A Preliminary Study on Technological Innovation Capabilities (TICs) and Competitive Advantage in the Automotive Industry in Malaysia

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Keyword

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ABSTRACT

This study investigates the relationship of TIC dimensions on competitive advantage in the automotive industry in Malaysia.The purpose of this paper is to present the research model along side hypotheses development, and the results of a preliminary study on these relationships. A pilot study was conducted, with the aim of assessing the validity and reliability of the instruments that are designed to be replicated in the main survey. The PLS-SEM measurement model was applied to measure the reliability and validity of the items in this study. The results indicate that the measuring instruments are reliable and the data for pilot study showed a strong evidence of construct validity in terms of convergent and discriminate validity and there is no collinearity problem between the first-order constructs.

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1. INTRODUCTION

In the fast changing and unpredictable environments due to the globalization of markets, technological change, shortening product lifecycles and innovative new product development (NPD) (Bayraktar, Hancerliogullari, Cetinguc, & Calisir, 2016; Choi, Narasimhan, & Kim, 2016; Teece, Pisano, & Shuen, 1997) , firms find that to obtain and maintain competitive advantage is increasingly difficult (D. Li & Liu, 2014).

One popular approach used to understand competitive dynamics is the resource-based view (RBV) of the firm. According to this view, only those firms who have the unique resources and capabilities provide the ability for competitive advantage in rapidly changing and unpredictable environments which subsequently lead to higher performance. If the firms' resources and capabilities are valuable, rare, hard to imitate, cannot be substituted and the firm also could organize and fully utilized those resources and capabilities, then they could lead to better performance (J. Barney, 1991; J. B. Barney & Hesterly, 2012; Grant, 1991; Lioukas, Reuer, & Zollo, 2016). Several factors have been identified that could contribute to sustain competitive advantage and one of them is innovation. Fierce global competition needs firms to innovate continuously if they intend to survive and prosper in the long term (Parida, Pemartín, & Frishammar, 2009).

For that reason, technological innovation capabilities (TICs) have been considered as a significant strategic resource allowing firms to attain sustainable competitive advantage when firms meet a dynamic environment (Cheng & Lin, 2012; Henderson & Cockburn, 1994; Kong, Zhang, & Liu, 2008). Firms with more TICs can perform better in more turbulent environments as compared with firms with lesser levels of TICs. Moreover, superior TICs can accelerate the development of new product developments and adopt new processes in shorter lead time in order to reap the pioneer (Carbonell & Rodríguez-Escudero, 2009; J. C. Guan, Yam, Mok, & Ma, 2006; Prašnikar, Lisjak, Buhovac, & Štembergar, 2008). As a result, TICs can help a firm to create more value than its competitors and can receive a greater economic return above the industry average (Verdu, Tamayo, & Ruiz-Moreno, 2012). Facing competitive business environment, firms require recurring technological innovation to continuously retain their competitiveness and to face new challenges (Cheng & Lin, 2012; Lang, Hsiang, Nguyen, & Vy, 2012; Shan & Jolly, 2013). Therefore, the firms must assimilate firm resources and capabilities, such as TICs to maintain and improve their performance. According to Liu & Jiang, (2016) in a dynamic environment, the ability to introduce new products and adopt new processes in shorter lead time has become a vital competitive tool.

Many studies also have proven that technological innovation could establish positive impacts and enhance their competitiveness (Camisón & Villar-López, 2014; J. C. Guan et al., 2006; Karagouni & Papadopoulos, 2007; Lahovnik & Breznik, 2013; Lang et al., 2012; Liang, Liu, Zhang, & Zhang, 2010; Yam, Guan, Pun, & Tang, 2004; Yam, Lo, Tang, & Lau, 2011, 2010). Although studies on technological innovation are in abundance, there is nevertheless inadequate empirical evidence relating to how automotive firms improve their TICs.

Automotive industry faces high competitiveness and the various challenging business factors (Stefano, Montes-sancho, & Busch, 2016) such as the existing products are vulnerable, changing customer needs and tastes, new technologies, shortened product lifecycles, and increased international competition(Atalay, Anafarta, & Sarvan, 2013). The industry is also experiencing rapid technology changes (Oh & Rhee, 2008) and is currently taking up the challenge and demand for technological innovation in order to improve their business performance. Automotive industry in Malaysia was chosen due to high relevance of the automotive industry in the country's GDP. In fact, according to the Malaysian Automotive Association (MAA), production of motor vehicles for 2015 totaled 614,664 units comprising 563,883 units of passenger vehicles and 50,781 units of commercial vehicles. Sales of motor vehicles amounted to 666,674 units in 2015 consisting of 591,298 units of passenger vehicles and 75,376 units of commercial vehicles.With a ratio of 405 cars for every one thousand people in 2014, Malaysia ranked second highest position among ASEAN countries after Brunei with high motorization rate (Amira, Ali, Hanif, Gafar, & Akbar, 2013; International Organization of Motor Vehicle Manufacturers (OICA), 2017).

