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MOVING THAILAND'S AGRICULTURE INDUSTRY TO THE NEXT COMPETITIVE LEVEL THROUGH INTERNET OF THINGS (IOTS)

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Abstract

The Internet-of-things (IoT), or alternatively known as the Internet of Everything (IoE), or the Industrial Internet, is a new technology paradigm envisioned as another wave of enabling technologies and business approaches that would revolutionize the world businesses, productions and services. At this juncture, the body of literature still lacks of a framework that can provide guidance to the policymakers and the investors, at both national, and company-levels, for generating competitive advantages. Thailand and its agricultural industry are the focus of this research. To fill the gaps, three research objectives are raised, (1) to suggest a systems framework capable to illuminate how IoT investments in the agricultural industry can lead to competitive advantage at national level, (2) to develop a generic business model configuration that can provide an explicitly understandable base for the investors and owners to comprehend and form the logics of how to actually benefit from the IoT investment, and (3) to draw some implications and suggest significant propositions to illuminate some important hindering and enabling factors that influence the investments of IoTs in agricultural industry. Case study approach and purposively sampling are used for the data collection, which targeted the Thailand IoT Association and a smart hydroponic farm located in Chiang Rai. The research results also in a generic business model canvas (BMC) that could provide to the agricultural industry an intellectual base for IoT investments.

Keywords: Internet of Things, Thailand, Agriculture, Business Model, Porter Diamond, Theory of Planned Behavior.

Introduction

The Agriculture sector has a pivotal role in Thai economy, which is generally recognized in the Public as a key source of export-earning and rural income in Thailand (Suphannachart and Warr, 2010), contributing to an approximate GPD of 9%. Nevertheless, the fast disappearance of land surplus for agriculture development (Siamwalla, 1996) and the problem of cost-price squeeze in the 1980s-1990s, with a declining agricultural workforce and increasing water scarcity, continued to push the % GDP contribution to Thai economies on downward trend, as shown in Figure 1. As such, it motivated the Thai industry and government, in the early 2000s, to make some structural adjustments, in the hope to improve the competitive advantages of the industry, which included facilitating farmers to exploit the more liberal trading environment, supporting commercial farmers, investing on genetic improvement and postharvest technology, mechanization and resource management, incentivizing contract farming companies, agribusiness firms and exporters who were willing to take risks and to readily respond to price signals (Poapongsakorn and Anuchitworawong, 2019). Government assisted through policy supports, such as by means of public research in the areas of genetic improvement and postharvest technology, and biotechnology, and improvement of production means to stimulate the production of safe and high-value food, and towards land-intensive but less water-intensive cropping patterns, promoting professionalism in farming, and with social supports.

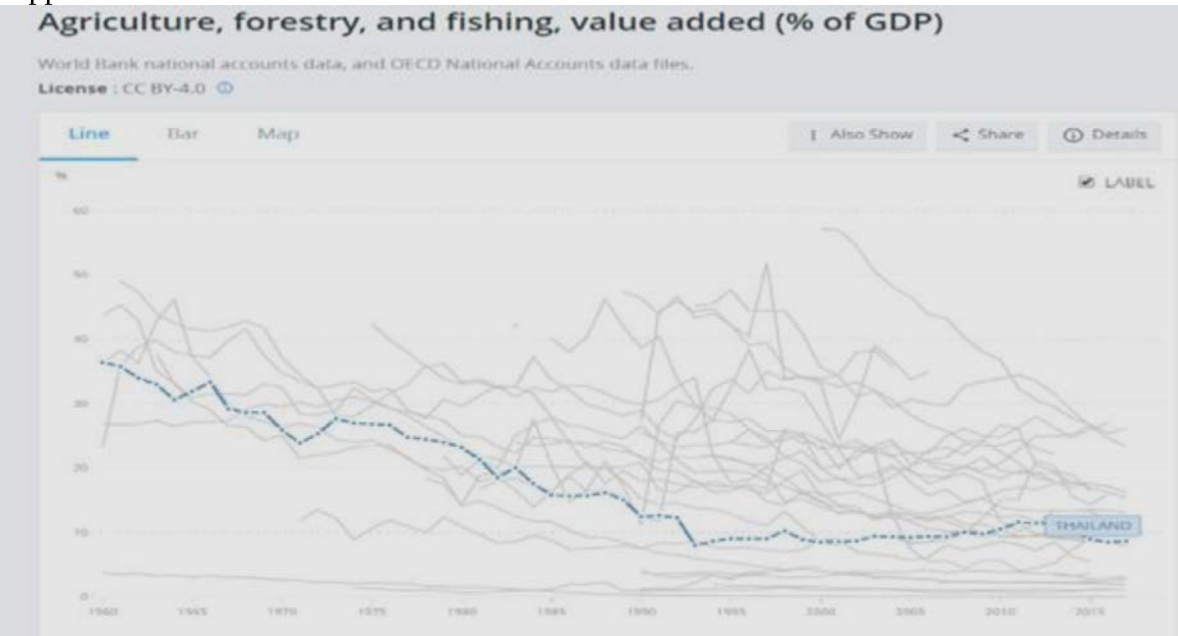

Figure 1 Continuing Downward Trend of GDP Contribution from Agriculture Industry in Thailand

With the flattening growth rate of the Thai population, as shown in Figure 2, it is strategically necessary to put forward an agricultural revolution to move towards a sustainable development avenue for smart agriculture. As Kumar and Sharma (2018) presented, the advent of intelligent techniques has changed the landscape of conventional agriculture tactics, which demands policy evaluation of various relevant schemes offered by the government.

