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Improving Salt Farmer's Bargain Power through Demand Allocation and Profit Sharing: A Cooperative Game Approach

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Abstract. Oligopoly has remained a serious problematic market structure in the Indonesian salt supply chain, which exterminates the bargaining power of farmers. To eradicate the problem, a hybrid collaboration structures, i.e., vertical collaboration (farmers with cooperatives) and horizontal collaboration (farmers with farmers), are proposed, enabling to bring positive economic impacts to farmers. This novel supply chain-system model follows the cooperative game theory with Shapley's value for decision-making process. This work aimed to evaluate the implementation of the two partnership models for the supply chain of salt regarding their impacts on economic benefits for farmers assessed by Shapley's value of coalitions. The constructed model revealed that collaborative works between salt stakeholders improved farmers' revenue, and the optimum benefit was achieved by farmers when their supply (≤20%) was purchased by cooperatives, while the remaining was bought by middlemen. In this regard, the significant capacity of the cooperative should be invigorated in various sectors, including saving and loan services, market seekers, salt price making, and improvement of salt quality. Although farmers-to-farmers collaboration also bring mutual benefits, additional attempts by cooperatives, especially for small farmers, can be created to nurture a partnership between cooperatives and farmers, enabling them to generate more benefits.

Keywords: Cooperative game; Horizontal collaboration; Revenue; Shapley value; Vertical collaboration

1. Introduction

Salt has become a pivotal food component for human consumption. In Indonesia, salt development is hindered by factors such as low salt quality, inadequate salt production, price uncertainty, and a complicated supply chain. The main problem of the Indonesian salt supply chain relates to inefficiency and imperfect competition market (oligopoly) (Mustofa *et al.*, 2021). The form of the oligopoly market is likely to be dominated by one of the actors, namely middlemen. The middlemen act as collection agents, purchasers, intermediaries and retailers. Domination of the middlemen includes the ability to control the price and quality of the product (Biglaiser and Li, 2018). Farmers only act as price recipients (Chandra and Sao, 2020) because they have limited market price information, making it difficult to

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bargain with middlemen (Mustofa *et al.*, 2021).

From 2016 to 2019, salt prices ranged $0.01 to $0.06 per kilogram (Suhendi, Abdullah, Shalihati, 2020). Farmers should get at least $0.06 per kilogram to cover production costs. The government regulates prices, but it is ineffective due to the role of intermediaries. In addition, the government needs to hold the number of salt imports and supply chain systems by increasing productivity. This effort is to increase income by improving the bargaining ability of farmers. The salt supply chain can be enhanced by involving cooperatives to increase farmers' revenue (Mustofa *et al.*, 2021).

Research on the salt supply chain have been approached using qualitative and quantitative approaches such as margin share methods (Rinardi and Rochwulaningsih, 2017), SWOT analysis (Holis, Sayyidi, and Musoffan, 2019), system dynamics (Muhandhis *et al.*, 2021), and SCOR approach (Purnanto, Suadi, and Ustadi, 2020). Unfortunately, those methods are unable to discuss a collaborative model of the salt supply system. This drawback can be solved by other approaches, such as game theory, which enables to overview of the collaborations aiming to increase farmer's revenue. The method can formulate and analyze competitive situations and conflicts implicating more than one player with disparate goals (Maschler, Solan, and Zamir, 2013). Determination of options for the supply chain system for agricultural products (Prasad, Shankar, and Roy, 2019) and allocation of product supply (Bonamini *et al.*, 2019) using the game theory. Game theory can be applied to agricultural products in various ways. For instance, it can use a single pricing strategy or a two-stage pricing strategy for products in the chain of two echelons - suppliers and retailers (Chen *et al.*, 2018). Additionally, game theory can also be used to determine the coordination approach between farmers and traders while accounting for uncertainties like harvesting yields and demand (Behzadi *et al.*, 2018; Gao, Yang, and Liu, 2017).

This study applies coalition game theory and transferable utility concepts using cooperative games. Coalition members are assumed to agree on the price and amount of payoff among the members (Maschler, Solan, and Zamir, 2013). The coalition in the salt supply-chain model involves a cooperative as one of the key elements in the system. In this regard, a cooperative has the functions of facilitating salt farmers to improve their revenue. Moreover, farmers, middlemen, and cooperatives have different interests. Implementing vertical (farmers with cooperative) and horizontal (farmers with farmers) collaboration systems is expected to improve the salt supply chain. Vertical collaboration is a partnership between farmers and cooperatives to reduce the role of the middlemen (Zhong *et al.*, 2018). In addition, a horizontal collaboration between farmers and farmers is also able to increase revenue (Martins, Trienekens, and Omta, 2019). This work aimed to evaluate the implementation of horizontal and vertical collaboration models regarding their impacts on farmers' revenue based on the Shapley value obtained from the salt supply chain coalition.

