COMPARISON OF JOINT-ORDER INVENTORY POLICIES: A SIMULATION STUDY OF PHARMA SALE DATA

BY

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ABSTRACT

This paper aims to provide a guideline for inventory policies by comparing their performance using Excel simulation methods. As businesses grapple with demand transformations driven by rapid technological changes and economic shifts, effective inventory management has become crucial. Several innovative inventory policies have emerged, each with unique advantages and trade-offs. Businesses are continually devising novel strategies to efficiently cater to their clients. Despite the practical guidelines offered by modern policies, a comparative framework for selecting the most appropriate policy is needed. This paper offers usage guidelines and recommendations based on a comparative simulation of evolved inventory policies, including the (s, S), the (s, c, S), the Q(s, S) policy, the Q,S policy, and the (Q, S, T) policy. Through this analysis, the paper seeks to equip users with a decision-making framework for navigating the complex landscape of inventory management and also suggest the Q(s, S)T policy, a new enhancement strategy that was created by adapting the existing approach based on simulation observations.

Keywords: Inventory Policies, Inventory Management, Simulation, Comparison

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Jomkwan Hirunyasiri

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LIST OF SYMBOLS/ABBREVIATIONS

Symbols/Abbreviations	**Terms**
ATC	Anatomical Therapeutic Chemical
NDI	National Drug Infermation
MLR	Minimum Leding Rate
CV	Coefficient of Variation

CHAPTER 1
INTRODUCTION

1.1 The Background

Driven by rapid developments in technology and huge economic shifts, several innovative inventory policies have been developed to meet issues; each has pros and cons of its own. While researchers have examined these policies, a thorough comparison has not yet been conducted the best perform policy. Enterprises in diverse sectors are creating new strategies to efficiently adapt to their clients, since inventory regulations undergo continuous modifications to satisfy ever-changing consumer needs. According to Jain (2015), effective resource management and control are critical for proper management; therefore, essential recommendations should be identified and integrated into their policy as guidelines.Despite the practical guidelines provided by modern policies, a comparative framework to help choose the policy for specific scenarios is lacking. To effectively resolve the complexity of modern inventory management, an integrated strategy is required.

1.2 The Method Plan

This research will analyze and contrast both conventional and contemporary adaptive inventory strategies through a simulation approach. The experiment will involve dataset of products demand. The simulation process will be executed using Excel Solver tool. This paper will explain how to use Excel to simulate the use, as a guideline, of total five evolve policies from the based policy of order-up-to-level policy which are the can-order policy (s, c, S), the the Q(s, S) policy, the Q,S policy, and the (Q, S, T) policy. Next, with a donation to offer a recommendation for a contribution as well as propose the new development Q(s, S)T pilicy. As a result of economic and technological developments, the (s, S) policy has gained acceptance as an inventory policy and has served as the foundation for numerous other policies. Businesses gain from these advancements in a number of ways. To assist practitioners in selecting the best policy for their needs, this paper examine at four updated policies along with a new one, merging them into a single guideline.

1.2.1 The order-up-to-level (s,S) policy

Either the inventory level hits the reorder point or drops below it, the order up to level is triggered. Maintaining an accurate order can be achieved by routinely reviewing the availability of items.

1.2.2 The can-order-policy (s, c, S) policy

Placed the order to bring the inventory position back to S when it approaches or drops below the must-order levels. Every item also has a can-order level of c. Any item having an inventory position at or below its can-order level is included to the order when it reaches its must-order level.

1.2.3 The Q(s, S) policy

The inventory is reviewed whenever the aggregate demand since the last order reaches quantity Q. If the inventory level of any item j is at or below sj, it is restocked up to Sj. This solution strategy uses a decomposition principle, assuming that the total order cost will be incurred at each review period, which is linked to the unknown review times. This policy treats all product types equally when setting the control parameter Q.

1.2.4 The (Q, S) policy

The (Q, S) policy states that once a cumulative total of Q demands has been met since the last order was placed, all inventory items are replaced up to their preset order-up-to levels. When the total demand reaches a predefined level, this method methodically initiates a resupply – Gupta(2017).

1.2.5. The (Q, S, T) policy

Under two distinct circumstances, the (Q, S, T) policy raises the inventory positions of products to their designated order-up-to levels: either when a an aggregate total of at least Q demands has been reached, or when T time units have passed since the last ordering instance. This two-pronged trigger system makes sure that stock replacement happens when demand spikes or when a predetermined amount of time passes, whichever comes first. by the combination of time-based and demand-based criteria – Gupta(2017).

1.2.6 The new Q(s, S)T policy

The Q(s, S)T policy combines the Q(s, S) and (Q, S, T) policies by reviewing inventories when T time units have elapsed since the last order or after an aggregate total of Q demands have accumulated since the last review. Items at or below their reorder point are then replenished to their order-up-to levels.

CHAPTER 2
REVIEW OF LITERATURE

Xue et al. (2011) examined the significance of information sharing in construction supply chains across various inventory policies. The study underscored the role of information sharing in mitigating supply chain risks and enhancing operational efficiency. It stressed the importance of aligning information-sharing practices with the chosen inventory policy to optimize collaboration benefits and reduce uncertainties in construction supply chains.

In a study by Nurprihatin, Rembulan, & Pratama (2022), the performance of two distinct inventory models—probabilistic economic order quantity (EOQ) and periodic order quantity models—was compared in the context of irregular demand environments. The research unveiled the implications of different models in efficiently managing inventory under conditions of irregular and unpredictable demand patterns. The results suggest that the selection of the inventory model should be customized based on specific demand characteristics to minimize costs and stockouts.

Within the automotive industry, Rizkya et al. (2018) conducted a comparative analysis between periodic review and continuous review policies for inventory systems. Their research focused on optimizing inventory management in a sector marked by high demand variability and seasonality. The study highlighted the importance of selecting the appropriate review policy to ensure the availability of crucial components in the production process while minimizing holding costs.

Escuín, Polo, & Ciprés (2017) delved into inventory replenishment policies under time-varying stochastic demand in the paper industry. Their analysis considered the complexities stemming from fluctuating demand patterns, prevalent in various industries. The research showcased the critical significance of dynamic decision-making in inventory control to adapt to changing demand patterns and maximize operational efficiency.

A joint ordering inventory strategy put out by Renberg and Planche was examined by Pantumsinchai, P. (1992), who demonstrated the policy's adaptability to Poisson demands. This policy was contrasted with Atkins and Iyogun's periodic policies and Balintfy's (S, c, s) or can-order policy. The Renberg and Planche policies performed well in certain scenarios, but overall there was no single policy that outperformed the others, according to the results.

Atkins, D. R., & Iyogun, P. O. (1988) were managing inventories with combined fixed costs for replenishment and item-specific fixed costs for every item in the order is the focus of the coordinated multi-item inventory problem. In this study, a new lower cost bound for the optimal policy is introduced, and a straightforward periodic policy that improves on 'can-order' policies for a wide range of datasets is suggested.

Creemers, S., & Boute, R. (2022) proposed a new technique for assessing stationary joint replenishment plans in the context of compound Poisson demand is presented. The technique reduces the state space and allows for exact analysis without approximation by focusing on the system state post-order placement through the use of an embedded Markov chain. A greedy-optimal method that extends the can-order policy within the joint replenishment policy class is created, and the optimal joint replenishment policy is defined. This enhanced can-order strategy shows marginal improvement based on numerical analysis. Additionally, the technique improves upon the commonly-used decomposition strategy for large systems that contain several elements.

To determine if the railway industry would benefit from using Economic Order Quantity (EOQ) and Economic Order Interval (EOI) inventory management techniques, Tebaldi, Bigliardi, Filippelli, and Bottani (2023) carried out simulation research. The study emphasizes how crucial it is to choose an inventory management policy that complies with industry-specific regulations. It highlights the importance of using simulation to evaluate the effectiveness of various inventory management techniques and customize them to the circumstances of the railroad sector.

Sbai and Berrado (2023) tackled the challenging task of selecting inventory systems in multi-echelon distribution networks using a simulation-based method in a different domain. The study demonstrates how flexible simulation methods are for assessing and improving inventory control systems at different stages of the supply chain. Distribution systems provide as an example of how simulation techniques may be used to help choose the right inventory rules in a variety of supply chain scenarios.

To enhance inventory control for various goods processed on a single machine with sequence-dependent setup durations, Mesquita and Tomotani (2022) used simulation-optimization techniques. The study emphasizes how crucial simulation is for figuring out the best inventory plans, especially when there are limited resources and complex production procedures involved. This method aids in the creation of efficient inventory control strategies for production environments.

