OPTIMAL INVENTORY THROUGH A REPLENISHMENT SYSTEM: A CASE OF A COSMETICS COMPANY

By

PIMNIPA KOWISETCHAI

A Final Report of the Six-Credit Course
SCM 2202 Graduate Project

Submitted in Partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN SUPPLY CHAIN MANAGEMENT

Martin de Tours School of Management
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Bangkok, Thailand

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Master of Science in Supply Chain Management

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and hereby certify that the verbiage, spelling and format is commensurate with the quality of internationally acceptable writing standards for a master degree in supply chain management.

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Master of Science in Supply Chain Management

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I, Ms. Pimnipa Kowisetchai declare that this thesis/project and the work presented in it are my own and has been generated by me as the result of my own original research.

[Title of thesis/project] Optimal inventory through replenishment system

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Signed:

(A. Thanapat Panthanapathez)
Advisor

Date

December 23, 2010

ABSTRACT

The aim of this project was to reduce excess inventory to an optimal inventory level and determine an optimal service level policy according to lost sale cost and holding cost, and recommend a suitable model of inventory – a replenishment system.

The study started with the data collection of historical demand and inventory data for both export products and domestic products which showed a comparison of both. The researcher selected domestic products as the first priority of high impact products, and applied two models of a replenishment system, which are fixed order quantity and periodic review with known stock-out cost, varying demand, and constant lead time.

The results show that the fixed order quantity model can provide the best outputs when compared to the periodic review, in terms of the lowest total inventory cost and number of days of inventory, while the periodic review offered a second alternative performance.

After the researcher applied the fixed order quantity model, the total inventory cost was reduced by 1.1 million baht or 76% of actual cost during one year of evaluation, the average inventory will be reduced by 4.6 million or 78% of the actual inventory value, and the number of days of inventory decreased from 174 to 26 days. Furthermore, the service level can be achieved at an optimal service level policy, based on stock-out cost and inventory cost.

ACKNOWLEDGEMENTS

First of all, I would like to express my deepest thankfulness to my advisor, Ajarn Thanapat Panthanapratez who always gave me guidance and encouragement regarding the way to complete this project. Without his support, this project would not have been achieved. My thanks also to all the committee, Ajarn Dr. Isamail Ali Siad , Asst.Prof.Dr. Nucharee Supatn and Ajarn Piyawan Puttibarncharoensri, for all their comments and for identifying the faults in this project before completion.

I would like to give special thanks to the faculty member and staff at the Faculty and Library of Assumption University, for their assistance and for use of their facilities and materials essential to my graduate project.

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Pimnipa Kowisetchai
Assumption University
September, 2010

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GENERALITIES OF THE STUDY

Managing inventory in today's business environment has become more challenging and involves selecting an overall strategy. At the same time, inventory decision making is now more complex. Firms have placed more pressure on themselves to structure a logistics system to manage inventories more effectively and to lower cost and improve service.

Colyjon (2003) believed that in many industries, supply chains emphasized the significance of inventory for several reasons of which a dominant one allows a buffer between supply and demand. A minimal level of inventory, called theoretical inventory, is needed to maintain a desired level of throughput in equilibrium. While there are several reasons for carrying inventory, it is expensive because of carrying cost and stock-out costs due to the capital tied up in stock (Ravi, 2006).

Effective supply chain management aims to reduce stock levels to the optimal inventory of the right quantity at the right time, at minimal cost and maximum service level (Levi & Kaminsky, 2008).

Financially, the inventory shown on the balance sheet is 20-60% of the total assets, because of the value of inventories converted into cash flow and return on investment. Eventually, the companies have "good" inventories management and return to profitability (Arnold & Chapman, 2004).

Generally, inventory classification consists of raw material (RM), component and work in progress (WIP), semi-finished product, and finished product (FG) (Lysons & Farrington, 2006).

Supply Chain Techniques, such as just in time, efficient consumer response, and quick response, are directed toward reducing a company's inventory level.

Colyjon (2003) studied many companies which focused on reducing the finished goods inventory (independent demand) because finished goods inventory has a higher value than raw material or work in process inventory and affords a greater potential for capital reduction per inventory unit reduction. The advantage of inventory management enable a company to minimize safety stock, optimize availability, improve information, and eliminate obsolete excess items.

Inventory replenishment systems solve problems in optimal inventory level and uncertain supply and demand at minimum cost in the supply chain of the company. These systems include the EOQ model, reorder point and periodic review as mathematical models of independent demand. What should be kept in stock? When are the orders placed? How much to order? These questions are common question of an inventory control model.

Waters (1999) studied many models and techniques of replenishment systems, as will be explained in the next chapter. However, that researcher focused on domestic products (finished products) which are suitable for an independent demand system which has two models: 1) Fixed order quantity and 2) Periodic review system, using mathematical models for calculations to relate their demand forecast, size of order and relevant cost. Therefore, other models will not be studied in this project.

1.1 Background of the Company

Cosmetics (Thailand) Company is a manufacturer of hair products and hair coloring, established in 2003, employing 50 people. Its capital investment is 110 million baht by a Japanese shareholder and management team. Cosmetic (Thailand) supplies the finished products and work in process to subsidiary companies and customer in several countries in Asia, Europe and USA.

Cosmetics (Japan) company has its Head Office of Cosmetics (Thailand) located at Nagoya, Japan, established over 100 years ago. It has operations in 9 countries including Asian, USA and UK countries with a high demand for the coloring of black hair. There are overseas subsidiaries and branches as follows:

Business Bases: USA, UK, China, Thailand, Indonesia, Korea, Singapore, Taiwan and Malaysia.

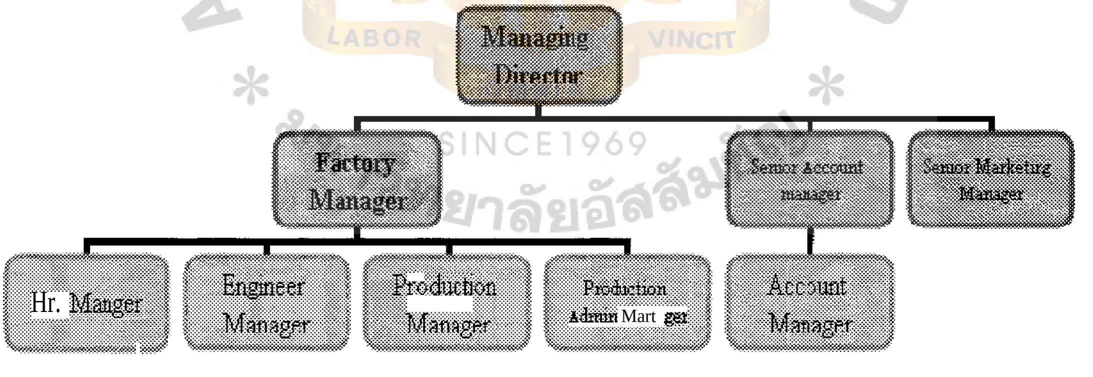
Factories: China, Thailand and Indonesia

Laboratory: Seto (Japan)

Business Process of the company

The factory manager is Japanese; he is also responsible for Planning and Co-ordination the Engineer, Production and Human Resource Departments to perform their tasks following the policy of the head office Company (see Figure 1.1).

Figure 1.1 Organization Chart of Cosmetics Company



Source: Cosmetics Company

The classification of hair coloring products divides them into two categories: (export & domestics products) with around 500 SKUs as named below:

Export products consist of three products in Asian, USA and European markets

1. Prominous 16 Colors
2. BSCC 7 Colors
3. Silk Touch 10 Colors

Domestic products consist of two products in the Thailand market

4. Beauteen 13 Colors
5. Menbeauteen 11 Colors

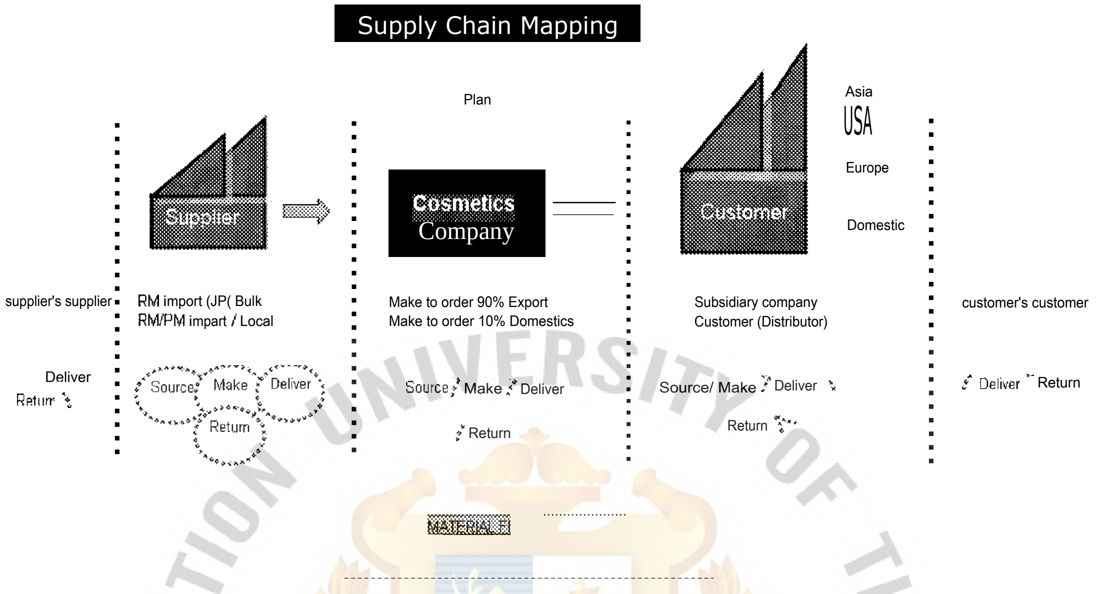
A cosmetics company classifies two types of sale, as follows:

1. 90% of export products include Silk Touch, Prominous and BSCC in Asia, USA and Europe markets.

2. 10% of domestic products include Beauteen and Menbeauteen in the Thailand market. One carton of finished goods of each product consists of:

1. Color Base 1 piece.
2. Developer 1 piece.
3. Conditioner 1 piece.
4. Packaging Materials
5. Others

Figure 1.2 Supply mapping process of Cosmetics Company



Source: Cosmetics Company

From the supply chain mapping of Cosmetics Company there are three processes, as follows:

1. Ordering Material process
2. Production process
3. Customer and Logistics process

1. Ordering material process:

The company imports the semi-finished raw material and finished products from Head Office (Japan). The other materials are imported and locally sourced. The lead time of ordering standardization is defined in Table 1.1:

Table 1.1 Standardization of order lead time

Type	Description	Lead time	Source
Semi- finish Raw material	Color Base ST,BSCC,PRO	60 – 90 days	Import-Japan
Semi- finish Raw material	Developer ST,BSCC,PRO	60 – 90 days	Import-Japan
Semi- finish Raw material	Cond. ST,BSCC,PRO	105 days	Import-Japan
Finished products	Beauteen, Menbeauteen	90 days	Import-Japan
Raw material	Chemical	3aays	Local
Packaging material	Accessories	45- 60 days	Import-China, Indonesia, local

Source: Cosmetics Company

To deal with an order, the fuirm would consider the customer's purchase order, production planning (material requirement planning) and inventory on hand. Whether the materials are enough, whenever the inventory on hand is enough the company will plan the production schedule with advice on timing of delivery to the customer. The fixed time interval of review orders is constant every 90 days for both finished products and semi-finish raw material. Then the company normally keeps stock on hand to cover at least 90 days. The majority of import shipments will be sea freight, and the transit time is around 10 days. The incoming material will be sent to QC for inspection and to release materials into the warehouse. Then, the material is issued by the Production Department. When QC finds nonconforming material they will be returned to the supplier.