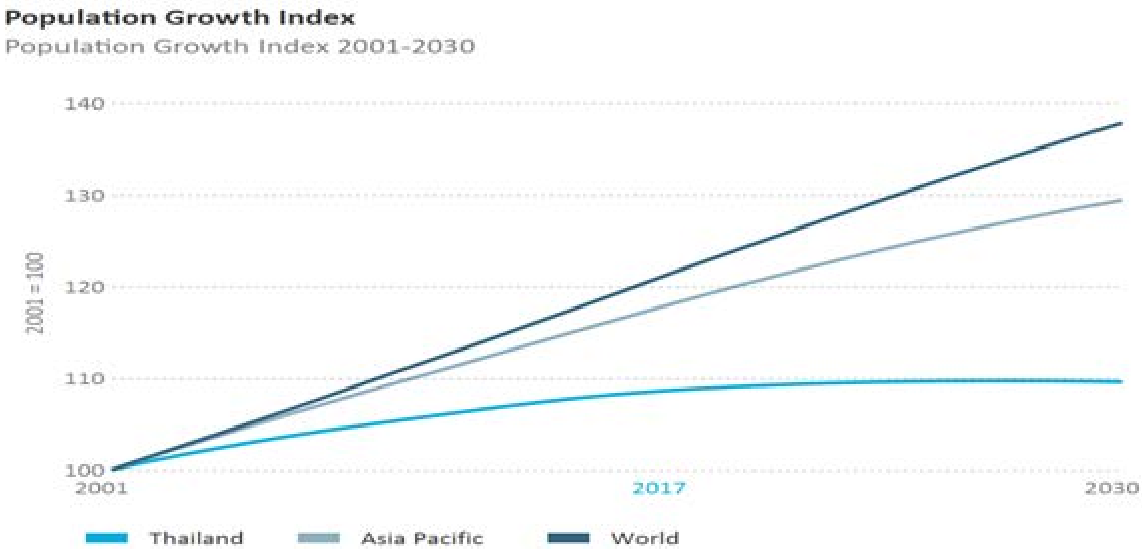

Figure 2 The Flattening Rate of Population Trend in Thailand

A recent trend towards accomplishing a sustainable agricultural industry development is by use of the Internet of Things (IoTs), partly propelled by the accelerated reliance on social media, Internet, and the obvious trend towards the roles played by big data and intensive use of analytics (Pham and Stack, 2017), and many countries have already started to address them as national policy. Nevertheless, the policy structure and the pattern of the emphasis in the policy towards IoT is unclear, which prompts for the first research objective, to be discussed in the sequel.

Figure 3 IoT Policy Launch Timeline of Some ASEAN Countries Compared to Other Developed Countries

Internet of Things (IoT) is a recent technology, which refers to the stringent connectedness between digital and physical world, known to capture numerous distinctive characteristics and advantages, such as the 3A concept (anytime, anywhere, and any media), and things having identities and virtual personalities operating in smart spaces (implying uniquely addressable) (Ray, 2016). Figure 4 is a typical layer configuration of IoT, which shows the value-adding functions that interconnect and integrate the physical layers, through the communication, service, and application layers. For instance, through cropping system modeling, made possible by intelligent software programming, a diversity of smart-data based applications can be made possible, such as on weather (environmental modification), management (i.e. planting, harvesting, irrigation, fertilizer application, residue placement, tillage), soil plant-atmosphere (soil temperature, evapotranspiration), soil (soil dynamics, soil water, soil N, soil P, etc.), and plant modules (Jones et al. 2017).

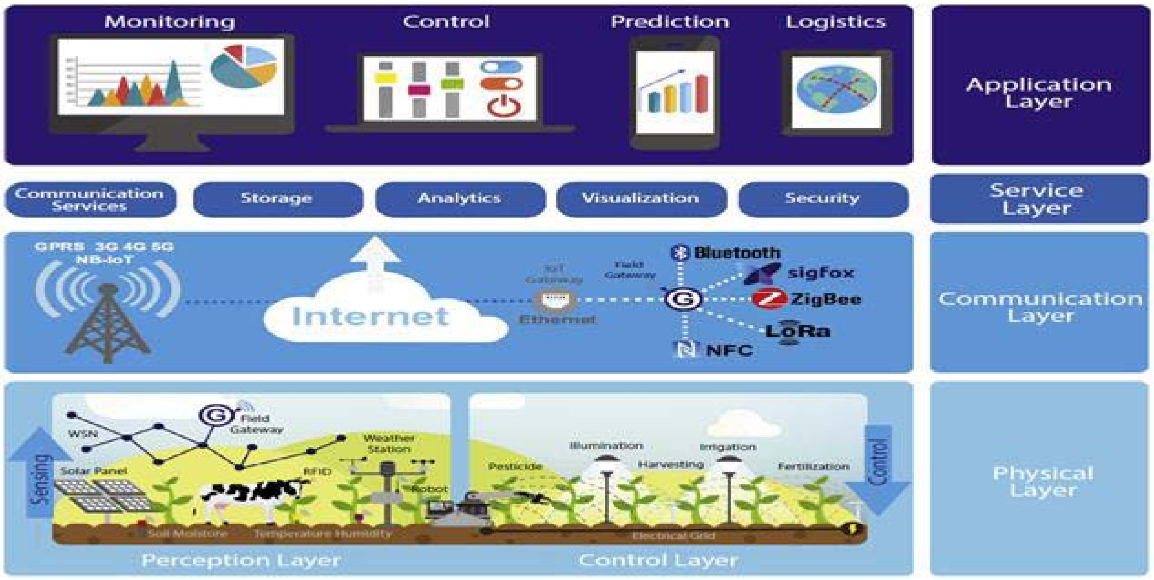

Figure 4 IoT Architecture Configuration

The fast-trending of the incorporation of IoTs, big data, AI (Artificial Intelligence), and intelligent data analytics, will, according to Porter and Heppelmann (2014, p. 66), eventually, force firms to reevaluate their business assumptions: “Smart, connected products raise a new set of strategic choices related to how value is created and captured, how the prodigious amount of new (and sensitive) data they generate is utilized and managed, how relationships with traditional business partners such as channels are redefined, and what role companies should play as industry boundaries are expanded.” (Also referred to Pham and Stack, 2017, p. 131).

Scholars have highlighted that to enhance the competitiveness of a nation’s industry and performance, an industry must be situated within a conducive environment that is supportive of the business (cf. Porter, 1980). Although IoT (Internet of Things) is a relatively new emergent technology, to make IoT popularly used in the industry, and nationwide, it can be inferred that an industry’s environment that captures the characteristics of competitive advantages at national level should be actively promoted, made possible and be supported by the government. IoTs are important technological inventions and components in realizing Industry 4.0, which are used to meet the demands for horizontal, vertical and end-to-end digital integration (Telukdarie, Buhulaiga, Bag, Gupta, and Luo, 2018). In particular, IoTs are capable to update the production and operations services in the context of Industry 4.0 to an intelligent level, by taking advantages of advanced information and manufacturing technologies to achieve flexible, smart, and reconfigurable manufacturing processes in order to address a dynamic and global market” (Zhong, Xu, Klotz, and Newman, 2017, p. 616). To be specific, based on the inter-networking world which offers advanced networked connectivity of physical objects, systems, and services (p. 619), and data that carry rich information and knowledge (p. 626), the typical production resources can be converted into smart manufacturing objects (SMOs) that are able to sense, interconnect, and interact with each other to automatically and adaptively carry out manufacturing logics (p. 618).

