SECOND ORDER CONFIRMATORY FACTOR ANALYSIS OF SMART AGRO-INDUSTRY MANAGEMENT METHODS TO INCREASE PRODUCTIVITIES AND QUALITIES

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ABSTRACT

Nowadays, the agricultural sector is encountering a lot of problems that need to be changed abruptly to become sustainable. The objective of this research is to study the smart agro-industry management methods to increase productivities and qualities. The sample group consisted of 500 agro-industry businesses. Second order confirmatory factor analysis was employed to acquire 5 components, namely Innovation, Knowledge Management, Information Technology, Resources, and Process. The results of the model analysis showed its result passed the assessment criteria in accordance with the empirical data and it was also found that Chi-square Probability Level was 0.061, Relative Chi-square was 1.136, Goodness of fit Index was 0.952 and Root Mean Square Error of Approximation was 0.017.

Keywords: Management Methods, Smart Agro-Industry, Second Order Confirmatory Factor Analysis.

INTRODUCTION

The agricultural industry is an industry that mainly depends on agricultural raw materials and environmental factors. Seasonality, natural disasters, drought, floods and other negative incidents are important factors that cause fluctuations in both quantity and quality. The impacts include a lack of precision of yield forecast, which affects the agricultural industry Entrepreneurs in the agricultural industry and farmers constitute a large proportion of population in Thailand. Nonetheless, the business and economic value of the agricultural industry is very low. If agricultural products are fed into the agricultural industry efficiently and effectively, the national economy will be enhanced, which will affect the country's GDP (Nova, 2015). The figure of Thailand's Gross Domestic Product (GDP) in 2019 equals to 16,875,891 million baht, and the GDP of agriculture represents a proportion of 7.98 percent of the total GDP or 1,347,421 million baht (The Office of the National Economic and Social Development Council, 2020). These two figures reveal a big discrepancy between the size and the economic value of the agricultural industry. It is imperative that methods to elevate quantity and quality levels of the industry be developed to make it sustainable and progressive (Moore, 2014; Paustian & Theuvsen, 2017; Reddy et al., 2015; Rosenzweig et al., 2014).

People involved in the agriculture industry should pay more attention to technology and modern innovation to improve the efficiency of production by using the concept "Smart

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Farming". There is an important mechanism to upgrade the traditional agricultural society to become a modern agricultural society which is called agriculture 4.0. It will also increase marketing opportunities and enhance competitiveness. The developing movement of smart agro-industry will be an enhancement to create a stable agricultural industry. The results of smart farming are to reduce losses, costs, and the use of pesticides, the use of chemical fertilizers, the use of water, and the labor force. It will also increase quantity and quality of yields, which will result in high and stable farmers' incomes. In addition, output prediction will be more precise. Moreover, it will provide marketing supports with effective marketing plans, especially with regards to the determination of market in advance. This will help stabilize agricultural prices under the concept of "*motivating the development of smart agro-industry in Thailand as a stable and sustainable agriculture industry*" (Narendar et al., 2015; Stevenson et al., 2014; Thierfelder et al., 2016).

LITERATURE REVIEW

The non-observed variables have been constructed to create a model of linear combination of possible factors plus error conditions. The factor analysis aimed at looking for extrogenous variables. There were two analyses:

1) Exploratory Factor Analysis (EFA) to identify complicated relationship between list and group list as a part of the holistic concept, which was not hypothesized prior to the research being conducted, and
2) Confirmatory Factor Analysis (CEA) as a more complicated approach to hypothesis testing that the list was related to specific confirmatory factors by using Structural Equation Modeling (SEM) to test the model with loading factors to estimate the relationship between observed and non-observed variables.

The SEM method could accommodate measurement errors with fewer limits than estimated least square method. The hypothesis model was tested with empirical data, and the analysis revealed the observable variable load of latent and the relationship among latent (Polit & Beck, 2008). In this research, the secondary confirmatory factor analysis was used to delineate approaches to the management of Smart Agro Industry.

An approach to the management of Smart Agro Industry to elevate quantity and quality of productivity is, in fact, the theory of supply chain management (Michael, 1985 cited in Thanit, 2016). It is a planning and managing process from raw materials to finished quality products to deliver to customers. The process must be regarded as a process to create a value chain of the industry. Every activity in the chain must add values along the process. Under this theoretical concept there must be innovative knowledge to apply technologies, and to create innovations to leverage resources for maximum benefits for the agricultural industry.

