PRICE STRATEGY STUDY OF TWO CASSAVA PROCESSING MANUFACTURERS

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ABSTRACT In Thailand, cassava is an agricultural product which is important in both social and economic aspects. Cassava industry is composed of cassava production in the agricultural and industrial sectors. Although the area of cultivation of cassava has been increasing every year, the industry sector is affected by raw material shortage, because production in the agricultural sectors are not enough to meet the demand of cassava processing firms. The demand for cassava in large quantities for use in the domestic processing industry and for use in exports continues to rise steadily. As a result, the cassava processing firms has competed in the cassava buying price in order to attract farmers do not have cultivated areas near cassava processing firms. This paper has studied the cassava buying price strategy for two cassava processing firms with fixed locations. An algorithm used to find the equilibrium price is proposed. The results show that the algorithm can find the equilibrium price.

1. INTRODUCTION

In Thailand, cassava is an agricultural product which is important in both social and economic aspects. Thailand is the world’s largest cassava exporter by Office of Agricultural Economics (2013). Cassava industry is composed of cassava production in the agricultural and industrial sectors. Although the area of cultivation of cassava has been increasing every year , the industry sector is affected by material shortage, because production in the agricultural sectors are not enough to meet the demand of cassava processing firms and volatile by Thai Tapioca Development Institute, TTDI. As a result, the cassava processing firms has competed in the cassava buying price in order to attract farmers do not have cultivated areas near cassava processing firm. In this paper studied the cassava buying price strategy for two cassava processing firms with fixed locations. Farmer’s area around cassava processing firms are also fixed, and can only sell their products to one cassava processing firm that provides the maximum profit. An algorithm used to find the equilibrium price is proposed. The results show that the algorithm can find the equilibrium price.

Based on the achieve paper of classical Maximal Covering Location Problem by Church and ReVelle (1974), a many number of models for location decisions under competition have been developed. The Maximum Capture Problem (MAXCAP) was developed by ReVelle (1986), presented the single firm which is siting the multiple entering servers is the capture of the maximum population from existing servers. This paper described a linear integer programming formulation. Serra and ReVelle (1994), considered a location and allocation game for two competitor firms want to locate one server at the nodes of the network so as to maximize their market share, and presented a Pre-Emptive Capture Heuristic Algorithm to solve the model. Another extension, Plastria and Vanhaverbeke (2007) presented aggregation approach is applied in particular to a competitive Maximal Covering Location Problem, and developed von Stackelberg model. This paper showed that the aggregation process proposed has an important influence on problem size and leads to improved solution times. Serra and ReVelle (1997) formulated the Maximum Capture Problem with Prices (PMAXCAP). This paper a competitive model addresses the issue of location of several retail outlets by firm and the fixing of price in order to maximize profit, given the presence of a competitor firm. And presented a Competitive Price-Location Heuristic (A Bi-Level Heuristic Procedure) to solve the model. Serra and ReVelle (1999) revisited this problem and presented a Hybrid Heuristic to solve it. Plastria and Vanhaverbeke (2009) formulated a revenue maximization model, based on the Maximal Covering model with a price decision, described properties of the problem which allowed obtaining exact solution methods, and presented two solution procedures to solve it; full enumeration solution procedure and intelligent solution procedure. Another paper of Fischer (2002) presented the two sequential models for duopolistic location planning with variable locations and prices, and suggested a heuristic solution procedure to solve it. Diakova and Kochetov (2012) considered the following facility location and pricing problem, and presented a two level local search heuristic based on the VNS framework for nonlinear problem. In addition, Matsubayashi , et al. (2004) presented a spatial duopoly model, and analyzed Bertrand-Nash equilibrium and derive a necessary and sufficient condition for the existence of equilibrium, and presented polynomial time algorithm to solve the model. We extended paper of Siriruk and Pumpeam (2014), this paper presented price strategy for two cassava processing firms and an algorithm to find the price equilibrium.

The paper is organized as follows. In section two, a problem described is presented. The solution methodology is described in section three. In section four, the numerical example with preliminary results are shown. In section five, presented conclusions are summarized.

