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INVENTORY MANAGEMENT IN SAN PA TONG AGRICULTURE COOPERATIVE LIMITED'S SUPERMARKET

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ABSTRACT

The aims of this study is to improve inventory management at San Pa Tong Agriculture Cooperative Limited's Supermarket by determining an appropriate inventory model for purchasing important items in order to reduced inventory management cost. Inventory items in the supermarket are usually large and it is not practical to manage all items with the same tight policy. Hence, they need to be categorized into groups based on their important. The traditional method for inventory classification is the ABC analysis. In ABC analysis, inventory classified into 3 groups based on one criterion, which is the annual baht usage value. However, one single criteria is not suitable in managing inventory of supermarket. In supermarket, other criteria such as unit cost, unit price, lead time and inventory turnover also have significant impact on inventory management. Therefore, multi-criteria inventory classification (MCIC) was applied in this research by using clustering algorithm. Two clustering algorithms including K-means clustering and X-means clustering were used. Important clusters were selected for tight control by determining appropriate inventory policy. Inventory management cost before and after improvement for both traditional ABC and clustering algorithm were calculated. The result revealed that the group clustered by k-means was the most effective which results in 64.23% or 200,831 Baht reduction in inventory management cost. This method could also be applied to other supermarkets in order to gain better control of their inventory.

KEYWORDS: Inventory Management, Multi-criteria Inventory Classification, Cluster Analysis, ABC Analysis.

Retail industry in Asia is expanding rapidly and Thailand is ranked second place in terms of growth in retail industry especially Modern Trade, inferior to only China [1]. Modern Trade is a modern retail business that sale product and direct service to customer. Modern trade consists of 7 categories including department store, supercenter, supermarket, cash & carry, specialty store, convenience store and category killers [2]. The companies in these categories sometime sell similar items. For example, Supercenter and supermarket are selling of the same consumer products which make competition more intense. Supermarket carries large numbers of inventory items in order to meet customer demand. Holding too many inventories increase holding cost. On the other hand, too few inventories lead to lost profit. Therefore, appropriate inventory policy is very important as inventory is current assets or main of resource an organization. Inventory management cost comprises of four costs including ordering cost, carrying cost or holding cost, shortage cost or stock out cost and setup cost.

San Pa Tong Agriculture Cooperative Limited's Supermarket is a supermarket, which sale finished goods to for customer. Products sold by this supermarket are grouped into several categories such as drink, snack, household, etc. The number of inventory items for sale in the supermarket is 10,419 SKU (stock keeping units). With this large amount of items, it is very difficult to effectively manage all of them with equals attention. ABC analysis is the traditional techniques used to classify inventory in to groups based on annual dollar usage. However, in supermarket, other factor such as unit price and lead time should also be considered as unit price has influence in customer's decision and lead time has an influence in manager's supermarket decision for purchasing inventory items. As a result, there is a need for multi-criteria inventory classification to better classify inventory in groups so that manager can focused their attention into cluster with high important.

Currently purchasing officer at this supermarket issue purchasing order based on experience, which sometime results in ordering too many in items that cannot be sold and sometime shortage in some item that are in high demand. This problem results in increasing of inventory management cost. Hence, there is a need for appropriate inventory model for items that are important in order to minimize inventory management cost.

This research proposed a comparison between classifying inventory in to groups based in the traditional method, the ABC and novel approach for MCIC based on clustering algorithms. Group A inventory and important group clusters obtained from clustering algorithm were selected. Inventory model either Economic order quantity(EOQ) or Newsboy model ware applied to those group. Finally inventory management cost were compared using real data from San Pa Tong Agriculture Cooperative Limited's Supermarket.

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LITERATURE REVIEW

Criteria For Inventory Classification

ABC analysis is the most widely employed technique for inventory classification in organization.