2. Methods

2.1. Cooperative Game Theory

Shapley's value is used to determine the optimal solution in cooperative game theory. Each participant's final result in the game focuses on the acquisition in the cooperative game. The coalition is an agreement of the N player set based on the game's mathematical model and is represented by the symbol S (Brown and Shoham, 2008). A grand coalition is an agreement of all players (n players) without an empty coalition with a 2n possible alliance. The structure coalition is how the player forms a coalition where a set of S = (S1, S2, ..., Sm) of the m coalition is built. Some definitions of the Shapley value concept in cooperative game theory are as follows:

Definition 1 The transferable utility used in coalition games (N,v) consists of: (1) a set of N players; (2) the characteristic function of the game v(S) is the total coalition available to all members of S of N players, which N is the set for each player, for i = 1, 2, ..., n. $x = (x_1, x_2, \ldots, x_n)$ $x_1 + x_2 + x_3 + x_4 + x_5 = v(N) x_1 \geq v(i)$. The grand coalition is the N set and not the empty set $\emptyset$. Model $v(S) + v(T) \leq v(S \cup T)$, for all S and T where $S \cap T = \emptyset$. The concept of cooperative games is a **super additive** ($S \cap T = \emptyset$) where the acquisition of coalition results must be greater or equal to non-coalition income (Brown & Shoham, 2008).

Definition 2 (Brown & Shoham, 2008): The axiomatic method is used to obtain Shapley values, including game values v with n-vector, which must meet the following requirements: $\varphi_i(v)$ if xx is the xx carrier, then $\sum_S \varphi(v) = v(S)$, for each permutation π^{**}, ei $\in N$; $\varphi_{\pi(i)} \pi v = \varphi_i v$; if u and v are two games: $\varphi_i u| + v = \varphi_i u| + \varphi_i v|$, then Shapley's value $\varphi_i(N, v) = \frac{1}{|N|!} \sum_{S \subseteq N} (s-1)! ([N] - s)! (v(S) - v(S \setminus \{[i]\}))$, with the number of players in the S,∀i $\in N$ Each player has 2n-1 possible coalition forms. Player *i* revenue from a coalition is called the payoff value, so the value of the player's contribution is $(N, v) \varphi(N, v) = (\varphi_i(N, v))_{i \epsilon N} \sum_{i \in N} \varphi_i(N, v) = v(N) \Delta_i(S) = v(S) - v(S(j))$ i to the S coalition.

Definition 3 (Brown & Shoham, 2008): The dummy player *i* in (N, v) if $v(S) - v(s\{i\}) = v(\{i\})$ for each coalition S with *i*.

Definition 4 (Brown & Shoham, 2008): Shapley's axiom and characteristic function. When players *i* and *j* are exchangeable on (N, v), if $v(S\{i\}) = v(S\{j\}), \forall S \subseteq N$, some of the axiom used are (1) **symmetry**: If *i* and *j* are exchangeable in (N, v), then, $\varphi_i(N, v) = \varphi_j(N, v)$; (2) **dummy**: If *i* is a dummy player in (N, v), then, $\varphi_i(N, v) = v(\{i\})$; and (3) **additivity**: If there are two games *v* and *w*, then, $\varphi_i(v + w) = \varphi_i(v) + \varphi_i(w)$ for every, *i* ϵ N, where $(v + w)(S) = v(S) + w(S), \forall S \subset \subseteq N$.

2.2. Model Formulation

Vertical and horizontal collaboration model is used to solve the salt supply chain problem. The stakeholders involved in this coalition are farmers, middlemen, and cooperatives (Figure 1). Farmers, as members, are obliged to sell a certain amount of salt through cooperatives.