A continuously monitoring system was investigated by Liu, Chang, and Chen (2023) in the context of combining inventory management with predictive maintenance. The project tackled inventory policies and predictive maintenance through simulation optimization. The study underscores the possible advantages of combining inventory management and maintenance tactics to lower expenses and improve operational effectiveness, particularly in sectors where equipment dependability is critical.

According to Larsen, C. (2019) satate that item differences present challenges for the Q(s,S) policy, despite its effectiveness. For various item contexts, a new (c,S,α) policy that employs a single joint order choice and a policy iteration step greatly enhances performance. It outperforms Q(s,S) and produces superior policies from optimal can-order methods by adjusting joint order ease with α and incorporating can-order points for extra items.

An effective approach to solving the stochastic joint replenishment problem in single-location, multi-item contexts is presented by Özkaya, Gurler, and Berk (2006). Group order quantity, the amount of time since the last order, and a group reorder point form the basis of their policy. Important traits of both compound and unit Poisson demand are found. This method works well in settings where demand variability is minimal as well. Moreover, a two-echelon situation with several stores, a single item, and cross-docking at the higher echelon is modeled by expanding the inventory system.

Table 2.1 A table of comparisons between related studies

Authors	Objective	Methodology
Pantumsinchai, P. (1992)	To compare the effectiveness of two other well-known policies—the can-order policy and periodic policies—with the joint ordering inventory policies of Renberg and Planche. The assessment of each policy's effectiveness under various scenarios is based on long-term total average expenses.	Quantitative approach, analyzing cost parameters, such as setup costs, stockout costs, and order quantities, to determine the overall performance of each policy in managing inventory.
Atkins, D. R., & Iyogun, P. O. (1988)	To compare the performance of (s, c, S) and periodic policies in coordinated multi-item inventory systems	A simulation-based approach to compare the performance of (s, c, S) policy and periodic policies in joint-replenishment inventory systems
Özkaya, Gurler, and Berk (2006)	To develop the more efficient computational methods and propose the new stochastic joint replenishment inventory policy. By study the existing joint replenishment policy such as (s, c, S), Q(s, S), (Q, S), and (Q, S, T).	Decomposition method by assuming demand arrival rate.
This Study	To provide the gudeline of comparing the cost performance of base policy of order-up-to-level policy with three developed joint replenishment policies which are can-order policy, Q(s,S), (Q, S) , and Q,S, T. Additionally, propose the new enhancement pilicy of Q(s, S)T.	A Excel simulation by focusing on the basic term of use

Table 2.2 Distinctive parameters of each policy

	Reorder Point	Can-order Point	Order-up-to Level	Accumulated Demand	T-time Units Have Pass
(s, S)	✓		✓		
(s, c, S)	✓	✓	✓		
Q(s, S)	✓		✓	✓	
Q, S	✓		✓		
Q, S, T	✓		✓		✓
Q(s, S)T	✓		✓	✓	✓

For the research gaps, a review of all available literature indicates that, although it is more difficult these days, comparing and assessing to adopt the appropriate inventory policy for a certain industry or to accomplish a specific business's goal is still necessary or even the guideline for beginner of this field. This indicates that there is a gap to provide the guideline as a basic application or study guide that can be filled by using a straightforward method software, such as Excel, to simulate the benefits and how to implement the best policies for those who are new to the sector. Moreover, each policy has a distinct background, with each revision concentrating on a single area of improvement. For this reason, this study will use simulation to compare the evolution of the order-up-to policy and suggesting some fresh ideas to enhance the application and also provide the new proposal of new enhancement policy.

CHAPTER 3
METHODOLOGY

3.1 Data Preparation

This paper uses "Pharma Sales Data," which includes 600,000 transactional records collected over six years (2014–2019). The dataset was extracted from each pharmacy's point-of-sale system and contains information such as the pharmaceutical drug's brand name, quantity sold, and the date and time of sale. A subset of the dataset's 57 drugs falls under the following Anatomical Therapeutic Chemical (ATC) Classification System categories (ZDRAVKOVIĆ, 2020):

- M01AB - Anti-inflammatory, Acetic acid derivatives, and related substances
- M01AE - Anti-inflammatory, Propionic acid derivatives
- N02BA - Other analgesics, Salicylic acid, and derivatives
- N02BE - Other analgesics and Pyrazolones, and Anilides
- N05B - Psycholeptics, Anxiolytics
- N05C - Psycholeptics, Hypnotics, and sedatives
- R03 - Drugs for obstructive airway diseases
- R06 - Antihistamines for systemic use

The demand data quantities are not expressed as whole numbers because the pharmacy allows the sale of individual tablets from packages, rather than requiring the purchase of entire packages.

To replicate the comparison, only a portion of the data will be used in this paper. Tree products of data will be created from the data: distinct demand patterns. Weekly data for products M01AB, N02BE, and N05C over four years are among the data used. The order-up-to-level policy, the can-order policy (s, c, S), the the Q(s, S) policy, the Q,S policy, the (Q, S, T) and the new Q(s, S)T policy will all be represented by the simulation in this paper, according to order. All three-demand of M01AB, N02BE, and N05C trend graph are shown in the Figure 1, 2, and 3 respectively.

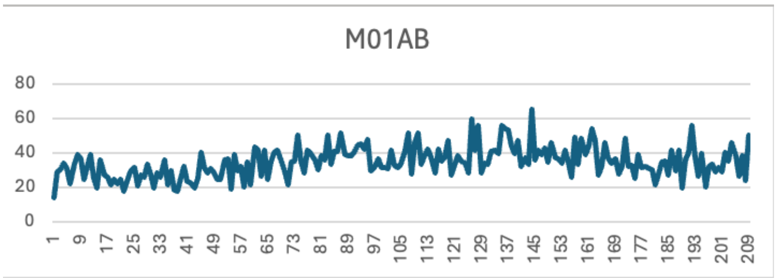

Figure 3.1 M01AB Demand Trend

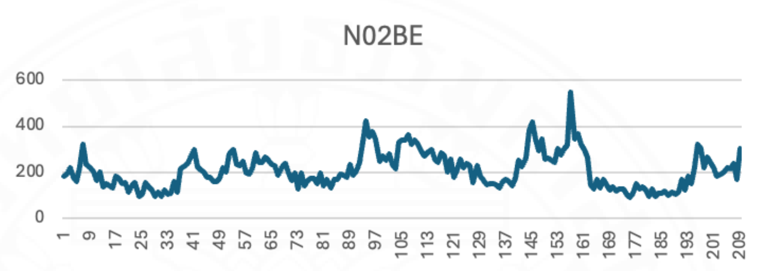

Figure 3.2 N02BE Demand Trend

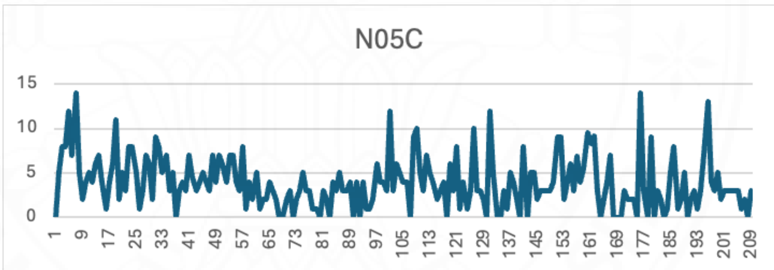

Figure 3.3 N05C Demand Trend

3.2 Mathematic Model

3.2.1 Notation and Parameter Description for Policies

i	Week index
X	Product ID
D_{ix}	Demand of product x on week i, units
μ	Average of total demand
σ	Standard deviation of total demand
OH_{ix}	Beginning inventory on-hand of product x on week i, units
O_{bix}	On Order at the beginning of product x on week i, units

BO_{ix}	Back order of product x on week i, units
IP_{ix}	Beginning inventory position of product x on week i, units
Q_{ix}	Order quantity of product x on week i, units
AQ_{ix}	Order arrived of product x on week i, units
A_{ix}	Aggregate demand of product x on week i, units
LT	Lead time, days
IL_{bix}	Inventory Level in the Beginning of product x on period i
IL_{eix}	Inventory Level in the end of product x on period i
RC	Re-Ordering Cost, THB/order
HC	Holding Cost, THB/unit/week
UC_x	Unit Cost of Product x
β	Average Inventory Expense
I	Interest Rate: average Minimum Lending Rate (MLR)
BC	Back Order Cost, THB/back order in unit of delivery package
TC	Total expected inventory cost, THB
s	Reorder level, units
S	Order-up-to level, units
c	Can-order level, units
TK	Truck Cost (Joint Order Cost)
k	Other Related Fixed Cost
T	Duration of inventory checking
LO_x	Last Placed Order on week i of Product x, week index