This technique that based on Pareto principle is an easy to understand method that divides the inventory items into three classes [3]. Class A items contribute the majority (70-80%) of the total inventory value of the items. Class B contributes (10-15%) and Class C consist of 5% of the total inventory value of the items [4]. ABC analysis is based on only one single criteria which is "annual usage value". However, with changing in business environment, there has been reports in literature of the important of other factors such as such as lead time, obsolescence, substitutability, repair ability, commonality, order size requirement, stock ability, demand distribution, scarcity, durability and stock-out penalty [5-8]. Thus, only one criterion is not enough to reach a good decision [9]. Therefore, there is a need for multi-criteria inventory classification

Method For Inventory Classification

Various techniques have been applied for classifying inventory items taking into that taking into accounts of multiple-criteria. These techniques can help manager's in company to identify important inventory items and efficient control inventory in stock. Balaji and Kumar [4] proposed the analytic hierarchy process(AHP) method to classify inventory in an automobile rubber components manufacturing industry. The classification is based on the criteria of demand, unit price, annual consumption value, unit weight and shape of the component. The idea of using AHP is to convert multiple criteria in to single value based on relative important of each criterion. Partovi and Anadarajan [5] applied an artificial neural network(ANN) to classify inventory items based on the criteria including unit price, ordering cost, demand range and lead time in a pharmaceutical company. In ANN, expert opinion is used classify a part of inventory into groups by considering multiple criteria at the same time. These data were then used as training data to train ANN to predict class of other inventory items. Ramanathan [6] proposed a weighted linear optimization that is similar to a data envelopment analysis(DEA). The classification is based on criteria of average unit cost, annual dollar usage, critical factor and lead time. Babai et al. [10] proposed the R-model, the ZF-model, the Ng-model and the H-model that classify inventory items based on weight linear and non-linear mathematical programming in retailer in the Netherland. Saric et al. [9] presented AHP method, neural networks and cluster analysis classify inventory items and considering three criteria including annual cost usage, criticality factor and lead time in agricultural machine.

Cluster analysis is one of the techniques for classify multiple-criteria used by researchers [9] and [17]. In this research, cluster analysis was applied because multiple -criteria inventory classification of supermarket, which including annual baht usage, lead time, unit cost, unit price and inventory turnover.

Cluster Analysis

Cluster analysis is a technique in data mining, which is used to classify object into group based on their attributes [11]. This method offers several advantages over a manual grouping process. First, a clustering program can apply a specified objective criterion consistently to form the group. Second, a clustering algorithm can form the groups in a fraction of time required by manual grouping [12].

K-Means clustering is one of the most popular algorithms used for clustering as it is simple and effective. In order to cluster n object into k clusters, k objects are randomly selected as cluster center. Then objects are assigned to each cluster center based on similarity measurement. Then the new cluster means are calculated. With the new cluster mean, the distance from each object to each cluster mean is calculated and objects are assigned to the cluster in which they are most similar. These processes repeat until the criterion function is met. One of the most widely used similarity measurement is the Euclidean distance, which can be calculated from

$$d(p, q) = \sqrt{\sum_{i=1}^{n} (p_i - q_i)^2} \quad (1)$$

Where $d_{p,q}$ is distance between p and q and n is dimension of data

X-means clustering was introduced by Pelleg and Moore. [13] This algorithm is a variation of the Bayesian Information Criterion(BIC) based model selection. Instead of running the model selection algorithm k times. The X-means clustering stars with a minimum number of k centroid and continually adds new centroids by splitting the existing centroids unit an upper bound k is reached. At each split, the new BIC value of the resulting (local) model is compare against the parent BIC value. A split is kept if the local score (BIC) is better, otherwise the new split is discarded and the previous (parent) structure is retained.

Inventory Model

Inventory model is used to identify appropriate order size in order to find optimal inventory that minimize inventory management cost. There are two type of inventory model. Deterministic model is used in the case of known demand. The most widely used deterministic inventory model is the economics ordering quantity(EOQ). Stochastic model is used for unknown or uncertain demand. Stochastic inventory model used in the research is the Newsboy model.