Agro-industry and smart farming have the components that lead to changes and impacts on the industrial sector. The major component is knowledge, since knowledge will affect the transition from traditional agriculture to modern agriculture. It will be an important part of improving farmers' quality of life. In the present, application of digital agriculture, which results in fundamental components of knowledge shifting from traditional agriculture knowledge to modern knowledge of agriculture (Mohanraj et al., 2016; Tomich et al., 2019; Zhang & Wu, 2018).

Concepts of using information technology and the development of knowledge in the operation of smart agro-industry to increase productivities result in innovative analyses and classification (Capolupoetal, 2015). The information technology components are an important

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part for development in order to classify problems into categories of information to analyze the comparison between smart farming operation (Chen, 2014) and traditional agricultural practices.

Innovative concepts suggest that agricultural scientists are well receptive to innovations and technologies in the agricultural industry sector and smart farming (Thomas et al., 2019). This means they agree with the idea to change from traditional agriculture that uses human labors and tacit knowledge created form practical experiences inherited form the past to modern agriculture. This includes the transformation from using human labors to using agricultural machinery, such as robots and data management to improve quality and quantity of productivity (Andersson & D'Souza, 2014).

Concepts of resources for smart farming suggest that it is important to have experts to gather the knowledge of agriculture and agricultural technology (Liyan & Bin, 2018). It will assure credibility for the development of digital technology to be methods used by farmers (Margaret et al., 2019), which result in changing from traditional agriculture to smart farming. Therefore, the objective is to utilize various agricultural resources (Christian et al., 2016). To gain maximum benefits for the agricultural industry to improve both quality and quantity of productivity. Smart farming must be well equipped with appropriate and necessary resources.

Process concepts for the transformation to smart farming state that production structure and processes must be designed to achieve are speed, modern farming using technologies to replace human labors, simplification, and the reducing complexity in every step. Farmers must have convenient accesses data, be able to inspect reports quickly, and to increase productivity at all steps within the industry chain (Kruizeet et al., 2016), which results in the strength of the industry.

Research objectives

1. To analyze the smart agro-industry management methods in second order confirmatory factor to increase quantities and qualities of productivity
2. To study the smart agro-industry management methods to increase quantities and qualities of productivity.

RESEARCH METHODS

The population in this research consists of mini and medium-sized agricultural entrepreneurs and large industrial businesses. The total number is 30,822 persons (Office of Small and Medium Enterprise Promotion, 2019). The subjects were divided into 2 groups; one being small and medium businesses, and the other being large industrial businesses. The number in each group is in accordance with specifying sizes of the samples in the research. A sample of 500 subjects was chosen by simple random method to be analyzed in the research (Silpcharu, 2020).

The research instrument for composition analysis was a questionnaire with Rating Scale, set weight criteria to 5 levels according to Likert method (David & Sutton, 2011) with 100 items. The research instruments were tested for quality check. The Index of Item Objective Congruence (IOC) is between 0.60-1.00. The analysis was classified into single items, getting Corrected Item-Total Correlation between 0.31-1.44. The analysis for confidence level comes up with Alpha Coefficient being 0.97.

Data collection was done by means of interviewing subjects in the sample. Data analysis was conducted by using descriptive statistics with SPSS software. The Multivariate Statistical Analysis used was AMOS software for evaluating the Data-Model Fit. The analysis considered 4

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values: 1) Chi-square Probability Level being greater than 0.05. 2) Relative Chi-square being less than 2. 3) Goodness of fit Index being greater than 0.90, and 4) Root Mean Square Error of Approximation being less than 0.08 (Silpcharu, 2020).