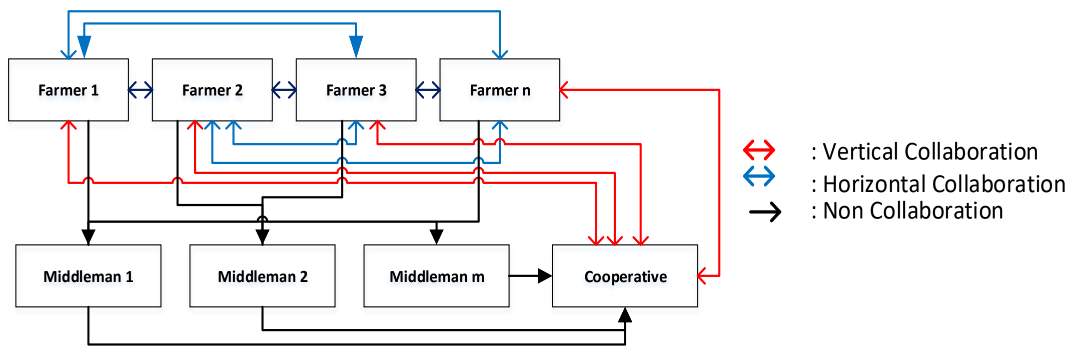


Figure 1 The Salt Supply Chain Coalition Model

The research used six players (farmers 1, 2, 3, 4, 5, and 6). The characteristic function as follows: $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = v\{1,2,3,4,5,6\}$ where $x_1 \geq v(1)$; $x_2 \geq v(2)$; $x_3 \geq v(3)$; $x_4 \geq v(4)$; $x_5 \geq v(5)$; $x_6 \geq v(6)$. The Shapley values were $x^* = x = (x_1^*, x_2^*, x_3^*, x_4^*, x_5^*, x_6^*)$.

The Shapley value was determined using a selling scenario in which salt was sold based on the farmer's minimum obligation as cooperative members and the rest is sold through middlemen. As cooperative members, farmers are required to sell salt for at least

10% of the total production through the cooperative. The scenarios for selling salt from farmers to middlemen 1, middlemen 2, middlemen 3 and cooperatives are: scenario 1 (30%, 40%, 20%, and 10%); scenario 2 (30%, 30%, 20%, and 20%); scenario 3 (25%, 25%, 25%, and 25%); Scenario 4 (40%, 20%, 10%, and 30%); Scenario 5 (10%, 30%, 20%, and 40%); and Scenario 6 (20%, 10%, 10%, and 60%).

2.3. Construction of Shapley Value Salt Coalition Model

The model illustrates the average contribution of six farmer coalition members {1, 2, 3, 4, 5, 6} in all possible steps. Moreover, the player revenue is used for Shapley value calculations. The salt supply chain channel will determine the amount of farmer revenue. Members of the salt supply chain are i^{th} farmer (i=1,2, ..., n), j^{th} middleman (j=1, 2. ..., m), and k^{th} cooperatives (k=1, 2, ..., h), while the salt supply and salt price in the intermediary depend on t^{th} time (t = 1.2, ..., l). In addition, the salt demand middlemen j at the time t (Da_{jt}) and cooperative k at the time t (qb_{kit}). The price offered by each middleman j to the farmer i at time t is different (pa_{jit}), the price offered by the cooperative k to all i farmers at the time t (pb_{kit}), and the salt price in the market at the time t (pm_t).

Middleman revenue is obtained from the sale of salt by seeing the negotiation cost (Ca), and salt carrying capacity (G). The formula of the middleman's revenue j (πa_{jt}) at time t is shown in Equation 1.

$$\pi a_{jt} = \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m}(pm_t - pa_{jit})min(qa_{ijt}, Da_{jt}) - Ca\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m}\frac{min(qa_{ijt},Da_{jt})}{G} \quad (1)$$

The cooperative's revenue is revenue from procuring salt from farmers i and benefits distribution $(1-\beta)$. The membership fee of the cooperative is Cm_i, the supply chain channel through cooperatives has market unpredictability risk (Hao *et al.*, 2018), and the negotiation costs (Cb), and salt carrying capacity (G) are allocated to the farmers at $\left(\frac{(1-\vartheta)}{2}\right)$. The formula of the cooperative revenue k at the time t (πb_{kt}) defined in Equation 2.

$$\pi b_{kt} = \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}(pm_t - pb_{kt}) * min(qb_{kit}, Db_{kt})\right) + \left(1 - \beta\right)\sum_{t=1}^{l}\sum_{i=1}^{n} qb_{kit} * (pm_t - pb_{kt})\Big) + \sum_{i=1}^{n}\sum_{t=1}^{l} Cm_{it} - \left(\left(\frac{(1-\vartheta)}{2}\right)\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}((pm_t - pb_{kt})) * min(qb_{kit}, Db_{kt})\right) - Cb\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(\frac{min(qb_{kit},Db_{kt})}{G}\right) \quad (2)$$

