Technological Innovation Capabilities and Competitive Advantage: A Measurement Model using PLS-SEM in the Automotive Industry in Malaysia

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Abstract— Study on technological innovation capabilities (TICs) and competitive advantage have been emerged in recent years. However, the conceptualization and measurement of technological innovation capabilities and competitive advantage in the automotive industry has little come to attention. This study aims to specify and assess technological innovation capabilities dimensions and competitive advantage as a second-order formative construct and provide empirical support for their measurement model. Based on the literatures, this study proposes four dimensions to measure technological innovation capabilities (R&D capability, manufacturing capability, networking capability and human resource capability). For competitive advantage, four dimensions which are cost advantage, differentiation advantage, product innovation and process innovation have been proposed to measure competitive advantage. This study adopted the two-stage approaches in partial least square-structural equation modelling to examine the appropriateness of hierarchical modelling for technological innovation capabilities and competitive advantage. Partial least squares-structural equation modeling (PLS-SEM) to approach using WarpPLS 6.0 software was utilized to analyze the data. The findings confirmed the convergent and discriminant validity of eighteen reflective first-orders constructs establishing validity and reliability of five formative second-order constructs. The analysis of second-order formative technological innovation capabilities and competitive advantage constructs revealed that Variance Inflation Factor (VIF) was found lower than five and the outer weights were significant at the level of .05 through survey data from 136 companies in the automotive industry in Malaysia. Finally, this study also concludes with limitations and directions for future research.

Keywords— Technological Innovation Capabilities; Competitive Advantage; Automotive Industry

1. INTRODUCTION

Technological innovation capabilities (TICs) are viewable as one of the most important sources of sustainable competitive advantage when firms met a competitive environment [1], [1, 2, 3]. According to [4] in a competitive environment, the ability to introduce new products and adopt new processes in shorter lead time has become a vital competitive tools. Many studies also have proven that technological innovation could establish positive impacts and enhance their competitiveness [5, 6, 7, 8, 9, 10, 11, 12, 13]. Although studies on TICs and competitive advantage are abundance, evaluating the TICs and competitive advantage can be viewed as a multi criteria problem in the literatures especially in the automotive industry [14, 15, 16, 17, 18]. Evaluating TICs can help firms know their capabilities and technology potentials, providing as an instrument to analyze performance and support decision making, as well as references to firms within an industry or region.

This paper develops a model for measuring TICs and competitive advantage in the automotive industry in Malaysia. Hence, this study develops and empirically validates a multi-dimensional measurement model for TICs dimensions and competitive advantage especially for the automotive industry. In particular, new measurement items are developed for TIC dimensions. The current study attempts to assess this second-order formative construct using partial least squares-structural equation modeling (PLS-SEM) approach as an integrated TICs dimensions and competitive advantage. . The study develops knowledge by investigating these capabilities and competitive advantage as a second-order latent construct level of abstraction. Currently, these comprehensive aspects have not yet been empirically measured in the literature. Furthermore, development of the TICs dimensions in the automotive industry will act as a catalyst for furthering research and extending its application in other manufacturing organisations

The automotive industry was chosen to implement the model due to its economic importance in terms of high relevance to this industry to the country's GDP and the large number of different products it produces, In fact, according to the Malaysian Automotive Association (MAA), production of motor vehicles for 2017 totalled 499,639 units comprising 459,558 units of passenger vehicles and 40,081 units of commercial vehicles. With a ratio of 439 cars for every one thousand people in 2015, Malaysia ranked second the highest position among ASEAN countries after Brunei with high motorization rates [19, 20].

This paper is structured as follows. Section 2 presents the conceptual aspects of TIC dimensions and competitive advantage The TIC dimensions' measurement forms based on four dimensions of the TICs dimensions– R&D capability, manufacturing capability, networking capability and human resources capability. Section 3 describes the research methodology including the data collection and measurement analysis using the PLS SEM techniques. The paper concluded with limitation and plans for future research.

2. Literature Review And Hypothesis Development

A. Technological Innovation Capabilities (TICs) Dimensions

TICs were viewed as comprehensive dimensions of firms' capabilities that facilitate and support its technological innovation strategies [21] 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 [22]. 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 [6, 8, 13, 23]. In theory of resource-based view, when firms have successfully established unique resources that they own, they could better satisfy their customers' needs, they could produce more proficiently, and in the long run, they achieved competitive advantage and improve their performance [24, 25].

Previous studies have conceptualized TICs with different approaches that result in various sets of capabilities to assessing a firm's TICs. [12] proposed 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 proposed an innovation framework of 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. [26] 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 from [12] and [27] examines the effect of diverse sources of innovation on a firm's TICs and the extent to which such capabilities mediate the improvement on product competitiveness. While in a study investigating how TICs impact on new product development performance and product competitiveness of Chinese manufacturing enterprises, [4] classifies 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.