Despite the growing trend of TICs, there are very limited sources of literatures on TIC in Malaysia especially in the automotive industry.Hence, it is crucial in the Malaysian context to understand the extent of TICs in this country and the relevant trends. In this study, we examine additional information to the existing body of knowledge that will evaluate the dimensions of TICs that contribute to the competitive advantage of the firms and help improve the firms'capabilities in the automotive industry in Malaysia. Consistent with prior research, this study develops and empirically validates a multi-dimensional measurement model for TICs especially for the automotive industry. In particular, new measurement items are developed for TIC dimensions. The aim of this research is to understand the TIC dimensions and operationalize its concept as a second-order construct that contribute towards firm's competitive advantage by using the Partial Least Square (PLS) technique to check on the reliability and validity of the survey instrument.

This paper is organized as follows: firstly, the explanation of the relationship of the research model, followed by a description of the research methodology, including the data collection and preliminary data analysis using the PLS SEM technique. The paper concluded with plans for future research.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1 Theoretical framework

TICs were viewed as comprehensive dimensions of firms' capabilities that facilitate and support its technological innovation strategies (Burgelman, Christensen, & Wheelwright, 2009) in the business environment and how they successfully manage to enhance efficiency and effectiveness of these capabilities to sustain competitive advantage of the firm and to gain entry into new markets (Krishnaswamy, Mathirajan, & Subrahmanya, 2014). TICs are a kind of combination of special assets or resources of the firm which comprises various assets such as technology, product, process, knowledge, experience (J. Guan & Ma, 2003; Karagouni & Papadopoulos, 2007; Türker, 2012; Yam et al., 2010). In the theory of resource-based view, when firms have successfully established unique resources that they own, they could better satisfy their customers' needs, they could produced more proficiently, and in the long run, they achieved competitive advantage and improve their performance (J. Barney, 1991; Ismail, Rose, Uli, & Abdullah, 2012).The relationship of TICs on firm's performance indicators such as sales growth, product performance and innovation performance has been supported by many researchers (e.g. (Azubuike, 2013; Camisón & Villar-López, 2014; Lang et al., 2012; Shan & Jolly, 2012, 2013, Yam et al., 2004, 2011, 2010).Thus, TICs are a strategic resource and whose exploitation may provide a firm with a competitive advantage and superior performance (Azubuike, 2013; J. B. Barney, 1986; Newbert, 2007, 2008; Shan & Jolly, 2013).

Previous studies have conceptualized TICs with different approaches that result in various sets of capabilities to assessing a firm's TICs. Yam et al. (2004) presented an innovation audit model which is grouped under seven capability dimensions namely – R&D, manufacturing, marketing, organizing, resource allocation learning capability and strategic planning.Guan et al.(2006) proposed an innovation framework for assessing a firm's technological innovation performance and competitiveness. The framework comprises seven capability dimensions, namely, learning capability; R&D capability; marketing capability manufacturing capability; organizational capability; resource exploiting capability; and strategic capability. Wang et al. (2008) introduced a simple and suitable method to discover the primary criteria affecting TICs at hi-tech firms. The approach adopts a fuzzy measure and non-additive fuzzy integral method, by which valuable information can be obtained with regards to hierarchical TIC framework which conisists of R&D capabilities, innovation decision capabilities, marketing capabilities, manufacturing capabilities and capital capabilities. Cheng & Lin (2012) recommended the approach of adopting trapezoid fuzzy numbers and expanding a technique for ordering performance by similarly addressing the evaluation of TICs which comprises planning and commitment of the management capability, marketing capability, innovative capability knowledge and skills capability, information and communication capability, external environment capability and operational capability. The hybrid method is a suitable and effective method for identifying and analyzing the competitiveness in the context of uncertainty. Shan and Jolly (2012) introduce a three-dimensional of TICs which are, investment capability, production capability, and network capability affecting product strategies (product innovation) for the electronic information industry. Using similar approach with Yam et al. (2004), Lau, Baark, & Lo (2013) examines the effect of diverse sources of innovation on a firm's TICs and the extent to which such capabilities mediate the improvement of product competitiveness. While in a study investigating how TICs impact on new product development performance and product competitiveness of Chinese manufacturing enterprises, Liu & Jiang (2016) classify TICs into seven dimensions that are organizational capabilities, strategies capabilities, human, finance, and material resources, knowledge resources, fundamental research, application R&D and manufacturing capabilities.

