INDUSTRY 4.0 READINESS IN THE THAI AUTOMOTIVE INDUSTRY

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ABSTRACT

The Industry 4.0 concept has been boon developed in the auto industry and taken on worldwide. This research aims to examined Thai automotive industry's readiness for Industry 4.0. This is a quantitative research. The researcher used survey as a research tool and descriptive statistics to analyze the data. The sample was employees who work in automotive industry. The results showed that Thai automotive industry is comparatively prepared for implementing Industry 4.0 therefore it is undertaking horizontal and vertical system, workflow, process and operations integration.

Keword: industry 4.0.

INTRODUCTION

The concept of Industry 4.0 was developed in German manufacturing, through government development of advanced automation and integration (Kagermann, Lukas & Wahlster, Online, 2011). Industry 4.0 addresses incorporates social, technological and industrial change stemming from rapid advancement of ubiquitous computing technology, increasingly cheap and ubiquitous online communication, and growing social demand for high-quality products that can be integrated into consumer's personal and digital lives (Schwab, 2016). Technical implementation, leveraging Internet of Things (IoT) and big data technologies (Kagermann, Lukas & Wahlster, Online, 2011), has been limited mostly to German firms.

This objective of this research is to measure Industry 4.0 readiness in the Thai automotive industry. Thailand is Southeast Asia's leading automotive

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manufacturer, with more than 2,400 firms and 500,000 skilled employees (International Trade Association, Online, 2016; Thailand Automotive Institute, Online, 2012). Thailand's automotive industry produced 1,920,000 vehicles in 2014, and will manufacture 3,000,000 in 2017, mostly for export by global manufacturers and local Tier 2 and Tier 3 suppliers (Chu & Chaichalearmmongkol, Online, 2015). Industry challenges include high SME participation, limiting resource and skills availability (Charoenrat & Harvie, 2013; Ghazal et al., Online, 2011). Thus, the Thai automotive industry represents national automotive industries in developing countries, rather than the highly developed German industry.

LITERATURE REVIEW

The concept of Industry 4.0

Industry 4.0, or the fourth industrial revolution, is a revolution of standard manufacturing practices, integrating global networks for warehousing, production, logistics, and information exchange controlled by cyberphysical systems (CPS) (Hermann, Pentek & Otto, 2016). In Industry 4.0, products can tell virtual systems what they require to reach their desired end states, providing details about the production steps, and monitor processes and alert the CPS to problems (Kagermann, Lukas & Wahlster, Online, 2011). Industry 4.0 can solve technical problems and improve manufacturing efficiency, safety and quality (Schwab, 2016). It could also address global problems by reducing energy requirements and waste and increasing automation (Wang et al., 2016).

Components and Characteristics of Industry 4.0

CPS are integrated computational and physical systems with multiple modes of human-machine interaction (Baheti & Gill, 2011). CPS interact with other systems and use machine learning to improve performance and self-maintain (Lee, Bagheri & Kao, 2015). IoT incorporates physical objects with embedded communication technologies like RFID, enabling decentralized communication and coordination between manufacturing systems, materials and products (Xia et al., 2012). Real-time collection, computation, comparison, and analysis of big data is also incorporated (Lee, Kao & Yang, 2014). These technologies are combined into smart factories that combine physical resources, industrial network, cloud, and supervision and control (Marr, Online, 2016; Wang et al., 2016).

Key principles of Industry 4.0 are interoperability and integration. In smart factories, engineering, manufacturing, materials, and logistics are under the integrated control of CPS. Horizontal integration between partner companies supports flows of materials, information and money, while vertical integration of factory systems allow for increasing operations efficiency. Eventually, vertical systems could be self-organizing, incorporating factory floor sensor systems and manufacturing, production management, and strategic planning systems (Hermann, Pentek & Otto, 2016). The automotive industry's level of integration is high due to the global industry and supply chain integration (Sturgeon, Van Biesebroeck & Gereffi, 2008). Horizontal integration of partner firms and in-factory vertical integration are the next developments (Baheti & Gill, 2011).

