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THE EFFECTS OF R&D AND INNOVATION CAPABILITIES ON THE THAI AUTOMOTIVE INDUSTRY PART'S COMPETITIVE ADVANTAGE: A SEM APPROACH

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ABSTRACT

A structural equation model was used to verify both the direct and indirect influences on research and development and innovation capabilities that affect Thai automotive parts enterprises competitive advantage. Thailand's automotive sector is a major driver of the economy with a multi-thousand network of both domestic and international companies contributing a significant amount to both domestic and Asian economic growth. After peaking in 2013 and reaching the Top 10 automotive nations, there has been a slide backwards. Competition is fierce and the pace of change ever quickening. Therefore, the researchers sought to determine how the automotive parts sector needed to improve in capability, skills and infrastructure to maintain a sustainable competitive advantage. From the structural equation model analysis of 220 regional automotive parts sector managers and use of AMOS software, it was determined that research and development combined with innovation plays key roles in the industry's profitability and survivability. Additionally, there must be support across a wide sector of the economy, including universities, government agencies and institutions. Once championed as the 'Detroit of Asia', Thailand's recognized success as a global automotive hub is a classic case of a well-executed industrial plan but that lead can potentially slip away without embracing new technologies and innovative thinking.

KEYWORDS

research and development, innovation capability, Thai auto parts industry, structural equation model.

Introduction

Within the competitive automotive sector, overcapacity, high market penetration, high labor and fixed costs, and the need for constant product development and innovation are normal components. With Thailand's entry at the end 2015 into the ten nations AEC (ASEAN Economic Community), the contribution to Thailand's automotive sector from the economic integration is still unsure. Hosting 50 of the top 100 global OEM parts suppliers,

the world can be assured that Thailand will continue to play a leading role but that leadership is dependent of a sustainable competitive advantage as surging competition is everywhere.

Examples include China, which in 2015 produced 25.5 million vehicles compared to Thailand's 1.9 million [2] and Indonesia which in 2016 is expected to grow at five percent reaching over one million vehicles [3]. China alone represented a value of US\$ 13 billion of the approximate global total of US\$ 834 billion dollars [4].

In this global race to the top, 2012 and 2013 were the ‘Golden Years’ for Thailand with Thailand producing nearly 2.5 million units in 2013, moving it into the top ten of automotive manufacturers worldwide. After peaking however in 2013, domestic sales dropped in 2014, partially due to the lack of government incentives and continuous political turmoil [5].

In its 3rd master plan for the Thai automobile sector, the Thailand Automotive Institute (TAI) has indicated that the industry needs to concentrate on 5 key development sectors [6]:

1. technology and R&D;
2. skilled labor excellence;
3. human-resource development; strengthening manufacturers’ competitiveness;
4. environmental management and infrastructure development; and
5. establishment of administrative body to coordinate policies for the automotive sectors.

There are three major groups of Thai industrial and automotive parts sectors: steel parts including the engine; car body parts; and electronics and other parts (Fig. 1). Another challenge of Thailand’s automotive industry is a goal to produce a yearly total of 3 million cars by 2017, with the majority to be exported to foreign markets such as Japan and Europe, which require high quality standards.

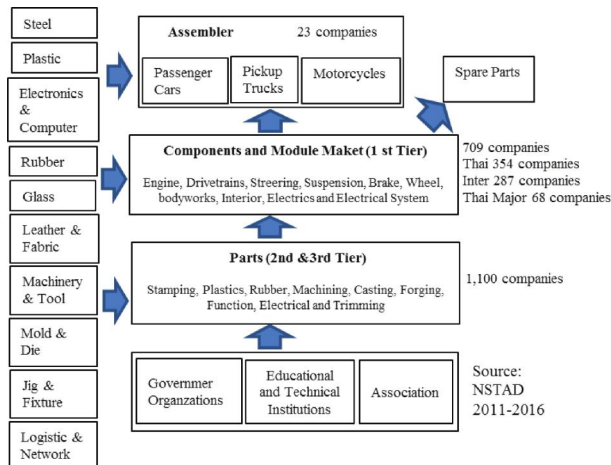


Fig. 1. Thailand’s Main Stream Automotive Industry Map. Source: NSTDA’s 2012-2016 Strategic Plan [7].