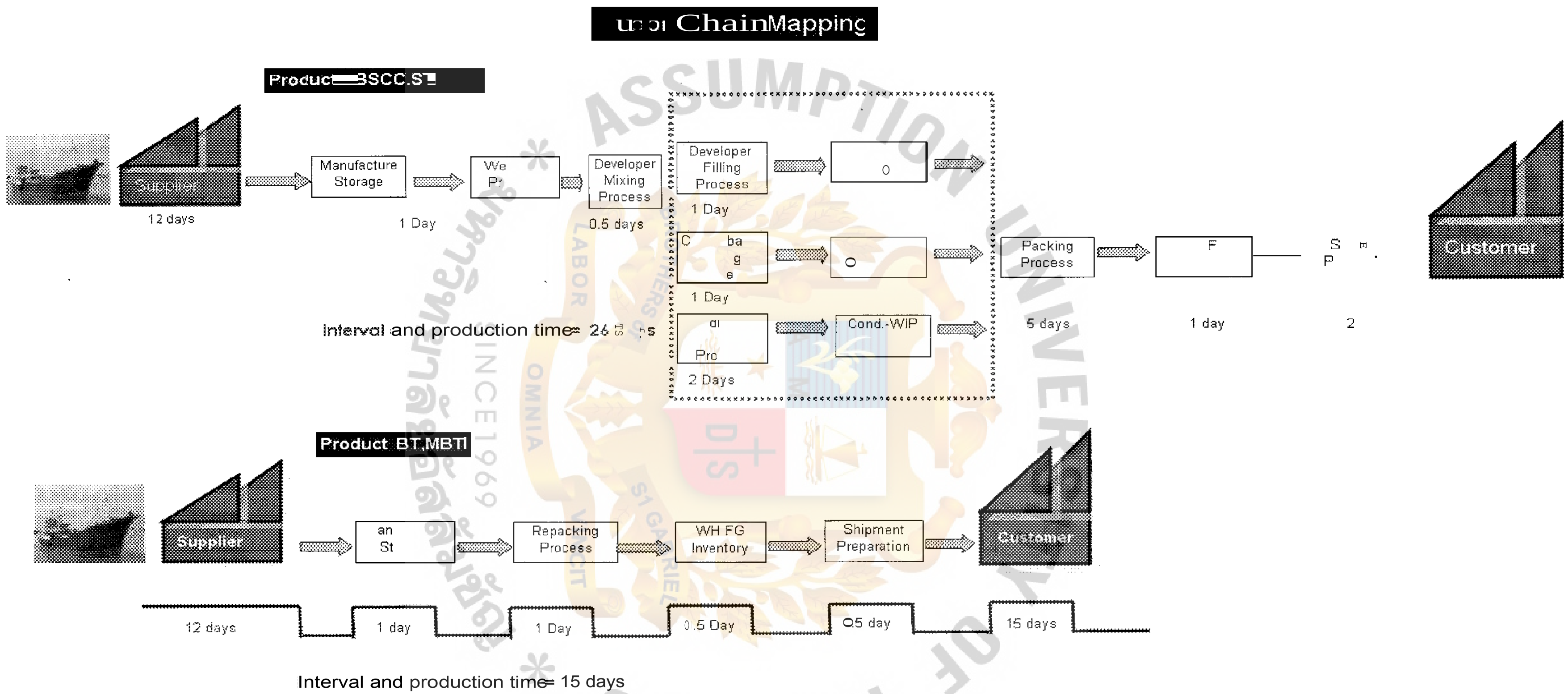
2. Production process:

From supply chain mapping of Cosmetics Company, it is divided into two types of production: 90% of make to order for export and 10% of make to order for domestic products, as in Figure 1.3.

2.1 90% of Make to order are for export products. Whenever the company receives a purchase order in advance the company produces the customer requirement. Figure 1.3 represents the initial input process (weighing, mixing, filling and packing) the output finish to the products, then store them in a warehouse. The company awaits the shipment preparation; the finished products are also stamped with the manufacture date on a small carton. All products have been produced by Cosmetics Company. The shelf life of products is around 2-5 years depending on the regulation in each country or customer requirement. The duration of production time of the export products is approximately 26 days. Then the material is shipped by the supplier of the company for the production run and then delivery to the customer.

2.2 10% of make to order domestic products are repacked with an attached instruction sheet and labels and then kept in the warehouse. When a customer places an order to the company, they stamp the manufacture date on a small carton; the shelf life of products is around one year. Figure 1.3 presents the material interval; the production time of domestic products is 15 days since materials are sent by a supplier to the company and sent for repacking and delivering to the customer.

Figure 1.3 Supply Chain mapping of export product and domestic products



Source: Cosmetics Company

3. Customer and logistics process:

Whenever finished products are ready, the company arranges the shipment to a distributor or customer in each country. Mostly, the arrangement is a full container load for export products, and less than truck load for domestic products. The logistics processes of export products can be isolated into two types:

3.1 Sell through head office:

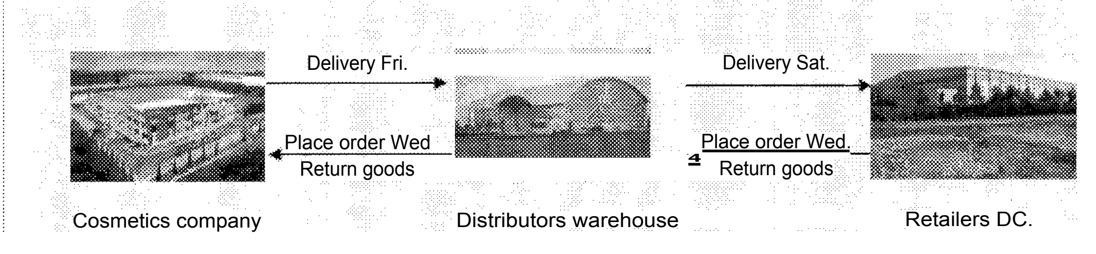
The company will deliver the products to head office; either the company consolidates the shipment to a customer or the company delivers to customer directly in each country regarding how to arrange the shipment on Head Office's suggestion.

3.2 Direct sell to customers:

The company will deliver to customer in each country to the customer's requirement. The company was contacted directly by the customer.

Figure 1.4 presents the logistics process of the domestic products which are distributed from the3 manufactory to a distributor's warehouse and then on to a retailer's distribution centre. Retailer will place orders to the distributor every week; whenever the distributor gets an order he places the order with the Cosmetics Company. The company prepares the shipment to distributors every week.

Figure 1.4 Logistics processes of domestic products



Source: Cosmetics Company

Whenever, the products are damaged by distribution, the customer claims the money and returns the products to the company. The sharing of information with head office **(JP)** and advice to customer when products are returned, is the next step.

1.2 Statement of Problem

From inventory reports, the as-is of the historical data fort 2009 shows that Cosmetics company keep tremendous stock. The inventory level is not correlated between demand and supply, and can be low demand yet high supply.

The excess inventory level has emerged with this bad performance in both domestic and export products. The domestic products were imported as finished products and sold in the Thailand market. The export products were imported as semi-finish raw material and sold to worldwide markets.

Regarding the excess inventory level of Cosmetics Company, it believed that the demand planner lacked the skill and experience for replenishment system determinants of **when to order? How much to order?** The demand planner is used to behavioral planning A cosmetics company is not a mathematical model and no planning is systematic.

Colyjon (2003) studied many companies focusing on reducing their finished goods inventory because a finished goods inventory has a higher value than raw material or work in process inventory and affords a greater potential for capital reduction per inventory unit reduction.

From the literature review mentioned, the company should focus on reducing its finished goods inventory and focus on that as a first priority for the reducing excess inventory level of domestic products.

Table 1.2 as is of current inventory turnover

DESCRIPTION	JAN'09	FEB'09	MAR'09	APR'09	MAY'09	JUN'09	JUL'09	AUG'09	SEP'09	OCT'09	NOV'09	DEC'09	A
DOMESTIC													
Sale	2.24	[illegible]	2.62	[illegible]	[illegible]	0.99	1.03	0.95	[illegible]	1.77	1.30	1.88	[illegible]
Domestic -COS	0.99	[illegible]	[illegible]	0.85	[illegible]	[illegible]	0.49	0.44	[illegible]	0.81	0.60	0.83	[illegible]
Packaging Materials	.08	0.14	.09	.07	0.10	[illegible]	[illegible]	.09	0.08	[illegible]	.11	.10	0.09
Finish products	[illegible]	[illegible]	4.74	3.80	[illegible]	[illegible]	[illegible]	7.45	[illegible]	[illegible]	.41	[illegible]	5.35
Domestic Inventory	1.95	1.30	4.83	3.98	6.16	8.46	7.98	7.54	6.84	6.03	5.52	[illegible]	5.44
Domesticstockturnover (day)	59	54	114	140	151	198	483	316	[illegible]	22	278	60	
EXPORT													
Sale	2.50	4.78	[illegible]	[illegible]	[illegible]	[illegible]	5.98	5.80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Export-COS	1.34	0.20	[illegible]	0.28	[illegible]	[illegible]	[illegible]	3.23	[illegible]	0.47	1.30	2.46	[illegible]
Semi-FinishRM	6.88	[illegible]	[illegible]	[illegible]	[illegible]	5.98	4.66	4.10	2.48	[illegible]	5.78	[illegible]	5.20
Packaging Materials	[illegible]	1.26	[illegible]	9.88	0.04	[illegible]	[illegible]	8.71	7.84	6.48	7.28	[illegible]	[illegible]
Work in Process	[illegible]	[illegible]	[illegible]	6.84	6.14	5.44	5.21	4.79	[illegible]	[illegible]	3.93	[illegible]	5.19
Finish products	2.39	2.8	3.33	2.48	0.51	0.38	1.32	[illegible]	[illegible]	1.04	[illegible]	[illegible]	2.01
Exportinventory	25.58	[illegible]	[illegible]	[illegible]	[illegible]	21.53	[illegible]	19.71	18.77	[illegible]	19.14	[illegible]	21.61
ExportStockturnover (day)	571	61	497	229	[illegible]	45	211	183	267	93	4401	218	

Source: Cosmetics Company Report

Table 1.2 reveals the high number of day to sell inventory for both domestic products and export products at the end of January-December 2009, with an average of 265 days for domestic and 277 days for export products.

After comparing the historical data of current and past performance (shown in Table 1.3 and 1.4) domestic products' inventory turnover averaged 112 days in 2008 and 53 days in 2007. The export products' inventory turnover averaged 162 days in 2008 and 200 days in 2007.