Another key principle is virtualization. Sensors and simulation create a virtual copy of the physical world (Hermann, Pentek & Otto, 2016). Cloud computing and networks of smart objects increases resource deployment for process and workflow automation (Brettel et al., 2014; Wang et al., 2016). Information transparency, or real-time examination and analysis of plant data, improves manufacturing decision-making (Hodge, Online, 2011). As Industry 4.0 develops, real-time observation and analysis capabilities of all sorts will become feasible, as increasing amounts of information are available from the manufacturing floor and from associated systems at suppliers, buyers and other partners (Hermann, Pentek & Otto, 2016; Tubbs, Online, 2015). Modular adaptive systems, or systems and sub-systems assembled from components will enable flexible production and rapid response (Vogel-Heuser et al., 2016).

Benefits of Industry 4.0

The smart factory offers flexibility and rapid response to changes in market demand, minimization of setup time enabling smaller batch and customized production, real-time feedback, and increased production efficiency and energy efficiency (Wang et al., 2016). CPS could enable communication between people and machines within large networks, enabling integration, virtualization, and self-optimization (Brettel et al., 2014). Horizontal systems integration offers possible cost efficiencies by consolidating fragmented IT systems (Baheti & Gill, 2011). Flexible modular systems allow the manufacturer to respond rapidly to changing demand (Vogel-Heuser et al., 2016). System decentralization means that systems become self-organizing, less vulnerable to failure, and more capable of self-diagnosis and self-repair (Marr, Online, 2016; Saldivar et al., Online, 2015; Vogel-Heuser et al., 2016).

Research Gap

There has been little study of Industry 4.0 readiness in developing industries. Most studies have taken place either in German firms or Chinese supply chain partners (Dai et al., 2012; Schmidt, Online, 2015; Tubbs, Online, 2015). This research examines Industry 4.0 readiness in the Thai automotive industry.

METHODOLOGY

A quantitative questionnaire based on PWC's (Online, 2016) readiness self-assessment was distributed to the firm sample (n = 332). The sample size was calculated using the total number of automotive firms in Thailand, which the Board of Investment [BOI] (2015) estimates at 2,427 (including 18 assemblers/car makers; 709 Tier 1 suppliers, and about 1,700 Tier 2 and 3 suppliers). Because the population size was known, the sample size was calculated using the equation: $n = \frac{N}{1 + N^{*}(e)^{2}}$, which assumes a 95% confidence level and +/-5% confidence interval to determine the sample size based on a proportion of the total population (Yamane, 1967). This instrument assesses four dimensions of Industry 4.0 readiness using five to 6 five-point Likert items. Current and Target measures were assessed, with levels based on means (Table 1). Analysis was conducted with descriptive statistics.

Table 1. Summary of interpretations of means

Mean Score	Industry 4.0 Readiness Level	Interpretation
1.00 to 2.00	Digital Novice	The firm has a separate online and offline presence, product focus, and fragmented IT infrastructure and processes.
2.01 to 3.00	Vertical Integrator	The firm is developing a digital product and service portfolio, multichannel communication and distribution, data and process integration, and homogenous IT systems.
3.01 to 4.00	Horizontal Collaborator	The firm uses integrated customer solutions, individual customer processes, and integrates IT architecture, data flows and processes with external partners and customers.
4.01 to 5.00	Digital Champion	The firm has an integrated customer journey and fully integrated partner system and can develop disruptive business models.

RESULTS

Company Information

Most firms were large firms (>200 employees) (209 firms, 63%) or medium firms (51-200 employees) (102 firms, 30.7%). Only 21 firms (6.3%) were small firms (≤50 employees). Most firms had annual income of BHT5 million or more (204 firms, 61.4%) or BHT500,000 to BHT5 million (27.7%). Only 36 firms (10.8%) had income of less than BHT500,000.

Business Models, Products and Services

Firms were asked five questions about their business models, products and services (Table 2). These items were ranked as either vertical integrator or horizontal collaborator. This indicates that while firms have not on average implemented Industry 4.0 principles in the business models, products and services focus, they are in the process of this implementation, though digitization is less advanced than developing customer focus and collaboration. Firms are targeting digital champion for all items.