Yam et al., (2011) has summarized three approaches to assess TIC which are asset approach, process approach and functional approach. According to Yam et al. (2004) functional approach is easier to understand and it facilitates the multi-informants approach for the survey. However, the asset and process approaches are rather more complex to understand (Liu & Jiang, 2016; Yam et al., 2011). In our study, the functional approach is adopted to analyze the relationship between TICs dimensions and competitive advantage.

The literature review highlights inconsistent dimensionality and operationalisation of the TIC construct. From pevious studies, the measurements of TICs are using only first-order construct. Research on the relationship between TICs and competitive advantage using hierarchical latent models is rare. According to Chin (1998) , hierarchical latent variable models, hierarchical component models,second-order contructs or higher-order constructs, are explicit representations of multidimensional constructs that exist at a higher level of abstraction and are related to other constructs at a related level of abstraction fully mediating the influence from or to their underlying dimensions. Modeling hierarchical component model or second order construct is useful for researchers to reframe the structure model to be more meaningful (Asyraf, 2014). According to Liu & Jiang (2016) other dimensions that are not mentioned in the functional approach may be important. Therefore, an exploratory study was conducted to evaluate the existing dimensions and explore other context-specific dimensions to measure TICs dimensions particularly in the automotive industry. In this study, we only focus on four dimensions of TIC namely R&D capability, manufacturing capability, networking capability and human resources capability.

2.2 Competitive Advantage

According to Porter (1985), competitive advantage is the ability to earn profits consistently above the average for the industry. Other scholars like J. Barney(1991) stated that competitive advantage can be accomplished if the firm implements a value-creating strategy that is not instantaneously being carried out by any existing or potential competitors. For a firm to be competitive, the firm resources must be valuable, rare, inimitable and non-substitutable. Newbert, (2008) defined competitive advantage as the implementation of a strategy not currently being implemented by other firms that enables the reduction of costs, the manipulation of market opportunities, and/or the neutralization of competitive threats. According to J. J. Li & Zhou (2010), there are three type of competitive advantage, namely, cost advantage, differentiation advantage and institutional advantage. Cost advantage, or cost leadership, occurs when the firm operates at a lower cost than its competitors, but gives a similar product. However, differentiation advantage is attained when customers always perceive a firm's products better than to those of its competitors (J. J. Li & Zhou, 2010; Porter, 1985; Wang, Lin, & Chu, 2011). Institutional advantage achieved when firms have superiority in obtaining scarce resources and superiority in gaining support from dominant institutions (J. J. Li & Zhou, 2010). However, Karagozoglu, (1993) also mentioned that the competitive advantage also can be gained by a firm via technological innovations which is operationalized as a multiple measure of its product innovation competitiveness and process innovation competitiveness. Based on the above, the dimensions of the competitive advantage constructs used in this study are cost advantage, differentiation advantage, institutional advantage, product innovation and process innovation.

2.3 Research model and hypotheses

Figure 1 illustrates the general framework of research model. In this study, the functional approach is adopted to analyze the relationship between TICs and competitive advantage.The theoretical and operational definitions of the main constructs in the model are presented in Table 1.