Table 1.3 Historical data of inventory turnover 2008

Data Analysis of Domestic and Export products Jan-Dec'2008

Unit: Million

DESCRIPTION	JAN'08	FEB'08	MAR'08	APR'08	MAY'08	JUN'08	JUL'08	AUG'08	SEP'08	OCT'08	NOV'08	DEC'08	AVG
DOMESTIC													
Sale	**1.41**	**1.53**	**1.57**	**1.88**	**0.75**	**0.55**	**1.04**	**1.35**	**1.14**	**1.04**	**0.93**	**1.31**	**1.21**
Domestic -COS	**0.53**	**0.52**	**0.66**	**0.72**	**0.28**	**0.21**	**0.40**	**0.53**	**0.44**	**0.43**	**0.37**	**0.53**	**0.47**
Packaging Materials	0.10	0.09	0.07	0.05	0.06	0.06	0.06	0.06	0.06	0.02	0.06	0.06	**0.06**
Finish products	0.88	1.78	1.22	1.49	1.23	2.43	2.03	1.58	1.13	1.20	0.91	1.14	**1.42**
Domestic Inventory	**0.98**	**1.87**	**1.28**	**1.54**	**1.29**	**2.49**	**2.09**	**1.63**	**1.19**	**1.22**	**0.97**	**1.19**	**1.48**
Domestic stockturnover (day)	56	108	58	64	140	354	157	93	80	85	79	67	112
EXPO													
Sale	**13.39**	**6.62**	**10.64**	**10.02**	**18.25**	**3.18**	**8.63**	**9.68**	**11.24**	**2.03**	**10.51**	**6.91**	**9.26**
Export-COS	**7.20**	**3.51**	**5.35**	**4.86**	**9.87**	**2.13**	**4.06**	**5.01**	**5.62**	**4.59**	**4.66**	**3.47**	**5.03**
Semi-Finish RM	4.39	6.97	5.41	5.48	3.21	3.67	4.26	3.38	5.23	5.53	4.68	4.52	**4.73**
Packaging Materials	11.38	11.21	10.21	9.82	10.96	10.58	8.98	10.58	10.75	9.32	9.32	11.57	**10.39**
Work in Process	3.59	5.11	5.18	5.01	4.64	3.66	3.91	4.43	3.58	3.02	1.93	2.01	**3.84**
Finish products	2.84	4.85	4.06	5.27	2.00	6.84	8.21	6.29	4.71	5.38	1.47	1.41	**4.44**
Export inventory	**22.20**	**28.14**	**24.85**	**25.59**	**20.81**	**24.75**	**25.35**	**24.67**	**24.26**	**23.25**	**17.40**	**19.51**	**23.40**
Export Stockturnover (day)	93	241	139	158	63	349	187	148	130	152	112	169	162

Source: Cosmetics Company Report

Table 1.4 Historical data of inventory turnover 2007

Data Analysis of Domestic and Export products Jan-Dec'2007 Unit: Million

DESCRIPTION	JAN'07	FEB'07	MAR'07	APR'07	MAY07	JUN'07	JUL'07	AUG'07	SEP'07	OCT'07	NOV'07	DEC'07	AVG
DOMESTIC													
Sale	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.74**	**1.43**	**1.55**	**1.45**	**1.29**
Domestic -COS	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.29**	**0.54**	**0.64**	**0.59**	**0.52**
Packaging Materials	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0.02	0.08	0.03	0.09	**0.06**
Finish products	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	0.28	0.78	1.20	1.37	**0.91**
Domestic Inventory	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.30**	**0.86**	**1.23**	**1.47**	**0.97**
Domestic stockturnover (day)									31	48	58	75	53
EXPO													
Sale	**7.01**	**2.95**	**1.98**	**8.93**	**9.11**	**8.70**	**7.60**	**3.46**	**7.14**	**20.68**	**5.62**	**7.83**	**7.58**
Export-COS	**3.82**	**2.00**	**1.64**	**4.86**	**4.01**	**5.39**	**3.50**	**1.61**	**3.50**	**8.19**	**4.80**	**3.62**	**3.91**
Semi-Finish RM	1.31	1.21	3.32	2.58	2.81	1.17	2.44	2.89	5.73	7.06	5.08	5.48	**3.42**
Packaging Materials	6.33	6.19	8.19	8.80	6.70	7.32	6.73	11.23	10.92	11.10	11.83	12.14	**8.96**
Work in Process	4.66	4.29	5.24	5.00	4.21	3.70	3.73	5.44	5.79	4.70	3.96	3,30	**4.50**
Finish products	6.14	6.17	6.07	2.79	2.55	2.30	2.27	3.64	6.03	1.28	2.50	4.22	**3.83**
Export inventory	**18.43**	**17.86**	**22.82**	**19.17**	**16.27**	**14.48**	**15.17**	**23.19**	**28.47**	**24.13**	**23.38**	**25.15**	**20.71**
Export Stockturnover (day)	145	268	416	118	122	81	130	431	244	88	146	209	200

Source: Cosmetics Company Report

1.3 Research Objective

To reduce the excess inventory level of domestic products in this Cosmetics Company to an optimal level, approximately saving costs of 1.5 - 2 million for domestic products by applying and simulating a replenishment system. Two models are tried and compared; the fixed order quantity model (continuous review) and the periodic review model, to find which model is best able to provide a likely return on assets in business performance

1.4 Research Questions

1. When should an order be placed for domestic products?
2. How many orders should be placed for domestic products?
3. Which models are suitable, either the fixed order or periodic review for this Cosmetics Company?

1.5 Significance of the Study

The importance of the study is that it applies the theory and formulation of a replenishment system into a mathematical model. In the literature review, many researchers have studied and applied the theory in real practice. Which model is suitable - either the fixed order quantity or periodic review? The researcher will simulate these using Microsoft Excel spread sheet in order to compare the advantage and disadvantage of each model with the key performance indices such as service level, inventory turnover and total cost. Then the more suitable model is selected for problem-solving the excess inventory to reach an optimal inventory level in this Cosmetics Company. 'When to order? How much to order?' are the significant questions.

1.6 Scope of research

This project is to study the replenishment system of all items of domestic products by comparing two models to reach an optimal inventory level in order to reduce the excess inventory level of this Cosmetics Company. The data was collected by the finance manager and the inventory report was analyzed by using the historical data from January —December 2009. The data was applied to a replenishment system by plying two model techniques (fixed order quantity and periodic review) to Microsoft Excel spread sheet as a tool.

1.7 Limitation of the research

1. The domestic products cover all items. New products, such as seasonal products or promotional products, are not considered in this study.
2. The duration of interval times of materials include the material shipped by suppliers, the production process and finishing products, is a constant 15 days for domestic products.

3. The assumptions in this study are that there are no limitations on the size of order or the possibility of splitting the order.

1.8 Definition terms

Export products: BSCC, Prominous, Silk Touch

Domestic products: Beauteen, Menbeauteen

Carrying cost: Cost of carrying per unit of an item in stock for a year.

COD: Cost of goods sold

Cycle time: is the time during two continuous replenishments.

Demand: number of products in stock supplied at a time

Dependent demand: the internal demand for parts which depend on demand for the final product in which are the materials, packaging material, and work in process.

Economic order quantity

A reorder method that attempts to estimate the best order quantity by balancing the conflicting costs of holding stock and placing replenishment orders. For the large orders, the unit cost may be lower, but the storage costs will be higher. This is because the average storage time will be increased. For the small orders, the cost of order processing and unit cost may be higher, but the storage costs will be lower, because of less average storage time. The most economic stock replenishment order size minimizes the sum of stock ordering costs and stockholding costs. EOQ is used in an "optimizing" stock control system.

Independent demand: are final products demands and the pattern of demand affected by trends, seasonal patterns and general market conditions.

Inventory level; a period of time it take time to sell all current items at the current sales pace if no new items become available. Generally, it is measured in months such there is stock available for 6 months

Lead time: the period of time between the order being placed until the supplier deliver the materials to the customer.

Make to order: a manufacturing firm produces one of a kind, a specialty product based on customer specification. Make to order is when the firm cannot produce the orders in advance as they do not know the actual specifications of the finished goods.

Order quantity: an order is placed and stock is replenishment; quantity ordered is Q.

Re-Order point: inventory level of an item signals the need for placement of a replenishment order, taking into account the consumption of the item during order lead time and the quantity required for the safety stock. It is also called Reorder Level, Reorder Quantity, or Replenishment Order Quantity.

Safety stock: inventory held as buffer against mismatch between forecasted and actual consumption or demand between expected and actual delivery time and unforeseen emergencies. It is also called reserve inventory.

Service level: stock level at which demand for an item, group of items, or a system can be met by stock held on-hand, defined as a percentage of orders pleasured.

Shortage cost: Cost of stock-outs are hidden in overhead costs and are difficult to estimate or incorporate into inventory models.

Unit cost: The supplier charges customers for one unit of the item as av quotation, or the total cost to the company of acquiring one unit.

CHAPTER II

LITERATURE REVIEW

This chapter provides explanations and applies a literature review to the concepts of the chosen research topic. Many researchers have investigated replenishment systems or inventory control systems in order to explore independent demand models which set an optimal level of inventory. One of the key uncertainties in the supply chain and supply management defines the significance of each definition, the attributes involved and some useful knowledge and theories and formulation of inventory control systems.

2.1 Definition and objective of inventory management

Several researchers studied and defined inventory control models which consist of all activities including (RM) raw materials, (WIP) work in progress, component, subassemblies and (FG) finished goods at an optimal level. They provide maximum service level at minimum cost with the right amount, at the right time and right place for each item held in stock (Leenders, 2002; Waters, 1999; Tersine, 1994; Levi et al., 2008).

Lysons and Farrington (2006) explained the aim of inventory management comprises four objectives, as follows:

- To provide the service level for response to customer requirements in terms of quantities and order fill rate
- To provide the requirement for all type of present and future ways for preventing overstocking and bottlenecks in production
- To minimize cost by reducing product variety, having economical lot sizes and the cost of analysis incurred in obtaining and holding costs
- To provide visibility upstream and downstream in a supply chain

Lambert (2002) said that there are five aims of inventory that enable the company to achieve economies of scale, balance supply and demand, have specialization in production, and provide a buffer between critical points within a supply chain.

There is the aim important of inventory control which provides a buffer at minimum cost comprising three significant questions.

Waters (1999) studied a Cosmetics Company which had no systematic planning and no mathematical model which could calculate how much to order, or when to place an order? The researcher can refer to model answering many questions, but the major questions are as follows:

1. What items should be stocked?
Controlling the inventory is expensive; cost needs to balance supply and demand; current stocks are kept at the optimal levels of equilibrium, the items which are obsolescent products should be removed from stock, and focus always on movement items.

2. When orders should be placed?
Independent demands have three different types of model, which can be summarized as :
1. Periodic review system; the placing of orders at regular intervals of time; demand varies with order size.
2. Fixed order quantity system; whenever stock falls to a specified level an order of fixed size is placed.
3. Demand and supply: is there enough stock to meet known demand; the time and quantity ordered depend on direct demand; when should an order be placed? It depends on consideration of the following factors.

- Details of the inventory control system used
- Type of item (materials, finished goods, and so on)
- Type of demand (high or low, constant or erratic, known exactly or estimated)
- Value of the item and associated holding costs

- Cost of placing an order
- Lead time between placing an order and receiving it
- Supplier (location, reliability, etc.)
- A range of other possible factors

3. How much quantities should be ordered?

From the issue of the company, the quantity of placing order in each time does not consider on economic order quantity; the company should be considering the purchasing cost, holding cost, stock out cost and unit price discount of large orders in case of price rises and demand patterns. If small frequent orders are placed, the costs of purchasing and logistics are high, but average stock level is low. On the other hand if large frequent orders are placed, costs of ordering and delivery are low, but average stock level is high,. The company should consider the economic order quantity for reducing carrying cost risks significantly.

2.2 Inventory Classification

Figure 2.1 Inventory classification

Production Application	ABC analysis	Demand type	Other
- Raw Material - Components - WIP - Subassemblies - FG - Maintenance,repair , - Operating material	- A items - B items - C items	- Independent - Dependent	- Maintenance repair and operating materials not embodies in the FG

Source: Lysons & Farrington (2006, p317)

Some companies have stock of only finished goods, such as a retailer and wholesaler. Meanwhile the others, manufacturers, have all three types, and the likely proportions of classifications are raw materials 30% ,work in process 40% and finished goods 30% Waters (1999), divided to inventory types or production application, as in Figure 2.1.