3.2.2 Mathematic Model for each policy purchase decision

- (s, S) Policy

If $IP_{ix} \leq s_x$

Then $Q = S_x - IP_{ix}$

- (s, c, S) Policy

If $IP_{ix} \leq s_x$

Then $Q_x = S_x - IP_{ix}$

If $IP_{ix} \leq s_x$ and $IP_{iy} \leq s_y$

Then $Q_x = S_x - IP_{ix}$ and $Q_y = S_y - IP_{iy}$

If $IP_{ix} \leq s_x$ and $IP_{iy} \leq s_y$ and $IP_{iz} \leq s_z$

Then $Q_x = S_x - IP_{ix}$ and $Q_y = S_y - IP_{iy}$ $Q_z = S_z - IP_{iz}$

- Q(s, S) Policy

If $A_{ix} \geq A_{i-1x} + Q$ and $IP_{ix} \leq s_x$

Then $Q_x = S_x - IP_{ix}$

If A = Q and $IP_{ix} \leq s_x$ and $IP_{iy} \leq s_y$

Then $Q_x = S_x - IP_{ix}$ and $Q_y = S_y - IP_{iy}$

If A = Q and $IP_{ix} \leq s_x$ and $IP_{iy} \leq s_y$ and $IP_{iz} \leq s_z$

Then $Q_x = S_x - IP_{ix}$ and $Q_y = S_y - IP_{iy}$ and $Q_z = S_z - IP_{iz}$

- Q, S Policy

If $A_{ix} \geq A_{i-1x} + Q$

Then $Q_x = S_x - IP_{ix}$

- Q, S, T Policy

If $A_{ix} \geq A_{i-1x} + Q$ or $LO_x - (i$ +T) = 0

Then $Q_x = S_x - IP_{ix}$

- Q(s, S,)T Policy

If $A_{ix} \geq A_{i-1x} + Q$ or $LO_x - (i$ +T) = 0 and $IP_{ix} \leq s_x$

Then $Q_x = S_x - IP_{ix}$

If A = Q or i / T = 0 and $IP_{ix} \leq s_x$ and $IP_{iy} \leq s_y$

Then $Q_x = S_x - IP_{ix}$ and $Q_y = S_y - IP_{iy}$

If A = Q or i / T = 0 and $IP_{ix} \leq s_x$ and $IP_{iy} \leq s_y$ and $IP_{iz} \leq s_z$

Then $Q_x = S_x - IP_{ix}$ and $Q_y = S_y - IP_{iy}$ and $Q_z = S_z - IP_{iz}$

3.2.3 Substitute Value Reference

a. Product Unit Cost

Specified by National Drug Infromation (NDI) market pharmacist with value added tax price record by group of medicine. In this paper take the average price of medicine type from NDI information and multiplied with number per package as a product unit cost as followed (Thailand National Drug Information, 2024), all products unit cost information is shown in Table 3.

Table 3.1 Products Unit Cost Information

Products for Cost Simulation			
Product	Price / Tablet or Capsule	Sale Unit / Package	Price / Package
M01AB	12.1 Baht	15 Capsules	181.5 Baht
N02BE	4.97 Baht	36 Tablets	178.92 Baht
N05C	1.95 Baht	100 Tablets	195 Baht
Additional products for demand simulation			
Product	Price / Tablet or Capsule	Sale Unit / Package	Price / Package
M01AE	25.61 Baht	6 Capsules	153.66 Baht
N02BA	15.82 Baht	12 Tablets	189.84 Baht
N05B	1.05 Baht	100 Tablets	105 Baht

b. Holding Cost

According to Thailand's Logistic Report 2019 state that holding cost or product's H_c can be calculated by product unit cost multiplied by 2019's average inventory expense (β) of 16.63% plus interest rate (I: average minimum lending rate or MLR) of 6.3%. Since, the data being used is a weekly demand so holding cost calculation according to to Thailand's Logistic Report must divided by 52; number of weeks in a year (Thailand Logistic Report, 2020).

c. Fixed Cost

- Joint Order Cost (Truck Cost)

In accordance with Thai Rent A Car Corporation Co., Ltd. provide rental 4-wheel of 1.5 x 2.1 x 2 meters truck price of 1,200 Baht per day (Thai Rent Car. 2024)

- Other Fixed Cost - Reorder Cost (Documents work)

This Paper assume other fixed cost of 200 Baht which comes from Thai's bachelor's degree-based salary of 18,000 (ThaiGov, 2024) divided by 22 working days a month and divided by 8-hour shift a day and then divided the assume document work hour of two.

d. Backorder Cost

According to Levi et al. (2008), the research of Approximation Algorithms for Capacitated Stochastic Inventory Control Models mentioned that the appropriate backorder cost calculation in this paper use the rate of 8 times larger than the holding cost.

3.3 Excel Simulation

3.3.1 The Excel Solver Setup

All policies select solving method as "Evolution" and all constraints must be non-negative. In part of evolutionary option all setup values are shown in Table 4.

Table 3.2 Evolutionary Option Setup

Convergence	0.0001
Mutation Rate	0.075
Population Size	500
Random Seed	0
Maximum Time without improvement	300
Require Bounds in Variables	

3.3.2 Policy Setup and Initial Value Result Comparison

(s, S) Policy: When the inventory level reaches the reorder point the order will be placed through keeping inventory level at regular intervals, maintain a proper order in balance. The Excel solver first determines that S is greater than s before calculating the values of s and S.

(s, c, S) Policy: Analyzing parameter relationships in an approach similar to the (s, S) policy, joint re-order costs caused by the joint replenishment policy regulation are also taken into account, if one or more products are being place at the same period calculated as one time truck cost. The study includes the correlation between every characteristic of products. This simulation method utilizes the functionality of the Excel solver. In order to determine the values of s, S, and c, the Excel solver first verifies that s is less than c and c is less than S.

Q(s, S) Policy: Whenever the aggregate demand of the most recent order instant reaches level Q, the inventory is assessed under the Q(s, S) policy. The inventory position of any item that is less than or equal to s is raised to level S. The Excel solver is used for generating the s and S values. The Excel solver indicates that s is less than S in the same method as the order-up-to-level policy configuration and a proper Q index.

(Q, S) Policy: All products' inventory levels are replenished to their order-up-to levels once a cumulative total of Q demands have been reached since the previous order. The S values and an accurate Q index are produced by the Excel solver.

Q(s, S)T Policy: The Q(s, S)T policy combines aspects of both the Q(s, S) and Q, S, T policies. Under this policy, inventories are reviewed when either a total of Q demands have accumulated since the last review or T time units have passed since the last order. Items with inventory positions at or below their reorder levels are then replenished to their order-up-to levels. Using the Excel Solver, the values of s, S, Q, and T are found, indicating that s is less than S.

As the aforementioned of all initial substitute value reference, the comparison of cost and parameter result of all six policies are shown in Table 5 and 6. The policies with the best cost performance are (s, c, S), followed by Q,S and Q,S,T. The (s, S) and Q(s, S) policies have the largest costs, whereas the Q(s, S)T policy performs moderately on average.

Table 3.3 Cost Comparison of Six Policies by Initial Value

	(s, S) Cost(฿)	(s, c, S) Cost(฿)	Q(s, S) Cost(฿)	Q, S Cost(฿)	Q, S, T Cost(฿)	Q(s, S)T Cost(฿)
M01AB	275	140.65	548.4	434.8	434.79	522.57
N02BE	935.7	665.48	670.97	775.2	775.22	691.01
N05C	89.4	47.84	94.35	68.6	68.85	81.35
Total Cost (฿)	1,300.05	**1,118.09**	**1,313.72**	1,278.50	1,278.85	1,294.90

Table 3.4 Parameters Comparison of Six Policies by Initial Value

	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
M01AB	(127.16, 496.63)	(110.6, 226.56, 345.29)	600(234.19, 283.58)	902.77, 314	903.1, 311.99, 6	654.12(225.95, 289.55)8
N02BE	(1082.23, 1942.94)	(1120.6,1329.1, 1982.4)	600(1471.7, 1696.7)	902.77, 1914.31	903.1, 1916.99, 6	654.12(1297.93, 1783.84)8
N05C	(4.52, 118.63)	(1.89, 36.05, 81.64)	600(34.98, 65.15)	902.77, 39.96	903.1, 42.12, 6	654.12(26.4, 41.35)8

3.4 Value Comparison

Every cost scenario simulation was put to the test in order to evaluate how efficiently various policies performed in various scenarios. Table 7 presents the initial and test values, which were increased and decreased sequentially. The simulation demonstrates the reorder cost, backorder cost, lead time, and holding cost. For the holding cost comparison, two different methods are used because changes in holding cost is depended on product unit cost and the change of holding cost will also impact backorder cost. Therefore, the simulation compares holding costs in two ways: first, change the product unit cost by fixing the backorder cost at an initial value, with the and second, by allowing the backorder cost to vary at 8 times ratio.

