Good Agricultural Practices and Coordination Strategies in Garlic Supply Chains

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Abstract

Garlic is one of the economic products cultivated in the northern region of Thailand, especially in the Chiang Mai and Mae Hong Son provinces. Currently, good agricultural practices (GAP) and supply chain coordination are the important mechanisms in which growers and other actors in the garlic supply chains share the same interest. Thus, many actors in the garlic supply chains have been attempting to find many appropriate practices or strategies to achieve their expectations in return. However, the practical intensive levels in GAP of each growers are different and the coordination strategies are accepted in some growers. Consequently, this paper aims to assess the GAP practical intensive levels and explores the best way in decision making on coordination strategy implementation by applying the game theory. The selected samples are GAP garlic growers in Chiang Mai and Mae Hong Son provinces for playing this game. The results showed that the strategy of horizontal coordination is among the GAP garlic growers as the cooperatives and the grower groups, and the vertical coordination is applied by making the contracts between the GAP garlic growers and buyers as the best choice of growers. It brings high economic payoffs and social utility. These findings are obviously useful for all scale GAP garlic growers in Thailand, such as small, medium and large scale growers, to make a decision for changing their production behaviors from private cultivation to cooperation, as well as not selling the GAP garlic products by themselves, but exploring on the partner contracts instead. However, the effective outcomes of strategy implementation lies within the trust of GAP garlic growers and buyers, and the same standardized control in the GAP garlic products.

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1. Introduction

Good Agricultural Practice (GAP) is the principle, regulation and technical recommendation for applying agricultural production, processing, and transportation, as well as focusing on improving the farmer's conditions, human health, and environment protection (Izquierdo et al., 2007). The idea of GAP is to provide benefits to the farmers and their families so that they will obtain healthy and good quality food, and generate added value into their products as they are sold in the markets. Moreover, the consumers will be satisfied in buying quality food that is safe to eat. Also, the general people will live in a much healthier environment.

In Thailand, GAP has been developed by the National Bureau of Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperatives to set the Thai agricultural standards for food crops such as fruits, vegetables, field crops, spices and herbs. It takes into account the environment, farmers' health, safety and welfare on every step of the farm and postharvest handling for obtaining safe quality product in consumption. This standard contains eight components which consist of 1) water usage, 2) planting area, 3) use of pesticides, 4) pre-harvest quality management, 5) harvest and postharvest handlings, 6) holding, moving produce in planting plot, and storage, 7) personal hygiene, and 8) record keeping and traceability (National Bureau of Agricultural Commodity and Food Standards, 2013). Nowadays, the cultivation of food crops that is abided by the GAP standard is increasing continuously, this is especially important in the economic food crops that include garlic, longan, and coffee.

Garlic is a crucial economic crop in the northern region of Thailand. The total planted areas in the crop year of 2017/18 are around 11,985.44 hectares. The highest quantity of cultivated areas is located in the provinces of Chiang Mai and Mae Hong Son (Office of Agricultural Economics, 2018). Although the garlics are highly grown in both areas, the planted cites have received

GAP certification that are approximately 626.44 hectares and 78.808 hectares, respectively (Department of Agriculture, 2018). This situation shows that there is a few proportion of successfulness in GAP garlic promotion. The supply chain coordination, in fact, is one of the important mechanisms in which the GAP growers and other actors in the GAP garlic supply chains share an interest to enhance their competitiveness. It is implemented as a tool for improving the overall performance of the supply chain in order to control the actors in the supply chain to behave as a unified system and be in coordination with each other (Arshinder et al., 2011). Supply chain coordination is classified into two perspectives. One is coordinating at the same level with at least two partners in the supply chain (horizontal coordination) while the other is coordinating in a different hierarchy of actors in the supply chain (vertical coordination) (Dries et al., 2009; Wilhelm, 2011; Agrell et al., 2017; Trifković, 2014). There are various supply chain coordination mechanisms which are adopted in the supply chain consisting of supply chain contracts (Henneta and Arda, 2008; Wong et al., 2009; Gramzow et al., 2018; Raj et al., 2018), information sharing (Ding et al., 2011; Safari and Soufi, 2014), and cooperatives (Nagarajan and Sosic, 2008; Ding et al., 2011; Agrell et al., 2017). In Chiang Mai and Mae Hong Son, the grower-buyer contract and grower cooperatives are the popular coordination patterns occurring in the GAP garlic supply chain. However, the coordination strategies are accepted with some growers. Some garlic growers in Chiang Mai and Mae Hong Son have been unsure in the coordination of GAP garlic supply chain. They have doubted the sustainability of GAP garlic markets by signing contracts, so they have to seek for the markets and sell their products by themselves. In addition, some GAP garlic growers have believed in doing things on their own rather than putting their trust with the grower groups or cooperatives because the practical intensive levels in GAP of each