To determine whether demand is constant, Peterson and Silver suggest the use of Variability Coefficient(VC) [16], which is calculated as follows

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i \quad (2)$$

$$\text{Est. Var D} = \frac{1}{n}\sum_{i=1}^{n} d_i^2 - \bar{d}^2 \quad (3)$$

$$VC = \frac{\text{Est. Var D}}{\bar{d}^2} \quad (4)$$

Where n is number of period and d_i is demand in period j If VC ≤ 0.25 that means the demand is constant and EOQ model can be used. If VC > 0.25, meaning that demand is not constant, therefore Newsboy model is used.

The economic order quantity model is a formula for determining the optimal order size that minimizes the sum of holding cost and ordering cost [14]. Economic order quantity(EOQ) and total cost (TC) is calculated using the following formula.

$$EOQ = \sqrt{\frac{2DS}{H}} \quad (5)$$

$$TC = \frac{D}{EOQ} S + \frac{EOQ}{2} H \quad (6)$$

Where D is Annual demand (Units), S is Ordering cost (Baht), H is Holding cost (Baht)

The objective of newsboy model is to find the optimal quantity that minimizes the newsboy's total expected cost [15]. In Newsboy model, Q* or Max quantity of inventory items per year and K* or total cost (Baht), is determined as follows:

$$Q^* = \mu + Z\sigma \quad (7)$$

$$K^* = nC_c + \frac{C_h \sum Qo}{N} \quad (8)$$

Where, μ is Average annual demand (Units), σ is standard deviation of annual demand, Z is value associated with a percent probability of not stocking out, Q_o is The total number of inventory order, C_c is Ordering cost (Baht), n is Number of times inventory ordered in per year, C_h is Holding cost (Baht), N is Number of cycles

RESEARCH METHODOLOGY

The methodology of this research is shown in Fig 1. The methodology is divided into two parts. First part is inventory classification. In this part, inventory items were classified by ABC analysis and cluster analysis separately. In cluster analysis, two methods were used, which are K-means clustering and X-means clustering. In the second part, inventory policy is applied to items in group A from ABC classification and important cluster from k-means and x-mean. Finally, inventory management cost before and after improvement were compared. The detail are as follows:

Inventory Data Collection

The case study company in this study is San pa tong agriculture cooperative limited' s supermarket, is located in Chiang Mai Thailand. Data of all inventory items in the past three years (2013-2015) ware collected items including; unit cost, unit price, lead time, inventory turnover, number of orders, ordering cost, holding cost etc.

Inventory Classification

First, inventory was classified based on the traditional ABC by calculating the annual baht usage of every items by multiplying unit prices with their corresponding annual demand. Next, inventory items were sorted based on annual baht usage from high to low. And selected inventory items class A only according the Pareto principle.

Cluster analysis was implemented by RapidMiner Studio 7.5. For k-means clustering, euclidean distance was used to measure similarity between objects. 4 attributes were used in cluster analysis, which are annual baht usage, lead time, unit cost, unit price and inventory turnover. Elbow method was used to determine number of cluster. Evidently, adding more cluster would reduce cluster variation, this method starts with k=2 (2 clusters). Then adding another cluster until adding more cluster does not significantly provide better modelling. Average within centroid distance was used to measure variance in cluster (the lower the variance the better). The results suggested that the appropriate number of cluster was 9 groups. For x-means clustering, number of cluster was determined automatically by x-means algorithms and the appropriate

number was 4 groups.