Due to the recent accelerated development of Internet-enabled technologies and systems of businesses exploiting Internet platform, it has resulted in a growing attention of researchers focusing on IoTs. To facilitate the decision-making of owners and investors in IoTs and their enabled business model design and implementation, it requires them to reasonably understand the logics and utilities behind the investment, and form a level of confidence.

Research of Objective

The three research objectives provide an intellectual structure to guide organizations invest and deploy IoT policies and identify clear organizational goals. The three research objectives are given below:

1. Suggest a systems framework capable to illuminate how IoT investments in the agricultural industry can lead to competitive advantage at national level, and thus, as an implication, the systems characteristics and strengths can lead to a favorable industry-level and market-level environment conducive for IoT investment.

2. Develop a generic business model configuration, which provides an explicitly understandable base for the investors and owners to comprehend and form the logics of how to actually benefit from IoT investments. In other words, the business model configuration should provide an insight into the integrative functions of IoTs and thus to draw the attention on key activities for success.

3. Draw some implications and suggest significant propositions to illuminate some important hindering and enabling factors that influence the investments of IoTs in agricultural industry, which structures the derivations based on the business model framework and the competitiveness systems.

The linkage between objective 1 and objective 2 can be rationalized in numerous ways. Objective 1 can serve as an opportunistic environment, of reduced or controllable risk, which provides an atmosphere of stimulation and confidence for the businesses. The second objective, which serves to facilitate the perceived usefulness of IoTs or technologies, can provide a structural guideline to help the businesses evaluate the fit between opportunities and business models up-front in a systematic way since “business model innovation is too important to be left to random chance and guesswork” (Christensen, Bartman, and Van Bever, 20160. The third objective can serve numerous functions, such as pointing out the areas of strategic potentials (Pricop, 2012), and as a preliminary examination of the stress factors affecting BM components, which Haaker et al. (2017) suggest using a concept of “Heat Map” of the following color coding:

-Red – The outcome on the stress factor, which makes a BM component no longer feasible.

-Orange – The outcome on the stress facto, which makes a BM component no longer viable.

-Green – The outcome on the stress factor, which affects the feasibility or viability of the BM component, but not in a negative way (p. 18).

Literature Review

A number of theories in the field and discipline of strategic management (SM) can be exploited to assist research scholars and practitioners derive understanding and conceptualize implementation design of IoTs, for instance, in the agricultural industry.

Based on IoTs’ capability on networked and seamless inter-connectivity and smart communication, its use can help leverage the stakeholder theory to a new level. That is, when rooted in solid knowledge, the IoT investment can help the firms provide a cybernetic platform to develop mutually trusting relationships with their stakeholders that will have a competitive advantage over firms that do not (Kull, Mena, and Korschun, 2016). To be exact, the stakeholders are both internal and external in the business ecosystems, including the fact that the business model components, i.e., the tangible and intangible resources (Pera, Occhiocupo, and Clarke, 2016), should also be treated as the stakeholders. The similar premise is found in the actor-network theory, which Laasch (2018) explains that in actor-network theory, “the list of who or what can be an actor is open ended, including human beings, machines, animals, nature, ideas, and organizations," (p. 4), which "an actor can literally be anything provided it is granted to be the source of action" (Latour, 1996, p. 373). In addition, by treating IoT resources as networked assets and capabilities, it can help the firm to flexibly and intelligently control and use their resources, that transcends given weather and operating environment – that is, IoTs enable a seamless conversation being established among the devices, systems of activities, and the environment, to make intelligent decision-making.

Being flexible and intelligent in the embedded IoTs, the technologies can pull stakeholders together to co-create values, and thus, another relevant theory is owed to the service-dominant (SD) logic of value creation (Meynhard, Chandler, and Strathoff, 2016). As advocated in Vargo and Lusch (2008), the activities and processes enabled by IoTs should be catalyzed by a service concept that emphasizes on offering a solution to a problem, and an application of competences for the benefits of others. To be specific, the SD logic of value creation should maximize the knowledge, skills, and competences of each of the stakeholders and their resources (Vargo and Lusch, 2016), for the benefits of the collective systems of businesses, and the industry. Another important theory is owed to Michael Porter, who is widely recognized in the academic circles as one of the most influential academicians that shaped the thinking of a generation of academics and managers (Dobbs, 2014). In particular, a theory that studies how companies position within the structure of the industry is highlighted, known as the industry-based view (Garrido, Gomez, Maicas, and Orcos, 2014). The industry-based view underlies on a logic that an industry's structure can be known by studying the five forces, which are considered as the threats posed by competitive rivalry, powerful buyers, powerful suppliers, potential new entrants and substitutes, and the collective strength of these forces, ultimately, determine the ultimate profit potential of the industry (Porter, 1980). On a creative front, Kim and Mauborgne (2005) advocate a strategic move by exploiting simultaneous value creation and cost strategies in making a major market-creating business offering.

In evolution, the practices of the Industry 4.0 would be widely recognized as the rules of the game in the industry (Williamson, 1998). The institution-based view of strategy advocates on these industrial rules and practices as the key factors that condition strategic choices (Garrido et al. 2014).

Business Model: Although the literature involving the studies of business model (BM) are still heterogeneous and fragmented (Biloslavo, Bagnoli, and Edgar, 2018), Osterwalder's (2004) business model canvas (BMC) is popularly cited in the extant literature. The business model canvas presents a structure of variables that integrates and explains the logics of competition, which serves to help the managers, the investors and owners make sense of doing business (Blank, 2013). Through an explicit configuration, BMC allows management to visualize, test, and fine-tune strategic decisions, and guide the implementation process (Biloslavo, Bagnoli and Edgar, 2018).