grower have been different. Thus, many actors in the garlic supply chains have attempted to find appropriate practices or strategies to achieve their expectations in returns and disregarded the impacts of their operations on others.

Under the doubtfulness in using the strategy of the grower – buyer contracts signing and GAP garlic grower cooperatives participation, the popularly tool used for making the decision is the game theory (Henneta and Arda, 2008; Nagarajan and Sosic, 2008). Game theory is widely applied for solving the action of someone having an impact on another person. It is the reasonable mechanism in consideration on both economic payoffs and the interaction between participants (Nagarajan and Sosic, 2008). Furthermore, game theory has been defined as the mathematical theory of interactive decision situations game that is used to simulate the situation of the facts. In a strategic game, it is assumed that each player choose a strategy to maximize the payoff for himself. The player chooses a dominant strategy regardless of the choices made by the other players. In a two-person game with two choices for consideration, each player has two ways for making the decision: participating or avoiding. Thus, the two players have a possibility in making a four joint decisions (Wen and Fang, 2012; Safari and Soufi, 2014).

To address the doubtfulness and the distrust of the garlic growers in the GAP supply chain mentioned in above, this paper aims to assess the GAP practical intensive levels and explores the best decision making on coordination strategy implementation by applying the game theory. The contributions of this paper are beneficial for the GAP garlic growers in Thailand to make a decision between private and cooperative cultivation, as well as private and contract selling. The rest of this paper is structured as follows. Section two describes the research methodology. Section three represents the empirical results, and section four summarizes and discusses the study's findings.

2. Research Methodology

Game theory is applied for making the decision of GAP garlic growers to choose the competitive strategies. In this research, the game assumptions and models are set by following Lui et al. (2011) and the important data, such as prices, costs and demand quantities; these are determined by interviewing the purposive samples of 100 GAP garlic growers that are approved by Department of Agriculture and separated in equally proportion between Chiang Mai and Mae Hong Son areas, and 20 consumers (or buyers) that are sampled by using snowball sampling method. The interview information is collected by using semi-structured questionnaire consisting of the quantity of GAP garlic product, the GAP garlic price, the unit cost of GAP garlic production, the grower-buyer contracts, etc. In addition, the scenario method is employed for setting some unavailable data.

2.1 Game Assumptions

1) Because of the geographical agglomeration, the GAP garlic production manners of each research area in Chiang Mai and Mae Hong Son are similar in the same area and differ among the different areas. Therefore, there are only two players in the game, such as GAP garlic growers in Chiang Mai (C) and GAP garlic growers in Mae Hong Son (M), existing in the market. The purpose of the economic activity of two GAP garlic growers is to maximize their profits.

2) The supply chain coordination is defined as a strategic tool for increasing garlic supply chains potentiality. There are two supply chain coordination such as the horizontal coordination among the GAP garlic growers, known as the GAP garlic growers' cooperative, and the vertical coordination between the GAP garlic growers and buyers, known as the centralized supply chain with contracts. Thus, the two supply chain coordination are brought to create the four supply chain strategies consisting of cooperative grower with contracts in supply chain (s_1), cooperative grower without contracts in

supply chain (s_2), private grower with contracts in supply chain (s_3), and private grower without contracts in supply chain (s_4), which are expressed in Figure 1. These coordination strategies are used in game models for the GAP garlic grower competitions.

3) The GAP garlic prices were obtained by two garlic growers that are homogeneous in the same strategy used but various in other parts. The GAP garlic prices of supply chain with a grower – buyer contract are higher than the supply chain without a grower – buyer contract, of cooperative growers and of private grower, respectively. In terms of the unit costs, they are different between the strategy used and garlic planting areas.