[28] has reviewed three approaches to assess TICs which is asset approach, process approach and functional approach. According to [12] 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 [4, 28]. In our study, the functional approach is adopted to analyses the relationship between TICs dimensions and competitive advantage.

The literature review highlights inconsistent dimension and operationalization of the TIC constructs. From previous studies, the measurements of TICs normally are using first-order construct. Research on the relationship between TICs and competitive advantage using hierarchical latent models is rare. According to [29], hierarchical latent models or higher-order constructs, are representing of multidimensional constructs that exist on a higher level of construct and are related to other constructs and fully mediating the influence from or to their underlying dimensions. Hierarchical latent models, higher-order constructs or second order construct is useful for researchers to reframe the structure model to be more meaningful [30]. According to [4] other dimensions that are not mentioned in the previous studies may be important. Therefore, an exploratory study was conducted to evaluate the existing dimensions and explore other dimensions and items to measure TICs dimensions particularly in the automotive industry. In this study, for beginning we only focus on four dimensions of TIC namely R&D capability, manufacturing capability, networking capability and human resources capability. These dimensions were chosen because prior literature found that the important of these dimensions in the automotive industry [15, 26, 31, 32, 33, 34, 35].

B. Research model and hypotheses development

Based upon definition of TIC dimensions as mentioned above, it was explored for the literature for TICs. Therefore, this study introduces the basic functional activities drawn from the literatures on TICs. This study suggests 4 dimensions on TICs: R&D capability, manufacturing capability, networking capability and human resources capability, which they are proposed to the following literature studies:

1. R&D capability

The primary component of TICs dimensions is R&D capability in affecting technological innovation and economic growth [12]. R&D capability is firm ability to develop new technologies. R&D capability is one of the strategic resources critical to firm success in terms of continuous innovation, due to increasing global competitive pressure, shortened product life cycles and ease of imitation[36]. Market and customers' preferences are changing rapidly, thus forcing firms to learn new knowledge to produce new products and services in order to address new market and customer demands[37]. Therefore firms need to continuously adopt, develop and innovate to enhance product competitiveness such as product designs and quality, technological service and reliability as well as generate new processes that help lower operational and production costs and delivery times and increase flexibility, quality and safety [36, 38, 39].

Researchers have employed numerous variables to measure R&D capability. [12] describe R&D capability from four dimensions, innovation strategy, project implementation, portfolio management and investment in R&D. On the other hand, [40] put forward five different dimensions namely R&D input intensity, ratio of R&D personnel, the number of new product development project, the number of science and technology centre and R&D output. [41] measure R&D capability from three dimensions 1) learning function (function related to exploration, absorption and integration of external technology and knowledge), 2) R&D function (R&D workforce and the relative size of R&D investment), and 3) external networking function (function related to active external technology cooperation). However, in terms of automotive industry, [32] categorized R&D capability into design., engineering and modularization capabilities. According to [32] firm in automotive industry interested in upgrading to design capability and now focus on modularization capability including engineering capability.

First sub-dimension, investment in R&D which refers to firm ability to achieving a higher standard of technology in firms, which would allow them to introduce new and superior products and/or processes, resulting in higher levels of income and growth [42]. Second sub-dimension, engineering capability refers ability of the firm to introducing new technology and develop materials for new product development as well as capability to uses computer simulations, such as computer-aided engineering (CAE) and also capability to ensure interfacing with other products [32]. In other words, engineering capability is firm's ability to develop the components, the modules or subsystems, and work to integrate all of these components to create the final product especially in complex product development projects such as in automotive industry [43]. Firms with R&D capabilities will have a full complement of process and product engineering, and substantial R&D capabilities and will typically have an R&D department [44].

Third sub-dimension, design capability refers to firm's ability to develop new products, composed of interdependent components, coordinate their interdependent tasks, and exchange information that can strengthen the firm's position on the market or enable its diversification by creating a leading position in a new market [43] Fourth sub dimension is modularization capability is ability of firm to decompose, decouple of interfaces and recombination of parts in order to achieve economies of scale [45]. In other words, modularity means that parts or components of a product are sub divisible into modules that can be easily interchanged and replaced and enable the configuration of a wide variety of end products [46, 47]. Modular design can address the need for a high number of product variants and further allow a higher degree of automation in the assembly line and has been employed in the automotive industry with a great success [45]. Modularity can bring flexibility to facilities and processes. These key dimensions of R&D capability are adapted from the literature and tested in the study through the following hypothesis:

H1: R&D capability is a second-order latent construct composed of investment in R&D, engineering capability, design capability, and modularization capability.