2. PROBLEM DESCRIPTION

This paper considered two cassava processing manufacturers (set J). Both cassava processing firms try to increase cassava buying prices in order to buy cassava as much possible from farmers (set I), while maximizing their profits. Likewise, farmers decided to sell their cassava, based on profit maximization ($FP^t_{i,j}$). The competition will increase the cassava buying prices as a leader and a follower. The cassava processing firm leader will increase cassava buying price first one, while the other cassava processing firm fixes its cassava buying price. Then cassava processing firm follower will increase the cassava buying price by on the basis of current cassava buying price of cassava processing firm leader. The locations of cassava processing firms and farmers are fixed, and farmers living in different areas around the cassava processing firms. The distance ($d_{i,j}$) between of locations of cassava processing firms and farmers are fixed. The total cost of farmers in area i, assumed to be equal in all areas, and consists of cassava production cost per ton (c_i) and transportation costs per ton (t_i). The total cassava production of farmers in each area i is (q_i), and to sell it to the only cassava processing firm that provides the highest profit. The total cost of cassava processing firms assumed to be equal in two cassava processing firms, and consists of total production and transportation costs per ton (C_j), and cassava buying price per ton (P^t_j), assumed the lowest cassava buying price is market value. The cassava processing firms selling processed cassava with the price per ton (s_j), and assumed to be equal to all cassava processing firms. The total amount of cassava purchased from farmers i are presented by (Q_j).

3. ANALYSIS

3.1 Solution Methodology

In competition between two cassava processing firms are j and j' by increasing cassava buying prices with fixed location. The algorithms to find the cassava buying price consists of two stages are initial and iterative stages. In the initial stage, presented farmers in different areas around cassava processing firms decided to sell their cassava, based on profit maximization, and calculated the minimum switch price. The iterative stage increases cassava buying prices of one cassava processing firm, while the other cassava processing firm fixes its cassava buying prices. The algorithm is described below.

<u>Initial Stage</u>

1. Set $t = 0$.
2. Calculate maximum cassava buying price of cassava processing firms j by
$$p^u_j = s_j - C_j$$
For $j \in J$.
3. Set initial cassava buying prices at market value for both cassava processing firms j and j' are $P^0_j < p^u_j$ and $P^0_{j'} < p^u_j$.
4. Calculated profits of farmers in area i that sell their products to cassava processing firms j and j' by
$$FP^0_{i,j} = P^0_j q_i - c_i q_i - t_i d_{i,j} q_i$$
$$FP^0_{i,j'} = P^0_{j'} q_i - c_i q_i - t_i d_{i,j'} q_i$$
For $i \in I$ and $j \in J$.
5. For $i \in I$.
If $FP^0_{i,j} > FP^0_{i,j'}$, farmers in area i will sell their products to cassava processing firm j. Subindex i will become a member of set X.
If $FP^0_{i,j} < FP^0_{i,j'}$, farmers in area i will sell their products to cassava processing firm j'. Subindex i will become a member of set Y.
END FOR
6. For $k \in Y$.
If cassava processing firm j is leader, calculated minimum switch cp_k that farmers in area i will make a sell to cassava processing firm j instead of j' by
$$cp_k = \frac{\left|FP^0_{i,j} - FP^0_{i,j'}\right|}{q_i}$$
If cassava processing firm j is follower, calculated minimum switch cp_k that farmers in area i will make a sell to cassava processing firm j instead of j' by

$$cp_k = \frac{\left|FP_{i,j}^0 - FP_{i,j'}^{t+1}\right|}{q_i}$$

For $i \in I$ and $j \in J$.

END FOR

Iterative Stage

7. Set $t = t + 1$.
8. For $m \in Y$.

   8.1. Include m in set X as a new subindex.

   8.2. Calculated new cassava buying price of cassava processing firm j as follows $P_j^t = P_j^{t-1} + cp_m + \varepsilon$, where ε is a small number, such as 0.01.

   8.3. Calculated the total amount of cassava Q_j which sells to cassava processing firm j by $Q_j = \sum_{i \in X} q_i$.

   8.4. Calculated new profit of cassava processing firm j after including a new subindex m as follows

   $\pi_{m,j}^t = s_j Q_j - C_j Q_j - P_j^t Q_j$.

   8.5. Exclude m from set X.

   END FOR

9. Choose subindex m which yields the highest profit from step 8 and include it in set X permanently as well as eliminate it from set Y.
10. For $n \in Y$.

    IF $cp_m > cp_n$, THEN subindex n becomes a member of set X and eliminate it from set Y.

    END IF

    END FOR
11. IF $Y = \{\emptyset\}$ OR $\pi_{m,j}^t < \pi_{m,j}^{t-1}$, THEN STOP.

    Otherwise, go to step 7.