Table 3.5 Cost Value Test Index

Tested Cost	Reference Value	Decrease Test Value	Increase Test Value
Reorder Cost (Baht)	200	0, 50, 100	0, 50, 100
Backorder Cost (Baht)	HC*8	HC*1, HC*4	HC*12, HC*16
Lead Time (Day)	4	1	10
Holding Cost (Baht) HC Vary by BC Fixed	Product Unit Cost of Hundreds	Product Unit Cost of Units, Tens	Product Unit Cost of Thousands, Ten Thousands
Holding Cost (Baht) HC Vary by 8 times BC	Product Unit Cost of Hundreds	Product Unit Cost of Units, Tens	Product Unit Cost of Thousands, Ten Thousands

The total cost, graph, and parameter index for every products under various reorder costs are displayed in Tables 8, Figure 4, and Table 9, which also demonstrate that the (s, c, S) policy consistently produces the lowest cost under all situations also shown by MODE statistic ranking in Table 10.This paper use MODE as a statistic ranking performance due to the reason that non-orderable nominal or categorical data, the mode is the sole appropriate metric. Moreover, it was noted that the Q(s, S) policy does not function well in scenarios with high reorder costs, while the (s, S) strategy is appropriate for these circumstances.

Table 3.6 Reorder Cost Comparison

RC (Baht)	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
0	**1,232.97**	**1,013.34**	1,101.38	1,112.29	1,122.70	1,104.90
50	**1,249.82**	**1,033.86**	1,149.60	1,158.94	1,162.72	1,149.43
100	**1,266.56**	**1,055.49**	1,199.07	1,205.59	1,209.00	1,195.78
200	1,300.05	**1,118.09**	**1,313.72**	1,278.50	1,278.85	1,294.93
400	1,364.19	**1,204.72**	**1,500.41**	1,419.13	1,418.65	1,418.27
800	1,487.76	**1,365.26**	**1,798.38**	1,671.20	1,671.21	1,669.65
1600	1,711.59	**1,616.66**	2,100.64	**2,142.02**	**2,142.02**	2,140.41

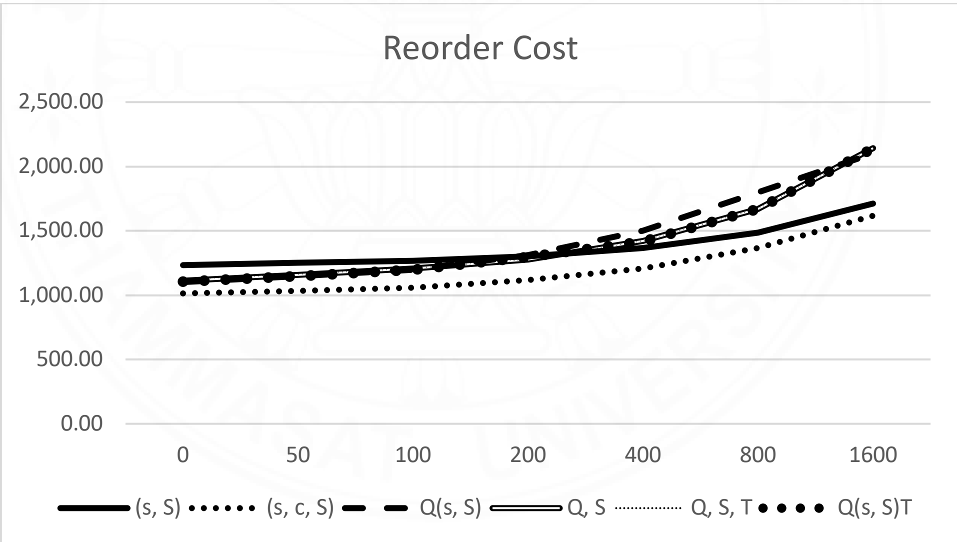

Figure 3.4 Reorder Cost Comparison

Table 3.7 Reorder Cost Index Comparison

Unit	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
RC = 0 Baht						
M01AB	(131.17, 449.56)	(130.24, 232.89, 359.93)	599.88(222.72, 282.96)	655.32, 277.87	656.66, 286.29, 6	656.31(227.38, 281.41)8
N02BE	(1,082.21, 1,942.94)	1,120.14, 1,324.80, 1,974.94)	599.88(1,452.51, 1,709.27)	655.32, 1,745.45	656.66, 1,802.15, 6	656.31(1,277.74, 1,767.99)8
N05C	(4.32, 118.62)	(10.34, 37.40, 55,87)	599.88(37.87, 39.36)	655.32, 35.96	656.66, 44.82, 6	656.31(29.62, 40.49)8
RC = 50 Baht						
M01AB	(126.81, 496.62)	(131.98, 238.43, 359.53)	599.89(231.77, 272.62)	655.32, 277.87	658.30, 290.38, 6	655.54(231.23, 275.45)8
N02BE	(1,082.21, 1,942.94)	(1,108.82, 1,316.74, 1,970.48)	599.89(1,426.63, 1,719.55)	655.32, 1,745.45	658.30, 1,765.39, 6	655.54(1,257.92, 1,748.18)8
N05C	(4.39, 118.62)	(0.22, 26.99, 48.40)	599.89(32.16, 41.61)	655.32, 35.96	658.30, 31.72, 6	655.54(29.66, 38.90)8
RC = 100 Baht						
M01AB	(127.57, 496.63)	(132.32, 239.28, 358.21)	599.89(237.14, 270.71)	655.32, 277.87	680.28, 288.88, 6	654.12, (230.59, 277.03)7
N02BE	(1,082.21, 1,942.94)	(1,107.35, 1,312.20, 1,967.95)	599.89(1,436.92, 1,718.36)	655.32, 1,745.45	680.28, 1,777.09, 6	654.12(1,252.45, 1,744.67)7
N05C	(4.39, 118.62)	(5.17, 33.71, 50.27)	599.89(29.12, 39.64)	655.32, 35.96	680.28, 39.73, 6	654.12(27.58, 36.91)7
RC = 200 Baht						
M01AB	(127.16, 496.63)	(110.6, 226.56, 345.29)	600(234.19, 283.58)	902.77, 314	903.1, 311.99, 6	654.12(225.95, 289.55)8
N02BE	(1082.23, 1942.94)	(1120.61, 1329.12, 1982.393)	600(1471.73, 1696.72)	902.77, 1914.31	903.1, 1916.99, 6	654.12(1297.93, 1783.84)8
N05C	(4.52, 118.63)	(1.89, 36.05, 81.64)	600(34.98, 65.15)	902.77, 39.96	903.1, 42.12, 6	654.12(26.4, 41.35)8
RC = 400 Baht						
M01AB	(127.56, 496.63)	(125.62, 235.76, 360.87)	599.97(236.28, 267.36)	903.25, 312.95	902.63, 308.47, 6	902.78(242.73, 309.5907
N02BE	(990.49, 2,000)	(1,103.95, 1,311.65, 1,964.84)	599.97(1,452.05, 1,720.64)	903.25, 1,913.81	902.63, 1,913.22, 6	902.78(1,423.90, 1,914.96)7
N05C	(4.39, 118.62)	(5.34, 31.35, 65.78)	599.97(29.40, 38.95)	903.25, 39.46	902.63, 40.84, 6	902.78(29.16, 44.54)7
RC = 800 Baht						
M01AB	(120.42, 558.04)	(141.35, 238.63, 378.13)	599.97(231.03, 266)	1,100.72, 335.97	1,099.55, 336.09, 8	1,101.59(238.98, 340.56)7
N02BE	(990.49, 2,000)	(960.57, 1,304.67, 1953.80)	599.97(1,267.90, 1,711.09)	1,100.72, 2,000	1,099.55, 2,000, 8	1,101.59(1,441.44, 2,000)7
N05C	(4.39, 118.62)	(0, 15.07, 98.71)	599.97(27.93, 36.33)	1,100.72, 40.01	1,099.55, 40.06,8	1,101.59(29.97, 39.95)7
RC = 1600 Baht						
M01AB	(106.34, 617.27)	(82.85, 212.27, 460.74)	599.91(238.45, 269.82)	1,100.70, 355.97	1,099.02, 335.96, 8	1,101.07(239.09, 338.39)7
N02BE	(990.49, 2000)	(915.85, 1,306.24, 1,999.96)	599.91(1,281.61, 1,721.29)	1,100.70, 2,000	1,099.02, 2,000, 8	1,101.07(1,535.49, 2,000)7
N05C	(0.03, 200.04)	(5.13, 16, 145.17)	599.91(29.78, 38.99)	1,100.70, 40	1,099.02, 40, 8	1,101.07(31.44, 40.99)7