The government coordinated with the private sectors and prepared a ‘Master Plan for Automotive Industry (2012–2016)’, with a focus on being a global green automotive production base, as well as increasing research and development for automotive technology.

Therefore, with a continued focus, Thailand’s automotive industry will continue to be a major industry that creates significant economic value for the country, which is currently estimated to employ

550,000 jobs (2013) with another 200,000 needed to reach the goal of 3 million vehicles by 2020 [8]. This doesn’t include thousands of labors employed in related value-added industries like upstream industries and service industries, such as financial, insurance and after sales service [9].

Automotive industry entrepreneurs also play a significant role in the production of replacement auto body parts, as well as in the upstream to downstream process. Referred to as ‘replacement equipment manufacturers’ or REM, the number of out-of-warranty passenger vehicles in Thailand is expected to exceed 14 million units by 2020, with more than five million units between the age of three and eight years [10]. The REM market in Thailand is expected to grow at a rate of 5.5 percent between 2015 and 2020, with over 60 authorized OEM parts distributors nationwide already in place.

Furthermore, Thailand has over 70 Tier 1 auto-parts suppliers (OEM) and 1,700 Tier 2/3 [8]. More than half of the Tier 1 suppliers are automotive component companies. Of the top 100 auto parts manufacturers in the world, 50% have factories in Thailand.

Also, Thailand’s export market for automotive parts is also significant with Australia and Indonesia representing nearly 23 percent of Thailand’s total automotive exports [8], which represented nearly US\$7 billion. Further data shows that US\$352 million in engine parts were exported representing 12.5 percent while automotive OEM parts exports represented 78.8 percent while 8 percent represented spare parts.

From all appearances, Thailand reached one step in its output goal, increasing by an average rate of ten percent annually [9]. Thailand also reached its goal of becoming a top 10 auto-manufacturing nation, but lost this status after peaking in 2013. It has also increased the use of local content from 40 to 50 percent, another strategic goal realized.

Mahmoud-Jouini and Lenfle [11] found that product development lead time could be reduced by up to 17 percent, as a result of the European automotive manufacturer platform strategy based on cost control and concurrent design development strategies. The numbers of models could also be tripled by reducing lead times from 2.5 years to 9 months.

Accordingly, technologically innovative organizations will be able to create value-added products or services faster. As a result, organizations must constantly strive to improve their technical skills and technological capabilities in R&D in order to strengthen their potential [12] and take advantage from the market needs.

In this matter, Kocoglu et al. [13] also confirmed that uncertainty, dynamism and volatility are major characteristics of global a competitive environment and technological learning is a key for the firms' success in competition.

Therefore, from the above overview the researchers continued to explore the issues surrounding R&D and innovation capabilities on the automotive parts sector's competitive advantage. By use of a structural equation model, the study evaluated how an enterprise embraces these variables. Additionally, it was believed that process, products and services were contingent factors as well and that the correct implementation of these processes would be beneficial to the Thai automotive parts industry by helping their executives better define the vision, mission, policies and strategic planning of their respective enterprises.

Purpose of this study

- To investigate the factors having direct and indirect effects on the multiple variable affecting Thailand's automotive parts industry competitive advantage.
- To also investigate and analyze the data through the development of a structural equation model.

Literature review

Competitive advantage

According to Porter [14], the learning rate is related to reduction in costs over the time in a value activity. Cost and differentiation are major sources of competitive advantage. New competitors that enter an existing market may find difficulties in setting up and selling because of several significant barriers.

Barney [15] also indicates that an enterprise gains a competitive advantage when it starts creating strategies that have various values from its current or potential competitors and when these competitors are unable to use the same strategy.