    END IF

After completing one iteration, cassava processing firm j is switched to the other cassava processing firm and follow the initial and iterative stages.

Conditions of price equilibrium

- For cassava processing firm j is leader as follow,

$$P_j^t \geq P_{j'}^{t-1} - t_i d_{i,j'} + t_i d_{i,j} + \epsilon \quad (1)$$

- For cassava processing firm j is follower as follow,

$$P_j^t \geq 2P_j^{t-2} - P_{j'}^{t-1} + t_i d_{i,j'} - t_i d_{i,j} + \epsilon \quad (2)$$

For $i \in I$ and $j \in J$.

3.2 Numerical Method

In competition between only two cassava processing firms are firm A and firm B, and firm B is leader and firm A is follower. Twenty cultivated areas are considered. The distance from each area to cassava processing firm A and B are fixed, and total cassava production each area shown in Table 1. Considered total production and transportation cost of firm A and B are \$18.46 per ton. The cassava market price is assumed to be \$53.61 per ton and the processed cassava selling is assumed to be \$82.64 per ton. The cassava production and transportation cost of farmers in area i are assumed to be \$27.22 per ton and \$0.18 per kilometer x ton.

Table 1 Distance and Total Cassava Production in each farmer's areas.

Farmer's Areas	Distance (Km) to Firm A	Distance (Km) to Firm B	Total Cassava Production (tons)
1	65	50	3,700
2	48	28	1,380
3	15	6	1,200
4	30	15	1,000
5	15	13	1,500
6	40	44	1,600
7	25	30	3,000
8	15	35	2,750
9	20	35	2,000
10	80	90	2,925
11	100	150	1,000
12	100	150	3,000
13	30	30	1,500
14	30	30	3,500
15	15	13	3,800
16	25	30	3,600
17	24	20	1,700
18	40	46	2,000
19	30	23	2,700
20	92	100	4,000

From an algorithm at initial stage, after step 5 that compare profit of farmers. The results show that farmers in areas 1, 2, 3, 4, 5, 15, 17 and 19 sell their products to firm B. The farmers in areas 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18 and 20 sell their products to firm. Then both firms try to increase cassava buying prices in order to buy cassava as much possible from farmers. The result show that in Table 2, iterations 5 and 7 show areas captured of firm B are same, but the profits are decreased. Thus, firm B should cassava buying price at iteration 5 is \$58.45 per ton. For firm A iterations 6 and 8 show areas captured of firm A are same, but the profits are decreased. Thus, firm

A should cassava buying price at iteration 5 is $58.83 per ton. Check price equilibrium for firm B is leader at iteration 5 follow (1), and used distance at farmer in area 14 because has yields the highest profit. Thus price equilibrium is $P_B^5 \geq \$58.45$ per ton. Price equilibrium of firm B will be rather than firm A's cassava buying price at iteration 4. Price equilibrium for firm A is follower at iteration 6 follow (2), and used distance at farmer in area 15 because has yields the highest profit. Thus price equilibrium is $P_A^6 \geq \$58.07$ per ton. Price equilibrium of firm A will be rather than firm B's cassava buying price at iteration 3.

Table 2 Results of competition between firm A and B.

Iteration	Firm	Areas Captured	Cassava Buying Price ($)	Profit ($)
1	B	1,2,3,4,5,6,7,10,13,14,15,16,17,18,19,20	55.46	340,876.11
2	A	5,6,7,8,9,10,11,12,13,14,15,16,17,18,20	56.21	301,979.48
3	B	1,2,3,4,5,6,7,10,13,14,15,16,17,18,19,20	58.06	239,203.11
4	A	5,6,7,8,9,10,11,12,13,14,15,16,18,20	58.44	207,654.55
5	B	1,2,3,4,5,13,14,15,17,19	58.45	125,914.87
6	A	5,6,7,8,9,10,11,12,13,14,15,16,18,20	58.83	193,546.30
7	B	1,2,3,4,5,13,14,15,17,19	58.84	117,342.67
8	A	5,6,7,8,9,10,11,12,13,14,15,16,18,20	59.22	179,438.05

CONCLUSION

In this paper studied the cassava buying price strategy for two cassava processing firms with fixed locations. Farmer's area around cassava processing firms are also fixed, and can only sell their products to one cassava processing firm that provides the maximum profit. Shown the algorithm to find price equilibrium. The numerical example considered are two cassava processing firms, firm A and firm B, and twenty cultivated areas. The result showed that it is required eight iterations to find price equilibrium.

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