RESEARCH RESULTS

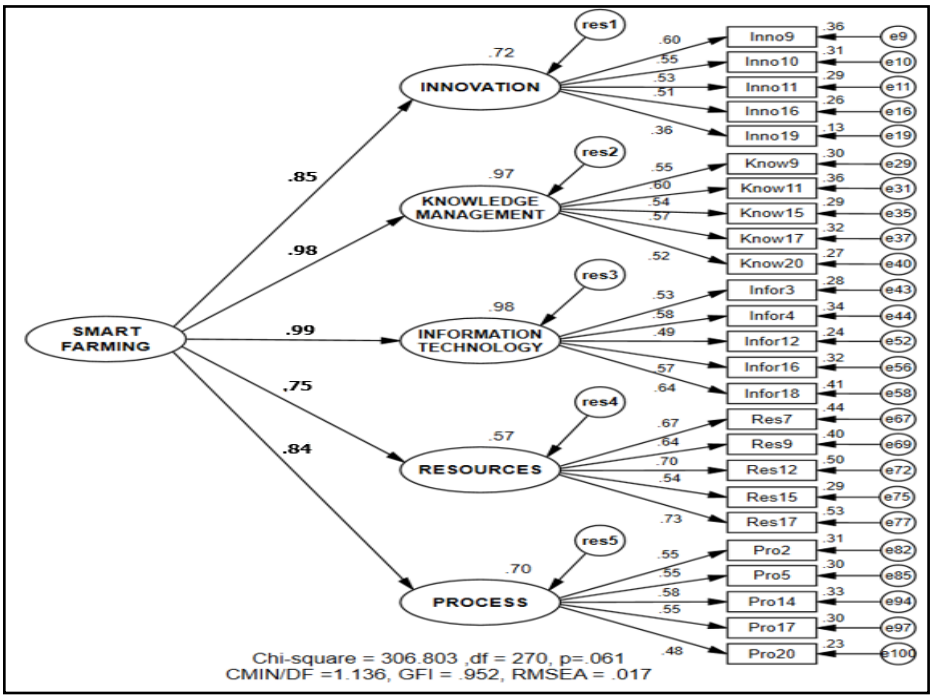

FIGURE 1
THE SMART AGRO-INDUSTRY MANAGEMENT METHODS IN SECOND ORDER CONFIRMATORY FACTOR TO INCREASE QUANTITIES AND QUALITIES OF PRODUCTIVITY

The Results of Smart Agro-Industry Management Methods in Second Order Confirmatory Factor to Increase Quantities and Qualities of Productivity in Overall

The Figure 1 showed the statistical value of the analysis model. The smart agro-industry management methods in second order confirmatory factor to increase quantities and qualities of productivity. After model improvement by modifying from the Modification Indices according to (Arbuckle, 2011) suggestion, the probability of chi-square is 0.061 and greater than 0.05. Chi-square (CMIN/DF) is 1.136 and less than 2. The goodness of fit (GFI) is 0.952 and greater than 0.90, and the root mean square of error approximation (RMSEA) is 0.017 and less than 0.08. Therefore, all 4 statistics have passed the evaluation criteria. The smart agro-industry management methods in second order confirmatory factor to increase quantities and qualities of productivity after improvement are consistent with the empirical data (Armstrong et al., 2014; Ayre et al., 2019).

The smart agro-industry management methods to increase quantities and qualities of productivity consists of 5 latent variables which can be ranked in descending order as follows: 1) Information Technology with Regression Weight=0.99, R2=0.98 2) Knowledge Management

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with egression Weight=0.98, R2=0.97 3) Innovation with Regression Weight=0.85, R2=0.72 4) Process with Regression Weight=0.84, R2=0.70 and 5) Resources with Regression Weight=0.75, R2=0.57.

The Results of Smart Agro-Industry Management Methods in Second Order Confirmatory Factor to Increase Quantities and Qualities of Productivity for Each Component

1. The figure 1 showed the smart agro-industry management methods in second order confirmatory factor to increase quantities and qualities of productivity. Productivities in 5 components as follows;
2. Innovation consists of 5 observable variables which can be sorted in descending order as follows: 1) Inno 9: promoting the patents for smart farming inventions, 2) Inno 10: supporting the innovative experts to create new ideas, 3) Inno 11: developing plant species to increase quantities and qualities of productivity, 4) Inno 16: developing the use of aerial photography, and 5) Inno 19: deciding and controlling the crops with high-precision agricultural machinery, respectively.
3. Knowledge Management consists of 5 observable variables which can be sorted in descending order as follows: 1) Know 11: storing knowledge in electronic format, 2) Know 17: Organizing and analyzing collected data to create new knowledge for further practices, 3) Know 9: eliciting tacit knowledge from experienced persons for explicit learning, 4) Know 15:forming a collaborative project within the agricultural sector to exchange knowledge among members, and 5) Know 20: supporting staff members to acquire knowledge of smart farming to keep up with changes, respectively.
4. Information Technology consists of 5 observable variables which can be sorted in descending order as follows: 1) Info 18: modern and efficient network management systemม 2) Info 4: promoting linking and exchanging information on smart farming with other agencies, 3) Info 16: using satellite technology to analyze smart farming results, 4) Info 3: a system to prevent interference of network and information security standards, and 5) Info 12: monitoring field works and the central unit for speeds in the management with Internet of Things, respectively.
5. Resources consist of 5 observable variables which can be arranged in descending order as follows: 1) Ress 17: systematically managing investment in industrial businesses, 2) Ress 12: procuring effective measuring tools and materials for clear visibility, 3) Ress 7: improving, developing and maintaining water sources to ensure the highest quality of water, 4) Ress 9: using land that is suitable for each type of agriculture, and 5) Ress 15: solving soil pollution and soil degradation, respectively.
6. Process consists of 5 observable variables which can be sorted in descending order as follows: 1) Pro 14: in-depth analyzing and inspecting the quality of work at all levels, 2) Pro 2: comparing between the operation of our organization and that of leading organizations, 3)Pro 5:an efficient logistics management system of which upstream, midstream, and downstream transportations are efficiently linked to form a network, 4) Pro 17: reporting operations to follow up and improve the unperfected points, and 5) Pro 20: supporting the transition from traditional agriculture to smart farming, respectively.