Table 3.8 Reorder Cost MODE Ranking

Reorder Cost MODE Ranking					
(s, S)	**(s, c, S)**	**Q(s, S)**	**Q, S**	**Q, S, T**	**Q(s, S)T**
2	1	5	4	4	3

When backorder costs are compared, it is discovered that Q(s, S) is unsuitable for low backorder costs, and both Q, S and Q, S, T perform poorly under high backorder costs. As a comparing result of cost, graph, and parameter index shown in Table 11, Figure 5, and Table 12 repectively. Moreover, (s, c, S) performs well under all conditions as observed by MODE statistic shown in Table 13.

Table 3.9 Backorder Cost Comparison

HC (Baht)	**(s, S)**	**(s, c, S)**	**Q(s, S)**	**Q, S**	**Q, S, T**	**Q(s, S)T**
HC*1	820.15	**667.18**	**886.44**	691.76	691.91	691.58
HC*4	1130	**1018.24**	**1143.99**	1056.18	1056.4	1056.26
HC*8	1300.05	**1118.09**	**1313.72**	1278.5	1278.85	1294.93
HC*12	1415.66	**1277.95**	1400.79	1427.34	1428.45	**1440.58**
HC*16	1505.68	**1376.37**	1519.93	**1538.04**	**1538.04**	1527.94

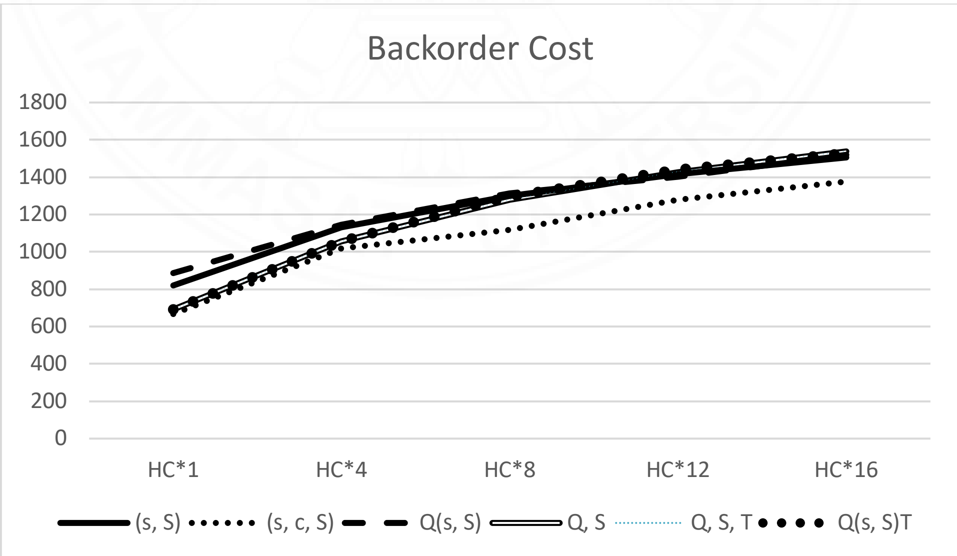

Figure 3.5 Backorder Cost Comparison

Table 3.10 Backorder Cost Index Comparison

Unit	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
BO = HC*1 (Baht)						
M01AB	(0, 433.07)	(0, 257.02, 309.77)	599.84(171.27, 209.17)	1,335.28, 261.78	1,323.95, 258.70, 9	1,325.33(172.93, 260.29)10
N02BE	(321.19, 1,630.97)	(349.39, 930.63, 1,622.60)	599.84(1,006.31, 1,230.68)	1,335.28, 1,554.18	1,323.95, 1,534.2, 9	1,325.33(1,057.20, 1,549.39)10
N05C	(0, 114.05)	(0, 27.15, 56.17)	599.84(15.72, 23.01)	1,335.28, 27.96	1,323.95, 29.49, 9	1,325(15.19, 29.60)10
BO = HC*4 (Baht)						
M01AB	(90.79, 459.26)	(166.46, 257.44, 296.04)	595.36(239.39, 255.40)	1,102.36, 301.41	1,098.62, 295.29, 8	1,098.68(230, 301.26)9
N02BE	(875.13, 1,884.48)	(136.90, 1,060.44, ,884.52)	595.36(1,185.58, 1,638.79)	1,102.36, 1,830.70	1,098.62, 1,832.66, 8	1,098.68(1,255.46, 1,840.39)9
N05C	(0.03, 114.03)	(10.78, 37.42, 78.71)	595.36(29.12, 43.78)	1,102.36, 36.46	1,098.62, 36.26, 8	1,098.68(24.39, 36.95)9
BO = HC*8 (Baht)						
M01AB	(127.16, 496.63)	(110.6, 226.56, 345.29)	600(234.19, 283.58)	902.77, 314	903.1, 311.99, 6	654.12(225.95, 289.55)8
N02BE	(1082.23, 1942.94)	(1120.61, 1329.12, 1982.393)	600(1471.73, 1696.72)	902.77, 1914.31	903.1, 1916.99, 6	654.12(1297.93, 1783.84)8
N05C	(4.52, 118.63)	(1.89, 36.05, 81.64)	600(34.98, 65.15)	902.77, 39.96	903.1, 42.12, 6	654.12(26.4, 41.35)8
BO = HC*12 (Baht)						
M01AB	(141.09, 510.19)	(202.24, 271.85, 309.93)	594.86(241.41, 28075)	681.47, 290.20	681.50, 291.65, 7	903.14(288.84, 325.48)9
N02BE	(1,176.26, 2000)	(90.97, 1,330, 1,939.83)	594.86(1,353.53, 1,836.68)	681.47, 1,894.47	681.50, 1,884.30, 7	903.14(1,563.57, 1,986.03)9
N05C	(8.88, 123)	(4.58, 23.63, 89.34)	594.86(33.64, 40.04)	681.47, 39.86	681.50, 42.31, 7	903.14(30.89, 46.19)9
BO = HC*16 (Baht)						
M01AB	(158, 525.86)	(202.24, 271.85, 309.93)	593.80(249.58, 361.37)	654.07, 298.55	656.39, 298.61, 7	655.56(266.88, 299.08)9
N02BE	(1,225.34, 2000)	(90.97, 1,330, 1939.83)	593.80(1,407.48, 1,863.23)	654.07, 1,977.35	656.39, 1,977.56, 7	655.56(1,464.05, 1,969.51)9
N05C	(11.90, 126)	(4.58, 23.63, 89.34)	593.80(40.02, 42.60)	654.07, 39.41	656.39, 39.37, 7	655.56(30.12, 39.58)9

Table 3.11 Backorder Cost MODE Ranking

Backorder Cost MODE Ranking					
(s, S)	**(s, c, S)**	**Q(s, S)**	**Q, S**	**Q, S, T**	**Q(s, S)T**
3	1	4	2	2	2

The cost results of the lead time simulation, as displayed in Table 14, Figure 6, and Table 15, imply that all policies have costs that vary directly with lead time and are independent of lead time. It should be observed, nonetheless, that the (s, S) policy is oriented toward shorter lead times, while the Q(s, S) policy tends to show a little rise in cost with longer lead times. The MODE statistic also computed for the led time simulation, the ranking shows that (s, c, S) policy still the best fit with the varying lead time as a result shown on Table 16.

