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Causal Relationship Model of Supply Chain Risk of Organic Rice in Thailand

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Abstract

This study aimed to gain a better understanding of the causal factors that affect dependent variables in the supply chain risk of organic rice in Thailand. Consequently, the purpose of this research was to develop a structural equation model of the supply chain risk. A questionnaire was used to gather data from a sample of 250 farmers who were certified under the organic agriculture standards in Thailand and the data were analyzed using LISREL 8.80. The Chi-square value of 192.21, a degree of freedom of 167, and a p-value of 0.08828 indicated that the model was consistent with the empirical data. The model was composed of 23 observed variables and 3 latent variables: input, organic agriculture standard, and supply chain risk. Input was found to have a positive and direct effect on organic agriculture standard (coefficient of 0.71), and a negative and direct effect on supply chain risk (coefficient of −0.65). Organic agriculture standard had no effect on supply chain risk.

Keywords: Causal relationship model, Supply chain risk, Organic rice

1. Introduction

Organic rice is rice that has been certified by an independent body that sets the standards for organic growing and processing. In Thailand, the total area under rice cultivation was 20 116.8, 21 040.32, and 26 929.6 hectares in 2013, 2014, and 2015, respectively. The area under rice cultivation increased by 28% between 2014 and 2015 (Panyakul, 2016). The value of organic rice exports was 273.25, 345.19, and 552.25 million baht, in 2012, 2013, and 2014, respectively (Kongsom, 2015). Consumer demand for organic products has increased dramatically in recent years and global sales are also increasing. Based on the production data and export values, the demand for organic rice is increasing.

Rice is included among the agricultural products that experience supply spikes and perishability. Yields vary and the process of planting, growing, and harvesting depends on the climate and season; the agricultural supply chain is more complex than other supply chains. The supply chain is also affected because of the several sources of uncertainty and the complex relationships between actors.

Rohmah (2015) determined the supply chain risk in ordering organic rice products in MUTOS. The results revealed that the risk priority order in the supply chain for organic rice, in descending order of importance, is as follows: risk of product return, loss in quality, product contamination during processing, lack of stock, competition, quality incompatibility, chemical contaminants, supply delays, processing delays, damage during processing, machine damage during processing, demand change, damage during storage, and risk of decreased production.

However, no clear relationship has been identified between these risks. Accordingly, the results of this study contribute to the development, improvement, and validation of a model of the causal relationships in the supply chain risk of organic rice in Thailand.

2. Literature Review

2.1 Input or Resource Factors of Production

Factors of production, resources, or inputs are used in the production process to produce output, that is, finished goods and services. The utilized amounts of the various inputs determine the quantity of output, according to the production function relationship. Ngige (2014) suggested that the problem for most industrialized and industrializing economies is how to coordinate and integrate all the factors of production for proper socio-economic development. Barro (1996) argued that there are other factors that lead to productivity improvements in societies or nations and that these are the determinants of economic growth.

Ngige (2014) suggested that the inputs of manpower, materials, machinery, and money do not by themselves ensure growth; they become productive only when management acts as a catalyst. Chang et al. (2015) found that lack of communication could lead to inaccurate or distorted information flow in a supply chain. Along with Tummala and Schoenherr (2011), they suggested that a lack of necessary information technology (IT) or IT failure should be considered an important risk element associated with information flow. According to

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Moslemi et al. (2016), the risk factors associated with information flow may be grouped into three categories: information delay, information inaccuracy, and IT problems.

Research conducted by Rostamzadeh and Sofian (2009) verified the effectiveness of the 7Ms (Management, Manpower, Marketing, Method, Machine, Material, Money) in improving the performance of production system. They suggested the following. (1) Management is one of the main components of the production system and can strengthen the other factors. (2) Money was a necessary investment in production systems, playing a critical role in the improvement of the systems. (3) Manpower is the only factor that is under mental conditions and response to any motive. Reinforcement and using manpower effectively improve labor performance. (4) Marketing also plays a major role in improving production systems because if it is not correctly implemented and if products cannot be sold at the right time, the production system will face an issue regarding sales. (5) Method is the most important factor in improving productivity because using different techniques, even through trial and error, can identify the best and lowest-cost methods of working. (6) The material used for manufacturing parts and products also influences improvements in system performance. (7) Machines are one of the important elements. With appropriate utilization of machines, one of the main components of the system can be strengthened, thereby guaranteeing the improvement of system performance.