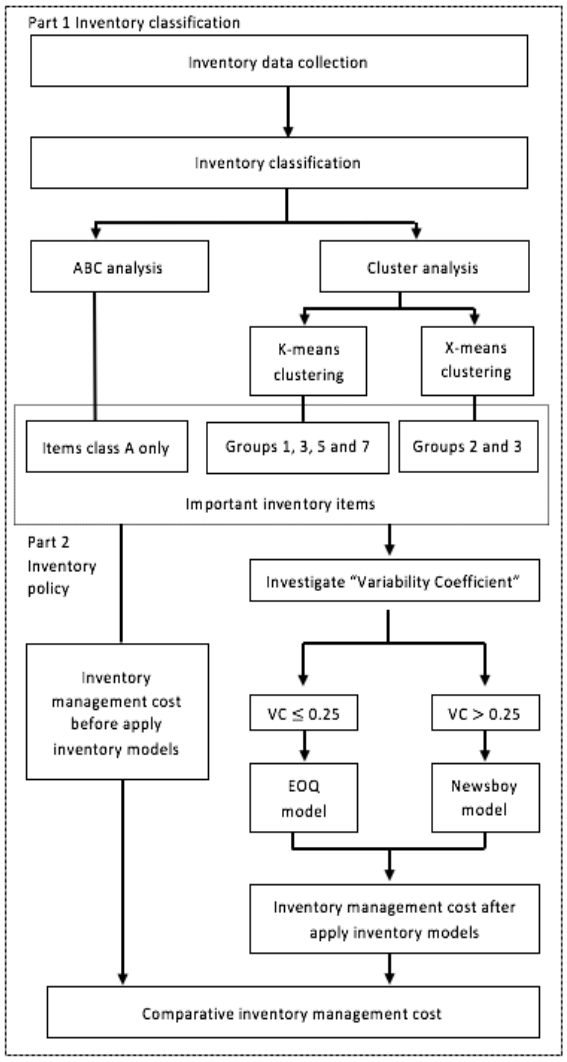

Figure 1: Research flow

Inventory Model And Inventory Management Cost Calculation

Inventory in group A classified by the traditional ABC and important groups selected from k-means and x-means were applied with inventory policy. VC for each item was calculated using equation (2) – (4) and used to select inventory model. EOQ model was used if VC is ≤ 0.25 and Newsboy model was used if VC is > 0.25. Finally, Inventory management cost before and after improvement with each method were compared.

RESULT AND DISCUSSION

Inventory Management Cost Determination

Inventory cost considered in was ordering cost and holding cost. These costs of inventory were determined as follows;

Ordering cost consists of fixed cost and variable cost. Fixed cost was calculated from salary of purchasing staff, cost of computer software, and depreciation of office equipment related to the order which include phone, desks, computers and printer. Total fixed cost was 143,892.67 Baht per years. Variable cost was calculated from internet and phone bill, material such as stapler staples, tape dispenser, plastic rope and documents. Variable cost was 23 Baht per order. The number of ordering was 62,680 order per year. Consequently, the ordering cost of supermarket equals to (143,892 / 6,280) + 23 = 25.30 Baht per order.

Holding cost of supermarket consist of warehouse tax, warehouse staff salary, warehouse security guards, electricity and cleaning which equal to 538,073.74 Baht per year. Average inventory value of supermarket has 15,461,266.33 Baht per year. Consequently, holding cost as a percentage of inventory value = 538,073.74 / 15,461,266.33 = 0.035 or 3.5%.

Inventory Data Collection

The case study supermarket has 2,882 inventory items in total. Table 1 is a sample of inventory data collected from the case study supermarket. The full table consist of 2,882 rows corresponding to each inventory item. Five criteria shown in Table 1 is calculated from the average of 3 years' data. Annual baht usage was calculated by multiply unit price with annual usage. Lead time which is number of day from pacing order until the order arrived. Unit price or the price charged from customer per one item. Item 00867 has highest annual baht usage at 247,809 per year. Inventory turnover [18] was calculated from cost of goods sold divided by average inventory.

ABC Inventory Classification

In order to do ABC classification, Inventory items were ranked by annual baht usage from high to low. In theory, item in group A would be item in the top 20% that would contribute to 70-80% of value. However, in this case from the result in Table 2, 459 items or 15.92% of items that were classified into group A, only contribute to 50% of value. This is due to the nature of this supermarket that items sold have price at the same range. Only item in group A that ware selected for the inventory policy calculation in the next step.