The formula of farmer i revenue at time t (π_{fit}) is the middlemen j revenue and cooperatives k revenue. Farmer i must become delegates cooperatives to achieve a vertical collaboration system. Furthermore, the supply farmer i through middlemen j at time t (qa_{jit}), and cooperatives k at time t (qb_{kit}). The cooperative and farmer I collaborates have to bear half of the percent real risks (ϑ), the negotiation fee (C), the membership fee (Cm_{it}), and receive a benefit distribution (β).

There are three types of farmer's revenue based on a horizontal collaboration, namely:

(i) Farmers only sell salt according to the supply produced $(\boldsymbol{S_{it} \leq Da_{jt} + Db_{kt}})$

The farmer's revenue is obtained from the salt supply through middlemen j and cooperative k, so the farmer i revenue at time t (π_{fit}) is explained in Equation 3.

$$\pi_{fit} = \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m} pa_{jit} * min(qa_{jit}, Da_{jt})\right) + \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h} pb_{kt} * min(qb_{kit}, Db_{kt})\right) + \beta\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(qb_{kit} * (pm_t - pb_{kt})\right) - \quad (3)$$

$$\left(Cb * \left(\frac{min(qb_{kit},Db_{kt})}{G}\right)\right) - \left(C \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(\frac{qb_{kit}}{G}\right)\right) - \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(\frac{(1-\vartheta)}{2}(pm_t - p_{bkt})\right) min(qb_{kit}, Db_{kt})\right) - \sum_{i=1}^{n}\sum_{t=1}^{l} Cm_{it}$$

(ii) The farmers who buy salt from other farmers

Farmers receive revenue through middlemen *j*, and cooperatives *k*, and part of the profits are shared from cooperatives. However, farmers, *i* have to pay for a certain amount of salt purchased from other farmers. Therefore, the formula of farmer *i* revenue at time *t* (π_{fit}) defined in Equation 4.

$$\pi_{fit} = \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m} pa_{jit} * min(qa_{jit}, Da_{jt})\right) + \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h} pb_{kt} * min(qb_{kit}, Db_{kt})\right) - \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(\frac{(1-\vartheta)}{2} min(pm_t - p_{bt})\right) * min(qb_{it}, Db_{kt})\right) + \left(\beta \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}(qb_{kit} * (pm_t - pb_{kt})) - \left(Cb * \left(\frac{min(qb_{kit},Db_{kt})}{G}\right)\right)\right) - \left(C \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(\frac{qb_{kit}}{G}\right)\right) - \left(\boldsymbol{r} \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m} min\,(pa_{jit}) * (S_{it} - qa_{jit})\right) + \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m} \min\,(pa_{jit}) * min(S_{it} - qa_{jit}, Da_{jt})\right) + \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h} pb_{kt} * min(S_{it} - qa_{jit}, Db_{kt})\right) - \sum_{i=1}^{n}\sum_{t=1}^{l} Cm_{it} \quad (4)$$

(iii) Farmers whose supply exceeds the demand of middlemen and cooperatives ($\boldsymbol{S_{it}} \geq \boldsymbol{Da_{jt}} + \boldsymbol{Db_{kt}}$)

Farmers' revenue is obtained from sales through middlemen, cooperatives, and coalitions with other farmers, so the farmer income model is described in Equation 5.

$$\pi_{fit} = \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m} pa_{jit} * min(qa_{jit}, Da_{jt})\right) + \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h} pb_{kt} * min(qb_{kit}, Db_{kt})\right) - \left(\sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(\frac{(1-\vartheta)}{2}(pm_t - p_{bt})\right) * min(qb_{it}, Db_{kt})\right) + \beta \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}(qb_{kit} * (pm_t - pb_{kt})) - \left(Cb * \left(\frac{min(qb_{kit},Db_{kt})}{G}\right)\right) - \left(C \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{k=1}^{h}\left(\frac{qb_{kit}}{G}\right)\right) + \boldsymbol{r} \sum_{t=1}^{l}\sum_{i=1}^{n}\sum_{j=1}^{m} \min\,(pa_{jit}) * (S_{it} - qa_{jit}) - \sum_{i=1}^{n}\sum_{t=1}^{l} Cm_{it} \quad (5)$$

