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**CHANITA PANMANEE**
**Faculty of Economics, Maejo University, Thailand**

**ROENGCHAI TANSUCHAT**
**Faculty of Economics, Chiangmai University, Thailand**

**AREE CHEAMUANGPHAN**
**Faculty of Economics, Maejo University, Thailand**

**KASEM KUNASRI**
**Faculty of Management Sciences, Chiangmai Rajabhat University, Thailand**

**NISACHON LEERATTANAKORN**
**Faculty of Economics, Maejo University, Thailand**

# GAME THEORY OF GREEN AND NON-GREEN ORIENTED PRODUCTIONS: DRIED LONGAN ENTERPRISES

## Abstract:

Dried longan is one of economic product in the northern of Thailand. It does not only solve the excess supply problem of fresh longan, but increase employment opportunities. Currently, the environmental responsibility is the important issue in which both producers and consumers are interested. Dried longan production system, thus, changes from traditional system using extravagant energy to environmentally friendly system using green technology. However, the green products are accepted in some consumer groups. Consequently, this paper explores the best decision making on green or non-green oriented productions of the dried longan enterprises by applying the game theory. The selected samples are two dried longan enterprise clusters in Chiang Mai and Lamphun provinces for playing in this game. The results represent that the green production system is the best choice of producers. It brings about the high economic payoffs but low physical resource usage. However, the information is necessary for the consumers to perceive value of green consumption and increase demand of green products. This findings are obviously useful for the dried longan enterprises in Thailand to make a decision for changing their production from traditional to green orientation.

## Keywords:

Dried longan enterprise clusters, Green production, Non-green production, Game theory

**JEL Classification:** C70, C79, C71

## 1. Introduction

The green concept is a new paradigm in Thailand bringing about not only adding value of products but enhancing competitiveness and sustainability of enterprises. It plays a role as the productivity-driven that takes into account of environmental impact and physical resources usage, such as the reduction in energy, inputs, pollution, waste, etc. The outcomes of green approach lead to maximization of overall productivity in economic, society and environment (APO, 2005; Gandhi et al., 2006).

Although the green orientation is not widespread known in Thailand, it tends to continuously increase in both production and consumption perspectives. Various enterprises have adopt this concept to improve their products, create product value and enhance the competitiveness. One of many interesting cases is the dried longan production. It is the major economic activity which is important in the northern of Thailand, especially Chiang Mai and Lamphun provinces. Dried longan enterprise clusters were established to solve the excess supply problem as well as generate the income for the people in these areas. Nowadays, these enterprise clusters begin to apply this approach for developing their production and marketing but some enterprises have not yet realized the importance of green concept. The conflict of them causes the obstacles to achieve the goal and strengthen in the long term (Patti, 2006). The tool popularly used for making the decision under the conflict is the game theory (Aumann and Dreze, 1974; Nagarajan and Sosic, 2008).

According to economic theory, the decision making of the producers in the oligopoly market have the impacts on each other. The strategy use of one person leads to the counteraction of the others so the optimal strategy of each producer is depended on the strategic interaction of the competitors. Hence, the producers have to be prudent to choose their strategies for competing. (Aumann and Dreze, 1974; Wen and Fang, 2012).

Game theory is widely applied for analyzing competitive behavior and explaining why the competitors choose the different strategies. It is the reasonable tool in consideration not only on economic payoffs, but also the interaction between participants (Nagarajan and Sosic, 2008). In addition, game theory have defined as the mathematical theory of interactive decision situations game used to simulate the fact situations. In a strategic game, it is assumed that each player choose the strategy to maximize 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 choice consideration, each player has two ways for making the decision, participate or avoid. Thus, the two players have possibly four joint decisions (Wen and Fang, 2012; Safari and Soufi, 2014).

Consequently, this paper has applied the game theory for making the decision of the dried longan enterprise clusters to choose the competitive strategies, green or non-green productions. The contributions of this paper are beneficial for the enterprise clusters to develop their potential and enhance their competitiveness. The rests of this

paper are structured as follows. Section 2 describes the game assumptions and models. Section 3 represents the empirical results, and section 4 summarizes the study's findings.