Table 3.12 Lead Time Comparison

LT (Day)	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
1	**1,052.31**	**866**	1,006.97	957.84	958.13	976.95
4	1,300.05	**1118.09**	**1,313.72**	1278.5	1278.85	1294.93
10	4,660.63	**4474.46**	**4,726.27**	4654.94	4654.94	4671.8

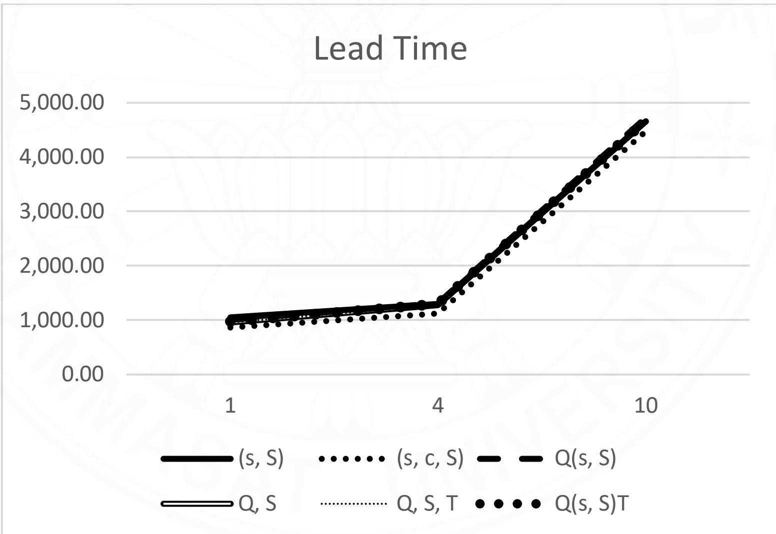

Figure 3.6 Lead Time Comparison

Table 3.13 Lead Time Index Comparison

Unit	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
LT = 1 (Day)						
M01AB	(29.67, 376.06)	(26.34, 125.28, 242.16)	599.36(107.82, 154.69)	903.56, 205.91	902.51, 204.90, 7	1,099.96(199.83, 221.94)7
N02BE	(289.62, 1262.81)	(325.93, 846.50, 1187.83)	599.36(693, 921.02)	903.56, 1,125.87	902.51, 1,134.03,7	1,099.96(956.83, 1,291.25)7
N05C	(0, 114.01)	(1.08, 16.56, 42.22)	599.36(17.36,20.99)	903.56, 26.44	902.51, 27.54, 7	1,099.96(23.06, 27.84)7
LT = 4 (Day)						
M01AB	(127.16, 496.63)	(110.6, 226.56, 345.29)	600(234.19, 283.58)	902.77, 314	903.1, 311.99, 6	654.12(225.95, 289.55)8
N02BE	(1082.23, 1942.94)	(1120.61,1329.12, 1982.393)	600(1471.73, 1696.72)	902.77, 1914.31	903.1, 1916.99, 6	654.12(1297.93, 1783.84)8
N05C	(4.52, 118.63)	(1.89, 36.05, 81.64)	600(34.98, 65.15)	902.77, 39.96	903.1, 42.12, 6	654.12(26.4, 41.35)8
LT = 10 (Day)						
M01AB	(349.36, 742.54)	(361.49, 431.51, 552.80)	348.33(442.51, 479.15)	379.20, 476.13	378.97, 475.91, 7	377.77(476.23, 500.09)6
N02BE	(1730.13, 2000)	(1,728.62,1,852.90, 1999.76)	348.33(1,910.43, 2000)	379.20, 2000	378.97, 2000, 7	377.77(1,779.02, 1,998.01)6
N05C	(29.92, 144)	(27, 41.26, 121.1)	348.33(98.34, 140.76)	379.20, 62	378.97, 62, 7	377.77(50.14, 76.49)6

Table 3.14 Lead Time MODE Ranking

Lead Time MODE Ranking					
(s, S)	**(s, c, S)**	**Q(s, S)**	**Q, S**	**Q, S, T**	**Q(s, S)T**
4	1	5	2	2	3

The (s, c, S) policy performs the best with the lowest cost in all situations, according to the holding cost simulation for both fixed and variable conditions which shown by MODE ranking of fixed and vary backorder cost on Table 19 and 22. The result shown in Table 17, Table 18, and Figure 7, which compare holding costs while fixing backorder at its initial value, the (s, S) policy does not perform well when holding costs are high. In contrast, the Q(s, S) policy is suitable for low holding costs when backorders vary up to 8 times the holding cost, as demonstrated by the cost and parameter index results in Table 20, Table 21, and the overall comparison graph in Figure 8. Additionally, the Q,S, Q,S,T, and Q(s, S)T policies perform well under low holding cost conditions, regardless of whether backorder costs are fixed or variable.

Table 3.15 Holding Cost by Fixing Backorder at an Initial Value Comparison

HC – Fixed (Baht)	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
Units	536.4	**509.41**	**737.8**	726.15	726.7	714.77
Tens	**652.89**	**597.75**	802.58	902.4	775.11	772.74
Hundreds	1300.05	**1118.09**	**1313.72**	1278.5	1278.85	1294.93
Thousands	**3381.22**	**2975.78**	3073.06	3082.74	3083.44	3061
Ten Thousands	**5300.48**	**4705.65**	4787.04	4776.34	4873.63	4805.32