2.2 Organic Agriculture

There are many definitions of organic agriculture. Lampkin and Padel (1994) provide a more operational definition of organic agriculture: "to create integrated, humane, environmentally and economically sustainable agricultural production systems, which maximize reliance on farm-derived renewable resources and the management of ecological and biological processes and interactions, so as to provide acceptable levels of crop, livestock and human nutrition, protection from pests and diseases, and an appropriate return to the human and other resources employed." Martin (2009) defines organic agriculture as an integrated farming system that strives for sustainability, the enhancement of soil fertility, and biological diversity while, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones. Le Guillou and Scharpe (2001) emphasized that organic farming involves holistic production management systems (for crops and livestock) and underlined the use of management practices as opposed to the use of on-farm inputs. A significant aspect of the principle of organic agriculture is presented by the International Federation of Organic Agriculture Movements (IFOAM, 2005), which states that "Organic agriculture is a production system that sustains the health of soils, ecosystems, and people. It relies on ecological processes, biodiversity, and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation, and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved."

Standards play a major role in organic agriculture, because they lay down the regulations that all agriculturists have to follow to upgrade production capacity and transform in order to gain greater advantage, increase consumer confidence, and exploit marketing opportunities.

Furthermore, Panyakul (2016) suggested that the Organic Agriculture Certification Thailand plays an important role in providing professional organic certification services for all agricultural production, processing, and handling operations. Hnin (2017) stated that standards regulate production methods for organic agriculture. There are several certification bodies operating in Thailand. "Certified organic" is a term given to products produced according to organic standards as certified by one of these bodies. Products from certified organic farms are labeled and promoted as "certified organic."

2.3 Supply Chain Risk (SCR)

Due to increasing globalization, supply chains are increasingly vulnerable because of economic and environmental changes. Therefore, risk management plays a vital role in effectively operating supply chains under a variety of uncertainties. Therefore, risk management is even more important for agricultural supply chains (Behzadi et al., 2018). The Committee of Sponsoring Organizations of the Treadway Commission (2004) explains that risk is an event that can have a negative impact. From a supply chain perspective, risk is associated with the negative consequences of uncertainty within the supply chain or network (Christopher & Lee, 2004; Wagner & Bode, 2006).

Aqlan and Lam (2016) stated that the sources of SCR consist of unpredictable variables within an organization, network, or environment. These risks exist because of uncertainty regarding future risk events, which can appear at any point of time in the supply chain. Tang and Tomlin (2008) define five regular types of risks: supply; process; demand; intellectual property; and behavioral, political, and social. Sreedevi and Saranga (2017) used structural equation modeling to identify three major aspects of SCR: supply, manufacturing process, and delivery risk.

In agricultural supply chain problems, risk has been discussed in various contexts such as yield, cost, and price variability for different agricultural products. Some practices for increasing yields in organic crop production carry a risk of reducing the current positive effects on biodiversity (Diehl et al., 2012). However, if inputs are applied with greater precision, this is likely to enhance yields and reduce nutrient losses and runoff, which will be positive for biodiversity due to lesser damage to surrounding ecosystems (Cunningham et al., 2013).

3. Methodology

This study was carried out using a survey method and a questionnaire was used to collect data. The questionnaire was based on previous studies as well as a review of the literature. A survey was conducted to collect data from farmers certified by the organic agriculture standards in Thailand by mail, telephone, and face-to-face interviews. The study was distributed using a simple random sampling technique.