GAP garlic supply chain coordination

		Grower - buyer contracts	No contracts between growers and buyers
GAP garlic growers' coordination	Cooperative	**Strategy 1** Cooperative grower with contracts in supply chain (s_1)	**Strategy 2** Cooperative grower without contracts in supply chain (s_2)
	Private	**Strategy 3** Private grower with contracts in supply chain (s_3)	**Strategy 4** Private grower without contracts in supply chain (s_4)

Figure 1. Coordination strategies used in game models.

4) The consumers (or buyers) have a relatively low awareness of GAP products because their markets are in the initial development, and the public relation of GAP product value is not widespread. Although these situations are the marketing obstacle of GAP garlic growers, they are able to break these barriers by using the supply chain coordination. Consequently, the demand quantities of GAP products having supply chain coordination, such as grower cooperation and supply chain contracts, are higher than the traditional GAP products consumption.

5) The GAP garlic growers in each area have the same characteristics and choose the same strategies, so the type of game is a simultaneous move game.

6) The game between the two GAP garlic growers is the one-stage static game of complete information. Accordingly, each player understands its own characteristics and utility but does not know the actions of the other player before making decisions.

2.2 Game Models

The GAP garlic growers' profit during the observed period is shown in equation (1).

$$\pi = pq - cq \qquad (1)$$

where q is the quantity of GAP garlic product, p is the GAP garlic price, and c is the unit cost of GAP garlic production.

From the assumption 1), the GAP garlic product quantities in the market are equal to the supply quantity of GAP garlic products of both growers. This is shown in equation (2) – (5).

$$q^{s_1} = q_C^{s_1} + q_M^{s_1} \qquad (2)$$

$$q^{s_2} = q_C^{s_2} + q_M^{s_2} \qquad (3)$$

$$q^{s_3} = q_C^{s_3} + q_M^{s_3} \qquad (4)$$

$$q^{s_4} = q_C^{s_4} + q_M^{s_4} \qquad (5)$$

The GAP garlic prices of supply chain with a grower – buyer contract are higher than the supply chain without a grower – buyer contract, as well as the prices of GAP garlic products of cooperative growers are higher than the private grower in the case of not having a supply chain contract. Thus, the formula represented in equation (6) is the following:

$$(p^{s_1} = p^{s_3}) > p^{s_2} > p^{s_4} \qquad (6)$$

According to the assumption 3), it means that:

$$p^{s_1} = p_C^{s_1} = p_M^{s_1} \qquad (7)$$

$$p^{s_2} = p_C^{s_2} = p_M^{s_2} \qquad (8)$$

$$p^{s_3} = p_C^{s_3} = p_M^{s_3} \qquad (9)$$

$$p^{s_4} = p_C^{s_4} = p_M^{s_4} \qquad (10)$$

$$c_C^{s_1} \neq c_M^{s_1} \qquad (11)$$

$$c_C^{s_2} \neq c_M^{s_2} \qquad (12)$$

$$c_C^{s_3} \neq c_M^{s_3} \qquad (13)$$

$$c_C^{s_4} \neq c_M^{s_4} \qquad (14)$$

In assumption 4), the demand of GAP garlic products having supply chain coordination is higher than the demand of non-strategy used products is shown in equation (15).

$$(q^{s_1} = q^{s_3}) > q^{s_2} > q^{s_4} \qquad (15)$$

2.3 Game Pay-off Matrix

The goal of profit maximization is used for the growers' decision-making. Thus, the game pay-off matrix of two coordination modes is shown in Table 1.

Table 1. Game pay-off matrix.

(Profits: Baht)