Table 1: Sample of inventory data including criteria for classification, classification results, inventory policy and inventory cost

No	Items No.	Criteria					ABC analysis	Cluster analysis		VC	Optimal inventory items (Units)		Optimal total cost (Baht)
		Annual Baht Usage	Lead Time (Days)	Unit Cost (Baht)	Unit Price (Baht)	Inventory turnover (Rate)		K-means	X-means		EOQ	Q*	
1	00867	247,809	3	32.46	37	2.28	A	7	2	0.12	545		615.67
2	00380	232,185	3	34.03	39	1.94	A	7	2	0.01	507		600.15
3	02491	153,854	7	103.08	116	1.80	A	7	2	0.02	137		490.66
4	00199	107,942	2	42.52	52	2.06	A	7	2	0.00	265		393.11
5	02584	100,011	7	693.74	870	1.35	A	3	3	0.04	16		444.71
6	02630	86,573	7	1,365.81	1,510	1.33	A	3	3	0.28		145	622.13
7	02673	59,170	7	1,209.76	1,335	1.53	A	3	3	0.36		121	475.10
8	02704	41,800	7	771.38	836	1.73	A	3	3	0.05	10		260.61
9	02849	16,925	7	1,439	1,611	0.96	B	1	3	0.51		34	1,816.64
10	01283	14,940	3	889.04	996	2.24	B	3	3	0.00	5		153.24
11	02850	14,110	7	1,095.89	1,227	1.29	B	3	3	0.23	4		148.97
12	01701	11,512	3	852.94	933	1.04	B	3	3	0.03	5		210.45
13	02818	11,957	7	970.90	1,087	0.87	B	3	3	0.05	5		78.35
14	02075	10,780	3	963.88	1,078	1.46	B	1	3	0.00	4		130.21
15	02881	10,248	7	762.92	854	1.20	B	5	3	0.00	5		126.97
16	01712	9,372	3	852.94	937	0.79	B	3	3	0.13	5		122.55
17	01730	6,131	3	916.15	1021	0.37	C	3	3	0.69		21	340.65
18	02821	5,757	7	970.37	1,152	1.04	C	3	3	0.16	3		45.93

Table 2: Number of items and value of each class classified by ABC analysis

Group Items	Number Of Inventory items	Percentage Items number	Annual Baht usage	Percentage of annual baht usage
A	459	15.92	18,975,013	50.03
B	949	32.92	11,370,309	29.98
C	1,474	51.14	5,693,728	15.01
Total	2,882	100	37,926,231	100

Inventory Classification With Cluster Analysis

K- means clustering and X-means clustering were used to classify inventory into groups based on annual baht usage, lead time, unit cost, unit price and inventory turnover.

K-means clustering divided inventory items into 9 groups. Table 3 shows the average value of criteria for each cluster classified by k-means.

Table 3: Average value of criteria for each cluster classified by k-means

Cluster Items	Annual Baht Usage	Lead Time (Days)	Unit Cost (Baht)	Unit Price (Baht)	Inventory Turnover (Rate)	Number Of Inventory items
0	46,067.97	3.39	102.24	115.63	1.92	136
1	10,750.32	6.71	146.29	164.77	1.45	330
2	8,582	6.14	66.73	76.66	2.16	451
3	40,782.69	5.23	1,093.81	1,213.86	1.27	59
4	9,351.76	2.82	51.74	60.30	2.11	1093
5	16,641.04	4.96	151.49	224.23	5.24	26
6	7,104.12	3.14	89.47	99.35	1.30	570
7	164,431.09	3	68.47	77.82	2.04	17
8	19,648.25	4.90	469.14	529.12	1.46	200

From Table 3 group 1, 3, 5, and 7 were selected for further analysis. Group 1 is the group that has very long lead time, medium unit cost and unit prices and low inventory turnover. Group 3 is the group that has high unit cost and unit price, long lead time, low inventory turnover.

Group 5 was selected due to its high inventory turnover rate and long lead time. Finally, group 7 was

selected due to its high of annual baht usage and high inventory turnover.