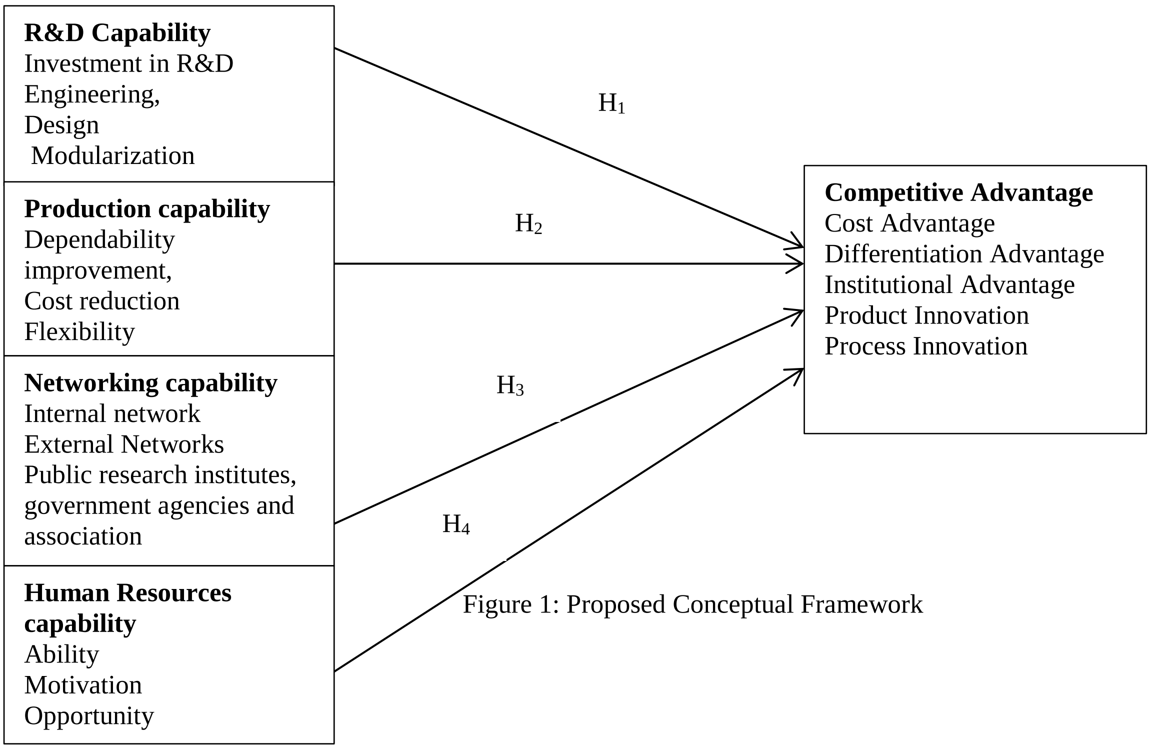

Figure 1: Proposed Conceptual Framework

Table 1: Definition of TICs

Technological Innovation Capabilites Dimensions	Operational Definition
R&D Capability	The extent to which firm has resource capacity to develop new technologies. R&D capability is subdivided into investment in R&D, engineering, design and modularization capabilities
Manufacturing capability	The extent to which firm has ability in operations strategies such as in dependability improvement, cost reduction and flexibility
Networking capability	The extent to which firm has the ability to transfer information, skills and technology, and to receive them from internal linkages such as other departments, headquarter and so on as well as external linkages such as commercial Linkage and public research institutes, association and government agencies
Human Resources capability	The extent to which firm has ability to develop skill to affect employees' ability to understand and combine new knowledge; an incentive structure that embraces motivation and commitment; and the design of work and relationships so that employees have the discretion and opportunity to use their skills in collaboration with other workers

2.3.1 TICs and competitive advantage

The R&D capability is to improve operational performance through investment in R&D activities, product improvement via design, engineering and module capabilities (Oh & Rhee, 2008; Yam et al., 2004). Lau, Yam, & Tang, (2010) found that R&D capability can significantly improve the innovation sales. Liu & Jiang (2016) also provide empirical evidence that application R&D have significant influence on the new product development performance and product competitiveness of Chinese manufacturing enterprises. Raymond & St-Pierre(2010) highlighted that R&D activities of manufacturing by SMEs will have a positive influence upon the level of product and process innovation in these firms. Therefore, the R&D capabilities have become of significance in the recent years (Lang et al., 2012; Liu & Jiang, 2016; Yam et al., 2010). Thus:

H_1: A firm's R&D capability has a positive impact on its level of competitive advantage.

Manufacturing capability indicate a firm's ability to alter R&D outcomes into final product. Manufacturing or production capability is related to competitive priorities in operations strategy, such dependability improvement, cost reduction, flexibility (Oh & Rhee, 2008). Furthermore, Shan & Jolly (2013) examined the relationships among production capability, product innovation and firm performance in Chinese companies from the electronics industry and found support for the proposition that production capability has a positive impact on product innovation and firm performance. Lang et al.(2012) also found that, manufacturing capability of Vietnam enterprises was positively correlated to their competitive performance. Furthermore (Liu & Jiang, 2016) provided supportive evidence that manufacturing capability positively impact new product development (NPD) performance. Hence, manufacturing capabilities are the crucial resource to improve competitive advantage. Thus:

H_2: A firm's manufacturing capability has a positive impact on its level of competitive advantage.

With respect to networking capability, the knowledge vested in the relationships among employees, customers, suppliers and others has the potential to a feasible strategy to achieve innovation (Parida et al., 2009). Additionally, teams and network in the firm enable better identification of customer needs so that novel solutions can be developed to satisfy those needs. Wu, Gu, & Zhang (2008) found that a nexus between external and internal innovation networks of industrial clusters supported by collective learning helps promote the effective development of technological capabilities of industrial clusters in China. Shan& Jolly (2012) suggested that the firm's internal networks within different departments in the firm and external networks such as with its customers, suppliers, and consultancy firms, and public research institutes do have positive influence on firm performance. In extending the concept of networking capability, empirical evidence provided by Shan & Jolly, (2013) indicates the importance of networking capability in regard to product innovation. Sobanke, Adegbite, Ilori, & Egbetokun (2014) concluded that experience gained by the entrepreneurs from their former employers and in-house training of technical employees continue to be the major internal factors supporting the technological capabilities of a technology-based firm while technical collaboration with numerous industrial associations is among one of the important external factors for firm's success in developing countries. Oh & Rhee (2010) also found that collaboration with supplier of automotive industry in new car development positively affects the competitive advantage of carmakers. Thus, we formulate the following hypothesis:

H_3: A firm's networking capability has a positive impact on its level of competitive advantage

Although various factors have previously been considered as relevant antecedents of innovation, researchers have focused on the human resource capability as one of the primary resources for innovation (Aryanto, Fontana, & Afiff, 2015; Chen & Huang, 2009; Ozbag, Esen, & Esen, 2013). Human resource capability is the primary resources by which firms can influence and shape the skills, attitudes, and behavior of employees and therefore achieve firm's targets (Chen & Huang, 2009). Prieto Pastor, Pérez Santana, & Martín Sierra (2010) generally clustered human resource capability into three dimensions of employee's ability, employee's motivation, and employee's opportunity to leverage knowledge, when they examined the relationship between human resource management (HRM) and knowledge management (KM) in the Spanish automotive industry. These three human resources capability dimensions can be described as: (1) skill development to affect employees' ability to understand and combine new knowledge; (2) an incentive structure that embraces motivation and commitment; and (3) the design of work and relationships so that employees have the discretion and opportunity to use their skills in collaboration with other workers (Prieto Pastor et al., 2010).

Hsu & Fang (2009) highlighted that human capital and relational capitals actually improve new product development performance through organizational learning capability. Furthermore, Sadeghi&Mohtashami (2011) examined the relationships between strategic human resource practices (staffing, training, participation, performance appraisal and reward) and organizational innovation in a military center and found that there was a significant relationship between strategic human resource practices dimension and organizational innovation.Chen& Huang (2009) indicate that strategic human resource practices are positively related to knowledge management capacity which, in turn, has a positive effect on innovation performance. Therefore, human resources capability is a necessary support to the process of technological innovation. Thus:

H_4: A firm's human resources capability has a positive impact on its level of competitive advantage

3. METHODOLOGY

This study employs a questionnaire survey approach to collect data for assessing the validity of the model. A survey is considered as the most cost-effective among methods available for data collection due to its ability in performing effective data collection (Zikmund, 2013). In view that this study is a pilot test, a small scale study of respondents is recommended for trial purpose before conducting the main study (Hazzi & Maldaon, 2015). Preferably, the sample size for pilot studies suggested is 30 samples from the population of the study and is a reasonable minimum requirement for a pilot study where the purpose is preliminary survey or scale development (Johanson& Brooks, 2010). The proposed conceptual model has been used to present the relationship between TIC dimensions; competitive advantage is as shown in Figure 1.

Accordingly, this paper presents the result of the pilot test with regard to the relationship between TIC dimensions and competitive advantages in the automotive industry in Malaysia.The unit of analysis for this study is a firm, thus, respondents were managers and top management, who work in a firm in the automotive industry operating in the Peninsular Malaysia.Target sample were suppliers and manufacturers in the automotive industry in Malaysia. Questionnaires were distributed to respondents from the listing of automotive industry obtained from Malaysian Automotive Institute (MAI) and Proton Vendors Association (PVA). Content validity was ascertained by consulting experts both within academics and practice before the conduct of the pilot testing of the questionnaire items. Specifically, three experts were selected from the Faculty of Industrial Management, University Malaysia Pahang (UMP). Meanwhile, another four automotive industry practitioners were also contacted for the same exercise. Their feedbacks and recommendations were then integrated into the final draft of the instrument.A questionnaire was distributed to the 100 firms, 57 of them returned the completed questionnaires. Responses were assessed on a seven-point Likert scale ranging from 1 = strongly disagree to 7 = strongly agree.

Partial least squares (PLS) analysis is chosen as the most suitable technique for analyzing our model. PLS was chosen because it well suited for complicated models which consist of Hierarchical Component Models (Asyraf, 2014) and it can operate under a limited number of sample size and is suitable when conducting a pilot study (Peng & Lai, 2012). In assessing a reflective –formative measurement model, three analyses are required, namely the assessment of construct reliability, convergent validity as well as discriminant validity. Since the construct of TIC dimensions is a second order reflective-formative construct consisting of eigthteen first-order constructs, it is important also to examine if multicollinearity is an issue within these constructs. In an attempt to determine the measurement accuracy, SMART PLS 3.0 was used to assess the reliability, validity and multicollinearity issues of the items in this study.

4. PRELIMINARY DATA ANALYSIS AND RESULTS

Partial Least Square (PLS) (smartPLS 3) was used (Ringle, Christian M., Wende, Sven, & Becker, 2015) as Partial Least Square is most popular. Structural Equation Modelling (SEM) technique is used in data analysis, basically due to its ability to accommodate relatively small sample size (Joe F. Hair, Sarstedt, Ringle, & Mena, 2012; Peng & Lai, 2012). as against other co-variance-based Structural Equation Modelling (AMOS, LISTREL). Thus, because this study's sample is small, the PLS SEM is considered appropriate.