		GAP garlic growers (M)			
		s_1	s_2	s_3	s_4
GAP garlic growers (C)	s_1	$\pi_C^{s_1}\big|_{M\,:\,s_1}$, $\pi_M^{s_1}\big|_{C\,:\,s_1}$	$\pi_C^{s_1}\big|_{M\,:\,s_2}$, $\pi_M^{s_2}\big|_{C\,:\,s_1}$	$\pi_C^{s_1}\big|_{M\,:\,s_3}$, $\pi_M^{s_3}\big|_{C\,:\,s_1}$	$\pi_C^{s_1}\big|_{M\,:\,s_4}$, $\pi_M^{s_4}\big|_{C\,:\,s_1}$
	s_2	$\pi_C^{s_2}\big|_{M\,:\,s_1}$, $\pi_M^{s_1}\big|_{C\,:\,s_2}$	$\pi_C^{s_2}\big|_{M\,:\,s_2}$, $\pi_M^{s_2}\big|_{C\,:\,s_2}$	$\pi_C^{s_2}\big|_{M\,:\,s_3}$, $\pi_M^{s_3}\big|_{C\,:\,s_2}$	$\pi_C^{s_2}\big|_{M\,:\,s_4}$, $\pi_M^{s_4}\big|_{C\,:\,s_2}$
	s_3	$\pi_C^{s_3}\big|_{M\,:\,s_1}$, $\pi_M^{s_1}\big|_{C\,:\,s_3}$	$\pi_C^{s_3}\big|_{M\,:\,s_2}$, $\pi_M^{s_2}\big|_{C\,:\,s_3}$	$\pi_C^{s_3}\big|_{M\,:\,s_3}$, $\pi_M^{s_3}\big|_{C\,:\,s_3}$	$\pi_C^{s_3}\big|_{M\,:\,s_4}$, $\pi_M^{s_4}\big|_{C\,:\,s_3}$
	s_4	$\pi_C^{s_4}\big|_{M\,:\,s_1}$, $\pi_M^{s_1}\big|_{C\,:\,s_4}$	$\pi_C^{s_4}\big|_{M\,:\,s_2}$, $\pi_M^{s_2}\big|_{C\,:\,s_4}$	$\pi_C^{s_4}\big|_{M\,:\,s_3}$, $\pi_M^{s_3}\big|_{C\,:\,s_4}$	$\pi_C^{s_4}\big|_{M\,:\,s_4}$, $\pi_M^{s_4}\big|_{C\,:\,s_4}$

Note: s_1 refers the strategy of cooperative grower with contracts in supply chain, s_2 refers the strategy of cooperative grower without contracts in supply chain, s_3 refers the strategy of private grower with contracts in supply chain, and s_4 refers the strategy of private grower without contracts in supply chain.

2.4 Dominant Strategy Equilibrium, Nash Equilibrium, and Pareto Optimality

The most important question in the game is about the balance point of the game. The proper behavior of competitors in equilibrium is expressed by the strategy use of each player that is best responded to other players' strategies. In the face of the competitor decision, the player should choose the strategy which brings the most payoffs for him. For solving this question, the principle of rationality is used. According to this principle, the strategy whose choice in the face of every single competitors' strategy, brings most payoffs for the player, is known as the *dominant strategy* (Mohtadi and Nogondarian, 2015). *Dominant strategy* is a strategy for player that is a best response to all strategy profiles

of other players (Varian, 2010). For each player i (where $i = C, M$), let S_i denote all possible strategies for player i. So, s_i will always refer to a strategy in S_i of player i, $s_i \in S_i$, and s_{-i} denote a strategy in S_{-i} of other players, $s_{-i} \in S_{-i}$. A strategy profile is a 4-tuple, $S = (s_1, s_2, s_3, s_4)$. Each player can choose only one strategy of a strategy profile. In terms of the utility of S, $U_i(S)$, is the payoff for player i if the strategy profile is S. Thus, s_i is a strictly dominant strategy if s_i strictly dominates every other strategy, s_i', of player i that is expressed in equation (16).

$$U_i(s_i, s_{-i}) > U_i(s_i', s_{-i}), \qquad \text{for}$$
$$\forall s_i \neq s_i', \quad \forall s_{-i} \in S_{-i} \qquad (16)$$

On the other hand, s_i weakly dominates s_i' if

player i never does worse with s_i than $s_i{}'$, and there is at least one case where player i does better with s_i than $s_i{}'$ that is shown in equation (17).

$$U_i(s_i, s_{-i}) \geq U_i(s_i', s_{-i}), \quad \text{for}$$

$$\forall s_i \neq s_i', \quad \forall s_{-i} \in S_{-i} \qquad (17)$$

According to a strategy profile, $S = (s_1, s_2, s_3, s_4)$, S is a strictly dominant-strategy equilibrium if, for every player i, s_i is a strictly dominant strategy, as well as S is a weakly dominant-strategy equilibrium if, for every player i, s_i is a weakly dominant strategy and, furthermore, for at least other player, s_{-i} is not a strictly dominant strategy (Bonanno, 2018). In the dominant strategy equilibrium, player i will do best by using s_i rather than a different strategy, regardless of what strategies the other players use. Such a strategy is called a best response.