- Raw material, unprocessed purchase inputs
- Work in process, (WIP) partially processed materials not yet ready for sale
- Component/subassemblies, such as parts, computer components
- Finished goods, products ready for shipment

Lysons and Farrington (2006) explained there are two model approaches to inventory control, depending on the method of assessment of demand and type of inventory. This is shown in Table 2.1, divided into two types of demand, as follows:

Table 2.1 Comparison between Independent and Dependent Demand

Independent Demand	Dependent Demand
Finished goods or other end items	Subassemblies or components used during the production of a finished or end product
Demand cannot be precisely forecast	Demand is acquired from number of units to be produced; for example demand for 10000 hair products will give rise to a derived demand for 20000 bottles.

Source: Lysons & Farrington (2006, p317)

1. Independent demand systems use mathematical models to relate demand forecast, size of order and relevant costs, which must be forecasted based on market conditions. Wisner (2005) studied independents demand related to manufacturing decisions for any other items held in stock. Waters (1999) studied manufacturing, but only end items or finished products sold to customer. Demand for them depends solely on the

customer requirements and customer demand, and both models can use both fixed order quantities and periodic reviews.

1.1 A fixed order quantity system places an order of fixed size whenever stock falls to a determined level. The system needs continuous monitoring of stock levels and is better suited to low, irregular demand for relatively expensive items.

1.2 A periodic review system places orders of varying size at regular intervals to raise the stock level to a specified value.

2. Dependent demand systems use production plans or operating schedules to calculate stock requirement. These are acquired from the product decisions for its "family", which is an item produced from one or more component items, normally subassemblies or parts used in the manufacture of the end product.

Waters (1999) said that the independent demand system is most suitable to stocks of finished goods and spare parts, while dependent demand systems are more suitable to raw materials and work in process.

Nevertheless, inventory control models are suitable as a type of inventory of the company, and the researcher values the independent demand because a Cosmetics Company focuses on finished product, as demonstrated in the literature review.

2.3 Relevant cost

A replenishment order system has relevant costs for both fixed order quantity and periodic review systems, which consist of carrying cost, purchase cost, stock out cost and item cost/unit cost. Colyjon (2003) explained the major cost categories which are relevant to the inventory decision: inventory carrying cost, and order / set up costs. They are expected for stock out costs. Waters (1999) explained that all stock carrying costs were originally around 25% of value each year, which is somewhat costly.

Mostly, organizations view cost as a necessary overhead. Generally, the stock holding costs are determined by a number of factors and an appropriate objective is to minimize total costs rather than the total stock. Stock holding costs usually are classified as follows:

1. Unit / Item Cost is the cost charged by suppliers for a unit of the item, or the cost of the company for acquiring one unit, based on a quotation or recent invoice from a supplier.

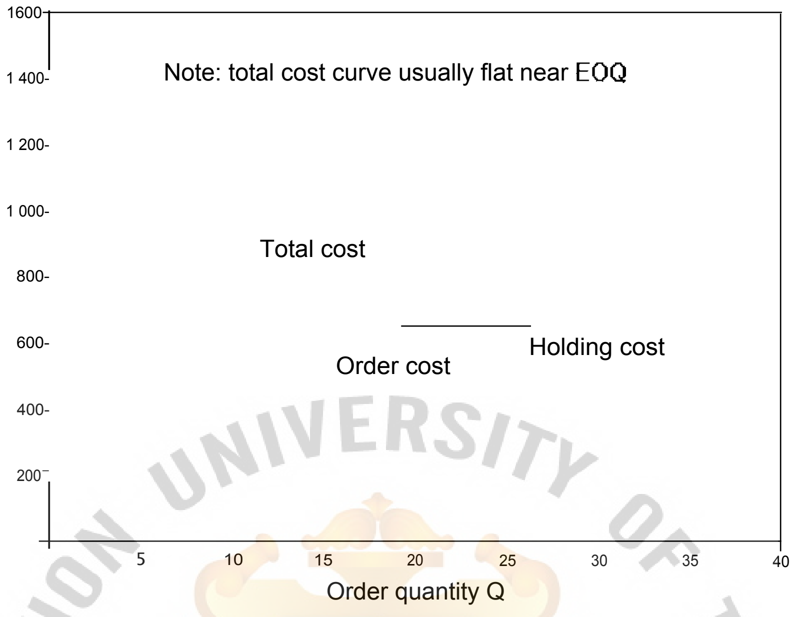
2. Reorder/Purchase cost is the cost of placing an order or repeat order for the item, and includes preliminary cost such preparing the requisition, vendor selection, negotiation placement cost such order preparation, stationery; and postage post-placement costs such as progressing, receipt of goods, materials, handling, inspection, certification and payment of invoice.

3. Carrying cost is divided into two types; first, financial cost, such as interest on capital tied up in inventory, insurance, losses in value due to deterioration, obsolescence and pilfering; second, storage, labor and clerical cost.

4. Stock out Cost is loss of production output, cost of idle time and of fixed overheads spread over a reduced level of output, loss of customer goodwill due to the inability to supply or late delivery. The costs of stock outs are hidden in overhead costs and are difficult to estimate or incorporate into inventory models.

Figure 2.2 shows the relevant total cost relationship between ordering cost, carrying cost and stock out cost which are as variable as the quantity ordered.

Figure 2.2 Total relevant costs



Source: Ballou (2004, p33'7)

The relevant cost depends on keeping inventory of each company. If a company needs to respond to customer requirements, it needs to keep high inventory which means the company has a high carrying cost. On the other hand, whenever a company keep low inventory there is also a low carrying cost. The relevant costs are considered important to company performance.

Waters (1999) explained inventory turnover can be measured in inventory performance. Inventory turnover is defined as the ratio of cost of units sold to average inventory, as in this formula:

$$\text{Inventory turnover} = \frac{\text{Cost of annual sales}}{\text{Average value of inventory}}$$

Higher values of this ratio indicate better organizational performance. In the website (www.bized.co.uk) it is explained that inventory turnover can be express as a ratio of a number of days, which is sometime; easier way to understand, and it uses the following calculation formula:

$$\text{Inventory turnover Ratio (day)} = \frac{\textit{Average inventory}}{(\textit{Cost of goods sold} /365)}$$

The result of this ratio gives the number of day on average or days sales in the inventory, during which the inventory is held in the business.

Suppose the result of number of days on average is low, that is good, whilst high equals bad performance.

A low inventory turnover ratio may indicate:

1. Too many inventories
2. No longer used or no movement (obsolescence)

John (2008) explained the definition of cost of goods and average inventory in the following formula:

Cost of goods sold = Beginning of inventory + purchase during the period – Ending of inventory

How the cost of goods sold is measured depends on the type of business you have. The example used above is the method which a retail operation might use. A manufacturing business would go about it in a different manner

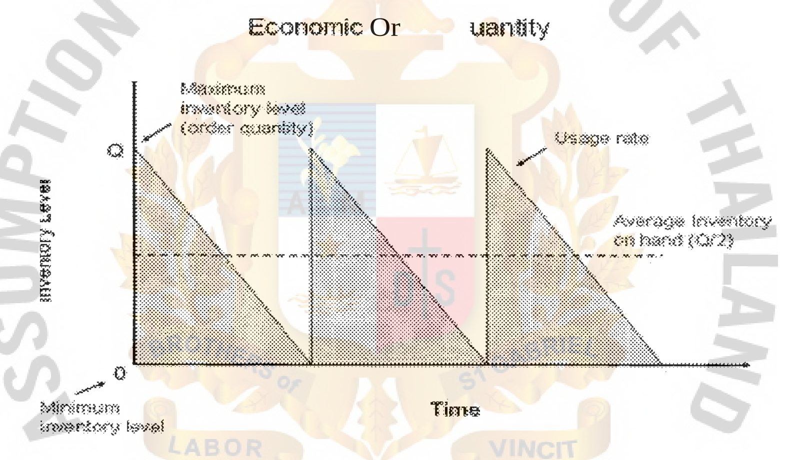
Average inventory = (Beginning of inventory + Ending of inventory)/2

2.4 Inventory model

According to Piasecki (2006), the inventory model addresses two important questions: 1) How much to order (EOQ), and 2) When should be orders be placed? (Reorder levels are related to an independent demand system).

EOQ or Economic order quantity (How much to order): see Figure 2.3

Figure 2.3 Economic order quantities



Source: Tersine (1994, p135)

The technique is based on several assumptions:

- Demand is known and constant
- Lead time is known and constant
- Receipt of inventory is instantaneous, which is inventory from an order arrives in one batch at one time
- Quantity discounts are not possible
- Variable costs are cost of placing an order and cost of holding inventory

EOQ may not apply to every inventory situation, but it beneficial in at least some aspect of the operation. Obvious applications for EOQ are purchase to stock distributors and make to stock manufacturer (Piasecki, 2006).

Although EOQ is generally recommended in operations where demand is relatively steady, items with demand variability such as seasonality can still use the model by going for shorter time periods for the EOQ calculation. Just make sure the usage and carrying costs are based on the same time period. The basic Economic Order Quantity (EOQ) formula is as follows:

$$\textbf{EOQ} = \sqrt{\frac{2(\textit{Annual demand in unit})(\textit{Order cost})}{(\textit{Annual carrying cost per unit})}}$$

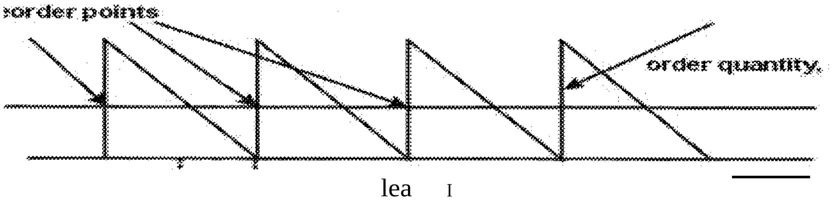
2.3.2 Reorder level (When to order), **certain demand**

In an optimal inventory policy, order an amount equal to the EOQ. Whenever the stock level falls to the reorder level, it is time to place an order.
Defines the reorder level where an order should be placed.
Reorder level = lead time x demand per unit time

ROL = Lead time x Demand = reorder level

The simple rule, then, is to order in batches of size Qo whenever the stock level falls to LT * D (see figure 2.4) optimal order level.

Figure 2.4 Reorder point



Source: Waters (1999, p67)

From observation, one can generalize a simple rule; place an order when stock on hand plus stock on order equals the lead time demand; or place an order when stock on hand falls to lead time demand minus stock on order.

Reorder level = lead time demand – stock on order

When lead time is particularly long, the number of orders outstanding at any time can be quite high; when the lead time is several times the stock cycle it is easy to lose track of the amount of goods on order based on observation, which suggests the rule:

When lead time is between n*T and (n+1) *T order an amount Qo whenever stock on hand falls to LT*D – n*Qo

In the case **of uncertain demand,** deterministic models would use mean values, so that the reorder level is calculated as follow:

Reorder level = mean demand mean lead time

There are three things which happen in demand, as Waters (1999) explained have the following factors:

Actual demand during lead time = expected demand = ideal pattern of stock

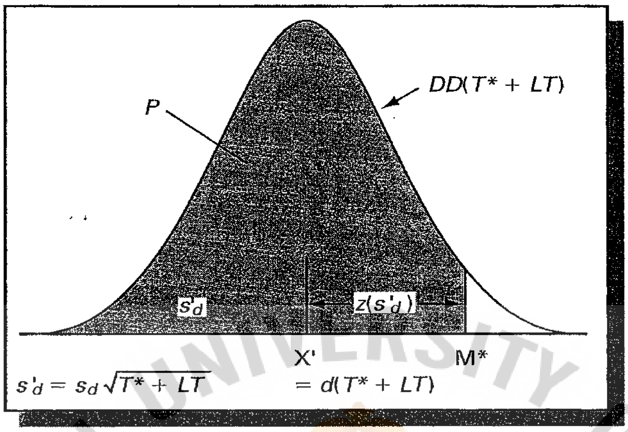
Actual demand during the lead time < expected demand = stock level is high
Actual demand during the lead time > expected demand = shortage

Normally, most organizations found actual demand during lead time to be greater than the expected demand, with uncertain demand as the common factor. The inventory systems of all company happened to be probabilistic models for dealing with significant uncertainty which assumes demand follows a known probability distribution.

