SILVER MEAL - MAXIMUM PRODUCTION QUANTITY (SM-MPQ) FOR THE LOT SIZING AND SCHEDULING PROBLEM IN THE CASHEW NUT COMMUNITY ENTERPRISE

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Abstract - Cashew nut crop is an economical important production in Uttaradit, Thailand.The suitable plan can help the enterprise in managing production process, efficiently. In this study, the Silver-Meal Heuristic (SM) is established to find the optimal production plan of cashew nut. The data used in this study covers the period from 1Septemberto 30 September in 2022. A maximum production amount is used as the limiting factor to the Silver Meal process (SM-Mpq) estimate the optimal cashew production plan in Uttaradit, Thailand. The results of SM algorithms are compared with two algorithms of Traditional and SM-Mpq.It is found that SM-Mpq provides the reliable results in reducing the production cost about 40.19% compared to others.

Keywords - Cashew Nut, Lot sizing, Silver Meal, SM-Mpq.

I. INTRODUCTION

The cashew nut is the edible seed of the cashew tree, which is native to Brazil but is now cultivated in numerous tropical places worldwide. Although cashews are produced at a higher rate than other nuts such as almonds, walnuts and hazelnuts, their surge in popularity is all the more notable. From 2010 to 2017, the ecological footprint connected with the production of cashews, which includes the cropland, developed area, and carbon emissions necessary for their collection and processing, increased by about 20%, as shown in Figure 1]1[.

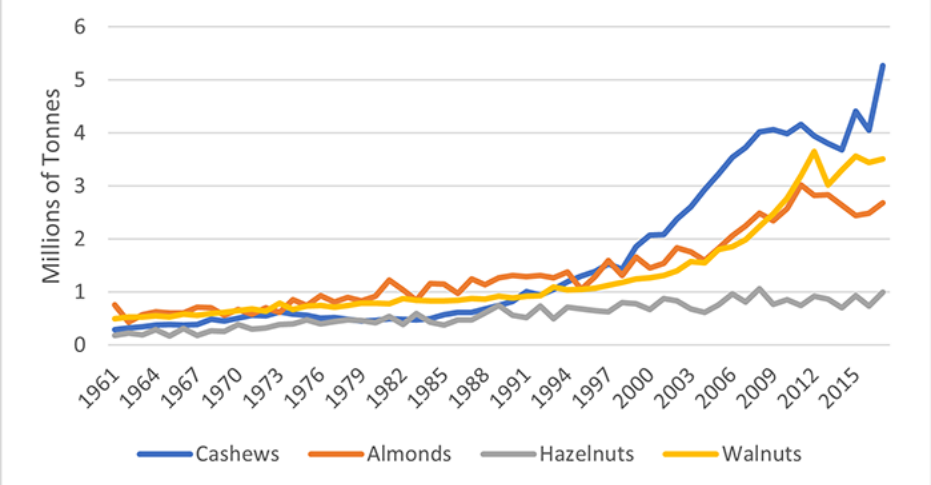

Figure 1: Global Production of Nuts.

The cashew nut growing in Thailand ranks number 18 compared to others countries in cashew nut production]2[.The cashew sector in Thailand provides farmers with a substantial source of income and employs a huge number of people, particularly in rural areas. The bulk of cashew nuts farmed in Thailand is exported to other countries, also consumed locally as a snack and used in traditional Thai cuisine. The government of Thailand encourages the cashew industry through a variety of initiatives and programs designed to boost productivity and competitiveness.As mentioned previously, Uttaradit province is one of many areas in Thailand given a good quality cashew nuts crop exported to different countries.

Inventory management in the manufacturing of cashew nuts comprises monitoring and regulating the flow of cashew nuts from procurement to sale. The objective is to ensure that the appropriate quantity of cashew nuts is available at the appropriate time while minimizing the costs associated with storing and retaining the cashew nuts. Commonly encountered in industrial and service firms, lot-sizing issues are a form of an inventory management challenge. The lot size influences the cost of ordering, producing, and

keeping inventory. Consequently, determining the correct lot size is essential for good inventory management.