2. Manufacturing capability

[12] stated that manufacturing capability as a firm's capacity to alter R&D results into products, which meet market needs, accord with design request and can be manufactured. Manufacturing capability is a quality of new product development that ensures the product can be produced efficiently and reliably in the manufacturing process [48]. The manufacturing capability

may not only guarantee the success of the transformation of R&D outcome into product, but also ensure its quality suits customer's needs [49]. Strong manufacturing capability leads to successful outcomes especially in the redesign and production stage of innovation process. From this standpoint, manufacturing capability is an important dimension of innovation capabilities [50].

Four sub dimensions that reflect the manufacturing capability constructs or dimensions are; cost, quality, delivery, and flexibility [51]. Similarly, for the automotive industry, [31] categorized process/manufacturing/production capability into dependability improvement, cost reduction, quality improvement, and flexibility capabilities. According to these researchers cost reductions relates to firm capability to reduce cost to achieve superior profitability. Through innovation in the process improvement, firm can reduce costs during the manufacturing process [52]. Cost reduction is viewed as a crucial capability for firms should have, which in turn enables their survival [46].

According to [33], manufacturing capabilities such as firm's ability to compete for the bases of time, flexibility, low costs, and product quality are acknowledged as a source of competitive success. Similarly, [53] also state that product quality, cost reduction, volume and product flexibility, and delivery dependability and speed have been long recognized as a source of competitive advantages and superior performance outcomes. This study hypothesis that:

H2: Manufacturing capability is a second-order latent construct composed of dependability improvement cost reduction, quality improvement, and flexibility capability.

3. Networking Capability

Networking capability is indicating as an important source of technological innovation capabilities, competitive performance and firm performance [15, 54]. Networking capability is defined as a capability to transmit to or receive from other departments within the company, and from customers, suppliers, consultants, and research institutions, among others, information, competencies, and technology [15]. Researchers have emphasized the importance of building relationships whether within firm or inter-firms or research institutions for developing product innovation and process innovation and technological development [15, 26, 55] as well as firm technological innovation capabilities [56, 57, 58]. Accordingly, innovation attends to result from numerous interactions with other departments within the company, and from customers, suppliers, consultants, and research institutions [15]. Networking capability enhances collaboration between network relationships and potentially improves innovation especially when complex information is shared among people. The formation of networking implies the effective and active interchange of information and implementation of routines that would improve a firm 's competitive advantage of new products, service or processes of from the ongoing changes of existing products, services or processes matched to customer preferences that are persistently assessed. It follows that networking capability will influence the capability to innovate, since information about this relationship are mainly used for upgrades, changes and the introduction to new ideas, products or services. According to [59] relational capital or networking capabilities have become a crucial factor of firms to improve new product development

[26] introduces a three dimensional linkage capabilities scale for electronic information industry, consisting of internal linkages, external commercial linkages and linkage with public research institutes. It is postulated that this study offers a more detailed and contextually insightful conceptualization of linkages/networking capability. The results show that the firm internal links and external linkages do have a positive influence on firm performance. [34] proposed other linkages that need to consider for automotive industry which is automotive associations. In their study, linkages/networks were recorded strongly with both local and national associations. The relationship between government agencies also important because [60] found the importance of government supports for regional SME innovations. Therefore, networking capability in term relationship between association and government agencies were considered in this study which can contribute to the relationship between networking capability, competitive advantage and firm performance. Thus, this study formulates the following hypothesis:

H3: Networking capability is a second-order latent construct composed of internal linkages, external commercial linkages, and linkages with public research institutes, associations and government agencies.

4. Human Resource Capability

Human resources are the major potential resources in the firms to enhance efficiency and productivity of any firms and an important resource to improve their firm performance [61] Human resource is critical to the firm's competitiveness because firms can effectively utilize human resources to help create and sustain competitive advantage [62, 63]. [64] defines human resources capability as the routines embedded in the tacit and implicit knowledge of the members of an organization functioning to acquire, develop, nurture, and re-deploy human resources through human resources management (HRM) practices in a dynamic competitive environment. According to [35] HR practices, are expected to support the achievement of the firm's objectives by using the learning and innovative capabilities of individuals more effectively. For automotive industry, [35] proposed three sub-dimensions of HR practices namely employees' ability, employees' motivation, and employees' opportunity to leverage knowledge within firms. These practices known as ability, motivation and opportunity (AMO) theory and appear to be the most popular theories applied in the studies that link HRM and performance [65]. These three HR practices dimensions can be described as: (1) skill development to affect employees' ability to understand and combine new knowledge; (2) an incentive structures 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 [35].