Safety stock

In the case of demand uncertainty, most organizations kept safety stock for preventing loss of sale; some organization had higher stock out cost. The safety stock is significant for the reorder point for demand, while safety stock is related to the service level when organization keep high safety stock, which means maximizing the level of customer satisfaction. Waters (1999) explained that under the fixed order size system (Q-system), a fixed order quantity is ordered every time the reorder point is reached. Safety stock is needed to protect against a stock out after that reorder point is reached, while safety stock is an important constituent of the reorder point. However, the demand of the lead time is normally distributed, it will be greater than the mean on half the occasions and there will be stock-outs in 50% of stock cycles. To give a cycle service level which is greater than 50% we must add a safety stock (see Figure 2.5).

Figure 2.5 Safety stock with uncertain demands



Source: Ballou (2004, p359)

Then, it can use a normal distribution table as the formula:

Safety stock = Z standard deviation of lead time demand

$$=Z* \quad * \sqrt{LT}$$

Where Z is the number of standard deviations from the mean, corresponding to the probability specified by the service level. Value Z can be found in the normal distribution table in Appendix A.

The main consequence of the safety stock calculation is the reorder level that is increased by the amount of the safety stock

Reorder level = lead time demand + Safety stock

$$= LT*D+Z* a * LT$$

When a continuous demand is uncertain, the lead time demand is important. When lead time demand is normally distributed, the reorder level is as given in the above formula where Z determines the cycle service level.

Service Level (Ballou, 2004).

To define service level optimization depends on the response to customer requirements. It is always found in a pull strategy, in the case of make to order or retailer. A wholesaler needs inventory to ensure the availability of products at the time and quantities desired. The probability or item fill rate refers to the service level, and for a single item can be defined as

$$\text{Service level} = 1 - \frac{\text{Expected number of units out of stock annually}}{\text{Total annual demand}}$$

$$SL = 1 \quad \frac{HQ}{kd - HQ}$$

Where k: Lost sales Cost per unit
Q: Order Quantity in units
H: Carrying cost per unit per year
d: Average annual demand in unit

Service level is always related to safety stock. When the service level is high the safety stock will follow the service level. When the service level is low the safety stock will be low as well.

The next step will be the equation of calculation and applying two mathematical models of fixed order quantity and periodic review system. Ballou (2004) explained that step by step it is easy to apply such an inventory model in the following steps:

Fixed order quantities (Ballou, 2004).

A fixed order quantity system places an order of fixed size whenever stock falls to a certain level. The system needs continuous monitoring of stock levels and is better suited to low, irregular demand for relatively expensive items.

The EOQ formula is developed from total cost, involving ordering cost and carrying cost, as in the equation following:

Total Cost = Ordering cost + Carrying cost	**(2-1)**

$$\textbf{TC} \;=\; \frac{DO}{Q} \qquad \frac{HCQ}{2}$$

Where

TC = Total annual relevant inventory cost, dollars

Q = Order size to replenish inventory, units

D = Item annual demand occurring at a certain and constant rate over time, unit/year

O = Ordering cost, dollars/order

C = Item value carried in inventory, dollar/unit

H = Holding cost as a percent of item value, percent/year

EOQ formula is:

$Q^* \quad 2DS$	**(2-2)**

Optimal time between orders is therefore

$\mathbf{T^*} = \frac{*}{D}$	**(2-3)**

And the optimal number of times per year to place an order is

$N \quad \frac{D}{Q^*}$	**(2-4)**

Reorder point (Ballou, 2004).

Reorder point formula (ROP) is

$$\text{ROP} = d \times LT \qquad (2\text{-}5)$$

Where

ROP = reorder point quantity, units

d = demand rate, in time units

LT = average lead time, in time units

The demand rate (d) and the average lead time (LT) must be expressed in the same time dimension.

Adjust Q* for computation of the EOQ: it is not very sensitive to incorrect data estimation. As shown in formula (2-4), the order quantity becomes the production run, or production lot size, quantity (POQ) labeled Q*p

To find Q*p the basic order quantity, the formula is modified as follows:

$$Q^*p = \sqrt{\frac{2DS}{H} \frac{p}{p-d}} \qquad (2\text{-}6)$$

Where p is the output rate, Computing Q*p only makes sense when the output rate p exceeds the demand rate d.

Reorder point Model with uncertain demand (Ballou, 2004).

Finding Q* and ROP

Optimal inventory level = inventory on hand + quantity on order – back order quantity

The entire quantity Q* arrives at a point in time offset by the lead time when the stock arrives at the reorder point. When it arrives in stock, there is a risk that demand will exceed the remaining amount of inventory. The probability of this occurring is controlled through raising or lowering the reorder point and by adjusting Q* as formula 2-5, where demand during lead time is known only to the extent of a normal probability distribution.

Demand during lead time (DDLT) distribution has a mean of X' and a standard deviation of s'_d the values for X' and s'_d are usually not known.

Determine adjust Q* according to the basic EOQ formula (Equation 2-2) find as

$$\mathbf{ROP = d \times LT + Z(s'_d)} \qquad \mathbf{(2\text{-}7)}$$

Term Z is a standard deviation from the mean of the DDLT distribution given the desired probability of being in stock during the lead time period **(P).** Value z is found in Appendix B for the area under the curve P.

Average inventory level (Ballou, 2004).

Average inventory level for this item is the total of the regular stock plus safety stock:

Average inventory = Regular stock + Safety stock

$$\mathbf{AIL} = \frac{Q}{2} + \mathbf{Z(s'_d)} \qquad \mathbf{(2\text{-}8)}$$

From equation (2-1) which account for uncertainty, total cost can now be expressed as

Total cost = Order cost + Carrying cost, regular stock + Carrying cost, safety stock + Stock out cost

$$\mathbf{TC} = \frac{D}{Q}\mathbf{S + IC}\frac{Q}{2}\mathbf{+ IC\,Zs'_d +} \frac{D}{Q}\mathbf{ls'_dE_{(z)}} \qquad \mathbf{(2\text{-}9)}$$

Where

l = lost sale or stockout cost per unit

$s'_dE_{(z)}$ = expected number of units out of stock during an order cycle

$E_{(z)}$ = unit normal loss integral whose values (Appendix B)

$$\frac{D}{Q} = \text{number of order cycles per period of time (a year)}$$

Therefore, multiplying by the out of stock cost yields the total period cost.

Service Level

The customer service level or item fill rate, achieved by a particular inventory policy was previously defined in Equation (2-10).

$$SL = 1 - \frac{(D/Q)(s'_d * E(z))}{D} = 1 - \frac{s'_d(E(z))}{Q} \qquad \textbf{(2-10)}$$

Reorder point method with known stock out costs

When stocks out cost are known, it is unnecessary to assign a customer service level. The optimum balance between service and cost can be calculated as follows:

1. EOQ formula = $Q^* = \sqrt{\frac{2DS}{H}}$

2. Compute the probability of being in stock during the lead time if back ordering is allowed

$$P = 1 - \frac{QH}{dk} \qquad \textbf{(2-11)}$$

Find s'_d, z value that correspond to P in the normal distribution table (Appendix B) find $E_{(z)}$ from the unit normal loss integral table (Appendix C)

3. Determine a revised Q from a modified EOQ formula, which is

$$= \sqrt{\frac{2D(S + ks'_d E(z))}{H}} \qquad \textbf{(2-13)}$$

4. Repeat step 2 and 3 unit there is no change in P or Q continues.

5. Compute ROP and other statistics as desired

Reorder Point method with demand and lead time uncertainty

The lead time of uncertainty can extend the realism of the reorder point model.

Where:

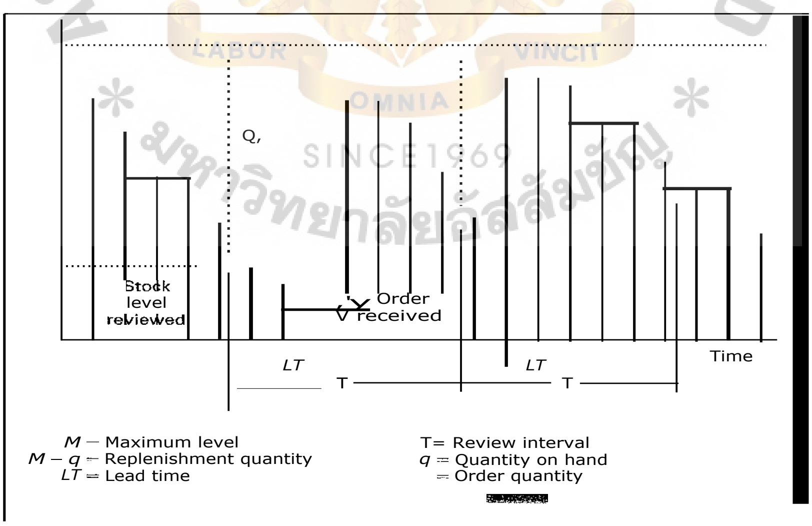
s'_d = Standard deviation of demand during lead time based on uncertainty in both demand and lead time. Adding the demand variance to the lead time variance gives a revised formula for S'_d which is

$$s'_d = \sqrt{LT s_d^2 + d^2 s_{LT}^2} \qquad \textbf{(2-14)}$$

Periodic review model with uncertain demand (Ballou, 2004)

Periodic review systems place orders of varying size at regular intervals to raise the stock level to a specified value, as in Figure 2.6.

Figure 2.6 Periodic review



Source: Ballou (2004, p359)

From the literature review, it is possible to summarize and represent the advantage and disadvantage of both two models (fixed order point and periodic review system) as depicted in Table 2.2

Table 2.2 Advantage and Disadvantage of independent demand

Fixed order quantity	Periodic review
Advantage	**Advantage**
Level of stock is lower than periodic review, EOQ is applicable	Greater chance of elimination of obsolete items due to periodic review of stock
Improved responsiveness to demand fluctuations.	Purchasing load spread more evenly, possible economies in placing orders
Replenishment order generated at appropriate time compares actual stock level and reorder level	Large quantity discounts negotiated when a range of stock items is ordered from the same supplier at the same time.
Appropriate for widely differing inventory categories	Production economies, more efficient production planning, and lower set up costs.
Disadvantage	**Disadvantage**
Reordering system become overloaded if many items of inventory reach their reorder level.	Larger stocks are required than with fixed order point systems as reorder quantities must provide for period between review as well as lead time. Reorder quantities are not based on EOQs
Random reordering pattern, due to items coming up for replenishment at different times	Usage rate changes shortly after a review period, stock out may occur before next review date, difficulty in determining appropriate review period unless demands are reasonably consistent

Source: Lysons & Farrington (2006, p318)

2.5 Summary result of independent demand

There are many researchers who studied independent demand systems and the results of reducing inventory in organization performance. However, in this study the researcher focused on independent demand of domestic products which are suitable for finished products, as in Table 2.3.