Considering the *Nash equilibrium*, it associates with the strategic choices that, once made, provide no incentives for the players to alter their behavior further. A Nash equilibrium is a strategy for each player that is the best choice for each player given the others' equilibrium strategies. Nash equilibrium can be defined very simply in terms of best responses (Nicholson and Snyder, 2008). From a strategy profile $S = (s_1, s_2, s_3, s_4)$, S is a Nash equilibrium if, for every i, s_i is a best response to S_{-i}, that is no player can do better by unilaterally changing his strategy. In terms of the Nash equilibrium theorem mentioned in Nash (1951), every game with a finite number of agents and action profiles has at least one Nash equilibrium and a dominant strategy equilibrium is always a Nash equilibrium.

The concept of the Nash equilibrium is closely linked to the concept of *Pareto optimality*. If two or more players are playing strategies such that (a) no other mixed strategies could increase at least one player's utility, and (b) without decreasing the payoffs of other players, then the outcome of game is said to be Pareto efficient. In Pareto optimal, a strategy profile S dominates a strategy profile S' if no player gets a worse payoff with S than with S', i.e., $U_i(S) \geq U_i(S')$ for all i, and at least one player gets a better payoff with S than with S' , i.e., $U_i(S) > U_i(S')$ for at least one i. In other words, a strategy s is Pareto optimal, or strictly Pareto efficient, if there's no strategy s' that dominates s. Consequently, every game has at least one Pareto optimal profile and always at least one Pareto optimal profile in which the strategies are pure. However, it is not guaranteed that a Nash equilibrium is Pareto optimality (Varian, 2010; Madani, 2010).

3. Empirical Results

The results of good agricultural practices and coordination strategies in the garlic supply chains are represented in three issues such as the practical intensive level of GAP of garlic production in the provinces of Chiang Mai and Mae Hong Son, the coordination in GAP garlic supply chains, and the economic costs and benefits of GAP garlic production under the supply chain coordination.

3.1 Good Agricultural Practices of Garlic Production in Chiang Mai and Mae Hong Son Provinces

The practical intensive levels of GAP of garlic production in the provinces of Chiang Mai and Mae Hong Son are assessed by using the eight criterions of the National Bureau of Agricultural Commodity and Food Standards, Ministry of Agriculture and Cooperatives which consisted of the water usage, planting area, use of pesticides, pre-harvest quality management, harvest and postharvest handlings, holding, moving produce in the planting plot, and storage, personal hygiene, and record keeping and traceability. The five-point Likert Scale is used to allow the growers to express how much they very low or very high intensity practice with a particular GAP principle statement. The results in Table 2 show that the garlic growers in Chiang Mai and Mae Hong Son give priority to the practices on soil management dealing with

contamination prevention and the use of chemicals in the production that has been abided by the Department of Agriculture recommendation in the high level. Whereas the practices on using the safe water sources in production and postharvest are not sufficiently monitored, the implementation and management of production control plan of the storage sites and vehicles are clean, well ventilated, and able to prevent contamination and contagion, and the personal hygiene knowledge and understanding of farmers and workers are in the moderate level. However, the data record about the use of agricultural hazardous substances, pest control and quality output management, harvesting in the proper period, usage of clean harvesting equipment, and packaging are in the low intensive level of growers' practices. These latter dimensions are the crucial issues of garlic growers which should be supported and encouraged for adopting better practices.

Table 2. Good agricultural practices in garlic production.

Dimension	Good Agricultural Practice	Practical Intensive Level
Water usage	• Water used in planting area and for postharvest practices come from the environmental sources that do not cause contamination of hazardous substances on produce.	Moderate
Planting area	• Planting areas are not to be located in the environment causing contamination of hazardous substances on produce, and usually manage the soil dealing with contamination prevention.	High
Use of pesticides	• The use of pesticides in the production abides by the Department of Agriculture (DOA) recommendation or instruction on the label registered with the DOA.	High
Pre-harvest quality management	• There is the implementation and management of the production control plans, list and record on production inputs and their sources, sufficient and appropriate agricultural tools and equipment for operations, management of production steps, and management of disposal of waste and unused or irrelevant production materials.	Moderate
Harvest and postharvest handling	• The yields are harvested in the proper period and the equipment, containers and materials are directly contacted with produce made of materials that do not cause contamination.	Low
Holding, moving produce in planting plot, and storage	• Storage sites and vehicles are clean, well ventilated, and able to prevent contamination and contagion.	Moderate
Personal hygiene	• Farmers and workers have the knowledge and understanding or receive personal hygiene training in order to work hygienically and apply the know-how related to GAP.	Moderate
Record keeping and traceability	• There are data records about the use of agricultural hazardous substances, pest control,	Low

Dimension	Good Agricultural Practice	Practical Intensive Level
	and quality output management, and traceability and verification systems.	