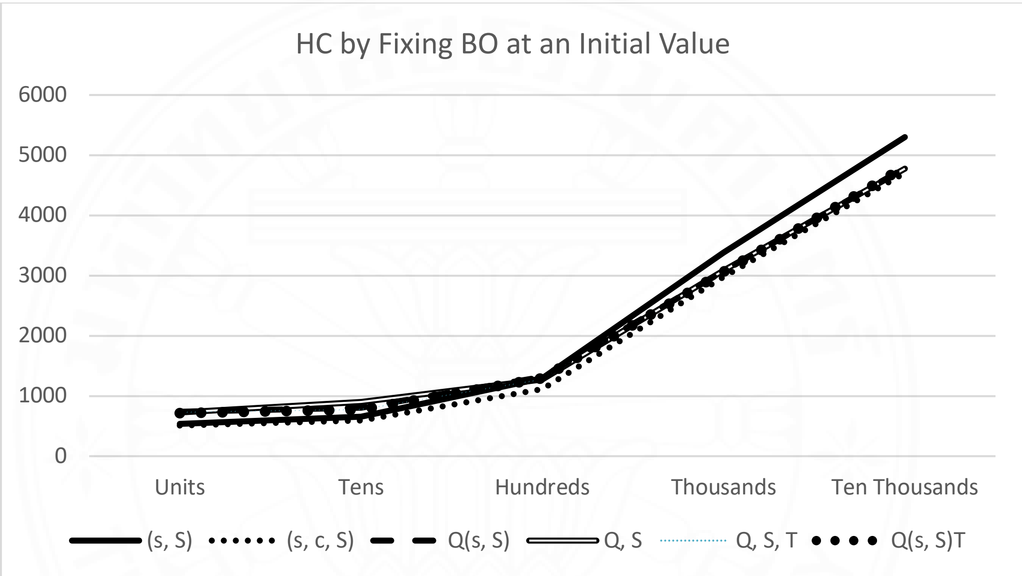

Figure 3.7 Holding Cost by Fixing Backorder at an Initial Value Comparison

Table 3.16 Holding Cost by Fixing Backorder at an Initial Value Index Comparison

Unit	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
Units						
M01AB	(179.56, 1,980.88)	(171.39, 393.71, 1,519.73)	599.89(399.35, 678.78)	863.12, 415.57	863.49, 412.66, 7	903.38(467.12, 471.19)6
N02BE	(1,224.57, 2,000)	(1,168.39, 1,290.9, 1999.84)	599.89(1,983.41, 2000)	863.12, 1,999.97	863.49, 1,998.64, 7	903.38(1,587.21, 2000)6
N05C	(3.11, 819.24)	(92.06, 164.65, 574.12)	599.89(209.95, 288.81)	863.12, 57.03	863.49, 64.54,7	903.38(76.47, 232.58)6
Tens						
M01AB	(158.78, 1,192.89)	(218.08, 321.66, 716.61)	599.94(346.67, 348.94)	902.40, 361.88	903.60, 395.12, 6	902.69(364.85, 394.92)6
N02BE	(1,169.66, 2,000)	(1,174.58, 1,328.72, 1,998.77)	599.94(1,941.98, 1,999.48)	902.40, 2000	903.60, 1,992.54, 6	902.69(1,586.47, 1,998.79)6
N05C	(14.74, 423.63)	(101.23, 187.86, 623.14)	599.94(39.45, 135.17)	902.40, 51.49	903.60, 72.58, 6	902.69(62.12, 75.13)6
Hundreds						
M01AB	(127.16, 496.63)	(110.6, 226.56, 345.29)	600(234.19, 283.58)	902.77, 314	903.1, 311.99, 6	654.12(225.95, 289.55)8
N02BE	(1082.23, 1942.94)	(1120.61, 1329.12, 1982.393)	600(1471.73, 1696.72)	902.77, 1914.31	903.1, 1916.99, 6	654.12(1297.93, 1783.84)8
N05C	(4.52, 118.63)	(1.89, 36.05, 81.64)	600(34.98, 65.15)	902.77, 39.96	903.1, 42.12, 6	654.12(26.4, 41.35)8
Tousands						
M01AB	(73.30, 234.97)	(73.31, 153.34, 194.72)	525.99(182.38, 192.75)	657.02, 209.39	653.86, 207.09, 7	658.94(173.07, 211.20)6
N02BE	(686.70, 1,151.60)	(647.87, 689.74, 1,124.90)	525.99(399.53, 1,118.63)	657.02, 1,196.60	653.86, 1,189.71, 7	658.94(741.60, 1,240.57)6
N05C	(0.01, 47.01)	(0.31, 16.43, 27.14)	525.99(10.55, 25.55)	657.02, 22.14	653.86, 22.04, 7	658.94(18.16, 31.62)6
The Thousands						
M01AB	(27.16, 158.74)	(61.22, 87.40, 142.74)	340.61(88.56, 145.35)	342.02, 139.68	362.07, 145.10, 3	346.10(97.59, 142.74)7
N02BE	(421.48, 689.11)	(403.84, 553.84, 669.78)	340.61(598.17, 706.07)	342.02, 688.88	362.07, 638.73, 3	346.10(502.33, 710.75)7
N05C	(0, 18.03)	(0.51, 3.54, 13.53)	340.61(2.48, 9.12)	342.02, 9.45	362.07, 7.06, 3	346.10(1.37, 11.91)7

Table 3.17 Holding Cost by Fixing Backorder at an Initial Value MODE ranking

Holding Cost by fixing the backorder cost at an initial value of 8 times the holding cost MODE Ranking					
(s, S)	**(s, c, S)**	**Q(s, S)**	**Q, S**	**Q, S, T**	**Q(s, S)T**
2	1	5	4	4	3

Table 3.18 Holding Cost by Allowing Backoder Cost to vary at 8 times Comparison

HC -Vary (Baht)	**(s, S)**	**(s, c, S)**	**Q(s, S)**	**Q, S**	**Q, S, T**	**Q(s, S)T**
Units	203.94	**176.23**	**609.84**	226.35	235	235
Tens	405.05	**360.15**	**672.54**	393.21	395.92	395.92
Hundreds	**1,300.05**	**1,118.09**	1,313.72	1,278.50	1,278.85	1,294.93
Thousands	**7,507.13**	**7,273.83**	7,396.22	7,285.64	7,277.33	7,369.25
Ten Thousands	61,175.18	**60,153.00**	60,335.97	61,778.82	61,846.51	**60,874.78**

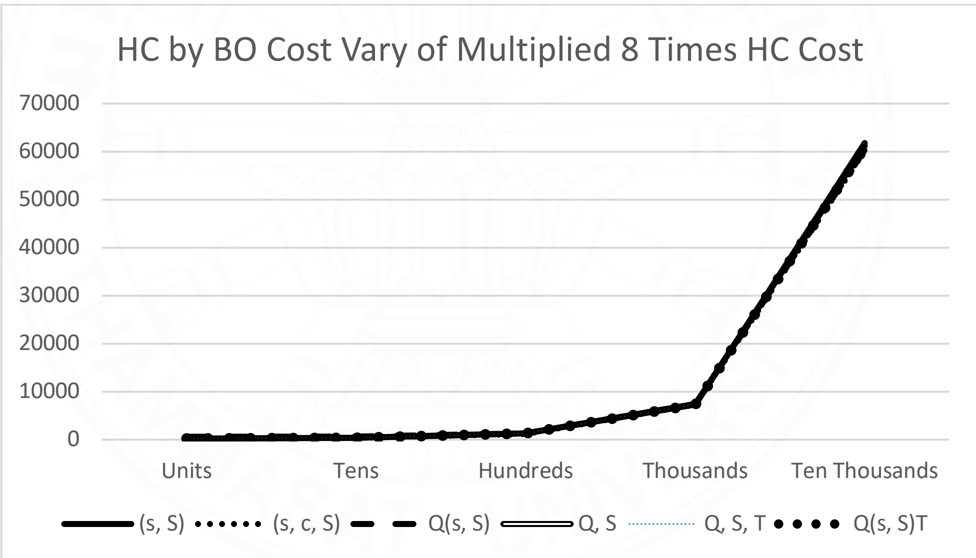

Figure 3.8 Holding Cost by Allowing Backoder Cost to vary at 8 times Comparison

Table 3.19 Holding Cost by Allowing Backoder Cost to vary at 8 times Index Comparison

Unit	(s, S)	(s, c, S)	Q(s, S)	Q, S	Q, S, T	Q(s, S)T
Units						
M01AB	(0, 1,793.36)	(81.03, 178.24, 1,468.93)	599.83(23.37, 267.78)	1,963.14, 455.61	1,989.45, 425.31, 9	1,990.63(344.30, 425.65)9
N02BE	(25.96, 2000)	(2.66, 762.99, 2000)	599.83(1,433.27, 1,718.52)	1,963.14, 2000	1,989.45, 2000, 9	1,990.63(1,232.11, 2,000)9
N05C	(0.09, 816.25)	(146.55, 211.64, 609.99)	599.83(29.31, 38.70)	1,963.14, 53.86	1,989.45, 51.76, 9	1,990.63(47.84, 51.93)9
Tens						
M01AB	(23.98, 1,219.25)	(48.99, 318.96, 804.18)	599.86(240.37, 267.86)	1,672.77, 400.88	1,686.54, 399.35, 10	1,677.62(308.31, 398.21)9
N02BE	(557.06, 2,000)	(573.20, 1,380.21, 1,998.20)	599.86(1,424.73, 1,718.80)	1,672.77, 2000	1,686.54, 2000, 10	1,677.62(1,320.98, 2,000)9
N05C	(0.09, 402.72)	(167.28, 219.26, 404.23)	599.86(29.75, 40.13)	1,672.77, 47.01	1,686.54, 47.77, 10	1,677.62(43.52, 47.40)9
Hundreds						
M01AB	(127.16, 496.63)	(110.6, 226.56, 345.29)	600(234.19, 283.58)	902.77, 314	903.1, 311.99, 6	654.12(225.95, 289.55)8
N02BE	(1082.23, 1942.94)	(1120.61, 1329.12, 1982.393)	600(1471.73, 1696.72)	902.77, 1914.31	903.1, 1916.99, 6	654.12(1297.93, 1783.84)8
N05C	(4.52, 118.63)	(1.89, 36.05, 81.64)	600(34.98, 65.15)	902.77, 39.96	903.1, 42.12, 6	654.12(26.4, 41.35)8
Tousands						
M01AB	(169.47, 261.84)	(288.15, 373.14, 374.95)	185.07(196.69, 220.55)	301.15, 233.60	302.14, 233.65, 3	199.54(200.10, 223.23)6
N02BE	(1,322.97, 1,596.81)	(785.53, 802.10, 1,235.80)	185.07(1,348.76, 1,565.16)	301.15, 1,638.81	302.14, 1,594.09, 3	199.54(1,306.53, 1,548.47)6
N05C	(16.01, 55.62)	(162.46, 172.97, 198.15)	185.07(26.13, 40.98)	301.15, 32.00	302.14, 33.91, 3	199.54(28.92, 38.39)6
Ten Thousands						
M01AB	(184.47, 216.95)	(110.48, 228.59, 345.89)	172.18(194.77, 216.15)	193.19, 220.87	198.36, 211.70, 4	163.45(204.35, 231.07)7
N02BE	(1,303.70, 1,519.73)	(1,120.44,1,328.85, 1,981.72)	172.18(1,372.75, 1,561.46)	193.19, 1,511.05	198.36, 1,521.28, 4	163.45(1,350.73, 1,566.75)7
N05C	(21.43, 40)	(2.74, 36.37, 83.34)	172.18(21.68, 43.04)	193.19, 29.82	198.36, 30.44, 4	163.45(38.23, 39.88)7

Table 3.20 Holding Cost by Allowing Backoder Cost to vary at 8 times MODE Ranking

Holding Cost at the same 8 times ratio the holding cost MODE Ranking					
(s, S)	**(s, c, S)**	**Q(s, S)**	**Q, S**	**Q, S, T**	**Q(s, S)T**
4	1	5	2	2	3

In addition to cost comparison, this paper also examines product demand grouping in two ways. The first method groups products by their ranking of mean demand from lowest(1) to hignest (6), while the second groups them by ranking demand coefficient of variation (CV) from smallest(1) to highest(6). Each method further divides the products into two sets: low/high demand (rank 1, 2, 3 and rank 4, 5, 6) and low-medium-high demand (rank 1, 3, 5 and rank 2, 4, 6). Table 23 and 24 show products' demand mean value/rank and products' demand CV value/rank. The clarification of mean and coefficient of variation grouping and the differece of set I each group are shown in Table 25.