Table 1
MEAN AND STANDARD DEVIATION OF MANAGEMENT METHODS OF SMART AGRO-INDUSTRY FOR INCREASING QUANTITIES AND QUALITIES OF PRODUCTIVITY

Methods of Smart Agro-Industry for Increasing Quantities and Qualities of Productivity.		$\overline{X}$	S.D.
Overall of Smart Farming		**4.17**	**0.38**
1. Innovation		**4.15**	**0.44**
Inno9	promoting the patents for smart farming inventions	4.15	0.68

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Inno10	supporting the innovative experts to create new ideas	4.16	0.67
Inno11	developing plant species to increase quantities and qualities of productivity	4.22	0.65
Inno16	developing the use of aerial photography to use the findings concerning leave colors and trunk colors of agricultural plants for quality analysis	4.15	0.7
Inno19	analyzing system of plant and soil photographs to transform them to become agricultural data for deciding and controlling the crops with high-precision agricultural machinery	4.04	0.79
2. Knowledge Management		**4.23**	**0.46**
Know9	eliciting tacit knowledge from experienced persons for explicit learning in forms of manuals and mentoring	4.24	0.67
Know11	gathering from various sources and storing knowledge in electronic formats for further uses	4.25	0.68
Know15	forming a collaborative project within the agricultural sector to exchange knowledge between farmers practicing traditional agriculture and those practicing smart farming	4.16	0.75
Know17	organizing and analyzing collected data to create new knowledge for further practices	4.29	0.69
Know20	supporting staff members to acquire knowledge of smart farming to keep up with changes	4.21	0.68
3. Information Technology		**4.24**	**0.44**
Info3	a system to prevent interference of network and information security standards modern and efficient network management system	4.31	0.66
Info4	promoting linking and exchanging information on smart farming with other agencies	4.17	0.68
Info12	monitoring field works and the central unit for speeds in the management with Internet of Things: IoT	4.28	0.61
Info16	using satellite technology to analyze smart farming results	4.21	0.67
Info18	modern and efficient network management system	4.24	0.67
4. Resources		**4.07**	**0.55**
Ress7	improving, developing and maintaining water sources to ensure the highest quality of water	4.14	0.74
Ress9	using land that is suitable for each type of agriculture	4.1	0.68
Ress12	procuring effective measuring tools and materials for clear visibility	4.06	0.73
Ress15	solving soil pollution and soil degradation	4.05	0.82
Ress17	systematically managing investment in industrial businesses	4.01	0.76
5. Process		**4.14**	**0.46**
Pro2	comparing between the operation of our organization and that of leading organizations	4.19	0.72
Pro5	an efficient logistics management system of which upstream, midstream, and downstream transportations are efficiently linked to form a network	4.22	0.69
Pro14	in-depth analyzing and inspecting the quality of work at all levels	4.17	0.65
Por17	reporting operations to follow up and improve the unperfected points	4.05	0.7
Pro20	supporting the transition from traditional agriculture to smart farming	4.06	0.73

Results of the Analysis of the Important Management Methods of Smart Agro-Industry for Increasing Overall Quantities and Qualities of Productivity

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Table 1 revealed that the level of importance of the results of smart agro-industry management methods in second order confirmatory factor to increase quantities and qualities of productivity as a whole had an average of 4.17. It was found that all aspects could be arranged in descending order as follows: 1) Information Technology with an average of 4.24, 2) Knowledge Management with an average of 4.23, 3) Innovation with an average of 4.15, 4) Process with an average of 4.14, and 5) Resources with an average of 4.07, respectively.

The Results of Smart Agro-Industry Management Methods in Second Order Confirmatory Factor to Increase Quantities and Qualities of Productivity in terms of each Component

The importance level of smart agro-industry management methods of each item is high. They can be arranged in descending order from each side; the first 3 are as follows.