Source: From author analysis.

3.2 Coordination in GAP Garlic Supply Chains

The coordination in GAP garlic supply chains in the research areas reveals two crystal clear patterns (shown in Figure 2), namely the horizontal coordination among the GAP garlic growers, and the vertical coordination between the GAP garlic growers and buyers by using contracts.

The horizontal coordination occurring in the research areas is the cooperation among the GAP garlic growers that include the cooperatives and the grower groups. The objectives of GAP garlic grower cooperation are to control the yield standard, reduce the production costs, and increase the marketing and competitive opportunities. Moreover, the horizontal coordination among the GAP garlic growers induce the government agencies such as the Department of Internal Trade, Office of Commercial Affairs, etc., and the relevant private agencies to promote and link the networks of private companies for purchasing the GAP garlic yields in the harvest seasons. The outcomes of this coordination bring about a rise in the price of GAP garlics around 1-3 times that calculated by using the contracts price of GAP garlic and the price of GAP garlic of private grower without contracts obtained from interviewing.
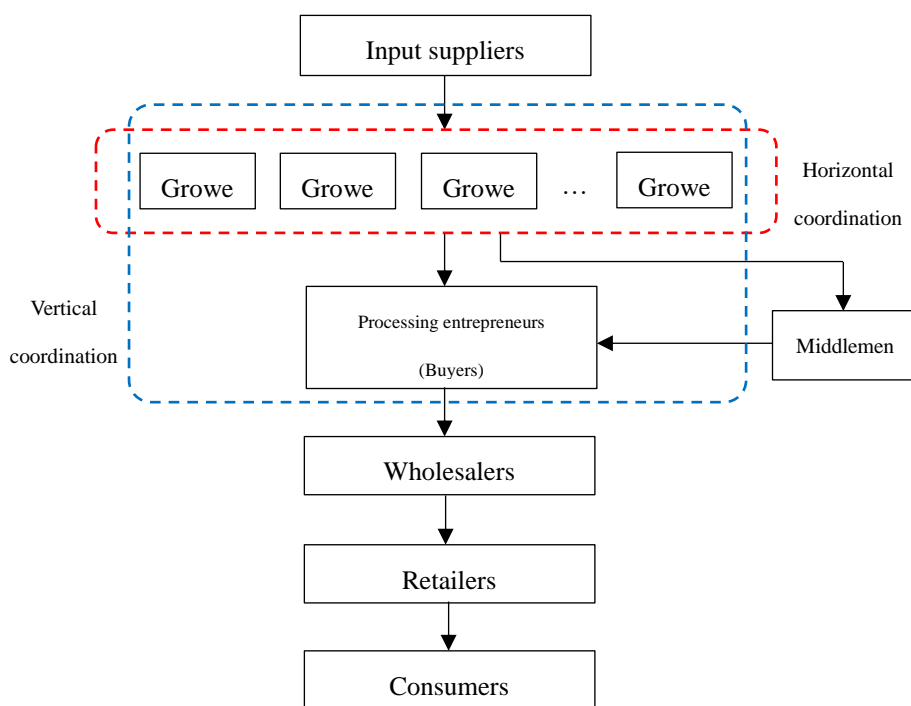

Figure 2. The coordination form in GAP garlic supply chain.

In terms of the vertical coordination, the results represent that there are contracts between the GAP garlic growers and buyers. These contracts are a project promoted by the Department of Internal Trade, Ministry of Commerce which aims to solve the problem of low prices of garlic and to guarantee the products' prices and quantities for the GAP garlic growers. The major conditions/criterions of contracts are 1) the specific production areas only in Chiang Mai and Mae Hong Son, 2) the quality and standard of product features and sizes such as perfect shapes, complete garlic peels, more than 3 centimeters in diameter of garlic head, etc., 3) the packaging sizes of 10 or 40 kilograms per sack, 4) the definite purchasing prices, 5) the exact purchasing quantities, 6) the determination of payment, and 7) one year contract period (Department of Internal Trade, Ministry of Commerce, 2018a, 2018b).