Table 3.21 Products' Demand Mean Value/Rank

Demand Mean		
Product	**Mean**	**Rank**
M01AB	34.91	4
M01AE	27.42	2
N02BA	29.51	3
N02BE	209.53	6
N05B	62.08	5
N05C	3.92	1

Table 3.22 Products' Demand CV Value/Rank

Demand Coefficient of Variation (CV)		
Product	**CV**	**Rank**
M01AB	0.255	2
M01AE	0.234	1
N02BA	0.264	3
N02BE	0.365	4
N05B	0.405	5
N05C	0.750	6

Table 3.23 Mean and Coefficient of Variation Grouping and Set

Demand Grouping					
By Mean			**By Coefficient of Variation**		
Group 1	Set 1	Rank 1, 2, 3 : N05C, M01AE, N02BA	**Group 1**	Set 1	Rank 1, 2, 3 : M01AE, M01AB, N02BA
	Set 2	Rank 4, 5, 6: M01AB, N05B, N02BE		Set 2	Rank 4, 5, 6: N02BE, N05B, N05C
Group 2	Set 1	Rank 1, 3, 5: N05C, N02BA, N05B	**Group 2**	Set 1	Rank 1, 3, 5: M01AE, N02BA, N05B
	Set 2	Rank 2, 4, 6: M01AE, M01AB, N02BE		Set 2	Rank 2, 4, 6: M01AB, N02BE, N05C

The total cost and individual cost results of the demand grouping simulation—categorized by low-high and low-medium-high mean of demand group as shown in Table 26 and Table 27 respectively as well as low-high and low-medium-high coefficient of variation of demand group that show in Table 28 and Table 29. Group product by focusing on mean of demand should group them by mixed products that have demand in low-medium-high rank within a set. If the piority of grouping product is on the level of consistantcy should group products with low inconsistent demand together would be beneficial.

Table 3.24 Low-High Mean Demand Group

Low-High Mean Demand Group 1	
Low Mean Demand Set 1 Parameter	
N05C	(0.85, 35.50, 66.82)
M01AE	(86.10, 307.00, 381.89)
N02BA	(99.01, 333.81, 389.48)
Set 1 Cost (Baht)	425.15
High Mean Demand Set 2 Parameter	
M01AB	(127.26, 208.55, 385.65)
N05B	(135.38, 451.95, 707.93)
N02BE	(1,067.16, 1,310.66, 1,927.26)
Set 2 Cost (Baht)	1,261.18
Total Cost (Baht)	**1,686.33**

Table 3.25 Low-Medium-High Mean Demand Group

Low-Medium-High Mean Demand Group 2	
Low-Medium-High Mean Demand Set 1 (Low) Parameter	
N05C	(0, 35.17, 95.82)
N02BA	(48.23, 251.83, 403.84)
N05B	(275.71, 731.23, 785.78)
Set 1 Cost (Baht)	513.11
Low-Medium-High Mean Demand Set 2 (High) Parameter	
M01AE	(103.03, 265.33, 348.66)
M01AB	(124.50, 337.11, 447.92)
N02BE	(98.99, 354.56, 399.12)
Set 2 Cost (Baht)	551.41
Total Cost (Baht)	**1,064.52**

Table 3.26 Low-High CV Demand Group

Low-High CV Demand Group 1	
Low CV Demand Set 1 Parameter	
N05C	(0.13, 34.38, 70.79)
M01AE	(79.66, 231.18, 373.26)
N02BA	(104.49, 313.17, 395.03)
Set 1 Cost (Baht)	425.24
High CV Demand Set 2 Parameter	
M01AB	(110.53, 228.24, 374.72)
N05B	(263.83, 470.85, 702.24)
N02BE	(1,051.74, 1,380.85, 1,910.14)
Set 2 Cost (Baht)	1,260.75
Total Cost (Baht)	1,685.99

Table 3.27 Low-Medium-High CV Demand Group

Low-Medium-High CV Demand Group 2	
Low-Medium-High CV Demand Set 1 (Low) Parameter	
N05C	(1.52, 35.23, 65.79)
N02BA	(75.47, 317.61, 390.20)
N05B	(247.60, 770.33, 805.13)
Set 1 Cost (Baht)	509.12
Low-Medium-High CV Demand Set 2 (High) Parameter	
M01AE	(82.86, 218.22, 278.55)
M01AB	(98.06, 349.38, 357.11)
N02BE	(930.97, 1,171.28, 1,956.47)
Set 2 Cost (Baht)	1,209.00
Total Cost (Baht)	**1,718.12**

3.5 Result Discussion

The simulation results for reorder costs consistently show that the (s, c, S) policy is the most cost-effective across all scenarios. It's worth noting that the Q(s, S) policy struggles in situations with high reorder costs, whereas the (s, S) strategy is suitable for such conditions.

In the part of comparing backorder costs, it becomes evident that the Q(s, S) policy is not optimal for low backorder costs, and both the Q, S and Q, S, T policies perform poorly under high backorder conditions. Conversely, the (s, c, S) policy performs well under all circumstances.

In the context of lead time costs, all policies exhibit costs directly proportional to lead time and are independent of it. However, it's important to note that the (s, S) policy is more suited for shorter lead times, whereas the Q(s, S) policy shows a slight increase in costs with longer lead times. Nevertheless, the (s, c, S) policy remains the most suitable option for varying lead times, as determined by the MODE and ranking method.

Regarding holding costs, the (s, c, S) policy consistently outperforms others by maintaining the lowest costs across different scenarios. When comparing fixed and variable holding costs, the (s, S) policy struggles with high holding costs, while the Q(s, S) policy is effective for lower holding costs, especially when backorders are up to 8 times the holding cost. Additionally, the Q, S, Q, S, T, and Q(s, S)T policies perform well under low holding cost conditions, regardless of fixed or variable backorder costs.

Due to the limitations of Excel Solver used in this study intentionally for the practitioner, the optimization did not fully consider multiple parameters. Ideally, the Q(s, S)T policy should outperform the Q(s, S) policy, and the Q, S, T policy should be better than the Q, S policy. Future studies should address these performance gaps in the simulation. Additionally, further research into demand grouping recommendations would be beneficial.

CHAPTER 4
CONCLUSION

By analyzing inventory policies' performance using Excel simulation techniques, this study offers guidelines. While policies provide useful guidance for practitioner, choosing the best policy requires a comparative approach. Based on the comparative analysis, the following guidelines and recommendations are provided by the simulation and comparison results in this paper. The (s, c, S) policy is the best fit in all aspects of cost simulation, demonstrating the lowest total cost under all conditions. The (s, S) policy performs well in high reorder cost conditions but does not performs well with short lead times and high holding costs. The Q(s, S) policy is effective for low holding costs when backorder costs vary but is not suitable for products with high reorder costs, low backorder costs, and long lead times. The Q, S and Q, S, T policies are appropriate for products with low holding costs, both with fixed and variable backorder costs, but are not suitable for products with high backorder costs. The Q(s, S)T policy shows good results for products with low holding costs under both fixed and variable backorder costs, but performs only average in other aspects.

For demand grouping recommendations, products with distinct mean demand should be grouped together (mixed with high, average, and low product demand together) for joint replenishment to optimize truck space per trip. Grouping high demand and low demand products together can increase total costs due to the high demand products' needs and insufficient truck space for transportation. In testing inconsistent production demand, the total cost remains quite similar whether grouping products with similar or distinct levels of demand inconsistency, based on the data used in the paper. The recommendation from the results is to group products with low inconsistent demand together to maintain high consistency in cost and replenishment duration. For products with highly inconsistent demand, this paper cannot conclusively determine whether they should be grouped together or excluded from joint replenishment. The most optimize way of grouping is by mean of demand with the set product of low-medium-high demand products within one set.

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