3. Results and Discussion

In this scenario, all farmers (Farmer 1, Farmer 2, Farmer 3, Farmer 4, Farmer 5, and Farmer 6) are responsible for meeting the demands of three middlemen (Middlemen 1, Middlemen 2, and Middlemen 3) and the cooperative. The supply of salt from the farmers, as well as the demand from the middlemen and the cooperative, varies for each time period. Additionally, the prices offered to the farmers by each middleman and the cooperative also differ. The salt price at the market in period t (Pm_t) \$83.22/tons; cooperative salt price k in period t (Pb_{kt}) \$76.28/tons; salt carrying capacity (G) 9 tons; risk of selling through cooperatives (ϑ)8%; benefit distribution (cooperatives and farmers) (β)15%; negotiation costs from pond to cooperatives (C) \$3.12/tons; salt negotiation costs by middlemen to the market (Ca) \$6.73/tons; negotiation fee from cooperative to market (Cb) \$3.12/tons; percentage drop in salt price (r) 40%; cooperative membership fee (Cm_{it}) \$2.08/period.

The salt supply chain system without a coalition is the initial scenario in which farmers sell through middlemen 1, 2, and 3 (30%, 20%, 20%) and cooperatives (20%). Based on the scenario, the total revenue of farmer is: farmer 1, farmer 2, farmer 3, farmer 4, farmer 5, and Farmer 6 (\$18,079; \$27,450; \$10,346; \$5,703; \$47,854; \$2,532).

Horizontal collaborations are used as the basis for the coalition game scenario. A coalition carried out by farmers is expected to provide a minimum revenue equal to or greater than not conducting a coalition. The coalition of six farmers in each coalition formed the functional characteristics based on **Definition 1** (Table 1). Shapley's value is the solution problem states that the concept of a coalition forms a grand coalition in each game (Brown & Shoham, 2008).

Table 1 Farmer supply as a base, for example, Characteristics of the v(S) function

Number Coalition Farmer	Farmers Revenue v(S) ($)	Number Coalition Farmer	Farmers Revenue v(S) ($)	Number Coalition Farmer	Farmers Revenue v(S) ($)
1	18,079	3-2-1	55,848	5-3-2-1	103,760
2	27,450	4-2-1	51,193	5-4-2-1	99,104
3	10,346	4-3-1	34,038	5-4-3-1	81,949
4	5,703	4-3-2	43,438	5-4-3-2	91,349
5	47,854	5-2-1	93,470	6-3-2-1	58,302
6	2,532	5-3-1	76,315	6-4-2-1	53,647
6-5	50,435	4-3-2-1	61,482	6-5-4-3-2-1	111,848

Shapley value ($18,092.40; $27,486.39; $10,355.17; $5,702.19; $47,940.93; $2,617.90)

The Shapley value obtained is the average contribution of the farmer coalition {1,2,3,4,5,6}. When one of the players performs an S coalition, then contribute to improving the game by as much as $v(S \cup 1) - v(S)$. Farmer's contribution 6 to the grand coalition {6,5,4,3,2,1} is only v ({6}) = v(6) = $2,532 . The number of grand coalition combinations is 6! - 1 = 719, producing the same value. Suppose that the grand coalition formed from the coalition {4,2,6,1,3,5} gives the same result as the coalition {1,2,3,4,5,6}, which is $111,848. In the farmer coalition {4,2,6,1,3,5}: revenue contributions from farmers 1 ($18,079); farmer 2 ($27,450); farmer 3 ($10,346); farmer 4 ($5,703); farmer 5 ($47,854); and farmer 6 ($2,532). While the contribution of farmers from the coalition {1,2,3,4,5,6}, namely farmers 1 ($18,079.34), farmers 2 ($27,479), farmers 3 ($10,289.68), farmers 4 ($5,634.29); farmer 5 ($47,376.24); and farmer 6 ($2,989.68).

There are still 5! – 2 = 118 remaining permutations in the Shapley value step present, and the results were averaged for each farmer. Thus, the imputation is as follows: $x = (x_1^*, x_2^*, x_3^*, x_4^*, x_5^*, x_6^*)$.

Theorem 1: Table 1 shows *the characteristic function that produces the shapley value* for farmers 1, 2, 3, 4, 5, and 6 as follows: $18,092.40; $27,486.39; $10,355.17; $5,702.19; $47,940.93; and $2,617.90. Teorema Shapley value (**super additive**) i.e. the revenue of each player with coalition system must be greater than or equal to revenue non-coalition (Brown & Shoham, 2008). This is evidenced by the increase in farmers' incomes with the concept of a coalition based on Shapley values of: 100.45%, 100,386%, 100.76%, 101.22%, 100.33%, and 106.29%.