First dimension, employees' skills and abilities have long been conceptualized as human capital, which can result from training and career development chances across the organization [35]. The second dimensions, employees' motivation refers to the rewards and appraisal that provide by firms to motivate their employees to engage in creative behaviours and participate in innovation processes [66]. The third dimensions, employees' opportunity refers to organizations are more efficient than markets at this process because they offer access to stronger social networks and norms in a context that can value and support individual contributions. Thus:

H4: Human resources capability is a second-order latent construct composed of employees' skills and abilities, employees' motivation and employees' opportunity.

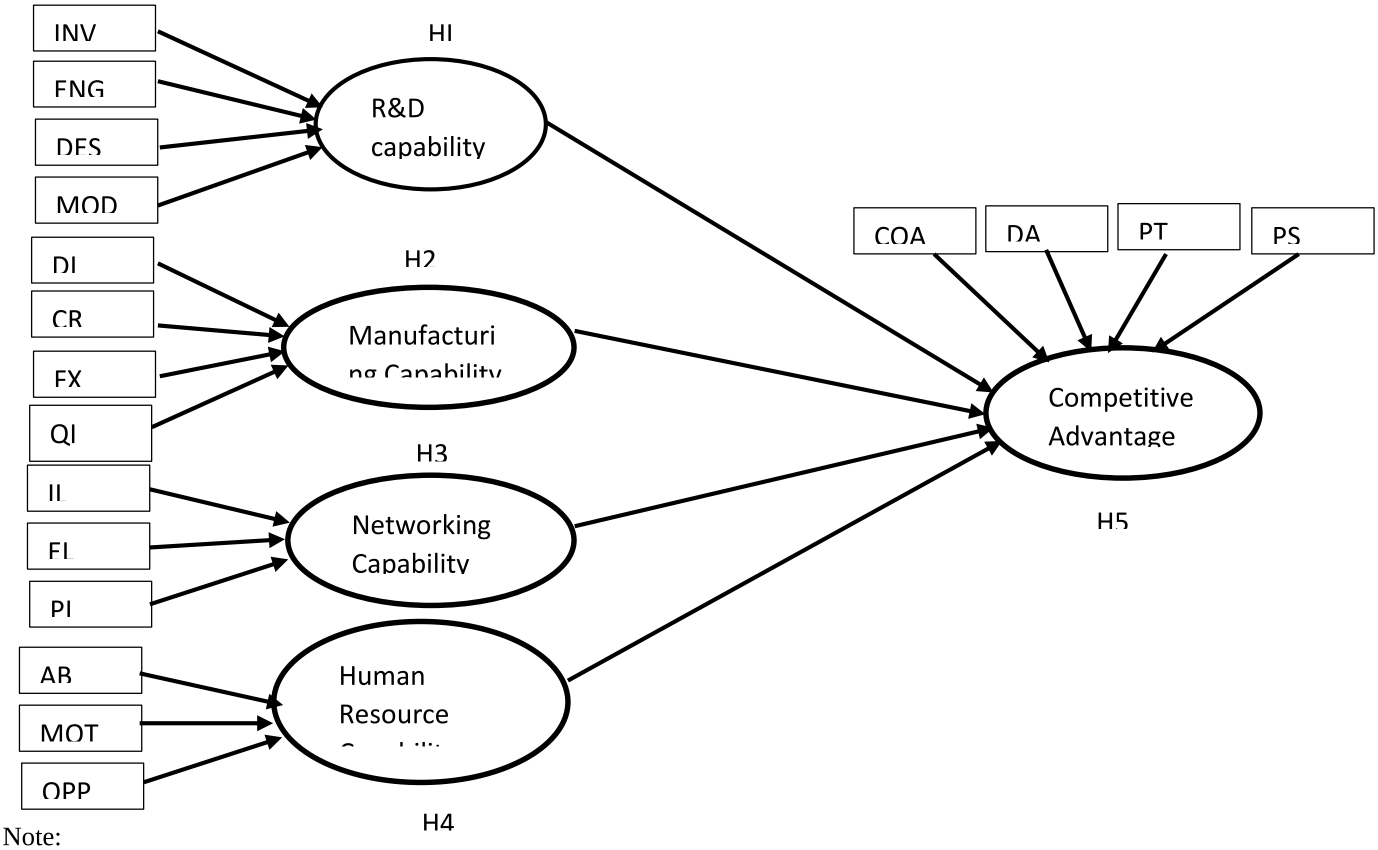
C. Competitive Advantage

The term 'competitive advantage' was made popular by Michael Porter through his book "Competitive advantage: creating and sustaining superior performance" which published in 1985. According to [67], competitive advantage is the ability to earn profits consistently above the average for the industry. Other scholars like [24] 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. Similarly, [68] defined competitive advantage as the implementation of a strategy not currently being implemented by other firms that facilitate the reduction of costs, the exploitation of market opportunities, and/or the neutralization of competitive threats. Based on [68] definition, [69] defined competitive advantage as the above industry average manifested exploitation of all market opportunities and full (exploitation of) the market opportunities, and neutralization of all competitive threats, full (neutralization of) the competitive threats. [69] found that numerous definitions of CA which are available in the strategic management literature ever since the term was introduced. Notably, [68] and [69] stated that some scholars seems to confuse competitive advantage with firm's superior performance. Some scholars also conceptualize competitive advantage definition which focused more on sources of competitive advantage such as market position, market barriers, firm specific resources are associated. [69] believed the problem of these competitive advantage conceptualizations occurs because competitive advantage is poorly defined and inability to operationalize the construct of competitive advantage in an empirical research study.

In terms competitive advantage constructs or dimensions, [67] suggests that firms can achieve one of two basic types of competitive advantage namely, low cost (advantage) or differentiation advantage. Cost advantage, or cost leadership, occurs when the firm operates on 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 [67, 70]. These dimensions are widely used by the researchers in strategic management to measure competitive advantage [71]. However, today environment, firm cannot only depend on cost advantage and differentiation advantage, innovation also has become a prime source for larger firms as well as small firms to gain a competitive advantage.[72]. [73] also mentioned that the competitive advantage 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, product innovation and process innovation. Thus:

H5: Competitive Advantage is a second-order latent construct composed of cost advantage, differentiation advantage, product innovation, and process innovation.

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.



Note:
Investment in R&D (INV), Engineering (ENG), Design (DES), Modularization (MOD), Dependability improvement (DI), Cost Reduction (CR), Flexibility (FE), Quality Improvement (QI), Internal linkages (IL), External Commercial Linkage (EL), Linkages with public research institutions, government agencies and association (PL), Ability (AB), Motivation (MOT), Opportunity (OPP), Cost Advantage (COA), Differentiation Advantage (DA), Product innovation (PT) and Process innovation (PS)