1. **Innovation:** 1) the development of plant species could increase quantities and qualities of productivity with an average of 4.22, 2) encouraging innovative experts to create new concepts with an average of 4.16, and 3) promoting the patents of smart farming inventions with an average of 4.15, respectively.
2. **Knowledge Management:** 1) analyzing existing knowledge to create new knowledge with an average of 4.29, 2) storing information in electronic format with an average of 4.25, and 3) eliciting tacit knowledge from experienced persons for explicit learning with an average of 4.24, respectively.
3. **Information Technology:** 1) having a standardized and secure network interference prevention system with an average of 4.31, 2) increasing the speed of management with the Internet of Thinks: IoT with an average of 4.28, and 3) having modern and efficient network management has an average of 4.24, respectively.
4. **Resources:** 1) improving, developing, and maintaining water sources for the highest quality of water with an average of 4.14, 2) using land suitably for each type of agriculture with an average of 4.10, and 3) procuring effective measuring tools and materials for clear display with an average of 4.06 respectively.
5. **Process:** 1) logistics management should be efficiently linked to be a logistics network with an average of 4.22, 2) comparing operation between our company and top five companies with an average of 4.19 and 3) analyzing and inspecting tacit quality at all levels with an average of 4.17, respectively.

DISCUSSION

The significant influencing factors for smart agro-industry management methods to increase quantities and qualities of productivity in the industrial sector are information technology with the Standardized Regression Weight=0.99 with a statistical significance at 0.001. Due to smart agro-industry management methods is an agricultural process that requires information technology for screening, classifying, and distributing information through technology, communications, and telecommunications to shift to smart farming. This is in line with a theory stating that smart farming needs information technology for information dissemination. It is also needed for creating relationship and information sharing among various organizations (Margit & Ludwig, 2016). Classifying and analyzing big data must be in harmony with technology and resource management for maximum benefits (Chen, 2014).

Regarding information technology, standardized and safe network for interference prevention is important as a smart agro-industry management method. This is due to the fact that a process of prevention and security of information under the information technology management from foundation to the analysis of agricultural yields through information technology systems is important. It is necessary that information be confidential and difficult to access because all information details are important in terms of technology, academic

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confidentiality, and legal protection against data offenses. This is correspondent with the principle of attack rish prevention, therefore, protecting the system is necessary (Sukglun et al., 2018). Information technologies help promote and develop smart farming information in a big volume with an easy access (Suthiprapa, 2017).

Data collected should be stored for processing and analyzing, and the results are used to create new knowledge for practical sectors. Knowledge management method is the most important because results for analyses will be important tools for businesses in the industry. This will become a big vein to send information to the center to create additional knowledge (Senthilvadivuet al., 2016).

Improvement and development of water resources to ensure the highest water quality is to be used properly in accordance with the condition of landscape in different areas. This is a smart agricultural industry management method. Due to agricultural practices, water is an important resource for all kinds of crops and all types of agriculture. It is an important part of the entire agricultural operation, which will affect an increase of quantities and qualities of productivity. Agriculture productivity relies on seasonality, nature conditions, the management of irrigation systems, and water storage for agriculture (Cynthia et al., 2014). Moreover, choosing an appropriate area with good environments has impacts on agriculture productivity (Claire et al., 2104).

The development of plant species to increase quantities and qualities of productivity is the most important approach to smart agro-industry management in terms of innovation. This is because the development of species can increase both quantities and qualities of agricultural yields. Agricultural evolution must be developed in accordance with changes in plant species in order to increase productivity (Kaboonkham et al., 2019). The development of species can reduce harvest times and increase crop cycles. After that, this development will be integrated with the use of agricultural machinery, technology, and innovation.

RECOMMENDATIONS

The smart agro-industry management methods in second order confirmatory factor to increase quantities and qualities of productivity can lead to the following recommendations.

Knowledge management is an important development of innovation and information technology. It will be able to motivate farmers to improve economy and society. Educational institutes in the education sector need to adapt their practices by applying innovative knowledge in the agricultural sector. Research data of various researches should be used in corporation with digital technology to create a definite structure of co-operation among various private businesses. To create a perfect education system, educational institutes should take leading roles through the use of innovative tools.

Agricultural industry must bring effective knowledge and operational ways of value chain management by promoting the co-operation between societies of agricultural groups, and industrial agricultural sectors with efficient and effective connectivity. Furthermore, they should recognize the importance of information transferring information among them. This should cover all aspects including production, management, and marketing for them to have confidence in 7 smart agro-industries in the future.

The government should have regulations to control actions that lead to integration for sharing and disclosing agricultural information that helps solve agriculture problems, dissolve resistance to changes from chemical agriculture to organic agriculture. Digital technology both in

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terms of information management and data analysis throughout the agricultural industry chain must be fully integrated to shorten operation cycles and expedite practical processes.

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