Theorem 2: *The core of the cooperative game is Shapley values based on characteristic functions* (Table 1).

Evidence: Based on Shapley's value, the total revenue of coalition farmers 4-3 ($16,057.35), coalition farmers 4-3-1 ($34,149.75), and coalition farmers 5-4-3-1 ($82,090.68). This value is used to verify the revenue presented on Shapley's solution $x = (x_1^*, x_2^*, x_3^*, x_4^*, x_5^*, x_6^*)$ which is $18,092.40; $27,486.39; $10,355.17; $5,702.19; $47,940.93; and $2,617.90.

The revenue generated by the player is higher than the revenue determined by the characteristic function (Table 1), and an example of a verified coalition is {1, 3, 6}. The total revenue earned by this particular coalition, as determined by Shapley's solution, is $31,065.47, which is the sum of the revenues earned individually by players 1, 3, and 6:

$18,092.40; $10,355.17; and $ 2,617.90, respectively. Shapley's value solution shows the total revenue of the farmer coalition {1,3.6} is $31,065.47. This value is smaller than the characteristic function (Table 1) which is v {1, 3, 6} = $30,857.99. It is conformity Shapley's value concept in **Definition 1,** which indicates that v(S) is the maximum value guaranteed by the S coalition by coordinating the strategies of its members regardless of the activities of other players (Brown & Shoham, 2008). The revenue of each farmer based on the scenario is shown in Figure 2.