4.1 Participants' Characteristics

Of the 100 questionnaires distributed to the automotive companies' population as listed in the sampling frame, a total of 57 completed questionnaires were collected. Table 2 presents the characteristics of participants surveyed. More than 80% of the participants held managerial and higher positions in the companies, while 57.9% have bachelors' degree and 12.2% have a diploma. Only 21.1% possess master's degree and doctorate degree.

Table 2. Participants' Profile

Measure		**Frequency (n=57)**	**Percentage (%)**
Position	CEO	3	5.2%
	General Manager	12	21.1%
	Managing Director	5	8.9%
	Director	6	10.5%
	Manager	22	38.5%
	Others	9	15.8%
Education	Diploma	7	12.2%
	Bachelor's degree	33	57.9%
	Master's degree	10	17.5%
	Doctorate	2	3.6%
	Others	5	8.8%

Table3 shows the company characteristics. With regard to the type of industry, the majority of responding companies is from component manufacturer (31.6%), followed by the component supplier (29.8%), material supplier (19.3%) Original Equipment Manufacturer (OEM), (10.5%) and the remaining responding companies are module assembly, (8.8%). In terms of ownership of the company, 66.7% are fully local, followed by foreign firms (17.5%). The remaining is a joint venture (15.8%). In terms of number of employees, 54.4% of companies have over than 200 employees. 22.8% companies employ between 75-200 and 22.8% companies employ between 5 to 74 employees. A wide distribution of annual sales turnover for the financial year 2015 is evident with 49.1% turning over RM50m.

Table 3: Company's Characteristics

Measure		**Frequency (n=57)**	**Percentage (%)**
Automotive Industry	Material supplier Component supplier Component manufacturer Module Assembler OEM	11 17 18 5 6	19.3% 29.8% 31.6% 8.8% 10.5%
Legal structure	Fully local Foreign firms operating in Malaysia Joint Venture Government Linked Companies	38 10 9	66.7% 17.5% 15.8%
Number of employees	Less than 5 5.- 74 75 -100 101 – 200 Over 200	0 13 6 7 31	0.0% 22.8% 10.5% 12.3% 54.4%
Sales turnover	Less than RM300,000 RM300,000 – RM14,999,999 RM15,000,000 –RM49,999,999 Over than RM50,000,000	1 18 10 28	1.8% 31.6% 17.5% 49.1%

4.2 Measurement Model

The items used in this study were adopted from previous empirical studies that were published inreputable academic journals. Table 4 shows the sources of measurement in this study.

Table 4: Sources of Measurement of Constructs

Second Construct	**First Construct**	**Sources**	**Remarks**
RD Capability	Investment in R&D Engineering Design Modularization	Lau, Yam, & Tang (2010), Oh & Rhee (2008), and Oh & Rhee (2010)	Adapted
Production/ Manufacturing Capability	Dependability improvement Cost Reduction Flexibility	Yang (2013), Oh & Rhee (2008), and Oh & Rhee (2010)	Adapted
Networking capability	Internal linkages External Commercial Linkage Linkages with public research institutions, government agencies and association (PGL)	Shan & Jolly (2013), Shan & Jolly (2012) and Oluwale, Ilori, & Oyebisi (2013)	Adapted
Human Resource Capability	Ability Motivation Opportunity	(Prieto Pastor et al., 2010)	Adapted
Competitive Advantage	Cost Advantage Differentiation Advantage Institutional Advantage Product Innovation Process Innovation	(Akgün, Keskin, & Byrne, 2009; J. J. Li & Zhou, 2010)	Adapted

Construct reliability is assessed using composite reliability (CR) (Vinzi, Chin, Henseler, & Wang, 2011). Table 5 presents the assessment of construct reliability as well as convergent validity for the key constructs of this study. TIC dimensions, in this study, are second orders construct which consist of four dimensions namely R&D capability, manufacturing capability, networking capability and human resource capability. For the purpose of measurement model evaluation, eighteen of first order construct (Table 5) will be of primary concern in validating construct reliability as well as convergent validity.

As illustrated in Table 5, all key constructs possesses high internal consistency suggesting that the items measuring the construct achieved desired reliability. Similarly, all constructs demonstrate good convergent validity, such that the AVE score for each of the construct is more than the minimum threshold value of 0.5 suggesting that more than 50% of the variation in the construct are explained by its item (J F. Hair, Sarstedt, Hopkins, & G. Kuppelwieser, 2014).