Yinghong and Wang [16] noted that collaboration is paramount in competitive price advantage which helps maintain better services through efficient distribution channels. Kristal et al. [17] discovered the benefits to enterprise performance by use of a combination of an ambidextrous supply chain strategy with competitive capabilities. Therefore, enterprises must always be searching for ways to improve their technical and technological skills and capabilities in R&D [12] and take advantage from the market's requirements.

Multiple researchers agree that high performance organizations continually improve their selves by use of state-of-the-art technologies which helps compa-

nies create sustainable competitive advantages while increasing operational efficiency [14, 18].

Oh and Rhee [19] are in agreement from their Korean automotive supplier research which concluded that flexibility, engineering and modularization capabilities have positive influences on collaboration in new car development which, in turn, positively affects competitive advantage of carmakers.

Research in Taiwan concerning the semiconductor industry (TSI) by Wang and Chiu [20] indicated that a competitive edge entailed speed, cost, flexibility, and quality. This was driven by policy formulation, bridging institutions, public infrastructure, vertical disintegration, entrepreneurship, and human capital. However, leadership depended on the development of additional core competencies to increase competitiveness.

Verma and Jayasimha [21] also suggested that technology, value creation, sustainability and brand strategy helped increase competitive advantage with product innovation and product quality being key elements.

Antonio et al. [22] researched competitive capabilities and concluded that product innovation, product quality, delivery, flexibility and customer services could be significantly improved with better internal integration.

From the study and after a review of the literature concerning competition advantage, the following four variables were determined which included:

- 1) **Cost** – Cost is concerned with the analysis of operations, internal finances, and marketing operations which can benefit productivity increases [19–25].
- 2) **Quality** is the degree of excellence of a particular product or service with the global auto maker embracing this idea with the corporate slogan “*Quality is Job 1*”. Quality is also concerned with product longevity and strength, as well consumer satisfaction in the after-sales service process and through advertisement through word-of-mouth [20, 23, 26–29].
- 3) **Delivery** – The overnight airfreight carrier FedEx marketed multiple slogans in their growth to fame and fortune, but two which best summarize and highlight both the scholarly and commercial importance of delivery to competitive advantage are, “*When it Absolutely, Positively has to be there overnight*” and “*It's not Just a Package, It's Your Business*” [19, 20, 22, 27, 30].
- 4) **Flexibility** – Supply chain flexibility has become increasingly more important with most executive surveys indicating that flexibility is the ability to respond more quickly to demand and opportunities [17, 19, 23, 31].

Research and development capability

Governmental organizations have invested in research and development (R&D) to create innovative new products in order to increase market share [32]. Thailand's has been successful in the past with these investments as seen from the doubling of vehicle production from 1.2 million units in 2006 to nearly 2.5 million units in [5]. Nevertheless, without continual improvement in quality, R&D and innovative processes, organizations can lose their competitive advantage [12].

Trott [33] investigated Taiwan's hi-tech companies' R&D processes and determined that when R&D and technology management ability and performance is strong, new product development increases. Further research also indicates that when both upstream and downstream R&D cooperation is strong, process innovation is high [34], and that external R&D collaborations with universities and suppliers are the most helpful.

Lee [35] examined the controversial relationship between market competition and R&D and determined that a company's ability to compete is tied to the firm's expertise in technical competency and R&D productivity.

Research conducted on American technology firms indicated that competitive advantage is tied to knowledge and external leveraging strategies and that companies lacking knowledge depth should place their emphasis on internal R&D while groups with strong knowledge depth should move their strategic resources to inter-firm partnerships and acquisitions [36]. This was consistent with Wang et al. [37] which also recognized that R&D value chains play an integral role in enterprise productivity and information flow for decision makers.

This additional review of the literature concerning R&D capability added two dimensions to the research including:

1) **Product** – New product development research is believed to increase the return on investment (ROI) as well as substantially increasing the ability for success. It also quickens the move of new products into the market which increases competitive advantage by having the ability to create and improve products of better quality with higher performance [5, 19, 25, 32, 33, 36].

2) **Process** – Process can enhance production efficiency, flexibility and safety while reducing operational and production cost [4, 19, 25, 34].