Table 2.3 Summary of independent demand

Authors	Finding and Summary
Levi et al. (2008)	GM inventory valued at $7.4 billion, 70% WIP , Rest finished vehicles, implemented reducing the combined corporate cost of inventory by adjusting inventory policy and transportation strategy, costs could be reduced by about 26% annually
Chiang and Gutierrez (1996); Teunter and Vlachos (2001); Rao (2003); Bollapragada and Rao (2006)	Many authors have addressed various replenishment policy intended for either continuous or periodic inventory review
Rau (2003)	Compare 2 control policies: the periodic review (R,T) policy and continuous review, reorder point (Q,r) shows that economic order interval from analysis can provide a good approximation to the optimal T.
Cachon (2001)	the competitive and cooperative selection of inventory policies that each location implements a continuous review policy
Lewis (1980)	The successful development of ROL module provided the company with a scientific and systematic means of evaluating the re-order level for all finished stock; calculation of re-order level in ROL module and EOQ module.
Waters (1999)	Most stocks are controlled by independent demand systems; most suited to stocks of finished goods.

Source: Author

CHAPTER III

RESEARCH METHODOLOGY

This chapter is to applies and simulates replenishment order models, when to order (Reorder point) and how much to order (EOQ), for domestic finished products. As the current operation is without mathematical models, new models were identified and applied after collecting the historical data of all SKUs of domestic products. Because domestic products have a high cost per unit and are imported from head office, the data analysis was used for the two proposed models, both fixed order quantity and periodic review system. However, the researcher applied and simulated the two models by finding and calculating EOQ, ROP and Safety stock for fixed order quantity, and target stock level and order quantity for the periodic review system. Later a comparison was made between the current and new performance measurements for total inventory cost, stock turnover and service level, related to the key performance index, and finding the company's optimal stock level by selecting the more suitable model which regard the right time, right quantity , minimized cost and maximized service level. The methodology has six steps in order to propose replenishment models, as explained below.

Step 1 Collect Data

Step 2 Data Analysis

Step 3 Problem finding

Step 4 Propose 2 models (Independent demand)

Step 5 Simulation of 2 models by Excel

Step 6 Conclusion and recommendation

3.1 Data collection

The data was collected from the finance manager in the report of the end of the inventory period, fort the historical data of all SKUs from January-December 2009. The inventory data was studied and analyzed in order to find the issues and the current company performance. The details of the finding are as follows:

- End period of domestic and export products inventory of all SKUs in each month.
- Cost of goods sold of domestic and export products of all SKUs in each month.
- Demand of domestic and export products of all SKUs in each month.

3.2 Data analysis

After the researcher collected the data between January-December' 2009, the next step was to find the issues of the current operation. What are the issues of inventory management in this Cosmetics Company? Export or domestic products are analyzed for good or bad performances through the data analysis shown in Appendix A, by calculating the key words as follows:

3.2.1 Ending Inventory
3.2.2 Cost of goods Sold
3.2.3 Sales Turnover
3.2.4 Stock turnover (days)

The data were analyzed after the researcher had analyzed, summarized and represented each month in Table 3.1

Table 3.1 as is of current domestic and export products.

Data Analysis of Domestic and Export products Jan-Dec'2009 — Unit: Million

DESCRIPTION	JAN'09	FEB'09	MAR'09	APR'09	MAY09	JUN'09	JUL'09	AUG'09	SEP'09	OCT'09	NOV'09	DEC'09	AVG
DOMESTIC													
Sale	**2.24**	**1.51**	**2.62**	**1.79**	**1.61**	**0.93**	1.03	**0.95**	1.51	**1.77**	**1.30**	**1.88**	**1.60**
Domestic -COS	**0.99**	**0.72**	**1.27**	**0.85**	**0.74**	**0.42**	**0.49**	**0.44**	**0.70**	**0.81**	**0.60**	**0.83**	**0.74**
Packaging Materials	0.08	0.14	0.09	0.07	0.10	0.09	0.09	0.09	0.08	0.07	0.11	0.10	**0.09**
Finish products	1.87	1.16	.4.74	3.90	6.06	8.37	7.88	7.45	6.76	5.96	5M	4.59	**5.35**
Domestic Inventory	**1.95**	**1.30**	**4.83**	**3.98**	**6.16**	**8.46**	**7.96**	**7.54**	**6.84**	**6.03**	**5.52**	**4.69**	5.44
Domestic stockturnover (day)	59	54	114	140	251	598	483	518	293	224	278	169	
EXPORT													
Sale	**2.59**	**4.76**	**3.87**	**7.25**	**11.72**	**8.74**	**5.38**	**5.50**	**4.06**	**10.02**	**2.27**	**4.26**	**5.87**
Export-COS	**1.34**	**2.20**	**1.62**	**3.28**	**5.74**	**4.46**	**2.98**	**3.23**	**2.11**	**5.47**	1.30	**2.46**	**3.02**
Semi-Raw material	6.83	7.32	6.55	5.47	4.37	5.98	4.66	4.10	2.48	5.13	5.76	3.74	**5.20**
Packaging Materials	12.15	11.26	10.77	9.83	10.04	9.74	9.84	8.71	7.84	6.48	7.28	6.52	**9.21**
Work in Process	4.22	5.02	6.25	6.64	6.14	5.44	5.21	4.79	5.29	4.29	3.93	5.10	**5.19**
Finish products	2.39	2.82	3.23	2.46	0.51	0.38	1.32	2.10	3.16	1.04	2.16	2.56	**2.01**
Export inventory	**25.58**	**26.42**	**26.80**	**24.39**	**21.06**	**21.53**	**21.01**	**19.71**	**18.77**	**16.94**	**19.14**	**17.92**	21.61
Export Stockturnover (day)	571	361	497	223	110	145	211	183	267	93		215	277

Source: Cosmetics Company Report

Table 3.1 shows the current domestic and export products, the domestic products had an average cost of goods sold January-December 2009 at 0.74 million baht; the average inventory January-December 2009 was 5.44 million baht; and average stock turnover (days) January-December 2009 was 265 days.

Export products' average cost of goods sold between January-December 2009 was 3.02 million baht; average inventory January-December 2009 was 21.61 million baht; and average stock turnover (days) January-December 2009 was 277 days.

The issue of domestic and export products' company's performance emerged in Table 3.1, derive3d from calculations using formulae from the literature review:

How to calculate the inventory:

3.2.1. Inventory = (Ending of inventory)

For example: January 2009 = (Ending January 2009)

= (1,948,348)

= 1.95 million baht.

Table 3.1 shows that the average inventory export and domestic products' average inventory export January-December 2009 was 21.72 million baht; and domestic January-December 2009 was 5.29 million baht; which shows that the average export inventory was more than for domestic products.

How to calculate the cost of goods sold:

3.2.2. Cost of goods sold = Beginning of inventory 2009 + purchase during period – Ending of inventory 2009

For example: January 2009 = Ending December 2008+ Purchase during period – Ending January 2009

= (1,192,592+1,750,728 -1,948,348)

= 994,971.39

= 0.99 million baht

Costs of goods sold of export and domestic products had an average cost for export goods sold January 2009-December 2009 of 3.02 million baht; and domestic products January 2009-December 2009 was 0.74 million baht; thus, the export of cost of goods sold was more than for domestic products.

How to calculate the sales:

3.2.3 Actual sale was collected from actual sales data for each month, Sale data January 2009-December 2009 in Table 3.1 shows demands of export and domestic products such that export sales had a trend of increase growth of sale, while on the other hand, domestic products had fluctuated sales. Average domestic sale January 2009-December 2009 was 1.60 million baht, and average export sale January 2009-December 2009 was 5.87 million baht.

How to calculate the stock turnover ratio (days):

3.2.4. Inventory turnover ratio (day) = (Inventory / Cost of goods sold)*30 in this case, high number of day = bad low number of day = good

Example: January 2009 = (1.95/ 0.99)*30 = 59 days

Table 3.1 shows stock turnover ratio of export as average January 2009-December 2009 277 days and a domestic product as average January 2009-December 2009 265 days which is equivalent of day sale in inventory or stock turnover ratio.

3.3 Problem finding

One issue is that domestic products had average sale per month less than export products, at 4.47 million baht. Meanwhile the proportions are 20% for the domestic sale and 80% for export sale. The trend of obsolescence and carrying cost risk of domestic products are rather higher than export products (see Table 3.2).

3.2 Comparison of domestic and export products classification

Description	**Revenue** Million (Baht)	**Inventory** Million (Baht)	**Inventory Type**	**Turnover**	**Lead time**
Domestic	1.60 (21%)	5.44 (20%)	Finished products (Independent demand)	260 days	15 days
Export	5.87 (79%)	21.61 (80%)	Semi-finished RM (Dependent demand)	273 days	26 days
Total	**7.47**	**27.05**			

Sale growth of export products generated income greater than domestic products because export products have new channels in expanding marketplace to the Middle East. In future, the market share of export products will be higher than for domestic products, and it can be seen that 79% of export products cover worldwide channel s by reference to the supply mapping process of company.

At the same time, the item cost of domestic products was higher because of imported finished products from head office, and export products' cost was lower because of imported semi-finish raw material, while domestic had higher a carrying cost than export products.

As in Table 3.2, inventory of domestic January 2009-December 2009 was 5.44 million baht, a proportion of 20% of inventory on hand, and inventory of export products January 2009-December 2009 was 21.61 million baht, a proportion of 80% of inventory on hand, regarding stock turnover of domestic products January 2009-December 2009 was 265 days, and export products January-December 2009 was 277 days equivalent.

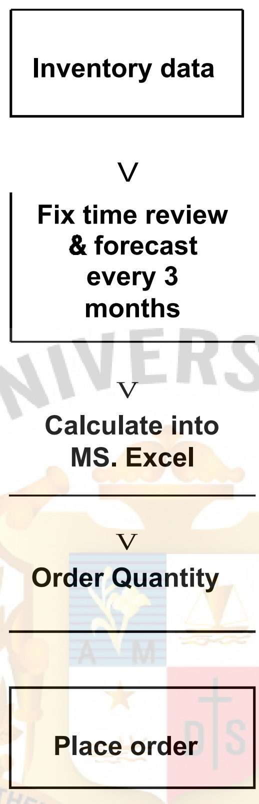
Nevertheless, the production lead time of domestic was 15 days and for export was 26 days; domestic lead time was rather shorter than export products in terms of speed of supply chain improvement in which domestic has much more.

Waters (1999) studied a replenishment order model in which independent demand was suitable for finished products, and dependent demand was suitable for raw material, work in process, or subassembly.

Colyjon (2003) explained that many companies focus on reducing finished goods inventory because finished goods inventory has a higher value than raw material or work in process inventory and affords a greater potential for capital reduction per inventory unit reduction.

Based on the current operation of this Cosmetics Company, a replenishment system is done by the demand planner of Cosmetics Company on a monthly basis without a systematic model of when the order should be placed and how much quantity should be ordered. There is no planning; the demand planner lacked skills and experience in replenishment system, according to the interview with the factory manager. The company has no obvious inventory management and operating process (see Figure 3.1).

Figure 3.1 Current processes



In the current process, the company uses the demand planner's skill and experience as in planning which was to fix the time review of placed orders every three months and keep inventory of approximately 3 months. In this case, the impact was an excess inventory level in current performance. Whenever the company has good performance in inventory management eventually, it will become a profitable business operation (Arnold & Chapman, 2004).