Whether explicitly recognized or not, Teece (2010) states that every company working in a competitive market has a business model (BM) that describes how the business creates, delivers and distributes, and captures values, for its stakeholders (Haaker, Bouman, Jansen, and de Reuver, 2017). Most publications on BM involve the domains of innovation and technology management (Chesbrough, 2007), and not specifically towards IoTs. For the papers with IoT focus, they tend to focus on treating IoTs with emerging outlook and a particular attention on the value creation and value capture aspects of the resources, such as values as newness, performance, customization, "getting the job done," cost reduction, accessibility, convenience and usability, possibility for updates, design, risk reduction, comfort and brand/status, and price (Metallo, Agrifoglio, Schiavone, and Mueller, 2018). Nevertheless, BM conception for IoTs lack of the support of empirical data and some very fundamental knowledge of cybernetic physical systems (CPS).

Research Methodology

The agricultural industry is targeted, as it makes an important contribution to the economies and competitiveness of Thailand as a nation. Case study method is used, which serves as particularly effective in research issue that is contemporary in nature, and could involve drilling into why, what and how types of questions (Tan, 2019). To enhance validity, the case method is supported by triangulated sources of evidences, i.e. systematic interviewing, focus-group observations, and public and private archival document reviews.

The sampling technique is purposive. The data collection took place in 2018 and focused on seeking the views and experiences of the President of Thailand IoT Association and owner of a smart-hydroponic farm towards their experiences in the use and promotion of IoTs in agricultural productions and businesses. While the former shares the experiences to benefit the industries at national level, the latter illustrates a single-case experience that sheds light on the utilities and benefits at a company level, and illuminates a partial picture of the proposed generic business model.

While interviewing the IoT Association President, a smart mushroom farm designed and implemented by the IoT Association President was introduced to the researcher, as shown in Figure 5.

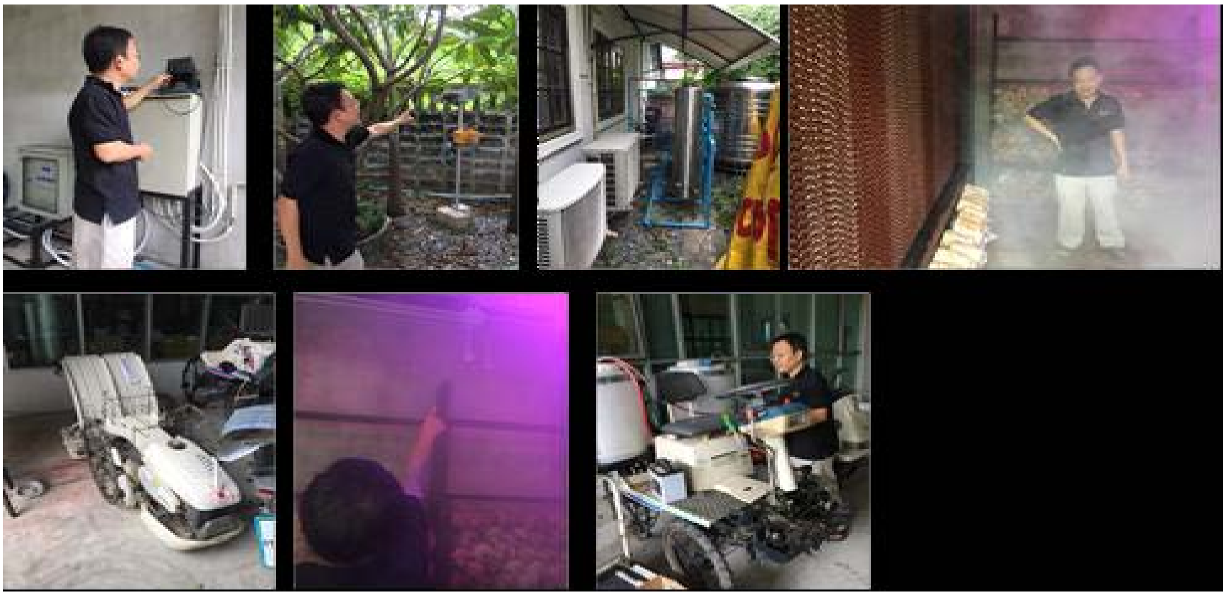

Figure 5 A Smart Mushroom Farm in Bangkok

A humidity-control aspect of the mushroom control system is illustrated schematically in Figure 6, which reiterates the role of “sound engineering knowledge” in the IoT smart farming investments, as also repeatedly reinforced in the second case with a smart agriculture farm in Chiang Rai, as shown in Figure 7.

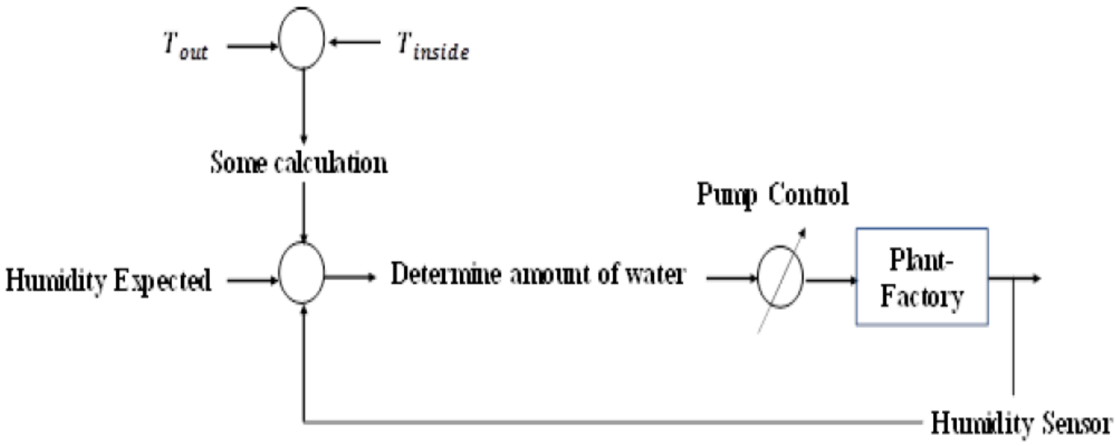

Figure 6 A Close-loop Control Logics of the Smart Mushroom Farm

Figure 7 Smart-Farm in Chiang Rai

To help the Thai government and the industries push forward the national IoT agenda, The IoT Association has established five strategic pillars of working groups, namely (1) technology development working group, i.e. the agricultural technology working group, as shown in Figure 8, (2) advanced business model promotion working group, (3) IoT security working group, (4) data flow working group, and (5) international cooperation working group.