Table 5.Reliability and Validity of Latent Constructs

Construct	**No. of items**	**Composite Reliability (CR)**	**Average Variance Extracted (AVE)**
R&D CAPABILITY (RDC)			
Investment in R&D (INV)	4	0.830	0.551
Engineering (ENG)	5	0.858	0.668
Design (DES)	4	0.844	0.730
Modularization (MOD)	5	0.885	0.658
MANUFACTURING CAPABILITY (MC)			
Dependability improvement (DI)	5	0.876	0.639
Cost Reduction (COST)	5	0.839	0.724
Flexibility (FLEX)	5	0.868	0.623
NETWORKING CAPABILITY (LC)			
Internal linkages (INL)	6	0.925	0.711
External Commercial Linkage (EXL)	6	0.905	0.655
Linkages with public research institutions, government agencies and association (PGL)	5	0.904	0.826
HUMAN RESOURCE CAPABILITY (HRC)			
Ability (A)	6	0.900	0.694
Motivation (M)	6	0.889	0.667
Opportunity (O)	7	0.912	0.675
COMPETITIVE ADVANTAGE (CA)			
Cost Advantage (COA)	4	0.839	0.724
Differentiation Advantage (DA)	4	0.948	0.819
Institutional Advantage (IA)	4	0.821	0.703
Product innovation (PRTI)	4	0.911	0.773
Process innovation (PRSI)	4	0.882	0.715

Appendix 1 and 2 illustrate the assessment of discriminant validity using Fornell & Larcker (1981) criterion as well as Henseler's HTMT (2015) criterion(Jorg Henseler, Ringle, & Sarstedt, 2015). Discriminant validity is established using the Fornell and Larcker criterion such that the square root of AVE for each construct is larger than the correlation estimate of the constructs. This is one of the indications that all key constructs in this study are different from one another. Similarly, the HTMT criterion suggests that discriminant validity is established at HTMT0.90 criterion such that the correlation score corresponds to the respective construct is lower than the moderate HTMT.90 criterion for assessing discriminant validity (Henseler, Ringle, &Sarstedt, 2015).As shown in Appendix 2, the maximum HTMT value is 0.8904 and this is below 1.0 (Jörg Henseler, Hubno, & Ray, 2016), which is the most conservative critical HTMT value. Hence, the result further confirms that the discriminant validity has been established.

As noted earlier, the construct of technological innovation capabilities dimensions is a second order reflective-formative construct which consists of eighteen first-order constructs, it is important to examine if multicollinearity is an issue within these constructs. Table 6 presents the outcome of collinearity test for the four dimensions of TIC. The VIF value for each of the constructs which is lower than the offending value of 5.0 (Hair, Ringle, &Sarstedt, 2011) indicates that there is no collinearity problem between the eighteen first-order constructs.

Table 6: Multicollinearity for First-Order Constructs

Second-order construct	**First-order construct**	**VIF**
R&D capability (RDC)	Investment in R&D (INV)	1.4957
	Engineering (ENG)	2.0042
	Design (DES)	2.0443
	Modularization (MOD)	1.8862
Manufacturing Capability (MC)	Dependability improvement (DI)	1.2051
	Cost Reduction (COST)	1.4391
	Flexibility (FLEX)	1.5170
Networking Capability (LC)	Internal linkages (INL)	1.3036
	External Commercial Linkage (EXL)	1.7713
	Linkages with public research institutions, government agencies and association (PGL)	1.4866
Human Resource Capability (HRC)	Ability (A)	1.8439
	Motivation (M)	1.9946
	Opportunity (O)	1.8348
Competitive Advantage (CA)	Cost Advantage (COA)	1.7313
	Differentiation Advantage (DA)	2.1648
	Institutional Advantage (IA)	1.8183
	Product innovation (PRTI)	1.8370
	Process innovation (PRSI)	1.9174

Basically, the results presented in Tables 5, 6, appendices 1 and 2 demonstrate that items for all the eighteen constructs are accurately measuring their respective constructs. Thus far, the other aims of this preliminary study, which are to validate the study items and establish their respective reliability, have been achieved.

5. CONCLUSION

The major contribution of this pilot study is to present the research model and explain the relationships among the study's exogenous latent variables and the endogenous latent variable); and also to empirically explore the strengthin terms of validity and reliability of the measuring instruments that are intended for use in the main survey using the PLS-SEM measurement model. The results from the PLS analysis showed that the items adopted in this study are indeed robust in measuring the constructs they are meant to measure, especially indicator loadings, composite reliability, the average variance extracted and multicollinearity. Specifically, content validity, convergent and discriminant validity were simultaneously conducted to ascertain this study's construct validity. The result shows that the measuring instruments are reliable and the data for this pilot study indicated strong evidence of rational validity and no multicollinearity issues are found.