The sample size was based on Hair et al. (2010), who stated that the sample size in structural equation modeling (SEM) analysis should be 10-20 times that of the observed variable. This study used a sample size 20 times that of the observed variables, subsequently the size was (20×23 = 460). Of these 460 questionnaires, 256 were returned, of which 250 were valid responses.

Furthermore, analysis of the causal relationship model of SCR of organic rice in Thailand was verified using LISREL 8.80 and Chi-square values showed no statistical significance at the 0.05 level

4. Data Analysis and Results

The results were illustrated as following:

4.1 Confirmatory Factors Analysis of Exogenous Variables

4.1.1 Confirmatory Factors Analysis of Exogenous Variables of Input (INPUT)

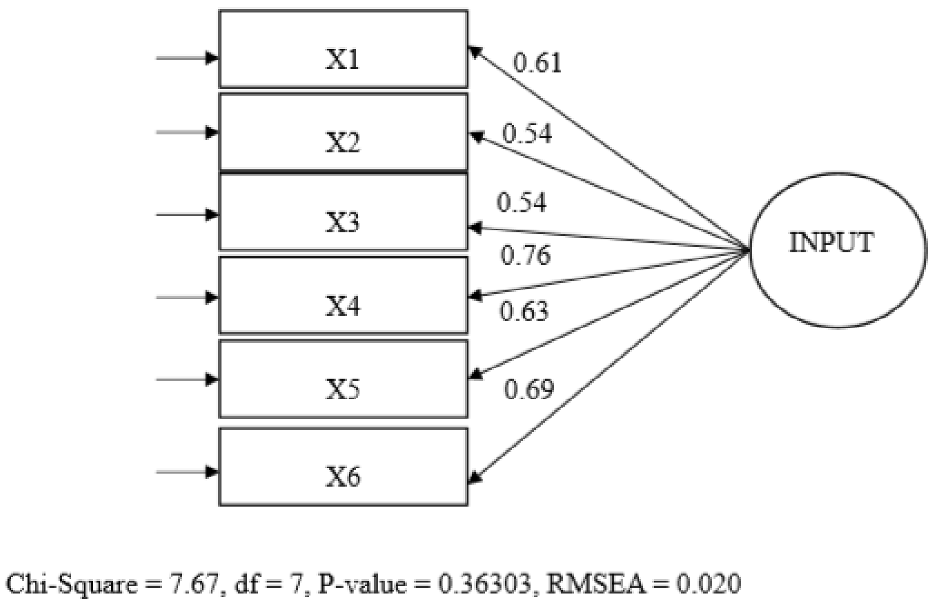

Figure 1. Model of confirmatory factors of input

Table 1. Results of analysis of confirmatory factors of input

Components of Input	Weight	R^2
X1 Man	0.61	0.37
X2 Money	0.54	0.30
X3 Machine	0.54	0.29
X4 Material	0.76	0.58
X5 Method	0.63	0.40
X6 Information	0.69	0.48

Chi-Square = 7.67, df = 7, P-value = 0.36303

GFI = 0.99, AGFI = 0.97, RMSEA = 0.020, SRMR = 0.025

** significant at the 0.05 level

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From Figure 1 and Table 1, the results of analysis of the confirmatory factors of INPUT from six observed variables revealed that the model was consistent with the empirical data as 1) the Chi-square value was not statistically significant at the 0.05 level and P=0.363, 2) goodness of fit index (GFI) was 0.99 and adjusted goodness of fit index (AGFI) was 0.97, 3) root mean square error of approximation (RMSEA) was 0.020 and the standardized root mean square residual (SRMR) was 0.025

The observed variables had loading weights ranging from 0.54 to 0.76 and the covariates of the model of INPUT ranged from 29.00 to 58.00 percent.