Figure 8 Agri-Tech Working Group in Session

The working group pillars of the IoT Association share the integrative Framework structure of Porter's Diamond that the ultimate purpose is to cultivate and nurture the strengths of national industry and the market activeness in order to acquire a national competitive advantage position, as shown in Figure 9.

Figure 9 Pillar of the Thai IoT Association's Working Groups.

In particular, the "advanced business model promotion" working group exploits a guiding principle that aims to build the confidence level of the investors, business owners and managers, which in a way shares the theoretical logics of the Theory of Planned Behaviors (Ajzen, 1991), by making use, also, of the theory of technology diffusion that maximizes the integrative functions of observability, trialability, compatibility, simplicity and relative advantage elements as advocated in Rogers (1995), and market externality effect, as shown in Figure 10.

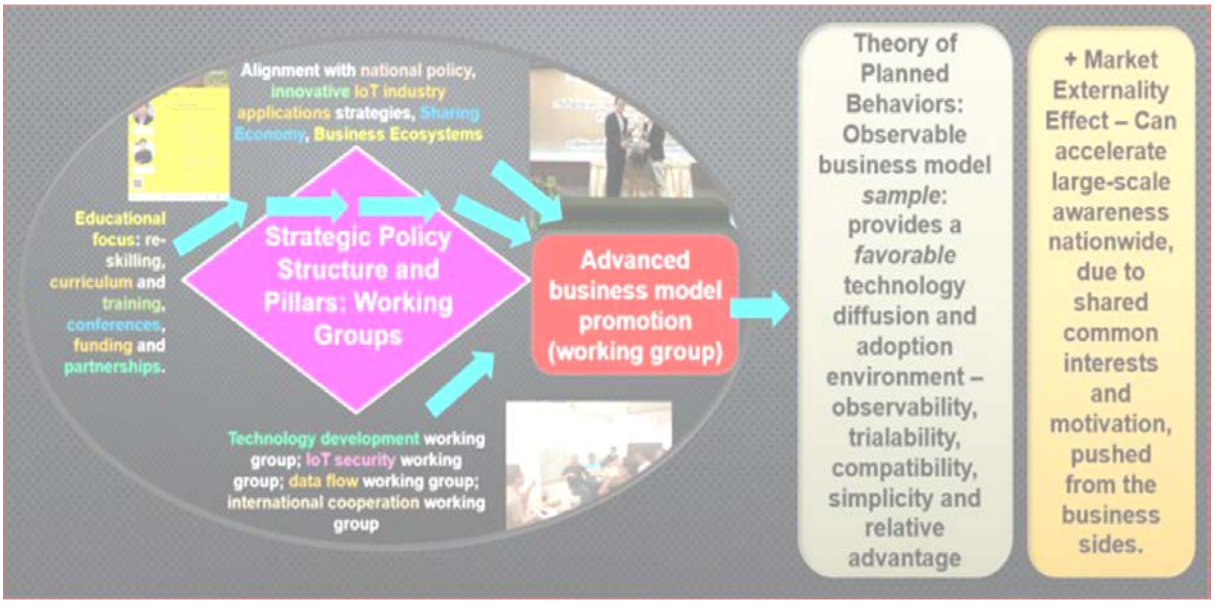

Figure 10 Pillars Guided by Theory of Planned Behaviors, Theory of Technology Diffusion, and Market Externality Goal

Research Results

The findings are presented in addressing each of the research objective raised in the Introduction section.

Objective 1: Suggest a systems framework capable to illuminate how IoT investments in the agricultural industry can lead to competitive advantage at national level, and thus, as an implication, the systems characteristics and strengths can lead to a favorable industry-level and market-level environment conducive for IoT investment.

To address the objective 1, we triangulate by (1) the available 110-nation data on Global Innovation Index, Global Competitiveness Index, Corruption Perceptions Index, World Digital Competitiveness Index, and Logistics-Performance Index, (2) the documentary study of policy-relating voices of the Thai government and some supporting offices, and private sectors of significant weights, and (3) the in-depth interview with the IoT Association President, and working-group observations.

Based on the recent updates of the 110- nation data, it shows that 89.8 per cents of the variance of global competitiveness index of a nation can be explained by the combined world digital competitiveness index and logistics performance index, which are representatives of both the digital and physical connectivity and competencies, as shown in Figure 11. In addition, governmental role and the innovation strategies of a nation are also significantly important in influencing the development of both digital and physical logistics infrastructures and capabilities. Together, Porter's Diamond structure of variables contributing towards national competitive advantages is revealed as a feasible, preferred systems framework to illuminate how IoT investments in the agricultural industry can lead to competitive advantage atnational level.

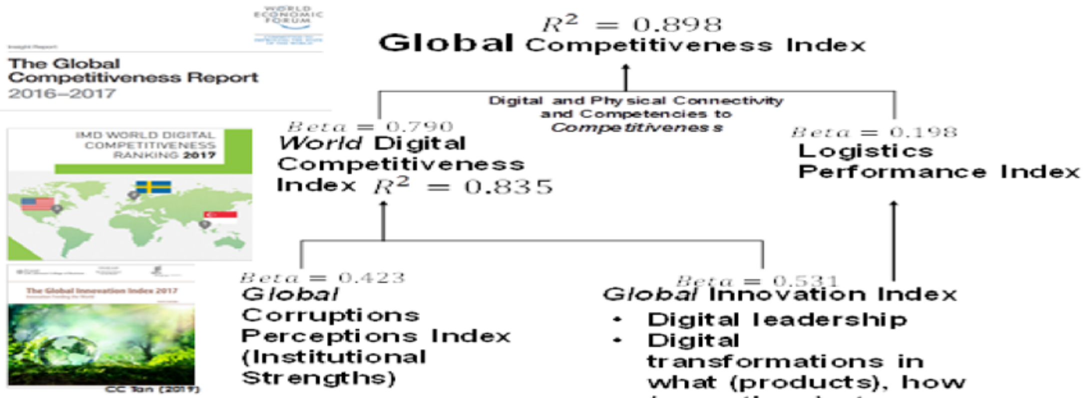

Figure 11 Global Competitiveness Index and its Digital and Physical Determinants

Specifically, both the documentary data analysis and an in-depth interview with the IoT Association President provide an evidence that their voices do reflect a structure of variables as advocated in Porter's Diamond framework of national competitive advantage, as shown in Figure 12. To realize Thailand as a "hub of IoT", the different stakeholders in the documentary analysis share a common understanding.