Considering the ratios of the GAP garlic growers concerning with the horizontal and vertical coordination in GAP garlic supply chains, the results in Table 3 show that 36.00% of GAP garlic growers in Chiang Mai province (*C*) join in cooperative and have grower-buyer contracts whereas 30.00%, 18.00%, and 16.00% only have grower-buyer contracts, only participate in cooperative, and private producers, respectively. To explore the coordination of GAP garlic growers in Mae Hong Son province (*M*), the findings display that they join in cooperative and have grower-buyer contracts at around 50.00%. On the contrary, they privately produce and sell at approximately 12.00%.

Table 3. Horizontal and vertical coordination in GAP garlic supply chains.

(Unit: Percentage)

			Vertical coordination	
			Grower-buyer contracts	No contracts
Horizontal coordination	GAP garlic growers in Chiang Mai (*C*)	Cooperative	36.00	18.00
		Private	30.00	16.00
	GAP garlic growers in Mae Hong Son (*M*)	Cooperative	50.00	22.00
		Private	16.00	12.00

Source: From calculation.

3.3 Economic Costs and Benefits of GAP Garlic Production under Supply Chain Coordination

Based on the interviews with the grower and buyer, the result represented that the contract price of GAP garlic (65 Baht/kg for GAP garlic growers in Chiang Mai, and 80 Baht/kg for GAP garlic growers in Mae Hong Son) is higher than the price of GAP garlic of cooperative growers without a contract (50 Baht/kg for both growers) and the price of GAP garlic of private growers without a contract (30 Baht/kg for GAP garlic growers in Chiang Mai, and 25 Baht/kg for GAP garlic growers in Mae Hong Son), approximate 30 – 60% and 117 – 220%, respectively. In view of the unit costs of GAP garlic production, the result shows the different cost between GAP garlic grower in Chiang Mai and Mae Hong Son. The economic costs and benefits of GAP garlic productions of each player are displayed in Table 4.

Table 4. Economic costs and benefits of GAP garlic productions.

(Unit: Baht/kg.)

Economic costs and benefits	GAP garlic grower (C)	GAP garlic grower (M)
Contract price of GAP garlic	65	80
Price of GAP garlic of cooperative grower without contracts	50	50
Price of GAP garlic of private grower without contracts	30	25
Unit cost	25	20

Source: From interview and calculation.

3.4 Games of the Two GAP Garlic Growers

In terms of the demand quantity, the findings from the grower and buyer interviews stated that the paired proportions of demand quantities of GAP garlic products with a contract is lower than without a contract (40 : 60) whereas the paired proportions of demand quantities of GAP garlic products from cooperative growers is higher than from private growers (80 : 20). Moreover, the paired proportion of same mode of strategy used among the two players is 0.5: 0.5. These proportions are separated by the coordination strategies, which is shown in Table 5.

Table 5. Proportions of GAP garlic demand among the coordination strategies.

(Unit: Percentage)

		GAP garlic grower (M)			
		Strategy s_1	Strategy s_2	Strategy s_3	Strategy s_4
GAP garlic grower (C)	Strategy s_1	50 : 50	46 : 54	67 : 33	60 : 40
	Strategy s_2	54 : 46	50 : 50	70 : 30	64: 36
	Strategy s_3	33 : 67	30 : 70	50 : 50	43 : 57
	Strategy s_4	40 : 60	36 : 64	57 : 43	50 : 50

Source: From interview and calculation.

The data in Table 4 and Table 5 are used for calculating the profits per kilogram of two GAP garlic growers, and is represented in Table 6.

Table 6. Pay-off matrix of two GAP garlic growers.
Pay-off: Profits

(Unit: Baht per kilogram)

		GAP garlic grower (M)			
		Strategy s_1	Strategy s_2	Strategy s_3	Strategy s_4
GAP garlic grower (C)	Strategy s_1	20.00 , 30.00	18.40 , 16.20	26.80 , 19.80	24.00 , 2.00
	Strategy s_2	13.50 , 27.60	12.50 , 15.00	17.50 , 18.00	16.00 , 1.80
	Strategy s_3	13.20 , 40.20	12.00 , 21.00	20.00 , 30.00	17.20 , 2.85
	Strategy s_4	2.00 , 36.00	1.80 , 19.20	2.85 , 25.80	2.50 , 2.50

Source: From calculation.