## 2. The Game Assumptions and Models

In this paper, the game assumptions and model are constructed by following Lui et al. (2011) and scenarios data, such as price, costs and demand quantity are determined from producers and consumers interviews.

### 2.1 Game Assumptions

1) There are only two dried longan enterprise clusters, Chiang Mai ($cm$) and Lamphun ($l$), exist in the market and the purpose of economic activity is to maximize their profits.

2) The two strategies that enterprise clusters can choose consisting of green oriented production ($g$) and non-green oriented production ($n$) with the same function.

3) The product's price of both enterprise clusters are alike but the unit costs and incremental costs of them are different.

4) The consumers have relatively low awareness of green products because the green market is in the initially development. Consequently, the demand of green products is lower than non-green consumption.

5) The game between the two enterprise clusters is the one-stage static game of complete information. Hence, each enterprise cluster understands their own characteristics and utility but does not know the actions of the other enterprise cluster before making decisions.

### 2.2 Game Models

The profit during on the operation period is shown in the formula:

$$\pi = pq - cq - \Delta c \tag{1}$$

Where $q$ is the amount of sell, $p$ is the price, $c$ is the unit cost, and $\Delta c$ is the incremental cost.

The incremental cost determines the differences in the costs between the green and non-green:

$$\Delta c = c^g - c^n \tag{2}$$

where $\Delta c$ is equal to $\Delta c^g$ when the enterprise cluster choose the green production and equal to 0 when the enterprise cluster choose the non-green production.

From the assumption (1), the demand of the market is equal to the supply:

$$\begin{aligned} q^g &= q^g_{cm} + q^g_l \\ q^n &= q^n_{cm} + q^n_l \end{aligned} \tag{3}$$

The price of green products is higher than the price of non-green products:

$$p^g > p^n \tag{4}$$

According to the assumption (3), it show that:

$$\begin{aligned} p^g &= p^g_{cm} = p^g_l \\ p^n &= p^n_{cm} = p^n_l \\ c^g_{cm} &\neq c^g_l \\ c^n_{cm} &\neq c^n_l \\ \Delta c_{cm} &\neq \Delta c_l \end{aligned} \tag{5}$$

In case of the assumption (4), the demand of green products is lower than the demand of non-green products:

### 2.3 Game Pay-off Matrix

Because profit maximization goal is used for decision-making, the game pay-off matrix of two enterprise clusters $cm, l$ is shown in table 1.

**Table 1: Game pay-off matrix.**

(Profits: Baht)

| | | Enterprise cluster $l$ | |
|---|---|---|---|
| | | Green orientation | Non-green orientation |
| Enterprise cluster $cm$ | Green orientation | $\pi^g_{cm}\big\vert_{l\,:\,green}, \pi^g_l\big\vert_{cm\,:\,green}$ | $\pi^g_{cm}\big\vert_{l\,:\,non\text{-}green}, \pi^n_l\big\vert_{cm\,:\,green}$ |
| | Non-green orientation | $\pi^n_{cm}\big\vert_{l\,:\,green}, \pi^g_l\big\vert_{cm\,:\,non\text{-}green}$ | $\pi^n_{cm}\big\vert_{l\,:\,non\text{-}green}, \pi^n_l\big\vert_{cm\,:\,non\text{-}green}$ |

## 3. Empirical Results

The scenario of green oriented productions is firstly used for constructing the situation for making decision of enterprise clusters because of the different thinking in green and non-green oriented productions.

### 3.1 Green Oriented Production of Dried Longan

Initial activity of dried longan production is fresh longan grading. The appropriate grades for processing are A and AA. The next processes are washing, peeling and seeding the fresh longan. The longan removed peel and seed are brought to wash again, put on the trays and baked around 10-12 hours. After cooling off, the dried longan is graded according to quality standard and packaged in sealed packaging. The processes of dried longan production are shown in figure 1.