Figure 1: Proposed Conceptual Framework.

3. METHODOLOGY

This study employs a questionnaire survey approach to collect data for assessing the validity of the model. Accordingly, this paper presents the result of the measurement model to validate TIC dimensions and competitive advantages dimensions a second-order constructs 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 samples 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 practitioners before conducting the survey. Specifically, three experts were selected from the Faculty of Industrial Management, University Malaysia Pahang (UMP). Meanwhile, another four automotive industry practitioners were also contacted with the same exercise. Their feedback and recommendations were then integrated into the final draft of the instrument. A questionnaire was distributed over the 309 firms, 136 of them returned the completed questionnaires. This yielded a response rate of 44.0% of the total population (309 companies). Of the 309 questionnaires distributed to the entire automotive companies' population in as listed in the sampling frame, 136 completed questionnaires were collected. These firms are mainly involved in component manufacturers and suppliers (63.6%), followed by module assembly and original equipment manufacturers (20.0%) and material suppliers (16.4%). In terms of the number of employees, 54.4% of firms have more than 200 employees. 23.6% of firms employ between 75 and 200 employees and 22.0% of firms employ less than 75 employees. 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 [30] and it can operate in a limited number of sample size [74]. In assessing a reflective –formative measurement model, three analyses are required, namely the assessment of construct reliability, convergent validity as well as discriminant validity. In an attempt to determine the measurement accuracy, WarpPLS 6.0 was used to assess the reliability, validity and multi collinearity issues of the items in this study [75].

4. MEASUREMENT MODEL RESULT

The research model was analyzed using partial least squares structural equation modeling (PLS-SEM) by utilizing WarpPLS 6.0 software for measurement data analysis [75]. According to the explanation proposed by [76], a model consisting of both reflective and formative constructs and second-order constructs are considered as a complex measurement model. The TICs dimensions and competitive advantage construct is therefore a complex reflective-formative-second-order measurement model. The TICs dimensions construct to include fourteen reflective constructs at the first order constructs that form the four second-order formative constructs. These four second-order formative constructs include (1) R&D capability, (2) manufacturing capability, (3) networking capability, and (4) human resources capability. The competitive advantage constructs to include four first order constructs namely cost advantage, differentiation advantage, product innovation and process innovation. Therefore, PLS-SEM is an appropriated approach to assess TIC dimensions and competitive advantage in the current study. The analyses were performed using WarpPLS 6.0 [75] software since it offers various options for the outer model parameters and latent variable scores calculation. PLS regression outer model algorithm was used to estimate the measurement (outer) model parameters and latent variable scores [75, 77]. The analyses took place in two stages: (1) assessment of first-order measurement model assessing reliability, and convergent validity with an estimation of composite reliability (CR), Average Variance Extracted (AVE), and discriminant validity; and followed with (2) assessment of second-order measurement model. The items used in this study were adopted from previous empirical studies that were published in reputable academic journals. Table 2 shows the sources of measurement of this study.