Currently, there are many researchers about metaheuristic approach in lot sizing problems. Chowdhury et al., [3] revisit algorithms for the Economic Lot-Sizing Problem (ELSP) and Single Machine Batch-Sizing Problem (SMBSP) under the Wagner and Whitin (WW) cost structure. They found that it executes fewer different actions throughout and hence it improves execution time by a maximum of 51.40% for the ELSP and 29.03% for the SMBSP. Budde et al., [4] integrate Discrete Event Simulation (DES) and Operations Management (OM) techniques to create a decision support system for lot size determination. The findings indicate that the model is suitable for offering transparency regarding impacts and a variety of effective remedies. Aryanny et al., [5] used the Silver Meal Heuristic Method to determine the amount of raw material inventory control for lubricating oil. The results indicate that the SM technique delivers a lower total cost of inventory than the company's method. Schulz [6] created a new Silver-Meal-based algorithm for the single-item dynamic lot sizing problem including returns and remanufacturing. This has resulted in a reduction of the percentage gap to the optimal solution, which has been employed as a performance metric, to less than half of its initial value in practically all tested scenarios.

As mentioned earlier, this study aims to apply the additional constraint to the Silver Meal Heuristic (SM) to estimate the optimal cashew production plan in Uttaradit, Thailand.

II. METHODOLOGY

Cashew Nut Production

Cashew nut processing industry in Thailand employs thousands of workers and contributes significantly to the country's economy. New processing and packaging technologies have also helped the industry by making it more efficient and cutting down on waste. Overall, Thailand's cashew nut transformation industry is a vital part of the country's food industry and a major contributor to the global supply of cashew nuts.

The cashew nut production in Uttaradit province to transform raw cashew nuts into finished products, the normally six stages in cashew nuts processing in Uttaradit are as follows.

1. Dry the raw cashew nuts on the field.
2. Pre-treat of raw cashew nuts in which the process of warehousing, calibration and heat treatment.
3. De-shell humidification of kernels in the oven drying.
4. Peel the outer seed coat (Testa) from the cashew kernel.
5. Grade the kernels into different quality grades.
6. Package the kernels for storage and shipment.



Figure 2: The cashew nuts production in Uttaradit, Thailand.

Lot Sizing Problem

The lot sizing problem in cashew nut production refers to the difficulty in establishing the ideal production or order quantity to minimize overall inventory and production costs. In other words, it is the process of discovering the most cost-effective approach to producing or ordering the appropriate quantity of cashew nuts to satisfy demand while minimizing inventory and production expenses. This problem is challenging because it requires a balance of several elements, including manufacturing costs, inventory maintenance costs, ordering costs, and fluctuating demand. The ideal approach should take into consideration constant production costs, variable inventory costs, and ordering costs. The nature of the product and the prevailing supply and demand conditions are the initial factors that influence inventory procedures. These characteristics are distinguished along the technical structures of lot sizing challenges in Figure 3.

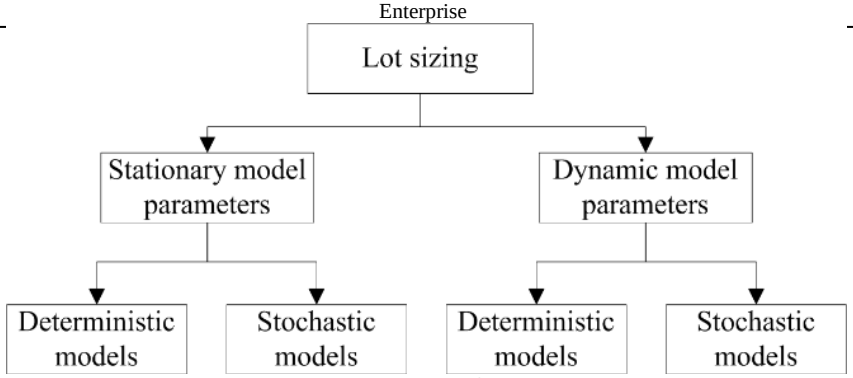

Figure 3: Technical structure of lot sizing problem.