4.1.2 Confirmatory Factors Analysis of Exogenous Variables of Organic Agriculture Standard (STD)

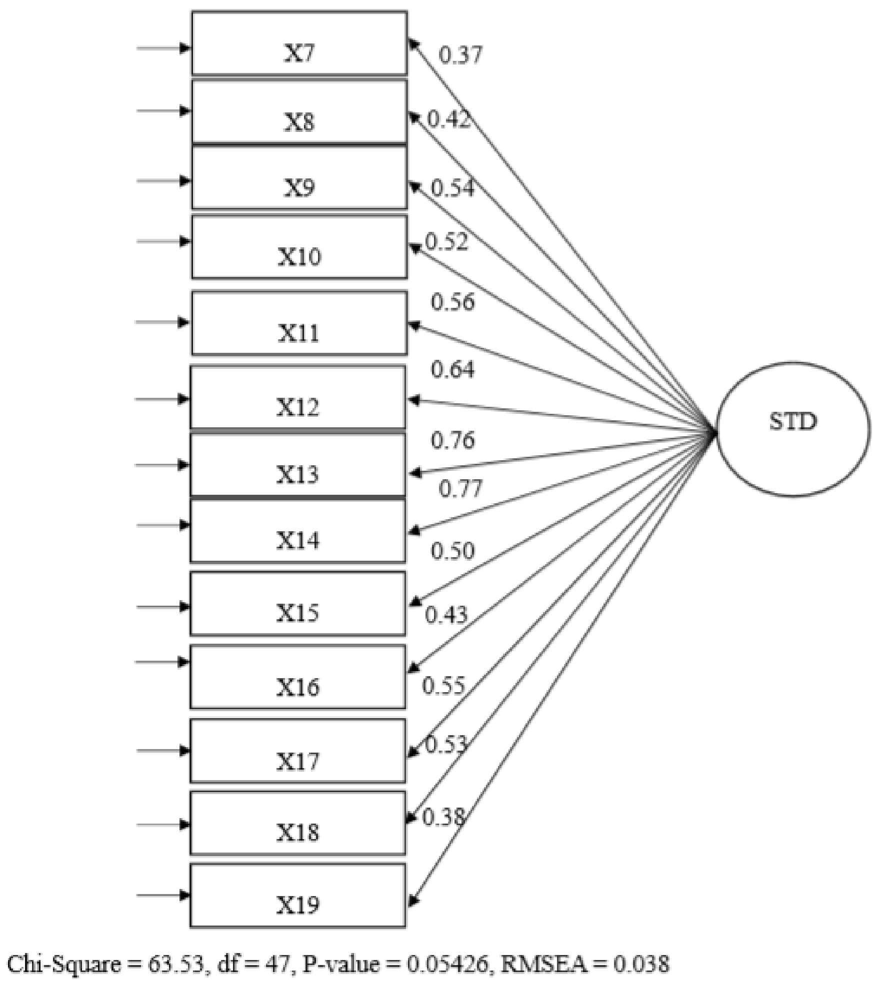

Figure 2. Model of confirmatory factors of organic agriculture standard

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Table 2. Results of analysis of confirmatory factors of organic agriculture standard

Components of Input	Weight	R^2
X7 Land	0.37	0.14
X8 Rice Varieties	0.42	0.18
X9 Seed	0.54	0.29
X10 Soil preparation	0.52	0.27
X11 Production	0.56	0.32
X12 Soil Management	0.64	0.41
X13 Weed control	0.76	0.57
X14 Prevention and Control of Disease, Insect and Weed	0.77	0.59
X15 Water Management	0.50	0.25
X16 Harvest Management	0.43	0.18
X17 Storage	0.55	0.30
X18 Processing	0.53	0.28
X19 Packaging and Labeling	0.38	0.14

Chi-Square = 63.53, df = 47, P-value = 0.05426

GFI = 0.96, AGFI = 0.93, RMSEA = 0.038, SRMR = 0.046

** significant at the 0.05 level

From Figure 2 and Table 2, results of analysis of confirmatory factors of STD from 13 observed variables revealed that the model was consistent with the empirical data as 1) the Chi-square value was not statistically significant at the 0.05 level and P=0.054, 2) GFI was 0.96 and AGFI was 0.93, and 3) RMSEA was 0.038 and SRMR was 0.046.