That is, Thailand needs to boost up the demands at many different market domains: at the domestic level (diversity of domestic industries, and local communities), at neighboring countries (ASEAN markets), and world markets. The Digital Economy Promotion Agency (DEPA), being established in 2017 with 280 million Baht budget and an ad-hoc Baht 1.5 billion budget, aims to drive the digital economy under Thailand's 4.0 strategic plan. To succeed, DEPA stresses policies that also reflect the systemic integration of the Porter's Diamond elements: "DEPA proposes digital HRs and talents, and technological competencies such as

AI, cloud computing, and multi-disciplinary and mechatronics engineering," as key elements in stimulating the factor condition.

"Actively promote new startup and new S-curves industries, focusing on innovation, scalability, and repeatability, with a need to enlarge the startups and advance them to mature stages, with particular emphasis on diversified industries in the country" (Strategy, DEPA).

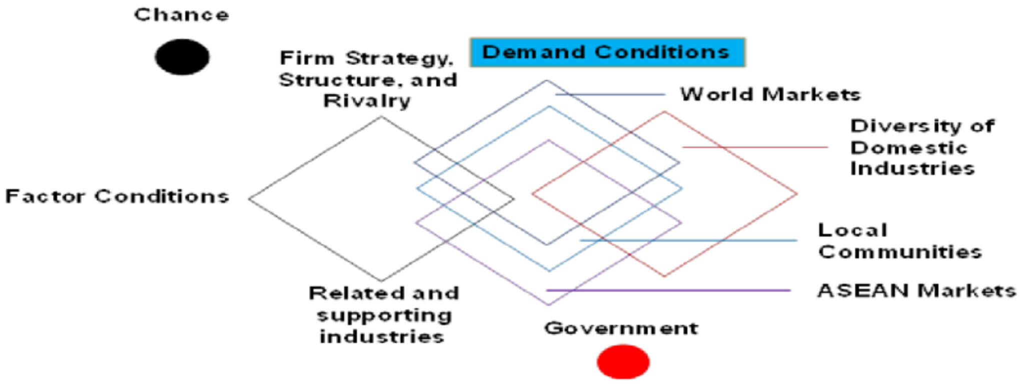

Figure 12 National Competitive Advantage Induced Structure of Factors

The following captures some of the voices expressed by the IoT Association President relating to the different elements illuminated in Porter's Diamond Model:"Without business activities pursuing IoTs in scales and scopes, it would be difficult to create large-scale awareness nationwide. A shared common interest and motivation is very important" (Strategy, Market Condition) "The IoT market should deliver clear benefits or values of IoT, i.e. cost reduction, operational equipment uptime, and availability improvement, operations speed increase, product quality improvement and safety" (Market, value-driven Strategy)

The market condition should stress on the entrepreneurial segments, as they play significant pull factor: "The entrepreneurial segments, including innovative retail sectors, are constantly in search of higher value-added products, such as fruits as herbal products, the cosmetics, chemical extract, rice varieties, and they have the ability to pull the upstream stakeholders to participate in IoTs" (Market Condition)

"Both the physical and the digital worlds must be integrated in the design and implementation, as the digital world does not have the resources as the physical world. The digital world, by its nature, has to use the resources of the physical world, as shown in the Grab taxi and shared motorbikes concepts." (Strategy)

"Where should Thailand focus in IoT investment. An example is to look at the IoT value chain. A typical IoT configuration is picturized by smart objects and smart devices at the field level, followed by connectivity and communication layer, and then, software customization and applications at the customer level. Typically, there is 5-10% of value at the smart-device level, but is dominated by China, with already around 80% of the smart-device market.

The smart-objects share the similar scenario, at 15- 20% of the value in the value chain. The 20-40% of the connectivity businesses are dominated by AIS, DTAC and TRUE companies in Thailand, which require big investments, and make it infeasible areas for IoT investments.

The feasible areas are the software customization, at 15-20% of value, and the applications another 10-20% of the total value of the IoT value chain." (Strategy direction). "IoT integrates both the physical objects and digital technologies, turning each physical object into smart object, that is capable of sensing and making intelligent decisions, based on programmable logics and deep learning, AI corrections" (Strategy)

"Market sustainability of new concept, that exploits IoTs or some emergent technological and business model concept, as illustrated in the shared motorbikes in China and elsewhere, has to stand on an ability on system-wide organization of physical resources, and the responsible attitude of consumers" (Factor and Market Conditions)

"Farmers often show phobia with technology and computers. They do get excited with the drone flying around their farms trying to collect data and providing the irrigation and chemical spraying services. However, farmers hesitate to engage with the computerized gadgets." (Factor condition)

"While the world population continues to grow, the agricultural workforces in both the developed and developing nations continue to show a downward trend. To alleviate the workforce shortages in the agricultural sectors, the IoT investment is a viable plan, by shifting to advanced technology" (Factor condition).

Technological trend and various governmental policies show "the chance" is there for IoT investments. "There is a closed 'plant factory' concept, for agricultures, which can offer safer and higher valued products, i.e. of higher vitamins and minerals, and use less spaces." (Chance)

The supporting role of Government has, also, to support the IoT investments. This is obvious from the documentary evidences.

A number of socio-psychological factors and concerns are also evidenced: "Our working groups work under a 3M principle, namely developing a Model to serve as a Motivator for the investors and business owners to invest on Money, …, and someone must take on a 'Leadership' role to establish the Model, so that others can emulate" (IoT Association, reflecting the Theory of Planned Behavior in the working).