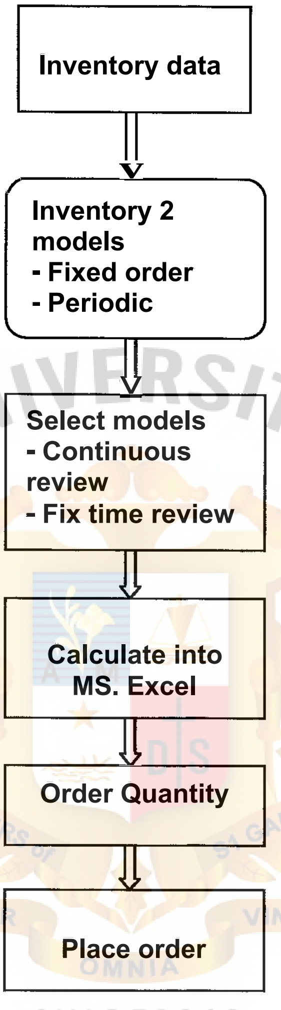
The researcher saw the issue of domestic products, and the company should improve the performance of domestic products as its first priority before export products, in terms of obsolescence and sale growth rate. In this study the researcher focuses on domestic products (Independent demand) two models for all items in which have an expensive cost per unit but low demand.

From this study, the researcher would suggest and propose two new models for an independent demand of replenishment system: the fixed order quantity and periodic review systems. This would solve the problems of optimal stock levels, such as when to order (Reorder point), and how much to order (EOQ), as included in the literature review, to be input into Microsoft Excel spreadsheet and simulated in the next step.

3.4 Propose (Independent demand) inventory replenishment. Two models (fixed order quantity and periodic review) by calculating relevant cost and ordering cost, carrying cost, stock out cost, safety stock and service level, and finding EOQ, ROP for fixed order quantity, target stock level and order quantity for periodic review by reference to literature review then simulation into Excel spread sheet.

From the literature review we would propose two new models to solve the problem by a replenishment system (independent demand). Figure 3.2 shows the new processes regarding optimal inventory level of how much to order (EOQ), when to order (reorder point), safety stock (prevent stock out) and service level (maximize level of response to customer requirement) for fixed order quantity. For target stock level and order quantity as periodic review, see the new processes in Figure 3.2.

Figure 3.2 New processes



Analyze the relevant cost by formula and simulation in the next step:

Ordering cost is approximate 50 baht/order. Ordering costs includes preliminary cost such as preparing the requisition, vendor selection, negotiation placement cost such as order preparation, stationery, postage; post-placement costs such as progressing, receipt of goods, materials, handling, inspection, certification and payment of invoice.

Carrying cost is approximate 25% of the cost items, as suggested by the finance manager which divided two types first: financial cost, such as interest on capital tied up in inventory, insurance, losses in value due to deterioration, obsolescence and pilfering; second, storage, labor and clerical cost.

Stock out cost is loss of production output, cost of idle time and of fixed overheads spread over a reduced level of output, loss of customer goodwill due to the inability to supply or late delivery. The costs of stock outs are hidden in overhead costs and are difficult to estimate or incorporate into inventory models.

Safety stock is inventory held as a buffer against mismatch between demand forecast and actual demand. Demand expected, actual delivery time and unforeseen emergencies also called reserve inventory, the service level give the required probability, the lead time is below the reorder level; Z is the number of standard deviations from the mean corresponding to the probability specified by the service level Z, which can found in normal distribution in Appendix B.

Service level determines the safety stock of this study; there is the variable demand and constant lead time with known lost sales from stock out cost per unit (all shortage are lost and not recovered), Ballou (2004), proposed the optimum for customer service level.

Fix order quantity system places an order of fixed size whenever the stock falls to a certain level with a need to continue the monitoring of stock level. This is suited to low, irregular demand for relatively expensive items.

To calculate EOQ and ROP Fix order quantity replenishment system

Bollou (2004) explained that if the lost sales costs are know, it is not necessary to assign a customer service level, and the optimum balance between service and cost be calculated. An iterative computational procedure for simulation and formula, are as follows:

1. Approximate the order quantity from the basic EOQ formula

$$Q^* = \sqrt{2DS.}$$

2. Compute that probability of being in stock during lead time; for this case, it is assumed that during a stock out, back ordering is allowed.

$$\mathbf{P}\ \mathbf{1}\ \frac{QH.}{Dk}$$

Find S'_d find the Z value that corresponds to P in the normal distribution Table (Appendix B). Find E (z) from the unit normal loss integral Table (Appendix C)

3. Determine a revised Q from a modified EOQ formula, which is

$$Q = \sqrt{\frac{2D(S + ks'dE(z)).}{H}}$$

4. Repeat step 2 and 3 until there is no change in P or Q, continue.

5. Compute ROP and other statistics as desired.

$$ROP = d \times LT + z(s'_d\ )$$

Periodic review system place orders of varying size at regular interval to raise the stock level to a specified value. The operating cost of this system is lower, and it is better suited to high, regular demand of low – value items (Waters, 1999).

To calculate Target Stock Level and order quantity (Periodic review replenishment system)

The periodic review system should be reviewed at regular intervals with two questions:

1. How long should be the interval between orders?
2. What should the maximum stock level be?

For the order interval, Tb can really be any convenient period.

For this study, it is convenient to place an order at the beginning of a month since Cosmetics Company can combine the items into a single order to the factory. At the same time, review the interval which can reduce the work load on the staff involved.

To find a suitable Maximum stock level, MSL is given by

Target stock level = (Demand over time + LT) + (Safety stock)

(TSL) = d* (Tb + LT) + (Z* a * sqrt (Tb + LT)

It depends on the usage average demand between order review periods. MSL for the item is developed based on usage during both the lead time and the fix time between orders. After a fixed time between orders (Tb) has passed, the stock position of the item is determined.

Maximum stock level = (Demand over Time + LT) + (Safety stock)

$$= d^* (Tb + LT) + (Z *a * \sqrt{(Tb + LT)}$$

Order Quantity = Target stock level – Stock on hand – Stock on order

Variables

d = average demand rate

Tb = the fixed time between orders

LT = lead time

$z\sigma$ d x sqrt (Tb + L) = safety stock

After finding EOQ, ROP, SS, for fix order quantity, TSL and order quantity for periodic review system, the researcher will apply and simulate two models in Microsoft Excel spreadsheet.
After simulation both models are compared: average inventory level of fix order quantity and periodic review system to current average inventory level:

Average inventory = Regular stock + Safety stock

$$\textbf{AIL} = \frac{Q}{2} + z(s'd)$$

3.5 Simulation in Microsoft Excel spreadsheet for each item, then measure total inventory cost, stock turnover and service level performance with the current performance data

The simulation method of a replenishment system will be applied using the results after finding EOQ, ROP, SS, target stock level and order quantity which the researcher obtained from step 4 of calculations after simulation. Then, comparison is made between the current and the new inventory performance for total inventory cost, stock turnover and service level, an either more or less benefit comparison between the current and the two proposed models performance, as in the formula:

1. The total inventory cost function can be measured as:

Total inventory cost = Annual ordering cost + Annual holding cost + Annual Lost sale cost

2. Stock turnover ratio (day) can be measured by thee inventory turnover ratio (days):

$$\text{Inventory turnover ratio (days)} = \frac{\text{average value of inventory}}{(\text{Cost of goods sold}/365)}$$

3. Service level can be measured by capability of demand to respond to customer requirements (Ballou, 2004). Comparison of current and new service levels:

$$\text{Service level} = 1 - \frac{\text{Number of stock out of annually}}{\text{Total Number of Unit demand}}$$

Lysons and Farrington (2006) studied inventory performance measurement. The number of key performance indicators (KPI) can be measured; the inventory performance for the right quantity, right place, right time of inventory and minimize cost, most useful lead time, service level and stock turnover.

Tersine (1994) explained that inventory costs are associated with the operating of an inventory system and result from action or the lack of action on the part of management in establishing the system, and are basic economic parameters to any inventory decision model; the more relevant ones to most system are ordering cost, holding cost and stock out cost.

Inventory turnover is also used to compare an organization's performance with other organizations in the same industry. The inventory turnover ratio can be useful, making comparative analyses between present and past performance.

3.6 Conclusion and recommendation

After simulation two proposed replenishment order models and key performance of index measurement taken from the total inventory cost, stock turnover and service level will be concluded, with recommendation of each model, with advantages and advantages. Whichever model is appropriate, the company would apply it into Microsoft Excel spreadsheet in order to adopt it for better company performance.

CHAPTER IV

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

From the research methodologies, in step 5 there was simulation of two models into Microsoft Excel spread sheet. This chapter provides the results of simulation, as in Table 2 models of the domestic products. All 24 items derive from the literature review Chapter 2 in order to simulate two models of a replenishment system for implementation. After the results, both models were compared for advantages and disadvantages, with key performance indices such as total cost, customer service level and inventory turnover, comparing between current and new performance. At the same time, the researcher presents a critical discussion of the results, step by step as follows:

4.1 Result: annual demand and relevant cost

↓

4.2 Result: fixed order quantity Q*, P*, SS and ROP

↓

4.3 Result: periodic review system TSL, order quantity

↓

4.4 Result: key performance index from total cost, customer service level and inventory turnover ratio

4.1 Result of annual demand and relevant cost

This step demonstrates and simulates, with example calculating the relevant cost of independent demand in domestic products of all 24 items, including the ordering cost, item cost, carrying cost and stock out cost. The annual demands of each item are found in the historical data of Cosmetics Company (Table 4.1). Simulation of annual demand and relevant cost calculations are:

4.1.1 Ordering cost per unit per year comprises of purchasing salary, operating issuance purchase order including fax and other cost of acquiring materials or goods. Calculations are:

For example: Item A (27)

Purchasing salary	= 16,000 baht/Month
Working days	= 22 days/Month
Hour/day	= 8 hours
Spent time (issue order)	= $\frac{1}{2}$ hour
Operating cost	= 5 baht

Total ordering cost = ((16,000/22)/8))/2 +5 = 50 baht

4.1.2 Item cost per unit per year is the average cost per unit at the end of the year, derived from an inventory report at the end of the year December 2009 for each item, can also be seen in Appendix A.

4.1.3 Carrying cost per unit per year comes from the item cost multiplied by 25% (in most organizations, this is based on 25% maximum of the holding cost percentage).

For example: Item cost of item A (27)

= 122 baht/unit/year (122*25%)

= 30 baht

4.1.4 Stock out cost/lost sale cost per unit per year come from selling price of 167.17 baht for all items, minus item cost per unit per year, equals profit. However it was difficult to calculate the stock out cost. Mostly it is calculated from the overhead cost.