Innovation capability

Innovation capability is involved with technological change and innovation and is involved with

the ability of the enterprise to transform ideas into profits. Innovation capability is also concerned with the creation, development, and promotion of new products, processes, techniques, and system management [30].

Generally speaking, innovation refers to the ability of a group of enterprises with similar ideas to be industry leaders when implementing similar ideas [38]. This is consistent with Rothwell [39] which indicated the current generation of innovation research which started in early 1990s can still be traced back to research from an earlier generation. Today however, more focus is being given to the relationships of a global economy that directly affects organizational innovation. Other innovation management models still see innovation as new product development only and therefore don't include the linkages with processes and therefore should only be considered as partial models [40].

Mazzola et al. [41] conducted a large study between 2006 and 2010 on pharmaceutical firms and determined that that new product development processes are positively affected by being centrally located in the network, while UK research indicated that open innovation activities of business service providers is greater than that of manufacturers [42].

By promoting, developing, and improving or creating a new process, product, and technical or management system for the organization [30], the focus should be organized on developing new products/services for the market to make money and on using the organization's existing internal and external resources [28]. Innovation and technology should be used for the successful launch of new products and services and process/product development, which can bring new and unique services to the market [43].

Krishnaswamy [44] indicated that the ability to work with customers on R&D projects was crucial for product innovation success and growth with leads to competitive advantage [45].

This additional review of the literature concerning innovation capability further added five dimensions to the research including:

1) **Product Innovation** is concerned with the development of new products or services which can be brought into the market-place, hopefully before the competition [28–30, 41, 44–47].

2) **Process Innovation** is focused on the implementation of new or greatly enhanced production or delivery methods [26, 28, 29, 44–46].

3) **Service Innovation** works best if the innovations are aligned with the firm's core purpose, meet

a customer's future requirement and can be practically realized by the enterprise [21, 41, 42, 44, 46].

4) **Organization Innovation** requires management to establish procedures for events and innovation-focused investment [28, 48–50].

5) **Marketing Innovation** is an ability to launch new products or services to market successfully and efficiently [28, 49, 51].

From the literature review analysis, the following three hypotheses were generated (Fig. 2 and Table 1):

H1: Research and Development Capability positively and directly affects Innovation Capability.

H2: Research and Development Capability positively and directly affects Competitive Advantage as well as positively affecting Competitive Advantage indirectly through Innovation Capability.

H3: Innovative Capability significantly, directly and positively affects Competitive Advantage.

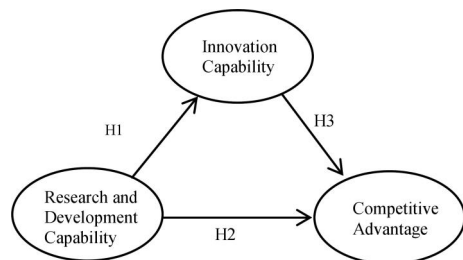


Fig. 2. The conceptual framework.

Methodology

Questionnaire design

For the study Cronbach's alpha (52-Cronbach, 1951) was used to evaluate the initial 30 samples

which used a 7-point Likert (53-29-1932) scale survey rating matrix. The value of alpha (α) that are considered acceptable ranges in value from 0 to 1 and may be used to describe the reliability of factors extracted from multi-point formatted questionnaires or scales, with a reliability score of 0.70 or higher being considered a reliable score by many researchers [54, 55]. As the study's average value of the correlation coefficient was found to be between 0.839 and 0.953, the results were deemed to be highly reliable.

Data collection and analysis

The structural equation model's (SEM) quantitative data was collected from the questionnaires which were collected from six regions around Thailand and included automotive enterprise engineers, managers, and supervisors. The relationships between the casual variables was analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows software program as well as the Analysis of Moment Structures (AMOS) SPSS module.

A ratio of 20:1 was adopted which represents 20 questionnaires for each of the 11 observed variables shown in Table 1 [55–57]. As Yamane [58] and Israel [59] have indicated that sample sizes beyond 400 are almost irrelevant, from the 3 latent variables in the model, and the 11 observed variables, the sample size of 220 enterprise managers selected by use of stratified sampling for the study was deemed adequate. Sample size confirmation was additionally validated by research [55, 56].