Table 2: Sources of Measurement of Constructs.

Second Construct	First Construct	Sources	Remarks
RD Capability	Investment in R&D Engineering Design Modularization	[13, 31, 32]	Adapted
Production/ Manufacturing Capability	Dependability improvement Cost Reduction Flexibility Quality Improvement	[31, 32, 33]	Adapted
Networking capability	Internal linkages External Commercial Linkage Linkages with public research institutions, government agencies and association (PGL)	[15, 26, 34]	Adapted
Human Resource Capability	Ability Motivation Opportunity	[35]	Adapted
Competitive Advantage	Cost Advantage Differentiation Advantage Product Innovation Process Innovation	[70, 78]	Adapted

A. Assessment of the First-Order Measurement Model

To assess the measurement model for the first-order constructs, the eighteen reflective first-order constructs were evaluated together [77]. For the reflective measurement model, reliability and validity using Composite Reliability (CR) and Average Variance Extracted (AVE) were assessed [80, 84]. According to [79] , loading with each indicator on its associated latent construct should be higher than 0.7. Table 3 presents the assessment of construct reliability as well as convergent validity of 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. The analysis revealed that indicator RDCE1, RDC4, MCDI2, MCCR1, MCCR2, MC1QI1, MC1Q4, MCF5, NCIL6, NCEL1, HRCA6, HRCM1, HRCM3, and CACOA4, had low loadings. Therefore, they were excluded and the analysis was rerunning. As presented in Table 3, loadings of all items were greater than 0.7. The AVEs of other first-order constructs were found higher than 0.5. The findings revealed that convergent validity was ensured for eighteen reflective first-order constructs. Moreover, all the constructs had high construct reliability through measures of composite reliability [80]. All CRs values exceeded the cut-off values of 0.7 ([79]. Overall, the results supported the acceptable reliability and convergent validity of reflective measurement model of all the eighteen first-order constructs.

Appendix 1 illustrates the assessment of discriminant validity using [81]. Discriminant validity is established using the Fornell and Larcker criterion such that the square root of AVE for each construct are 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. Hence, the result confirms that the discriminant validity has been established.

Table 3: Measurement model assessment of first-order constructs.

Second-order Constructs	First-order Constructs	Indicators	Composite Reliability (CR)	Average Variance Extracted (AVE)
R&D CAPABILITY (RDC)	**Investment in R&D (INV)**	**4**	**0.851**	**0.588**
	RDCIN1	0.762		
	RDCIN2	0.758		
	RDCIN3	0.706		
	RDCIN4	0.837		
	Engineering (ENG)	**3**	**0.877**	**0.704**
	RDCE3	0.804		
	RDCE4	0.809		
	RDCE5	0.901		
	Design (DES)	**3**	**0.826**	**0.614**
	RDCD1	0.774		
	RDCD2	0.856		
	RDCD3	0.715		
	Modularization (MOD)	**5**	**0.904**	**0.656**
	RDCM1	0.831		
	RDCM2	0.810		
	RDCM3	0.702		
	RDCM4	0.856		
	RDCM5	0.840		
MANUFACTURING CAPABILITY (MC)	**Dependability improvement (DI)**	**4**	**0.929**	**0.767**
	MCDI1	0.907		
	MCDI3	0.890		
	MCDI4	0.916		
	MCDI5	0.783		
	Cost Reduction (CR)	**3**	**0.910**	**0.773**
	MCCR3	0.917		
	MCCR4	0.783		
	MCCR5	0.930		
	Quality Improvement (QI)	**2**	**0.784**	**0.644**
	MC1QI1	0.803		
	MC1QI3	0.803		
	Flexibility (FX)	**4**	**0.884**	**0.656**
	MCF1	0.827		