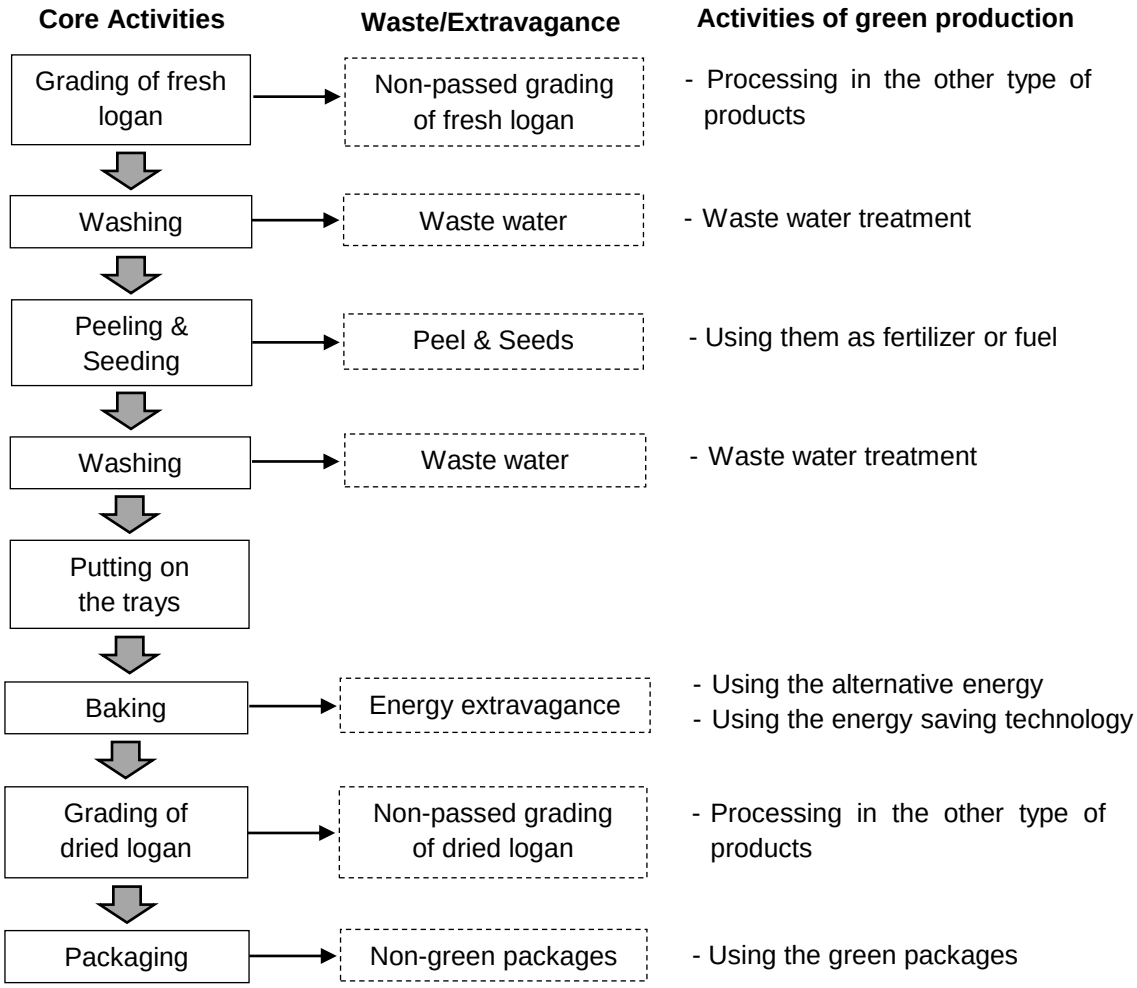


**Figure 1: Activities for green orientation in dried longan production.**

Considering the waste from processing stages (shown in figure 1), the result found that there are the wastes and resource extravagance in many processes such as failed graded fresh logan, waste water from washing procedure, peel and seed of longan, energy extravagance in baking stage, failed graded dried logan, and non-green packaging. As a result, the activities of green oriented production dealing with the waste disposal are took into account. This research have constructed the green production scenario for decision making of the longan enterprise clusters, for example, processing the other type of products from the non-passed graded longan, treating waste water, using byproducts for fertilizers or fuels, using the alternative energy and the energy saving technology, and using the green packages. The change from non-green to green productions bring about the high price of product but the high cost of waste disposal.