There are several methods for solving the lot sizing problem, including the Economic Order Quantity (EOQ) model established by Harris]3[is a simple and effective method for preventing organizations from amassing excessive inventory. the Wagner-Whitin algorithm]4[, and the Silver-Meal heuristic]5[is a simple rule-based algorithm for solving the lot sizing problem. It is a popular heuristic method used in operations management and logistics for determining the optimal lot size that minimizes costs. The method chosen will depend on the specific characteristics of the cashew nut production process and the available data.

The Implement Silver–Meal Heuristic

The Silver-Meal Heuristic is a successful technique for resolving lot-sizing issues in production and inventory management. In comparison to other heuristics, it offers a rapid and simple answer to the problem]6[. This approach is a forward method that needs calculating the average cost per period as a function of the number of periods the current order will span and stopping the computation when this function increases for the first time.]7[. The equation used is as follows equations (1).

Objective function

$$TRC_{agv} = \frac{C + P_h \sum_{t=1}^{T} (t-1) R_t}{T} \quad (1)$$

Where TRC_{agv} is the average total relevant cost, C is ordering cost per period, P_h is holding cost per period, T is additional time in period, and R_t is the demand level of period.

The Silver Meal method has several advantages, such as its simplicity and ease of use. Nevertheless, one of the limitations of this strategy is that it does not account for the time required to fulfill an order or restock inventory. This can result in stockouts or excess inventory if lead times are not taken into account.Based on the disadvantage, this study applies a new constraint to the Silver Meal method (SM-Mpq), where the maximum production quantity is the limiting factor, as flowing in Algorithm 1 and the constraint as equation (2).

Constraint

$$X_t - MY_t \le 0 \qquad \forall t > 1 \qquad (2)$$

Where X_t represents the number of production quantity of period t, M is the maximum of production quantity.

Algorithm 1. Pseudocode of SM-Mpq

Initialize the parameters C, P_h, M
while $t < T$ do
  Calculate the TRC_{agv} of period t by Eq (1)
  if $TRC_{agv}(t) > TRC_{agv}(t-1)$ then
    Update $X_t = R$
  else
    Update $R = R + R_t$
    // Consider constraint by Eq 2
    if $(R + R_{t+1}) > M$ then
      Update $X_t = R$
    end if
  end if
  $t = t + 1$
end while

Data Collection

The community enterprise in the ThaPla district of Uttaradit, Thailand, provided the information utilized in this study. The data includes demand, production quantity, production cost and holding cost. From the study of the production process, it was found thatthe production cost, the holding cost per period of time and the maximum production quantity are 14,420 baht, 0.17 baht per kg and 500 kg, respectively]8[. Data description is illustrated in Table 1.

According to Table 1, the total number of times the production process occurs is 15. It may be observed that the connection between output and demand is not balanced. This factor may have influenced the high price by causing excess inventories. Thus, the objective of this study is to plan the production of cashews using the SM approach, subject to a maximum production quantity limitation.

Time	Production quantity (Kg)	Demand (Kg)
1	276	170
2	276	119
3	282	280
4	282	121
5	276	392
6	276	495
7	276	89
8	276	285
9	276	125
10	282	220
11	276	321
12	276	349
13	282	117
14	276	147
15	276	102
Total	**4,164**	**3,332**

Table1The demand for cashew nuts in one month

III. RESULTS AND DISCUSSION

The Optimal Cashew Production

The simulation results of Traditional, SM, and SM-Mpqmethods for estimating the optimal cashew nuts production as in Table 2, Table 3 and Table 4, respectively.

As shown in Table 2, the traditional method is produced every period and inventory quantity is exceeded every period. The minimum cost is 217,274 THB.

Time	Demand (Kg)	Production quantity (Kg)	Inventory (Kg)
1	170	276	106
2	119	276	263
3	280	282	265
4	121	282	426
5	392	276	310
6	495	276	91
7	89	276	278
8	285	276	269
9	125	276	420
10	220	282	482
11	321	276	437
12	349	276	364
13	117	282	529
14	147	276	658
15	102	276	832