Second-order Constructs	First-order Constructs	Indicators	Composite Reliability (CR)	Average Variance Extracted (AVE)
	MCF2	0.832		
	MCF3	0.844		
	MCF4	0.730		
NETWORKING CAPABILITY (LC)	**Internal linkages (IL)**	**5**	**0.943**	**0.767**
	NCIL1	0.888		
	NCIL2	0.902		
	NCIL3	0.884		
	NCIL4	0.846		
	NCIL5	0.860		
	External Commercial Linkage (EL)	**5**	**0.923**	**0.707**
	NCEL2	0.803		
	NCEL3	0.861		
	NCEL4	0.854		
	NCEL5	0.804		
	NCEL6	0.881		
	Linkages with public research institutions, government agencies and association (PL)	**5**	**0.907**	**0.661**
	NCPL1	0.800		
	NCPL2	0.821		
	NCPL3	0.802		
	NCPL4	0.802		
	NCPL5	0.838		
HUMAN RESOURCE CAPABILITY (HRC)	**Ability (AB)**	**6**	**0.911**	**0.672**
	HRCA1	0.828		
	HRCA2	0.769		
	HRCA3	0.837		
	HRCA4	0.875		
	HRCA5	0.787		
	Motivation (MOT)	**6**	**0.920**	**0.741**
	HRCM2	0.876		
	HRCM4	0.891		
	HRCM5	0.838		
	HRCM6	0.838		
	Opportunity (OPP)	**7**	**0.926**	**0.643**
	HRCO1	0.839		
	HRCO2	0.752		
	HRCO3	0.852		
	HRCO4	0.767		
	HRCO5	0.790		
	HRCO6	0.744		
	HRCO7	0.859		
COMPETITIVE ADVANTAGE (CA)	**Cost Advantage (COA)**	**4**	**0.851**	**0.655**
	CACOA1	0.847		
	CACOA2	0.784		
	CACOA3	0.797		
	Differentiation Advantage (DA)	**4**	**0.880**	**0.649**
	CADA1	0.818		
	CADA2	0.751		

Second-order Constructs	First-order Constructs	Indicators	Composite Reliability (CR)	Average Variance Extracted (AVE)
	CADA3	0.863		
	CADA4	0.785		
	Product innovation (PT)	**4**	**0.930**	**0.768**
	CAPT1	0.846		
	CAPT2	0.921		
	CAPT3	0.902		
	CAPT4	0.833		
	Process innovation (PS)	**4**	**0.947**	**0.816**
	CAPS1	0.902		
	CAPS2	0.903		
	CAPS3	0.928		
	CAPS4	0.881		

B. Assessment of Second-Order Measurement Model

To generate the second-order formative constructs, a two-stage approach proposed by [83] was applied in the current study. Following a two-stage approach, the latent variable scores of the first-order constructs were used to establish formative second-order constructs. To establish measurement model for the second order formative constructs, the Variance Inflation Factor (VIF) (i.e. collinearity between the associated items), and the significance of item outer weight should be assessed [79, 84].

The results presented in Table 4 indicate that the VIF values of the associated items of the respective constructs (R&D capability, manufacturing capability, networking capability and human resources capability) are lower than 5 and the item outer weights are significant at .05 confidence level. Thus, the measurement model for the second-order formative constructs was confirmed. The results further revealed that the second-order constructs were significantly explained by the first-order constructs. Specifically, all the first-order constructs were positively associated with their respective second-order constructs with the beta weight ranged from 0.239 to 0.470. Overall, the results revealed that there is no issue with the conceptual overlap between the constructs. Basically, the results presented in Tables 3, 4, appendices 1 demonstrate that items for all the eighteen constructs are accurately measuring their respective constructs. Thus far, the other aims at this study, which are to validate the study items and establish their respective reliability, have been achieved.

Table 4: Measurement model assessment after generating second-order constructs

Hypothesis	Second-order construct	First-order construct	Weight	p - Value	VIF	Full Collinearity
H1	R&D capability (RDC)	Investment in R&D (INV)	0.239	0.002	1.382	2.154
		Engineering (ENG)	0.347	<0.001	2.492	
		Design (DES)	0.322	<0.001	1.932	
		Modularization (MOD)	0.330	<0.001	2.324	
H2	Manufacturing Capability (MC)	Dependability improvement (DI)	0.372	<0.001	1.513	1.471
		Cost Reduction (COST)	0.309	<0.001	1.257	
		Quality Improvement (QI)	0.341	<0.001	1.376	
		Flexibility (FLEX)	0.361	<0.001	1.42	
H3	Networking Capability (LC)	Internal linkages (INL)	0.345	<0.001	1.332	2.053
		External Commercial Linkage (EXL)	0.470	<0.001	2.264	
		Linkages with public research institutions, government agencies and association (PGL)	0.416	<0.001	1.833	
H4	Human Resource Capability (HRC)	Ability (A)	0.352	<0.001	2.15	1.412
		Motivation (M)	0.373	<0.001	3.438	
		Opportunity (O)	0.374	<0.001	3.465	
H5	Competitive Advantage (CA)	Cost Advantage (COA)	0.303	<0.001	1.37	1.358
		Differentiation Advantage (DA)	0.312	<0.001	1.433	
		Product innovation (PRTI)	0.343	<0.001	1.729	

Hypothesis	Second-order construct	First-order construct	Weight	p - Value	VIF	Full Collinearity
		Process innovation (PRSI)	0.350	<0.001	1.81	

5. CONCLUSION

Several features of the current findings deserve attention. First, the findings of the study supported that TIC dimensions such as R&D capability, manufacturing capability, networking capability and human resources capability as well as competitive advantage. These five dimensions are mutually exclusive as supported by low full collinearity values (VIFs) of these constructs. The significant outer weights, as shown in the findings, established the proposed second-order TIC dimensions and competitive advantage construct. The significant outer weight identifies the role of first-order constructs in establishing the respective second-order constructs.