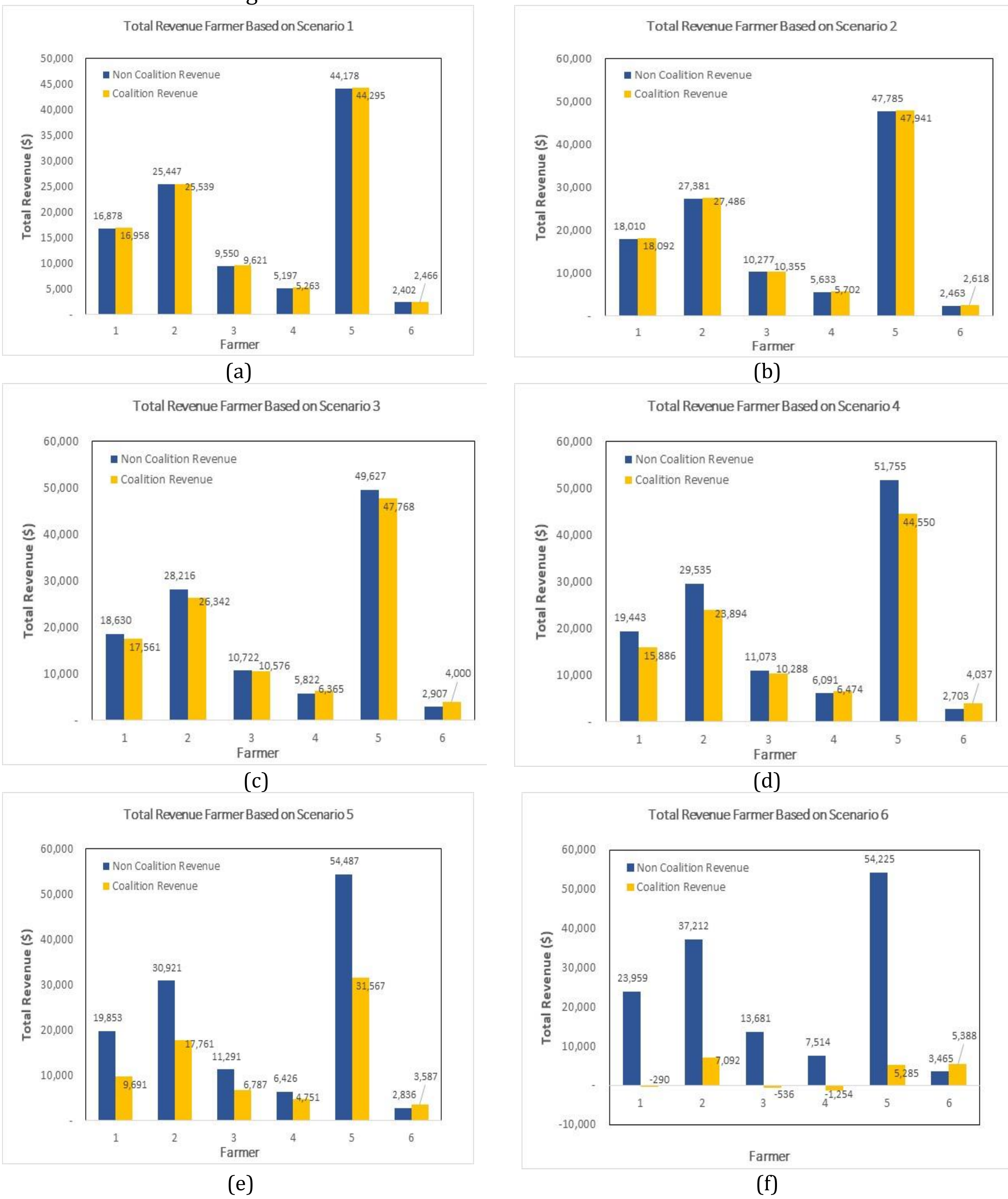
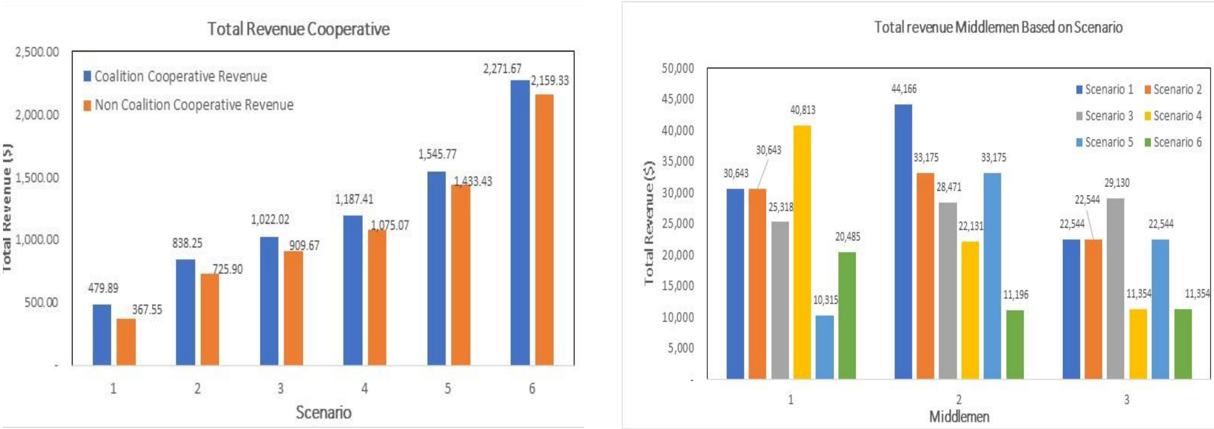


Figure 2 Farmer`s revenue: (a) Scenario 1; (b) Scenario 2; (c) Scenario 3; (d) Scenario 4; (e) Scenario 5; and (f) Scenario 6

Figure 3 shows the revenue of middlemen and cooperatives based on coalition and non-coalition models. In the vertical coalition model, farmers must contribute fees to cooperatives, but cooperatives must also provide profit sharing with farmers. In comparison, in the non-coalition model, farmers and cooperatives do not have obligations to each other.



(a) (b)

Figure 3 Total Revenue: (a) Cooperative; and (b) Middlemen

The cooperative revenue increases when the cooperative implements a vertical collaboration. Non-cooperative revenue is $367.55, cooperative revenue with a coalition system increases to $ 479.88 (scenario 1); $ 1187.41 (scenario 4) and continues to increase in line with the rise in the number of farmers buying salt (Figure 3 a). The increase in the cooperative's revenue is obtained from the value of member contributions of $ 2.08 per period.

Figure 3 (b) shows the revenue earned by the middlemen. The middleman's revenue is determined by the amount of salt purchased from the farmer. The middlemen's revenue decreases when farmers apply a coalition system in determining the channel of the salt trade system. The income of middleman 1 decreased from $30,642.86 to $25,777.05 when the farmer sold 30% of his salt supply. Likewise, when farmers sell 25% of the supply of salt to middlemen, the income of middleman 1 decreases to $10,315.19.