The proposed scale for measuring TICs consists of 4 dimensions (R&D capability, manufacturing capability, networking capability and human resource capability) and 5 dimensions of competitive advantage (cost advantage, differentation advantage, institutional advantage, product innovation and process innovation) that according to our results, explain the concept of TICs and competitive advantage well. The actual study is required to validate the proposed research model. In future, this proposed research instrument will be used with a larger sample size for hypothesis testing.

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APPENDIX 1: Convergent Validity and Discriminant Validity of First-Order Constructs-Fornell&Larcker Criterion

	Constructs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	**INV**	**0.742**																	
2	**ENG**	0.577	**0.817**																
3	**DES**	0.327	0.544	**0.854**															
4	**MOD**	0.460	0.495	0.656	**0.811**														
5	**DI**	0.211	0.054	0.296	0.033	**0.800**													
6	**COST**	0.349	0.387	0.287	0,343	0.322	**0.851**												
7	**FLEX**	0.414	0.405	0.522	0.462	0.377	0.539	**0.790**											
8	**INL**	0.376	0.346	0.467	0.460	0.357	0.182	0.240	**0.843**										
9	**EXL**	0.438	0.448	0.267	0.455	0.017	0.185	0.315	0.489	**0.809**									
10	**PGL**	0.321	0.383	0.257	0.374	0.045	0.247	0.243	0.296	0.568	**0.909**								
11	**A**	0.473	0285	0.169	0.222	0.115	0.570	0.403	0.104	0.190	0.405	**0.833**							
12	**M**	0.281	0.215	0.249	0.217	0.132	0.419	0.247	0.101	0.043	0.366	0.631	**0.817**						
13	**O**	0.122	0.047	0.039	0.112	0.017	0.430	0.188	0.174	0.037	0.221	0.588	0.639	**0.822**					
14	**COA**	0.119	-0.054	-0.022	0.005	-0.062	0.005	-0.049	0.185	-0.054	0.065	0.212	0.140	0.266	**0.850**				
15	**DA**	0.196	0.175	0.175	0.281	0.175	0.209	0.206	0.351	0.245	0.232	0.316	0.084	0.166	0.480	**0.905**			
16	**IA**	0.096	-0.018	0.036	-0.088	0.208	0.215	0.018	0.060	0.011	0.063	0.122	0.202	0.174	0.477	0.559	**0.838**		
17	**PRTI**	0.154	0.047	0.233	0.375	0.302	0.158	0.140	0.495	0.292	0.367	0.158	0.217	0.143	0.319	0.347	0,241	**0.879**	
18	**PRSI**	0.491	0.336	0.299	0.350	0.330	0.334	0.306	0.491	0.479	0.350	0.170	0.084	0.090	-0.020	0.257	0.071	0.553	**0.879**

APPENDIX 2 Convergent Validity and Discriminant Validity of First-Order Constructs-Heterotrait-Monotrait Ratio (HTMT)

	Constructs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	**INV**																		
2	**ENG**	0.748																	
3	**DES**	0.471	0.808																
4	**MOD**	0.403	0.631	0.812															
5	**DI**	0.294	0.179	0.402	0.182														
6	**COST**	0.492	0.534	0.409	0.467	0.410													
7	**FLEX**	0.551	0.521	0.751	0.577	0.466	0.740												
8	**INL**	0.492	0.417	0.614	0.537	0.413	0.265	0.283											
9	**EXL**	0.544	0.549	0.369	0.536	0.157	0.286	0.410	0.536										
10	**PGL**	0.417	0.483	0.377	0.443	0.396	0.355	0.317	0.339	0.689									
11	**A**	0.613	0.343	0.253	0.326	0.195	0.797	0.510	0.141	0.268	0.471								
12	**M**	0.411	0.277	0.350	0.283	0.187	0.574	0.343	0.213	0.170	0.413	0.730							
13	**O**	0.290	0.125	0.169	0.179	0.181	0.608	0.234	0.193	0.125	0.251	0.671	0.686						
14	**COA**	0.221	0.383	0.306	0.259	0.139	0.146	0.268	0.292	0.168	0.122	0.314	0.241	0.330					
15	**DA**	0.232	0.214	0.225	0.328	0.206	0.274	0.229	0.384	0.280	0.272	0.359	0.191	0.192	0.584				
16	**IA**	0.181	0.253	0.133	0.266	0.301	0.271	0.217	0.237	0.243	0.244	0.297	0.232	0.199	0.786	0.687			
17	**PRTI**	0.197	0.123	0.318	0.449	0.363	0.249	0.238	0.562	0.342	0.436	0.213	0.297	0.188	0.417	0.382	0.297		
18	**PRSI**	0.502	0.441	0.426	0.426	0.407	0.444	0.375	0.571	0.576	0.296	0.203	0.171	0.195	0.231	0.298	0.171	0.662	