Table 2. Descriptive statistics: Business models, products and services

Statement	Actual			Target		
	Mean	*SD*	Level	Mean	*SD*	Level
How would you rate the contribution of digital features, products and services to the overall value of your portfolio?	2.86	.98990	vertical integrator	4.01	.94721	digital champion
To which degree is the average product in your portfolio digitized? (e.g. RFID, sensors, IoT connection, smart products)	2.94	.99496	vertical integrator	4.04	.98234	digital champion
To which degree can your customers individualize their products?	3.32	.98096	horizontal collaborator	4.30	.79629	digital champion
To which degree are the life cycle phases of your products digitized? (digitization and integration of planning, engineering, production, services and recycling?)	2.85	.99814	vertical integrator	4.03	.93876	digital champion
How important is the usage and analysis of data for your business model?	3.40	.98863	horizontal collaborator	4.27	.80995	digital champion
How intense is your collaboration with partners, suppliers and clients for development of products and services?	3.55	1.05731	horizontal collaborator	4.43	.77643	digital champion

Market and Customer Access

There were six questions about market and customer access (Table 3). Once again, the firm's current performance falls into the vertical integrator and horizontal collaborator categories. In terms of future performance, firms aim to be at the digital champion level for all market and customer access aspects in five years. Overall, these results indicate that firms are developing their channel integration, digital enablement of sales, and customer focus, and have strong goals for improvement.

Table 3. Descriptive statistics: Market and customer access

Statement	Actual			Target		
	Mean	*SD*	Level	Mean	*SD*	Level
To which extent do you use multiple integrated sales channels to sell your products?	3.10	.99077	horizontal collaborator	4.16	.83694	digital champion
How far do you integrate multiple channels into your customer interactions for communicating news, receiving feedback, etc?	2.99	1.06295	vertical integrator	4.11	.95850	digital champion
How advanced is the digital enablement of your sales force?	2.99	1.03701	vertical integrator	4.01	.99085	digital champion
How dynamic and customer-tailored is your pricing system?	3.24	.91017	horizontal collaborator	4.20	.78405	digital champion
To which extent do you analyze customer data to increase customer insight?	3.24	.94681	horizontal collaborator	4.26	.82580	digital champion
How far do you collaborate with partners regarding your approach of accessing customers?	3.29	.96813	horizontal collaborator	4.22	.80854	digital champion

Value Chains and Processes

Five items addressed value chains and processes (Table 4). This area showed the strongest development, with all items in the horizontal collaborator category. Unsurprisingly, the mean target goal within five years for these items was the digital champion level. The value chains and processes focus is the area that may have received the most attention during preparation for Industry 4.0, as it is the strongest preparation area.

Table 4. Descriptive statistics: Value chains and processes

Statement	Actual			Target		
	Mean	*SD*	Level	Mean	*SD*	Level
How would you rate the degree of digitization of your vertical value chain from product development to production?	3.12	.98315	horizontal collaborator	4.17	.85250	digital champion
To what extent do you have a real-time view on your production and ability to dynamically react to changes in demand?	3.12	.86548	horizontal collaborator	4.14	.80230	digital champion
To which degree do you have an end-to-end IT enabled planning and steering process from sales forecasting over production to warehouse planning and logistics?	3.20	1.00974	horizontal collaborator	4.23	.89317	digital champion
How advanced is the digitization of your production equipment?	3.07	1.03621	horizontal collaborator	4.22	.82173	digital champion
How would you rate the degree of digitization of your horizontal value chain from customer order over supplier, production and logistics to service?	3.13	.99155	horizontal collaborator	4.17	.86071	digital champion

IT Architecture

Six items addressed IT architecture (Table 5). The firms' mean actual performance falls between vertical integrator and horizontal collaborator performance levels in this area. Unsurprisingly given the firm's performance goals for other Industry 4.0 focuses, the firms' mean target goal for five years fall entirely into the digital champion performance level.