Table 2The production plan for cashew nuts using thetraditional method

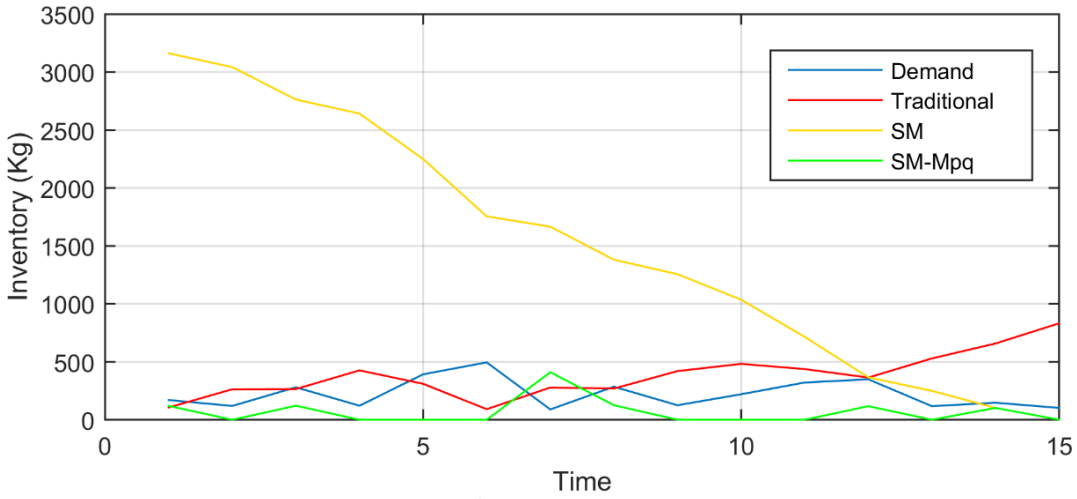

Figure 4: Comparing inventory quantities of Traditional, SM, and SM-Mpq methods with demand

Time	Demand (Kg)	Production quantity (Kg)	Inventory (Kg)
1	170	3,332	3,162
2	119	0	3,043
3	280	0	2,763
4	121	0	2,642
5	392	0	2,250
6	495	0	1,755
7	89	0	1,666
8	285	0	1,381
9	125	0	1,256
10	220	0	1,036
11	321	0	715
12	349	0	366
13	117	0	249
14	147	0	102
15	102	0	0

Table 3 The production plan for cashew nuts using SM method

From Table 3, the SM method is produced in the first period only. The inventory quantity is exceeded every period. The minimum cost is 18,225.62 THB. However, the production quantity exceeds the maximum production quantity limitation.

Table 4 indicates that the minimum cost is 129,948.98 THB. The best approach is the SM-Mpq method, which strikes a balance between production quantity and inventory quantity.

According to Table 3-5, when comparing the inventory quantities of Traditional, SM, and SM-Mpq methods with demand, as shown in Figure 4. The result found that the RMSE of Traditional, SM, and SM-Mpq methods is 311.67, 1650.88, and 235.38, respectively.

Time	Demand (Kg)	Production quantity (Kg)	Inventory (Kg)
1	170	289	119
2	119	0	0
3	280	401	121
4	121	0	0
5	392	392	0
6	495	495	0
7	89	499	410
8	285	0	125
9	125	0	0

Time	Demand (Kg)	Production quantity (Kg)	Inventory (Kg)
10	220	220	0
11	321	321	0
12	349	466	117
13	117	0	0
14	147	249	102
15	102	0	0

Table 4 The production plan for cashew nuts using SM-Mpq method

The Performance of Cost Reduction

The performances of Traditional, SM and SM-Mpq in terms of cost reduction are compared to the total cost of cashew nut production as in Table 5.

Method	Minimum cost (THB.)	Discount (%)
Traditional	217,274.00	-
SM-Mpq	129,948.98	40.19
SM	The production quantity exceeds the maximum production quantity limitation	

Table 5 The comparison between the performances of cost reduction

IV. CONCLUSION

In this study, the maximum production quantity is the limiting factor to the Silver Meal method (SM-Mpq). Three methods consist of Traditional, SM and SM-Mpq methods applied to estimate the optimal cashew production plan in Uttaradit, Thailand. The traditional method is produced every period and inventory quantity is exceeded every period. The minimum cost is 217,274 THB. The SM method is ineffective because of production quantity exceeds the maximum production quantity limitation. The SM-Mpq method, which achieves a balance between production quantity and inventory quantity, is the optimal option and reduces the production cost 40.19%.

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