The observed variables had loading weights ranging from 0.37 to 0.77 and the covariates of the model of STD ranged from 14.00 to 59.00 percent.

4.1.3 Confirmatory Factors Analysis of Exogenous Variables of Supply Chain Risk (SCR)

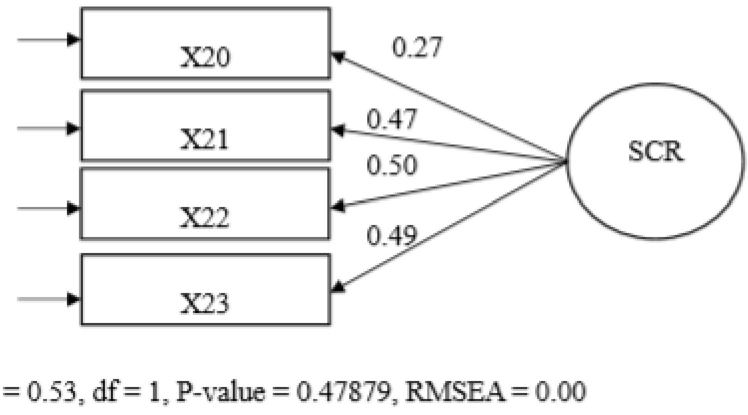

Figure 3. Model of confirmatory factors of supply chain risk

Table 3. Results of Analysis of Confirmatory Factors of Supply Chain Risk

Components of Input	Weight	R^2
X20 Source Risk	0.27	0.28
X21 Make Risk	0.47	0.68
X22 Deliver Risk	0.50	0.56
X23 Storage Risk	0.49	0.53

Chi-Square = 0.53, df = 1, P-value = 0.47879

GFI = 1.00, AGFI =0.99, RMSEA = 0.00, SRMR = 0.008

** significant at the 0.05 level

From Figure 3 and Table 3, results of analysis of confirmatory factors of SCR from four observed variables revealed that the model was consistent with the empirical data as 1) the Chi-Square value was not statistically significant at the 0.05 level and P=0.478, 2) GFI was 1.00 and AGFI was 0.99, and 3) RMSEA was 0.00 and SRMR was 0.008.

The observed variables had loading weights ranging from 0.27 to 0.50 and the covariates of the model of SCR ranged from 28.00 to 68.00 percent.

4.2 Analysis of Causal Relationship Model of Supply Chain Risk of Organic Rice in Thailand

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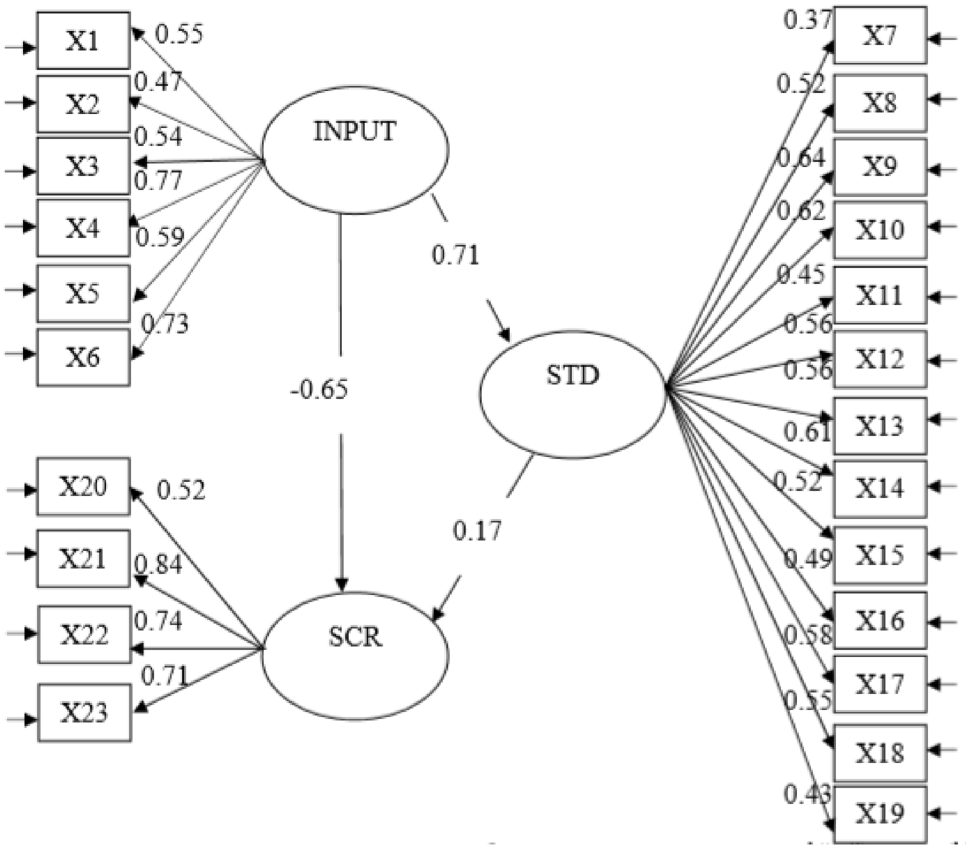