Table 4: Average value of criteria for each cluster classified by x-means

Cluster items	Annual Baht Usage	Lead Time (Days)	Unit Cost (Baht)	Unit Price (Baht)	Inventory Turnover (Rate)	Number Of Inventory items
0	10,225.49	6.22	103.66	118.67	1.86	931
1	11,982.81	2.84	72.35	83.01	1.88	1749
2	200,899.08	3.25	91.79	103.10	2.06	18
3	28,792.47	5.36	681.73	759.15	1.41	184

X-means clustering divided inventory items into 4 groups. The average value of criteria in each group is shown in Table 4. Group 2 and 3 were selected for further analysis. Group 2 was selected based in their high annual baht usage and fast inventory turnover. Group 3 was selected based on their long lead time and high unit cost and unit prices.

Where EOQ model is unit per order and Q* (Newsboy model) is max unit per year

Inventory Model Calculations

Inventory models were divided two models which is consisted EOQ model and newsboy model depending on VC. EOQ model used to applied when VC ≤ 0.25 and Newsboy model used to applied when VC > 0.25.

For example, From Table 1. Inventory item No. 00867 has VC equal 0.12. Hence, this inventory items should be applied with EOQ model. EOQ was calculate from formula (5). Item no. 00867 has average annual demand(D) of 6,632 units. Ordering cost(S) equal to 25.30 Baht per order (from section 4A). Holding cost is 3.5% of unit cost equal 32.46 x 0.035 = 1.13 baht. Therefore, EOQ can be calculated as follows

$$EOQ = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2(6,632)(25.30)}{1.13}} = 545 \text{ units}$$

Which means purchasing staff in supermarket should purchase items No.00867 at 545 units per order which would results in inventory management cost at 615.67 baht per order.

In order to demonstrate Newsboy model, inventory No. 02630 which has the VC equal 0.28 is used. The average demand and standard deviation (S.D) of inventory items No.02630 were 57 and 37 units. The researcher determined Z value as 99% probability of not stocking out is 2.35. Maximum quantity of Newsboy model was calculated from formula (7)

Max quantity $Q^* = \mu + Z\sigma = 57 + 2.35(37) = 145$ units per year

Newsboy total inventory cost were calculated from equation (8). The researcher determined usage cycle as 12 round that means 1 year has 12 month. The number of ordering has 5 order per year.

Optimal total inventory cost $K^* = nC_c + \frac{C_h \sum Q_o}{N}$

$= 5(25.30) + \frac{(47.53)(145)}{12} = 622.13$ baht per year

Which means purchasing staff in supermarket should purchase items No.02630 max quantity at 145 unit per year which would results in inventory management cost at 622.13 baht per year. Or should purchase items at 145/5 = 29 units per order that inventory management cost at 622.13/5 = 124.42 baht per order.

The EOQ and newsboy quantity and their corresponding inventory cost were calculated for each of the items in group A and important items from cluster analysis. Total cost for each method were sum-up and compared in the next section.

Inventory Management Cost Comparison

Table 5 summarize inventory management cost from ABC and cluster analysis before and after improvement. The results suggested that k-means clustering was the most effective method as it reduced inventory management cost at highest (64.23% reduction)

Table 5: The comparison of inventory management cost from the ABC and cluster analysis

		ABC Analysis	Cluster Analysis	
			K-means Clustering	X-means Clustering
Before improvement		176,707.19	312,695.13	155,201.26
After improvement	EOQ model	95,732.44	56,125.57	37,163.31
	Newsboy model	33,443.16	55.738.25	50,293.67
	Total	129,175.60	111,863.82	87,456.97
% Reduction		26.90%	64.23%	43.65%

CONCLUSION

This research proposed an improvement to the traditional ABC analysis by implementing cluster analysis to classify inventory base in multiple criteria. Real data from case study was used to demonstrate the proposed method. Inventory data were collected and the criteria used for inventory classification were annual baht usage, lead time, unit cost, unit price and inventory turnover. The clustering algorithm which are k-means and x-means were applied. Important inventory group were selected for inventory model calculations. EOQ model and Newsboy model were applied depending to the variability of the demand. Inventory management cost before and after improvement were compared. The result suggested that k-mean is the most effective method as it reduced inventory management cost at the highest ratio. The result not only act as guidelines for purchasing staff at the case study company but also can applied to other organization that wish to keep a better control of their inventory cost.

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