Table 5. Descriptive statistics: IT architecture

Statement	Actual			Target		
	Mean	*SD*	Level	Mean	*SD*	Level
To what extent does your IT architecture address the overall requirements from digitization and Industry 4.0?	3.00	.97708	vertical integrator	4.17	.79627	digital champion
To what extent do you use a manufacturing execution system or similar to control your manufacturing process?	3.00	1.03708	vertical integrator	4.15	.90612	digital champion
How mature is your IT and data architecture to gather, aggregate and interpret real-time manufacturing, product and client data?	3.02	1.00880	horizontal collaborator	4.14	.87535	digital champion
How important are new technologies like social media, mobility, analytics and cloud computing for enabling business operations?	3.2139	1.08243	horizontal collaborator	4.20	.87956	digital champion
To what extent is your IT organization able to fulfill business requirements in the requested time, quality and cost?	3.0994	1.02789	horizontal collaborator	4.18	.85834	digital champion
How advanced is your IT integration with customers, suppliers and fulfillment partners?	3.0994	.95158	horizontal collaborator	4.23	.79005	digital champion

DISCUSSION

The industry is clearly moving forward in developing maturity and readiness of the capabilities required for Industry 4.0 implementation. The four areas of concern in the PWC (Online, 2016) instrument are consistent with the Industry 4.0 literature, although the literature focuses on manufacturing context rather than on external development. This is an interesting gap between Industry 4.0 theory and one of the few assessment instruments available, suggesting that the concept of Industry 4.0 requires a more rigorous definition and operationalization before it can be used as a measure of firm competencies or resources.

The high maturity of value chains and processes suggests that firms focus on integrating in-factory processes and workflows and developing horizontal and vertical connections with other firms in their value chains. This area offers the highest value for immediate implementation, compared to long-term development objectives (Schwab, 2016). For example, process integration and automation provides production efficiency and cost savings (Hermann, Pentek & Otto, 2016; Schwab, 2016). Firms that have integrated their production processes and systems can expect to produce more efficiently and with higher quality (Schwab, 2016). Reducing waste, waiting time and manpower is also possible. The integration of IoT and big data, for example through RFID sensor tagging and tracking, can improve decision-making and strategy development (Kagermann, Lukas & Wahlster, Online, 2011). Because most firms in the Thai automotive industry are small firms with limited resources (Charoenrat & Harvie, 2013), these firms need to maximize their returns. Thus, focusing on developing the value chain and process perspective first makes sense. However, this does not mean that the other perspectives should be ignored, since they offer broader benefits for the firm and the industry in the long term. For example, developing digitized products and services and incorporating IoT and big data into the firm's business processes could result in better strategy choices and refinement of the business model to meet customer needs (Marr, Online, 2016).

Perhaps the most alarming gap is that firms have not focused on the development and integration of IT architecture. The integration and coordination of IT systems within the firm's own manufacturing and supporting business processes and with the systems of horizontal and vertical business partners is critical for maximizing the effectiveness of the smart factory. Without the firm's development of integrated IT systems, it cannot fully optimize the production process and systems or automate decision-making, diagnosis and repair systems (Wang et al., 2016). Thus, firms need to focus on this perspective urgently.

CONCLUSION

In conclusion, while the Thai automotive industry is not yet prepared for Industry 4.0 implementation, the industry is moving toward the horizontal and vertical integration of systems, workflows, processes and operations it will require for a full Industry 4.0 implementation. Right now, firms are mainly occupied with vertical and horizontal integration of systems and processes, including IT systems, customer and market access, and business processes and workflows. While some firms may have advanced systems, others will only be beginning to implement these processes. There are some possible barriers that could prevent full implementation of Industry 4.0, for example a lack of skilled human resources and the reliance on SMEs with limited financial resources for investment in new systems. However, it should not be overlooked that the history of industry 4.0 as an integrated manufacturing strategy or paradigm is very short, with the model emerging only within the past several years. Thus, even though the first work on Industry 4.0 was conducted in the German automotive manufacturing industry, this research shows that other national industries are also moving toward readiness for implementation. However, the Thai automotive industry is not ready for Industry 4.0 implementation yet. Furthermore, the industry may have difficulty in implementation unless the firms develop horizontal and vertical links into industry partner firms and within the factory.

There are some limitations to this study that provide opportunities for further research. This study only assessed readiness for Industry 4.0 implementation at a relatively early stage of implementation. This means that as the Industry 4.0 concept matures and is applied and examined in different industries and countries, there will be more opportunity to develop an empirical maturity model. This research also did not explore factors that led to Industry 4.0 readiness, which is a further opportunity for new research.

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