are remained with the same factor name with only slightly changes in the measuring items. Results of factor analysis with varimax rotation indicated the existence of four factors with initial eigenvalues greater than one that explained 77.50 percent of total variance.

The results also shows the KMO measure of sampling adequacy for manufacturing performance scale is 0.809 indicating that the items were interrelated. Bartlett's Test of Sphericity shows a significant value (Approx. Chi-Square = 1267.106, $p < 0.001$) indicating the significance of the correlation matrix and appropriateness for factor analysis. Moreover, the individual MSA values range from 0.771 to 0.903, indicating that the data matrix was suitable to be factor analyzed.

Table 4. Factor Analysis for Manufacturing Performance

Item Description	Component			
	1	2	3	4
PQ3 - Improve conformance to product specification	**0.894**			
PQ1 - Improve high performance product features	**0.880**			
PQ2 - Offer consistence and reliable product quality	**0.872**			
PF2 - Adjust capacity quickly		**0.838**		
PF3 - Adjust product mix quickly		**0.750**		
PF4 - Improve rapid equipment changeover		**0.745**		
PF1 - Make rapid volume changes		**0.666**		
PC1 - Reduce inventory			**0.841**	
PC3 - Reduce production costs			**0.834**	
PD3 - Reduce production lead time			**0.767**	
PD1 - Improve fast delivery				**0.878**
PD2 - Improve delivery on time				**0.796**
Initial Eigenvalues	5.328	1.626	1.302	1.044
% of Variance Explained (after rotation)	21.657	21.497	19.253	15.091
Total Variance Explained (%)	77.499			
KMO	0.809			
Bartlett's Test of Sphericity:				
Approx. Chi-Square	1267.106			
df	66			
Sig.	0.000			

Source: Computed data analysis

The first factor consisted of three items which were related to the Quality performance. This factor with loadings ranging from 0.872 to 0.894 accounted for 21.66 percent of the variance in the data. This factor was mainly concerned with respondents' perceptions on their companies' performance regarding of quality; therefore, the original name of Quality [59] was retained. The second factor which consisted of items related to the flexibility accounted for 21.50 percent of the total variance with factor loadings ranged from 0.666 to 0.838. The factor contained four items which reflected the respondents' perceptions on their flexibility performance; therefore, the original name of Flexibility [59] was upheld.

The third factor was represented by three items which comprised the items relating to cost. It was accounted for 19.25 percent of the total variance in the data with factor loadings ranged from 0.767 to 0.841. This factor was regarding the respondents' perceptions on the cost performance; thus, the original name of Cost [60] was maintained. Two items from the Cost factor were deleted due to low communalities values. The fourth factor accounted for 15.09 percent of the total variance in the data with loadings ranged from 0.796 to 0.878. The factor which consisted of two items was related to respondents' perceptions on the delivery performance; thus the original name of Delivery [59] was kept. One item from Delivery factor which considering "the reduction of production lead time" has been merged under the Cost variable.

6.3 Reliability Analysis

According to Hair, et al. [61], a reliability analysis determines the extent the variables are reliable to measure the constructs. It indicates the stability and consistency of the instrument in measuring a concept and helps to assess the goodness of a measure [62]. In determining the internal consistency of the measurement items, Cronbach's Alpha is suggested and has been commonly used for reliability coefficient. Accordingly, in this study, a reliability analysis has been conducted on the scale to ascertain the applicability of the instrument by computing the Cronbach's alpha coefficient values for each construct.

Sekaran [62] suggested that the minimum acceptable Cronbach's alpha value to be reliable at 0.60. By studying the recommendations, it is shown that this research has developed reliable constructs since the reliability analysis produced Cronbach's alpha values in the range of 0.678 to 0.924 as depicted in **Table 5**. The measurements used in this study were reliable and two items were deleted during this analysis which are; the manufacture with advanced technologies, and the reduction of production lead time. The deletion of these items hence improve the reliability values of the technological acquiring capability and cost performance scale, thus, suggested its readiness for further analyses.

Table 5. Reliability Analysis

Variable	No. of Items	No. of Item Deleted	Cronbach's Alpha
Technological Capability			
TAC	3	1	0.889
TUC	4	0	0.827
Manufacturing Performance			
Quality	3	0	0.910
Flexibility	4	0	0.821
Cost	2	1	0.903
Delivery	2	0	0.820

Note: TAC = Technological Acquiring Capability, TUC = Technological Upgrading Capability

6.4 Correlation Analysis

Table 6 depicts the results of the inter-correlation between variables. The correlation analysis of TAC and TUC with manufacturing performance were subjected to a two-tailed test of statistical significance at two different levels; significant ($p < 0.01$) and significant ($p < 0.05$). Overall, the results indicate that all the variables of TC dimensions and MP dimensions were significant at $p < 0.01$. For TAC, the strongest positive correlation is the relationship between TAC and cost performance ($r = 0.491$, $p < 0.01$) with a high level of TAC associated with a high level of cost performance. The next strongest positive correlation is between TAC and flexibility performance ($r = 0.490$, $p < 0.01$), subsequently between TAC and quality performance ($r = 0.321$, $p < 0.01$), and followed by TAC and delivery performance ($r = 0.320$, $p < 0.01$).

While for TUC, the strongest positive correlation is between TUC and flexibility performance ($r = 0.551$, $p < 0.01$) with a high level of TUC associated with a high level of flexibility performance. The next strongest positive correlation is between TUC and quality performance ($r = 0.548$, $p < 0.01$). Followed by TUC and cost performance ($r = 0.420$, $p < 0.01$) and finally, between TUC and delivery performance ($r = 0.410$, $p < 0.01$). All of the relationships were found to be positive and significant.

Table 6. Pearson's Correlation between the Constructs

	TAC	TUC	QP	FP	CP	DP
TAC	1					
TUC	.390**	1				
QP	.321**	.548**	1			
FP	.490**	.551**	.422**	1		
CP	.491**	.420**	.369**	.511**	1	
DP	.320**	.410**	.401**	.436**	.431**	1

Note: **. Correlation is significant at the 0.01 level (2-tailed), TAC = Technological Acquiring Capability, TUC = Technological Upgrading Capability, QP = Quality performance, FP = Flexibility performance, CP = Cost performance, DP = Delivery performance

7. Conclusion

This study proved that TC is important for manufacturing performance in Malaysia. The results reveal a positive linear relationship among the constructs which prove an increase in TC will also increase the performance in terms of quality, cost, flexibility and delivery. This will indicates to the different level of manufacturing performance in a better state. However, according to Zikmund, et al. [63], even though the results of the correlation analysis are reliable and support the hypothesis, the correlation analysis is unable to implicate cause and effect evidence.

Hence, multivariate statistical analysis is suggested for testing the hypothesis in order to examine the effect and influence of various interactions and combination of variables [63, 64]. This study is in line with Peerally et al.'s [65] suggestion, where further studies on TC building impacts on varies measures of performance should later be very fruitful for the benefits of firms' technological development [66]. Furthermore, the mixed scenarios between low and high capability firms on the uncertainty and speed in the future direction of technological change and risks preferences [10], promote the premise that TC stands as a critical component for organizational success. Despite the need for further investigation on the influence of TC upon performance measures, future research should explore in depth the company's readiness of TC and the dynamic model of TC implementation into the local context.

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