Table 1
Research questions development.

External latent variables	Manifest variables	Development
Research and development capability	1) Product 2) Process	[5, 12, 19, 25, 32, 34, 37, 51, 61, 62]
Intermediate variables	Manifest variables	Development
Innovation capability	1) Product 2) Process 3) Service 4) Organization 5) Marketing	[21, 28–30, 41, 42, 44–48, 51, 63, 64]
Internal latent variables	Manifest variables	Development
Competitive advantage	1) Cost 2) Quality 3) Delivery 4) Flexibility	[19, 20, 22, 23, 27, 30]

Measurement model results

For this study the SEM used a reflective measurement model [60] to posit the latent variables effect to the indicators with construct validity being tested by use of both convergent and discriminant validity. Measurement of the degree of the relationships was undertaken using correlation coefficient with correlations between theoretically similar measures as having a 'high' value, while correlations between the dissimilar measures are indicated as 'low'. The correlation therefore and can have a value between -1.0 and $+1.0$, with a negative (low) value indicating a negative relationship while a positive (high) has a positive relationship [65, 66].

Table 3 and Fig. 3 shows the results from the competitive advantage factor analysis where the composite reliability (CR) values were all higher than 0.60, with all resultant average variance extracted (AVE) values higher than 0.50, and all square of the correlation (R^2) values were determined to be higher than 0.20, representing the overall reliability of the measurements [65, 66].

Table 2 shows the various weights from the research constructs, with the variables for R&D capability indicated at 0.807 (product) and 0.913 (process). The variable weights for innovation capa-

bility were 0.491 (product), 0.870 (process), 0.885 (service), 0.883 (organization), and 0.793 (marketing). Finally, for competitive advantage, the variable weights were 0.754 (cost), 0.868 (quality), 0.753 (delivery), and 0.891 (flexibility).

Table 3 shows the correlation matrix of the CFA for the model and shows that the composite reliability (CR) values are significantly greater than 0.60 and were between 0.847–0.931. All AVE values were also significantly higher than the 0.50 cutoff and were between 0.784–0.860. And finally, all R^2 values were shown to be much higher than the cutoff of 0.20 and were from 0.758–0.795, indicting further proof of the reliability of the measurement.

It was also evident that data sets in the are higher than all of the corresponding values in the 'Cross Construct Correlation' in the same column, indicating discriminant validity of the measure in each construct, with AVE value greater than 0.50, as shown in Table 3.

As indicated from Table 3, results from the confirmatory factor analysis (CFA) suggest that Fig. 3 model was a good fit with the data. The χ^2 /degree of freedom were significant (1.347), and the CFI (0.995) and the GFI (0.968) indices suggested a good model fit. In addition, Fig. 3 shows that all of the items loaded significantly on their respective factors.

Table 2
Statistic values presenting convergent validity of reflective scales of latent variables.