"Depending on budget and operator's concern, the IoT investment could be arranged on gradual basis, in order to build confidence and establish the competencies step by step: We can start with localized automation, at machine level, and proceed to automation in a production line, and gradually be extended to factory wide, and beyond the production boundary, using a smart-logistics concept." (IoT Association)

"Without security and privacy standardization in place, and in support by the national Laws, the widespread usage of IoT would be very limited" (IoT Association)

"Sustainable commitment and efforts on shared things and systems could be hindered by human beings, being self-centered, with neglectful attitude towards shared responsibilities such as on devices and systems. If this could be resolved, we could, probably and easily, implement shared economy concept. IoT is suitable for realizing shared economy, as everything is connected on digital platform." (IoT Association)

Objective 2: Develop a generic business model configuration, which provides an explicitly understandable base for the investors and owners to comprehend and form the logics of how to actually benefit from IoT investments. In other words, the business model configuration should provide an insight into the integrative functions of IoTs and thus to draw the attention on key activities for success.

The business model concept is used to depict a logic of competition (Tan, 2018). Osterwalder and Pigneur (2009)'s business model canvas (BMC) is currently the most frequently used approach in presenting the business model concept of a firm, and its simplicity, as depicted in the nine-block canvas configuration, presents a shared language for describing, visualizing, assessing and adjusting the business strategies.

The interviews with Thailand IoT Association President and owner of a smart-hydrophobic farm in Chiang Rai reveal a generic BMC as shown in Figure 13. The IoT business model should be solution centric, and able to leverage networked resource capability, smart devices and smart interconnectivity, in order to innovate the activities on the various domains of BMC, such as the activities that can contribute to the planning, management and control of the supply chain (Accorsi et al. 2017). The business model should serve not only the operations of the businesses, in smart agricultural farms and their enterprises, but from the view of Thailand IoT Association, should also serve a "developmental" function, i.e. by making use of "Partnership" to instill nation-side motivations.

With IoTs, farmers can present to their wholesale or retail customers, and the markets, with a quality consistency image and reputation, in cost-efficient manner, and thus, are more capable to fight against the competition in the markets and the industry, and equip the farmers with the ability to provide a consistent service that the traditional farmers (those without IoTs) are not easily able to deliver: "By transforming my hydroponic farm into IoT system, it allows me to position myself as a supplier of consistent ability to supply to the volume and quality requirements. As such, I can maintain my selling price, while others have to face the price fluctuations in the market." (The smart-hydroponic farm case).

"The fresh vegetable supply system in the market is not a straightforward business, and I have seen businesses enter and exit continuously. During the Winter, the production goes smoothly, and suppliers can generally meet the market i.e. the wholesale / retailer expectations. In hot seasons, production goes down, along with diseases, quality issue and defects, which demotivate the suppliers, and cause exits. The IoT allows me to have the first-hand knowledge of the farms and their health in real-time basis, and the system adjusts itself automatically to maintain the quality expected." (The smart-hydroponic farm case).

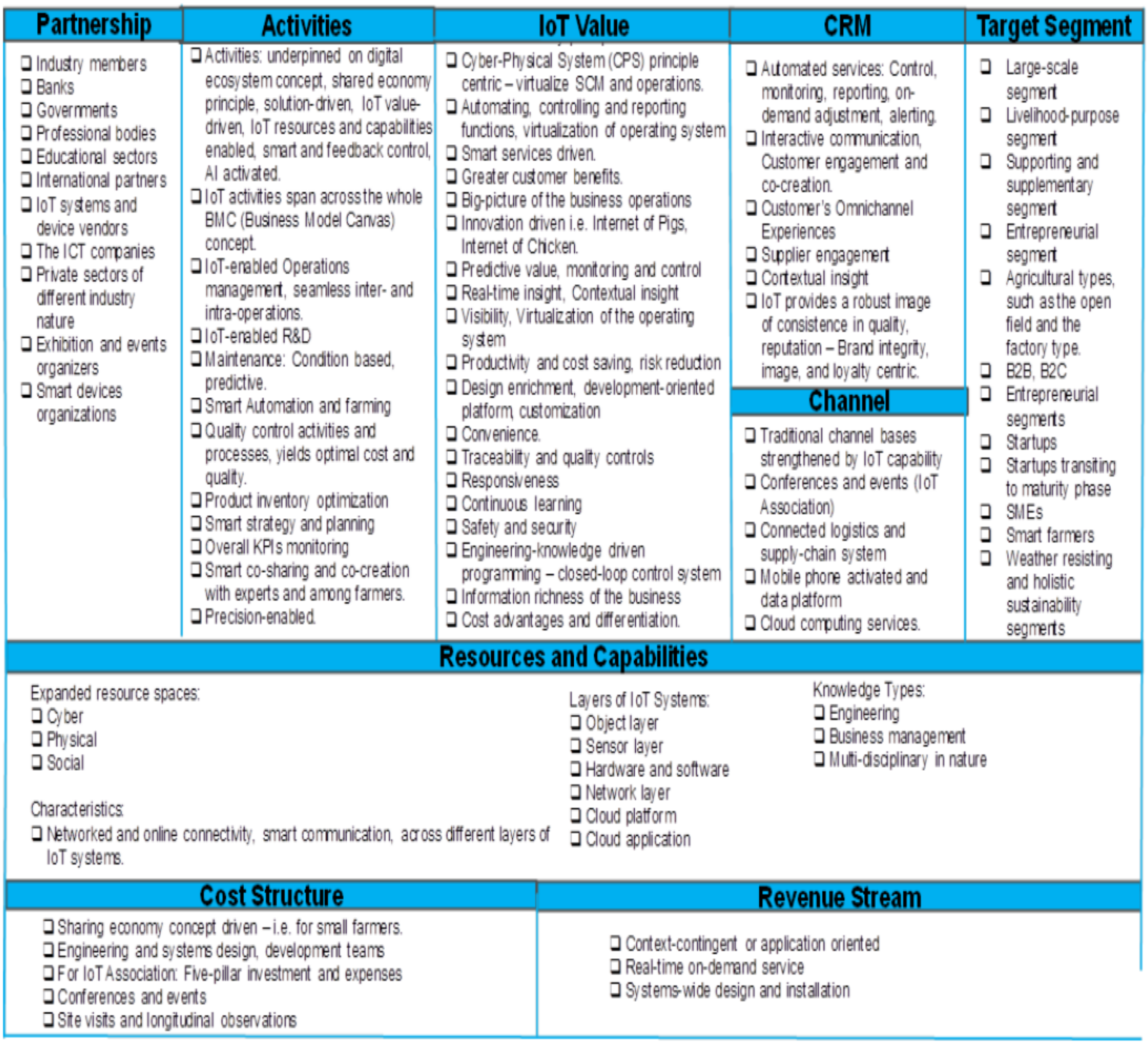

Figure 13 The Generic Business Model – for Thai Agriculture Industry

Objective 3: Draw some implications and suggest significant propositions to illuminate some important hindering and enabling factors that influence the investments of IoTs in agricultural industry, which structures the derivations based on the business model framework and the competitiveness systems.