Figure 2 and Figure 3 (a) represent the farmers and cooperative revenue. The total revenue of farmers with the coalition system in scenarios 1 and 2 is higher than that of non-coalition (Table 2). It is by Shapley's concept of value in Definitions 1, 2, and 3, which states that players' revenue is greater than or equal to the revenue of non-coalition.

Table 2 Addition of farmer`s revenue ($) with coalition system

	Farmer 1	Farmer 2	Farmer 3	Farmer 4	Farmer 5	Farmer 6
Scenario 1	79.56	91.25	70.41	65.84	116.66	63.30
Scenario 2	82.41	105.78	78.47	68.81	156.10	154.90

Farmers get different revenue when selling salt with a coalition system. Horizontal and vertical collaboration is essential for farmers because farmers get information on prices and the use of resources together (Martins, Trienekens, and Omta, 2019). The price information is vital to influence farmers' choice of supply chain channels. The maximum revenue of farmers based on the salt supply-chain coalition system is scenario 2. When farmers sell through cooperatives more than 20% of the salt supply, the farmers will experience losses. The decrease in farmer's revenue results from the significant rise in transaction costs. However, farmers are very dependent on middlemen, especially on providing cash and the payment system after harvest (Chandra & Sao, 2020). The banking system and cooperatives cannot do this. Farmers prefer to work with middlemen because farmers get a net income without thinking about the market. Likewise, salt farmers choose to sell salt through middlemen because the farmer sell their salt on the pond, and middlemen carry out the post-harvest processing (Mustofa *et al.*, 2021; Sasongko *et al.*, 2019). The biggest challenge is finding a market when the harvest season occurs (Kontogeorgos *et al.*, 2018). Due to a lack of access, salt farmers prefer to sell their salt to middlemen rather than send it directly to the company. On the other hand, the company only accepts salt from suppliers in partnership. To cope with this problem, a collaboration between farmers and cooperatives can be a promising strategy. Long-time partnerships between the cooperative and the company allow ensuring salt market certainty.

The role of cooperatives for farmers is to increase the revenue of their members. In addition, the collaboration of farmers and cooperatives can accommodate the products produced by farmers (Ma and Abdulai, 2016). Figure 2 shows farmers' revenue increase with the coalition supply chain system. However, farmers must become cooperative members in this supply chain system to benefit. Cooperatives can buy products from members and non-members, but the value of the profits obtained is different (Wicaksono, Arshad, and Sihombing, 2019). Another advantage obtained is that farmers do not have to look for market share, bear transaction costs, and protect products from market uncertainty (Alho, 2015). As members of the cooperative, farmers will receive training to improve product quality according to market demand. Product acceptance in the market and supplier selection depend on several variables, namely quality, price, marketing period, delivery time, and service (Al-Hazza *et al.*, 2022; Setyaningrum, Subagyo, and Wijaya, 2020). In this case, salt acceptance relies on the following requirements, i.e., salt quality, supply stability, and price. Salt price often positively relates to salt quality. Therefore, the use of advanced salt production technologies can raise salt quality (Amir *et al.*, 2021), which in turn, leads to improved farmer revenue.

To implement the proposed model, several conditions must be met. First, the government must closely collaborate with stakeholders, namely farmers and middlemen, to ensure price stability and continuity of salt supply. Second, cooperatives and salt processors must have an agreement on salt purchase commitments, which can be supported by government regulations and policies. Third, there must be financial support for cooperatives to enhance their buying power for farmers' salt. Fourth, a warehouse receipt system should be developed and implemented between cooperatives and stakeholders. Lastly, salt farmers must adopt proper technologies to improve salt quality in accordance with the required standards.

4. Conclusions

The current research is one of the studies to decide the utility of any element of the salt supply chain with different levels of importance. It only involves farmers, middlemen, and cooperatives as the salt supply chain elements. Based on the Shapley value obtained, the horizontal and vertical collaboration system can increase farmers' revenue, namely maximum sales through cooperatives, 20% of the salt supply produced. Cooperatives can increase farmers' revenue by improving services and reducing transaction costs. This research does not consider the traditional relationships between middlemen and farmers, including transaction (payment) methods between them. In addition, the proposed model is developed as a representation of a one supply chain system that consists of farmers and middlemen, whereas the supply chain between farmers to salt processing factories is not included. Further research is necessary to design other forms of partnership and rewards aiming to reveal the growing profitability due to partnerships between farmers and cooperatives. Models can be made through different commissions according to the amount of salt sold and different prices according to the quality of the salt produced.

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