### 3.2 Economic Costs and Benefits of Green and Non-green Oriented Productions

According to producer and consumer interviews, the result represented that the price of green product has increased from 350 baht/kg to 450 baht/kg, approximate 30% from traditional product. In the same time, the unit costs and incremental cost have also increase. The economic costs and benefits of green and non-green orientation of dried longan productions are shown in Table 2.

**Table 2: Economic costs and benefits of green and non-green orientation of dried longan productions.**

(Unit: Baht/kg.)

| Economic costs and benefits | Enterprise cluster *cm* | Enterprise cluster *l* |
|---|---|---|
| Price of green product | 450 | 450 |
| Price of non-green product | 350 | 350 |
| Unit cost | 187.23 | 183.50 |
| Incremental cost | 8.08 | 8.97 |

### 3.3 Games of Two Dried Longan Enterprise Clusters

In terms of demand quantity, the finding from producer and consumer interviews stated that the demand of green products is obviously lower than the demand of non-green products. The proportion of one-kilogram selling between dried longan with green production and dried longan with non-green production is 0.4:0.6 whereas the proportion of same mode of productions among two enterprises (green and green productions or non-green and non-green productions) is 0.5:0.5, as shown in Table 3.

**Table 3: Proportions of dried longan demand between green and non-green products.**

(Unit: Percentage)

| | | Enterprise cluster *l* | |
|---|---|---|---|
| | | Green product | Non-green product |
| Enterprise cluster *cm* | Green product | 50 : 50 | 40 : 60 |
| | Non-green product | 60 : 40 | 50 : 50 |

Note: The proportions of demand are received from producers and consumers interviews.

The above data in Table 2 and Table 3 are used for evaluating the profits share per kilogram of two dried longan enterprise clusters, as represented in Table 4.

**Table 4: Pay-off matrix of two dried longan enterprise clusters.**

Pay-off: Profits share per kilogram

(Unit: Baht)

| | | Enterprise cluster *l* | |
|---|---|---|---|
| | | Green orientation | Non-green orientation |
| Enterprise cluster *cm* | Green orientation | 122.35 , 123.77 | 101.88 , 99.90 |
| | Non-green orientation | 97.66 , 103.01 | 81.39 , 83.25 |

Under this situation in Table 4, the green production leads to the increase in price of product exceeding the reduction in the demand quantity and the increase in the incremental cost. Accordingly, whether the enterprise cluster *cm* choose green or non-green orientation, the enterprise cluster *l* will always choose green production. Similarly, the enterprise cluster *cm* will select green oriented production whether the enterprise cluster *l* will choose or not. This game represents the Nash Equilibrium and both enterprise clusters will implement green production for maximizing their profits as well as enhancing social utility.

## 4. Conclusions

For the importance of socioeconomics and environmental responsibility perspective, dried longan production system has become to change from traditional system using extravagant energy to environmentally friendly system using green technology. However, the green products are accepted in some consumer groups. Consequently, this paper explores the best decision making on green or non-green oriented productions of the dried longan enterprises by applying the game theory. The selected samples are two dried longan enterprise clusters in Chiang Mai and Lamphun provinces for playing in this game.

The result showed that there are the wastes and resource extravagance in many processes so the activities of green oriented production dealing with the waste disposal are took into account. This research have constructed the green production scenario for decision making of the longan enterprise clusters. However, the change from non-green to green productions bring about the high price of product but the high cost of waste disposal. Consequently, game theory is used as the decision tool of enterprise clusters. The pay-off matrix of two dried longan enterprise clusters represented that the green production system is the best choice of both producers. It brings about the high economic payoffs but low physical resource usage. However, the information is necessary for the consumers to perceive value of green consumption and increase demand of green products. This findings are obviously useful for the dried longan enterprises in Thailand to make a decision for changing their production from traditional to green orientation.

## 5. Acknowledgement

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