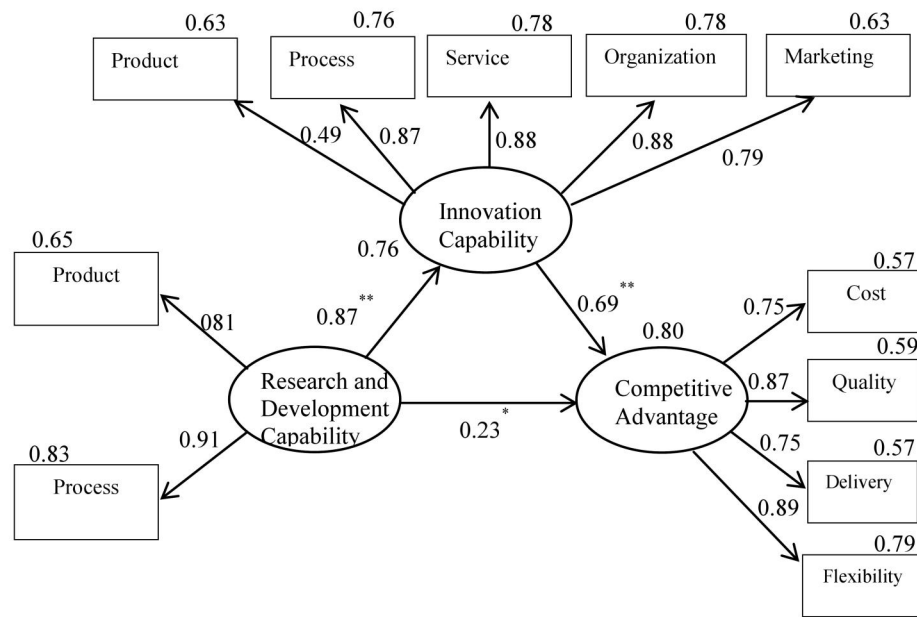
Construct	Element	Loading	t-stat
Research and development capability	Product	0.807	16.880
	Process	0.913	16.761
Innovation capability	Product	0.491	5.356
	Process	0.870	18.899
	Service	0.885	19.429
	Organization	0.883	20.115
	Marketing	0.793	16.314
Competitive advantage	Cost	0.754	12.595
	Quality	0.868	12.553
	Delivery	0.753	12.002
	Flexibility	0.891	14.306

Notes: all factor loadings are standardized, with significant level at 0.01.

Table 3
Correlation matrix.

Research construct	CR	AVE	R^2	Research and development capability	Innovation capability	Competitive advantage
Research and development capability	0.847	0.860		0.955		
Innovation capability	0.931	0.784	0.758	0.816	0.921	
Competitive advantage	0.880	0.817	0.795	0.678	0.714	0.705

Note: significant level is at $p < .001$, CR: Composite reliability, R^2 : Square of the correlation, AVE: Average variance extracted, Diagonal is the square root of the AVE.



Note. $\chi^2 = 45.792$, $df = 34$, $p = 0.085$, $CMIN/df (\chi^2/df) = 1.347$, $GFI = 0.968$, $NFI = 0.982$, $TLI = 0.992$, $CFI = 0.995$, and $RMSEA = 0.037$, $*p < .05$, $**p < .01$, $***p < .001$

Fig. 3. Final model.

Table 4
Hypothesis testing result of hypothetical research.

Hypotheses	Coefficient	t-test	TE	DE	IE	Results
H1: Research and development capability positively and directly affects innovation capability.	0.870**	13.266	0.870	0.870	—	confirmed
H2: Research and development capability positively and directly affects competitive advantage as well as positively affecting competitive advantage indirectly through innovation capability.	0.227*	2.208	0.826	0.227	0.599	confirmed
H3: Innovative capability significantly, directly and positively affects competitive advantage.	0.688**	6.399	0.688	0.688	—	confirmed

Note: $*p < .05$, $**p < .01$, $***p < .001$, T is total, D is Direct, I is Indirect, E is Effect.

Research and Development Capability was confirmed to positively and directly affect Innovation Capability as indicated from $\beta = 0.870$ and $p < .01$ while the variability of innovation ability could be explained by variables at percentage of 0.76 ($R^2 = 0.76$).

The model's test results give confirmation to the idea that R&D adoption by firms can increase Innovation Capability. This is confirmed with the positive and direct effects on Competitive Advantage ($\beta = 0.688$, $p < .001$), which supports the hypotheses H1 and H3.

Furthermore, R&D Capability also positively and directly affects Competitive Advantage ($\beta = 0.227$ and $p < .05$) with an indirect but positive affect

as well through Innovation Capability ($\beta = 0.599$, $p < .01$).

The total influence of Competitive Advantage ($\beta = 0.826$, $p < .01$) is confirmed in H2 with the variables explain the variability of advantage in the match percentage 0.80 ($R^2 = 0.80$). This confirms that the adoption of R&D Capability by organizations plays a significant role in increasing competitive advantage.