Under the coordination strategies in Table 6, whether the GAP garlic grower in the Mae Hon Son province (M) choose the strategy of cooperative and contracts in supply chain or not, the GAP garlic grower in the Chiang Mai province (C) will always choose the

strategy of a cooperative grower with a contract in the supply chain. Similarly, the GAP garlic grower in the Mae Hon Son province (M) will select the strategy of cooperative growers with a contract in supply whether the GAP garlic grower in the Chiang Mai province (C) will choose it or not. This game represents the Nash Equilibrium and GAP garlic grower in both areas that will implement the horizontal coordination among the GAP garlic growers, and the vertical coordination between the GAP garlic growers and buyers by using contracts for maximizing their profits as well as enhancing social utility.

4. Discussion and Conclusion

For strengthening the GAP garlic production and seeking the marketing opportunities and competitiveness, the horizontal and vertical coordination in GAP garlic supply chains become the crucial manners for the growers. However, these means are accepted in some GAP garlic growers. Consequently, this paper explores the best decision making on participating in cooperatives or private productions, and signing the contracts or not by applying the game theory. The selected samples are the GAP garlic growers in the provinces of Chiang Mai and Mae Hong Son for participating in this game.

The results showed that there is a horizontal coordination among the GAP garlic growers as the cooperatives and the grower groups, and there is a vertical coordination by making the contracts between the GAP garlic growers and buyers which had brought about an increase in yield prices, as well as exacting the purchasing quantities of garlic products. Consequently, the coordination is confirmed by this research as an appropriate strategic tool for the GAP garlic growers to earn the maximized profit and contribute in social utility maximization. Although the coordination is the potential tool in the GAP garlic supply chains, the effective outcomes of strategy implementation depend on the trust of GAP garlic growers and buyers. This

opinion is according to the study of Dries et al. (2009), Pezeshki et al. (2013), Aji (2016), Halil et al. (2016), Singh and Teng (2016), Agrell et al. (2017), Meqdadi et al. (2017), Gramzow et al. (2018) who have mentioned that first of all both growers and buyers must have a coordination consciousness amongst themselves so that it creates an establishment of reputation for honesty and fair dealing. The garlic growers and the buyers should think about themselves as partners who are working together rather than being rivals in the market. Moreover, both sides also need each other in order to make a contractual relationship that operates on a mutual benefit.

In addition, maintaining product quality and standard control system are important for an effective coordination strategy implementation as mentioned in Trifković (2014) and Gramzow et al. (2018). In Fact, the GAP practical intensive levels of each farmer are different, especially the dimensions of the data record about the use of agricultural hazardous substances, the pest control and quality output management, harvesting in the proper period, using clean harvesting equipment and packaging. These factors may lead to the inequity of product qualities. Thus, the quality control mechanisms are necessary for having the same standardizing procedures in being aligned with the GAP garlic products.

The research summaries mentioned above show that the coordination strategies contribute the benefits for the growers and cooperatives in GAP garlic supply chain in terms of achieve a maximizing profit. Therefore, from the findings of this research, the policy recommendations of GAP garlic supply chain coordination for Chiang Mai and Mae Hong Son areas are established in three steps, how to prepare the GAP garlic growers for operating under the coordination, how to construct the coordination, and how to maintain the supply chain coordination in the long term. In the first step, the preparation of the GAP garlic growers is initially done by building the trust and relationships among the

growers and stakeholders in the supply chain and then establishing the coordination, choosing the strong leaders, and providing the correct information. For the second step, the coordination is constructed by making a mutual agreement. The last step concerns about the sustainability of GAP garlic supply chain coordination consisting of the continually building of strong relationships or cluster among the growers and the relevant institutions, e.g. local authorities, educational institutions, and private organizations, etc., especially the knowledge and information sharing, the development of GAP garlic quality in accordance with market demand, etc. Moreover, the relevant agencies can bring the results as the guidelines for promoting agricultural coordination in other areas.

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