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Study findings provide both methodological and practical implications in generating new knowledge in terms of measurement model specification in the technology innovation management literature. The robust estimation of the constructs' measurement model using a second generation of data analysis techniques known as Partial Least Squares Structural Equation Modelling (PLS-SEM) provides a methodological implication for future studies. The procedures applied for this study for establishing measurement model could be followed by other researchers especially in the context of automotive industry. Moreover, assessing the second-order formative construct of TIC dimensions and competitive advantage enables researchers to conduct empirical studies based on the formative measurement model. This could open up new directions for measuring and understanding TIC and competitive advantage construct in future studies. This study also offers practical implications by providing a clear understanding of the TIC concept. The four identified dimensions of TICs could provide better understanding of senior managers and practitioners in the automotive industry in order to manage the issues involved in technological innovation capabilities

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This study has some limitations that suggest directions for future research. The present study conceptualised and assessed the second-order formative construct of TIC dimensions and competitive advantage based on automotive industry in Malaysia. Therefore, the findings of the study could be cross-validated in different contexts, such as firm size and types of firms. It is also recommended that future studies could conduct the analysis of measurement invariance to ensure all item measures for each respective construct are not biased towards a particular firm size and type of business. Another area of concern is the representativeness of the sample and generalizability of the findings. Hence, future studies could extend the sample size by selecting automotive firms from different countries in order to ensure the representativeness of the sample. In addition, the conceptualisation of TIC dimensions is limited to R&D capability, manufacturing capability, networking capability and human resources capability. Thus, future studies could include other dimensions of TIC dimensions in literature such as marketing capability, strategic planning capability and etc to further enrich the conceptualisation of TICs dimensions. In sum, this study offers fresh insights into conceptualising and measuring TIC dimensions and competitive advantage construct in the automotive industry in Malaysia.

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

	INV	ENG	DES	MOD	DI	CR	QI	FX	IL	EL	PL	AB	MOT	OPP	DA	COA	PT	PS
INV	**0.767**																	
ENG	0.514	**0.839**																
DES	0.316	0.603	**0.784**															
MOD	0.278	0.681	0.661	**0.810**														
DI	0.204	0.054	0.116	0.096	**0.876**													
CR	0.230	0.399	0.173	0.416	0.251	**0.879**												
QI	0.360	0.038	-0.025	-0.046	0.507	0.245	**0.803**											
FX	0.450	0.523	0.374	0.530	0.422	0.435	0.293	**0.810**										
IL	0.328	0.338	0.508	0.447	0.402	0.048	0.053	0.180	**0.876**									
EL	0.400	0.541	0.471	0.654	0.047	0.322	-0.196	0.420	0.486	**0.841**								
PL	0.311	0.419	0.289	0.363	-0.246	0.199	-0.122	0.178	0.237	0.667	**0.813**							
AB	0.427	0.213	0.223	0.208	0.239	0.353	0.426	0.305	0.214	0.103	0.246	**0.820**						
MOT	0.203	0.074	0.055	0.155	0.185	0.314	0.471	0.219	0.027	-0.120	0.075	0.697	**0.861**					
OPP	0.197	0.194	0.138	0.323	0.218	0.320	0.381	0.279	0.098	-0.014	0.102	0.700	0.825	**0.802**				
DA	0.227	0.042	0.270	0.262	0.304	0.082	-0.040	0.112	0.537	0.377	0.200	0.387	0.259	0.386	**0.805**			
COA	0.217	0.174	0.210	0.311	0.257	0.047	-0.007	0.047	0.438	0.418	0.201	0.196	0.053	0.086	0.392	**0.810**		
PT	0.268	0.028	0.003	0.122	0.280	0.116	0.131	0.086	0.214	0.048	0.009	0.366	0.318	0.424	0.458	0.353	**0.876**	
PS	0.223	0.121	0.059	0.162	0.298	0.344	0.167	0.194	0.189	0.242	0.044	0.237	0.126	0.205	0.354	0.499	0.593	**0.904**