The manufacturing process and product development are also affected by Innovation Capability ($p < 0.01$) with managers input into the process having a significant impact into the creation and development of new products. The knock-on effect from this is the creation of new processes which makes

tasks easier and more efficient resulting in the development of innovative new services, which leads to better customer service and greater customer satisfaction.

Finally, there was determined to be a significant, direct and positive effect by R&D Capability on Competitive Advantage as well as an indirect influence through Innovation Capability in the race for innovation at statistically significant level ($p < 0.05$). This could explain the need to increase R&D Capability, whether in product design or manufacturing. Also, the use of automated systems and processes to monitor parts quality that meet international standards at a lower cost was also judged to be of great importance.

Discussion and implementation

Results from the research concerning Thailand's automotive industry competitive advantage are discussed as follows:

Due to the moderating effects of technological uncertainty, the positive effects of collaboration on competitive advantage in new car development have been lessened. This is consistent with research in Korea by Oh and Rhee [19-38] which discovered that suppliers' flexibility, engineering and modularization capabilities had a positive influence on collaboration in new car development which, in turn, positively affects competitive advantage of carmakers. This was consistent with research in Turkey by Ar [30] which indicated that green product innovation has both a significant and positive effect on firm performance and competitive capability.

Focus should therefore be given to product and service development which has the ability to use a firm's existing internal and external resources and which has the potential to make a profit [28]. Innovation and technology resources should therefore be utilized in development which has the potential to meet changing customer demands [43].

Mazzola et al. [41] explored linkages among open innovation practices and firm performance while Bicen et al. [67] investigated new product creativity (NPC) and how it might be influenced by culture, specifically the relationships between 'East (Malaysia) and West' and Malaysians had a different concept concerning NPC, which entailed a combination of new product (NP) novelty and NP meaningfulness.

The finding that company performance is positively influenced by technology, technical skills and the ability to research and develop new products is consistent with the study of Colombo and Rab-

biosi [61]. Additionally, Chumaidiyah [12] confirmed that companies must always attempt to improve their technological skills and capabilities in R&D in order to increase as enterprise's strength. Furthermore, highly successful companies have significant dependence technological resources, including technical skills and the ability to research and develop new products in order to maximize profits [61].

The impact and importance of R&D collaboration on process innovation determined by the study was also collaborated by research from Un and Kazuhiro [34] which determined that R&D capability and innovation capability had positive influences on competitive advantage. This is consistent with Wingwon [68] who after researching 596 Thai SMEs (small-medium enterprises), concluded that innovation was the greatest component to competitive advantage. Furthermore, research in Taiwan by Lee and Hsieh [51] felt that entrepreneurship played the key role in competitive advantage.

Boon-itt and Paul [31] also confirmed the importance of technological advantage over the competitors which can result in a competitive advantage in terms of product quality, lower production costs, faster delivery, flexibility and product innovation [21, 25, 26, 30].

Change comes fast and to create a sustainable competitive advantage, Thai automotive parts enterprises need to carry out both internal and external R&D while increasing their investments, which allows them to develop innovative and creative products, as well as new services and workplaces and laboratories.

Conclusion

Governmental organizations should place emphasis on balancing economic restructuring and sustainability and focus on restructuring production, as well as coordinate linkages in a multinational, innovation capability. In addition, they need to focus on research and innovation development in Thailand, together with the development of skilled human resources who are capable of critical thinking and problem solving. These factors are all contribute to modernization and development that enable enterprises to adapt to future competition. Focus also needs to be given to cost, quality and on-time delivery.

Research concluded that R&D ability is critical for the innovation process, with product and service innovation playing key roles in maintaining a sustainable, international competitive advantage.

Domestic policies should be focused on a 'lifting capacity' to support industries which produce high

quality parts at a lower cost with on-time delivery. Government agencies need to balance economic restructuring and sustainability, including assisting enterprises' development in adapting to present and future competition. There must also be commitment to strategic vision, mission, policies and strategies within the Thai automotive parts industry, and not rest on the laurels of its past successes.

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