The interviews with Thailand IoT Association President and owner of a smart-hydrophobic farm in Chiang Rai reveal a generic BMC as shown in Figure 13, which also yield numerous important propositions stated below: "IoT as networked resources and resource-efficiency leveraging machines". The term, IoT, illuminates broadly an "extension of network connectivity and computing capability to objects, devices, sensors, and items not ordinarily considered to be computers" (Boyes et al. 2018, p. 3).

With the IoTs, the resources become networked resources, which have a spectrum of analytical and intelligence capabilities (Kane et al. 2015), and thus, the entire BMC elements are the domains of the IoT-induced functions. This proposition virtualizes the supply chain and can help organizations suggest the best ways to improve productivity and solve customer problems, and thus, can significantly improve the planning, orchestration and coordination of members of the supply chain in cost-efficient manner (Verdouw et al. 2013).

"Resources should simultaneously target on cyber-, social and physical spaces" by exploiting the cyberphysical computing (i.e. situation awareness, context-aware computing, data fusion and data mining), social computing (i.e. collective intelligence, recommendation system, crowdsourcing), and thinking computing (i.e. affective computing, brain informative) (Ning et al. 2016, p. 511) capabilities.

"IoT value proposition should rely on and make plan based on cybernetic-physical systems (CPS) principle." CPS is defined in Boyes et al. (2018) as "a system comprising a set of interacting physical and digital components, which may be centralized or distributed, that provides a combination of sensing, control, computation and networking functions to influence outcomes in the real world through physical processes", adapting the version of Boyes (2017).

Hindering areas could lie in both livelihood-purpose segment and large-scale segment. The former is a segment which is smaller in scale and whatever the agriculture focus it is livelihood-important. This segment has low propensity towards technology employment, because of cost-burden, and the intermediary buying that tends to push downward the selling price from the farmers. The latter is largescale operator segment, having own markets, with stability, and have some sufficient capability to resist pressures from the environment. The large-scale companies tend to source IoT designs from international suppliers, and have the capability to replicate with a low-cost version that would benefit them competitively in the markets.

"The smaller-sized segments in the agricultural sectors, generally, do not have the investment power as well as the market power. They have insufficient funds to make large-scale investment, coupled with low-return due to smaller scale. We suggest a "sharing" strategy, which can make use of integrating a group of small farmers, to share on IoT systems investment. Some challenges do exist, such as in how to convince the farmers on shared economy." (IoT Association).

Sound engineering knowledge of farming production is considered a crucial ingredient for success in the IoT systems design and implementation, as voiced from both the cases.

"Without sound engineering knowledge, it is quite impossible to succeed in, for instance, an IoT integrated plant-factory investment, such as a closed mushroom-plant factory." (IoT Association)

What is considered "valuable and rare" from the perspective of suppliers may not be similarly shared by the customers. For instance, the second informant, of the owner of a smart-hydroponic farm in Chiang Rai, highlights an aspect of a restraining force, as follows:

"Although IoT is a rare technology, considered of tremendous value, but our customers not really value, as they see the value from the product, that is, the hydroponic vegetables we deliver to them. (Hydroponic farm case)

Discussion of Research Results

This research provides a cross-sectional view of the current IoT market and industry in Thailand, as guided by the three research objectives in which the emerged themes and propositions identified are conceptually bounded and facilitated by Porter's Diamond Model framework and the business model canvas (BMC) concepts.

A fundamental goal of this research is to provide the information and inferred knowledge to the industries, in general, to help them understand the IoT-enabled business environment and learn of a generic configuration of IoT-enabled business model, which they can exploit. Osterwalder's business model canvas (BMC) configuration is selected as the basis for the summary of the qualitative data analysis, due to its simplicity and intuitive exhibit of the interrelations among the model's components(Rusu, 2016).

The three research objectives not only match the trilogy of strategy, which consists of context (Porter's diamond model), concept (i.e. for technology diffusion, based on theory of planned behavior, and national competitiveness atmosphere), and conduct (business model), but they can also be reckoned to underpin on three purposive perspectives, namely

(1) descriptive (supported and based on empirical data),

(2) normative (guided by Porter's diamond framework and business model canvas ontology), and

(3) instrumental view that establishes a connection between the business model and systems of efforts and the attainment of a firm's performance and industry's competitiveness.

The research also helps the research scholars to form an expanded understanding to some of the recognized theories commonly used in the discipline of strategic management. One important theory is the stakeholder theory, which the business model components should also be treated as the stakeholders, and in addition, the IoT invested should enable the firm to develop mutually trusting relationships with its stakeholders, leading to a competitive advantage over firms that do not yet implement IoTs through networked connectivity capability.

The seamless connectivity and smart communication of smart devices and sensors, through AI programmable logics and systems, and actuators eventually for the foundation to realize the so-called "business ecosystems", leading to shared competitive advantages.

When the business model is actively mastered, the case informants indicate that one will gain the competences to replicate them, and thus, provide an avenue for production and market expansions.

Suggestions

In sum, to serve to develop IoT investments at national level, this suggests shed light on a number of areas which the policy-makers can pursue:

1. An industrial environment showing national strength towards competitive advantage.

2.A big picture in IoT investments manifested in the IoT-enabled business model, with CPS-centered value propositions that can push forward the virtualization of supply chains and business ecosystem, and is leveraged through networked resources, capabilities and activities that exploit IoTs.

3.Resolving some of the restraining or hindering socio-psychological factors that relate to the motivation and confidence levels of potential investors, owners and managers.

4.The activities of the business model should underpin on digital ecosystem concept and the shared economy principle, and is solution-driven.

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