Figure 4. Causal relationship model of supply chain risk of organic rice in Thailand

Table 4. Influent Value Between Causal Variables and Result Variables

Causal Variables	Result Variables					
	STD			SCR		
	DE	IE	TE	DE	IE	TE
INPUT	0.71**	-	0.71**	-0.65**	0.12	-0.54**
STD	-	-	-	0.17	-	0.17

** significant at the 0.01 level, * significant at the 0.05 level

From Figure 4 and Table 4, it was revealed that the causal relationship model of Supply Chain Risk of Organic Rice in Thailand was consistent with the empirical data as 1) the Chi-square value was not statistically significant at the 0.05 level and P = 0.088, 2) GFI was 0.94 and AGFI was 0.90, 3) RMSEA was 0.025 and SRMR was 0.054. The model was composed of 23 observed variables and three latent variables. The latent variable of input was found to have a direct negative effect (-0.65) on SCR. Moreover, this variable had a direct positive effect (0.71) on organic agriculture standard. However, organic agriculture standard had no effect on SCR.

The following results were obtained regarding direct and indirect effects among variables in the model.

1). Input (INPUT) had a direct effect on organic agriculture standard (STD) (0.71) and SCR (-0.65) with statistical significance at the 0.01 level. Moreover, it also did not have an indirect effect on SCR as it was statistically significant at the 0.01 level.

2). Organic agriculture standard (STD) had no effect on SCR.

5. Conclusion

This paper investigated factors that influence the supply chain risk of organic rice in Thailand, specifically, the modern supply chain. This is more appropriate than the traditional supply chain, which comprises several members, such as the farmer, middleman, processor, wholesaler, retailer, and consumer. The data analysis consisted of confirmatory factor analysis and SEM. The model was composed of 23 observed variables and 3 latent variables: input, organic agriculture standard, and SCR. The causal relationship model was consistent with the empirical data.

The results revealed that the latent variable of input (INPUT) had a direct positive effect on organic agriculture standard (STD). This may be because when the factors of production were high, the standard of organic rice production was also high. Conversely, when the factors of production were low, the organic rice production was also low.

Additionally, input (INPUT) had a direct negative effect on SCR. This may be because when the factors of production were high, SCR was low. Similarly, when the factors of production were low, SCR was high. The factors of production had a negative influence on SCR with a coefficient of (-0.65).

Finally, SCR is an important consideration in operating a successful business. Accordingly, supply chain risk management can only decrease risk and improve performance by addressing the factors that influence supply chain risk, which, in this study, was input. Consequently, farmers should pay more attention to inputs, because they can minimize the risks and help improve the efficiency of the process. This is also in line with the study by Rostamzadeh and Sofian (2009), which suggests that all factors of production are affected by production efficiency. However, the organic agriculture standard should adopt a major role in the process, as it helps in upgrading products, building consumer confidence, and creating marketing opportunities.

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