For example: Item A (27)

= (167.17-122)

= 45 baht

Table 4.1 Result Table of annual demand and relevant cost

No	Code	Annual Demand (Carton)	Ordering Cost/Unit/Year	Item Cost/Unit/ Year	Holding Cost/Unit Year	Lost sale cost/Unit/Year
1	A(27)	3585	50	122	30	45
2	A(28)	4773	50	76	19	92
3	A(29)	13140	50	72	18	95
4	B(14)	8748	50	72	18	95
5	B(15)	4959	50	86	22	81
6	B(16)	10257	50	72	18	95
7	B(19)	8190	50	73	18	95
8	B(25)	9726	50	81	20	86
9	B(26)	5388	50	72	18	95
10	A(70)	5106	50	142	36	25
11	A(71)	4440	50	95	24	72
12	B(30)	5172	50	72	18	95
13	B(32)	6840	50	72	18	95
14	CA	2046	50	75	19	92
15	CB	1434	50	76	19	92
16	AM	1305	50	76	19	92
17	MO	1767	50	75	19	92
18	DA	2040	50	75	19	92
19	WC	1224	50	75	19	92
20	TS	5130	50	79	20	89
21	CO	3768	50	75	19	92
22	WI	1146	50	76	19	91
23	AB	3102	50	75	19	92
24	NA	1260	50	75	19	92

4.2 Result of EOQ, ROP and Safety stock for fixed order quantity

Fixed order quantity is a mathematical model which is suitable for continuous review. It always needs to be monitored frequently for this Cosmetics Company. In this model, we determined the lead time of the placed order as every 15 days or 0.50 month. Those relevant cost are to calculate the EOQ basic Q* and probability of being in stock **P***, in which stock out cost and back orders are allowed, found the Z value (Normal distribution and E(z) the unit normal loss integral Table in Appendices **B** and C) are examples of calculation from step 1 to step 5 within Tables 4.2, 4.3 and 4.4 simulation the result table as follows:

Step 1: Estimate Q*: Item A (27) Approximate the order quantity from basic EOQ formula (Equation 2-2)

$$Q = \sqrt{\frac{2DS}{H}} = \sqrt{\frac{2*3585*50}{30}}$$

$$= 109 \text{ cartons}$$

Step 2: Estimate P*: Item A (27) Compute the probability of being in stock during the lead time if back ordering is allowed:

$$P = 1 - \frac{QH}{Dk} = 1 - \frac{109*30}{3585*45}$$

$$= 0.98$$

From appendix **B, $z_{@}$0.98** = 2.06 from appendix **B,** $E_{(2.06)}$ = 0.0072

After we get the result from calculating shown estimate Q* item A(27) = 109 cartons and estimate P* = 98% normal distribution (Z) value = 2.06 and E (z) the unit normal loss integral = 0.0072 (see also Table 4.2) Simulation result table optimal estimates economic order quantity and probability of being in stock

Table 4.2 Result Table of optimal estimate of Economic Order Quantity and Probability of being in stock

No.	Code	Annual Demand (Pc) D	Ordering Cost	Item Cost	Holding Cost H	Lost sale Cost k	**EOQ** Q*	P* Probability of being in stock (1-QH/Dk)	Z	**Ez**
1	A(27)	3585	50	122	30	45	109	0.98	2.06	0.0072
2	A(28)	4773	50	76	19	92	159	0.99	2.33	0.0034
3	A(29)	13140	50	72	18	95	270	1.00	3.49	0.0001
4	B(14)	8748	50	72	18	95	220	1.00	3.49	0.0001
5	B(15)	4959	50	86	22	81	152	0.99	2.33	0.0034
6	B(16)	10257	50	72	18	95	238	1.00	3.49	0.0001
7	B(19)	8190	50	73	18	95	212	0.99	2.33	0.0034
8	B(25)	9726	50	81	20	86	219	0.99	2.33	0.0034
9	B(26)	5388	50	72	18	95	173	0.99	2.33	0.0034
10	A(70)	5106	50	142	36	25	120	0.97	1.89	0.0113
11	A(71)	4440	50	95	24	72	137	0.99	2.33	0.0034
12	B(30)	5172	50	72	18	95	170	0.99	2.33	0.0034
13	B(32)	6840	50	72	18	95	195	0.99	2.33	0.0034
14	CA	2046	50	75	19	92	105	0.99	2.33	0.0034
15	CB	1434	50	76	19	92	87	0.99	2.33	0.0034
16	AM	1305	50	76	19	92	83	0.99	2.33	0.0034
17	MO	1767	50	75	19	92	97	0.99	2.33	0.0034
18	DA	2040	50	75	19	92	104	0.99	2.33	0.0034
19	WC	1224	50	75	19	92	81	0.99	2.33	0.0034
20	TS	5130	50	79	20	89	162	0.99	2.33	0.0034
21	CO	3768	50	75	19	92	141	0.99	2.33	0.0034
22	WI	1146	50	76	19	91	78	0.99	2.33	0.0034
23	AB	3102	50	75	19	92	129	0.99	2.33	0.0034
24	NA	1260	50	75	19	92	82	0.99	2.33	0.0034

In the next step, we find out revised Q* and revised P* in order to find the optimal economic order quantity and service level, as in step 3 and 4 as follows:

Step 3: Revised Q* determine a revised Q* from a modified EOQ formula, the standard deviation of demand during lead time (DDLT) s'd = 120, and revised P* Probability of being in stock.

Revised Q* Item A (27) = $\sqrt{\dfrac{2D(S+ks'dEz)}{H}}$

= 2(3585) (50+45(120) (0.0072)/30

= 145 cartons

Revised P* Item A (27) = 1 $\dfrac{QH}{Dk}$

= 1 $\dfrac{145*30}{3585*45}$

= 0.97

Thus, Z@ 0.97 = 1.89 and $E_{(0.97)}$ = 0.0113

After **gaiing** the result from calculating the optimal Revised Q* = 145 cartons and Revised P* = 97%, normal distribution (Z) value = 1.89, and E (z) the unit normal loss integral = 0.0113

Step 4: Repeat Step 2 and 3 until there is no change in P* or Q* continue

Revised Q1* Item A (27) = $\sqrt{\dfrac{2D(S+ks'dEz)}{H}}$

$$\frac{\sqrt{2*3585*(50+45*120*0.0113)}}{30}$$

= 162 cartons

Revised P1* Item A (27) = 1 $\dfrac{QH}{Dk}$

= $\dfrac{162*30}{3585*45}$

= 0.97

Thus, Z@ 0.97 = 1.89 and $E_{(0.97)}$ = 0.0113

Revised Q2* Item A (27) = $\dfrac{\sqrt{2D(S+ks'dEz)}}{H}$

$$\frac{\sqrt{2*3585*(50+45*(120*0.0113)}}{30}$$

= 162 cartons

It can be seen that there are no changes in P* or Q* (see Table 4.3) with simulation of the results Table and modified Q* and P.

Table 4.3 Result Table: revised Q* and P* modified Economic Order Quantity and Probability of being in stock

No.	Code	Revised Q*	Revised P*	Z	Ez	Revised Q1*	Revised P1*	Z	Ez	Revised Q2*
1	A(27)	145	0.97	1.89	0.0113	162	0.97	1.89	0.0113	162
2	A(28)	228	0.99	2.33	0.0034	228	0.99	2.33	0.0034	228
3	A(29)	284	1.00	3.49	0.0001	284	1.00	3.49	0.0001	284
4	B(14)	227	1.00	3.49	0.0001	227	1.00	3.49	0.0001	227
5	B(15)	210	0.99	2.33	0.0034	210	0.99	2.33	0.0034	210
6	B(16)	246	1.00	3.49	0.0001	246	1.00	3.49	0.0001	246
7	B(19)	362	0.99	2.33	0.0034	362	0.99	2.33	0.0034	362
8	B(25)	324	0.99	2.33	0.0034	324	0.99	2.33	0.0034	324
9	B(26)	275	0.99	2.33	0.0034	275	0.99	2.33	0.0034	275
10	A(70)	154	0.96	1.76	0.0158	165	0.95	1.65	0.0206	177
11	A(71)	171	0.99	2.33	0.0034	171	0.99	2.33	0.0034	171
12	B(30)	238	0.99	2.33	0.0034	238	0.99	2.33	0.0034	238
13	B(32)	293	0.99	2.33	0.0034	293	0.99	2.33	0.0034	293
14	CA	132	0.99	2.33	0.0034	132	0.99	2.33	0.0034	132
15	CB	112	0.98	2.06	0.0072	135	0.98	2.06	0.0072	135
16	AM	108	0.98	2.06	0.0072	131	0.98	2.06	0.0072	131
17	MO	125	0.99	2.33	0.0034	125	0.99	2.33	0.0034	125
18	DA	134	0.99	2.33	0.0034	134	0.99	2.33	0.0034	134
19	WC	105	0.98	2.06	0.0072	127	0.98	2.06	0.0072	127
20	TS	215	0.99	2.33	0.0034	215	0.99	2.33	0.0034	215
21	CO	180	0.99	2.33	0.0034	180	0.99	2.33	0.0034	180
22	WI	101	0.98	2.06	0.0072	122	0.98	2.06	0.0072	122
23	AB	161	0.99	2.33	0.0034	161	0.99	2.33	0.0034	161
24	NA	106	0.98	2.06	0.0072	128	0.98	2.06	0.0072	128

When there are no changes in P* and Q* we could the find the reorder point and reorder level in step 5, calculating as follows:

Step 5: Compute Reorder point (ROP) and other statistics as desired:

For example; Item A (27) Reorder point (ROP) = d*LT + Z(S'd)

= (3585/12)*0.50+1.89(120)

= 150+227

= 377 cartons

Optimal time between order T*

= Q*/D

= 162/3585

= 0.045 year or 0.54 months

Production lead time = 15 days or 0.50 month

With lead time between n*T_o and (n+1)*T_o there will be n orders outstanding when it is time to place the next order. Reorder level (ROP) = LT*D-n*Q_o or (ROP-n*Q_o)

For example: Item A (27) lead time = 0.50 less than the cycle time or T* = 0.54, so n = 0 reorder level = 377 – 0(162) = 377 cartons.

When the stock on hand A (27) fall at certain level or reorder level = 377 cartons the order placed and order quantity = 162 cartons per time.

For example: Item A (29) lead time = 0.50 more than the cycle time or T* = 0.26 which lead time is between 1-2 cycles so n = 1 reorder level = 2395 – 1(284) = 2112 cartons.

When the stock on hand A (29) fall at certain level or reorder level = 2112 cartons the order placed and order quantity = 284 cartons per time.

For example: Item B (14) lead time = 0.50 more than the cycle time or T* = 0.31 in which lead time is between 1-2 cycles so n = 1 reorder level = 1575 – 1(227) = 1348 cartons.

When the stock on hand B (14) falls to a certain level or reorder level = 1348 cartons the order placed and order quantity = 227 cartons per time.

For example: Item B (16) lead time = 0.50 more than the cycle time or T* = 0.29 which lead time is between 1-2 cycles so n = 1 reorder level = 1702 – 1(246) = 1456 cartons.

When the stock on hand B (16) fall at certain level or reorder level = 1456 cartons the order placed and order quantity = 246 cartons per time.

For example: Item B (25) lead time = 0.50 more than the cycle time or T* = 0.40 which lead time is between 1-2 cycles so n = 1 reorder level = 876 – 1(324) = 552 cartons.

When the stock on hand B (25) fall at certain level or reorder level = 552 cartons the order placed and order quantity = 324 cartons per time.

From simulation result there are items A (29), B (14), B (16), B (25), A (70) and A (71); for optimal time between orders less than lead time see Table 4.4.

Table 4.4 Result Table of optimal safety stock and Reorder point and reorder level

No.	Code	Annual Demand (Carton)	**Sd**	**S'd**	Z	Revised Q2*	SS **Z(s'd)**	**ROP =dlt+ z(s'd)**	T*= **Q*/d** Cycle time	Lead Time (Month)	N	ROL **(LT*D)- n*Qo**
1	A(27)	3585	170	120	1.89	162	227	377	0.54	0.50	0	377
2	A(28)	4773	239	169	2.33	228	394	593	057	0.50	0	593
3	A(29)	13140	749	529	3.49	284	1848	2395	0.26	0.50		**2112**
4	B(14)	8748	490	347	3.49	227	1210	1575	0.31	0.50	1	1348:
5	B(15)	4959	236	167	2.33	210	389	595	0.51	0.50	0	595
6	B(16)	10257	517	365	3.49	246	1275	1702	0.29	0.50	1	1456
7	B(19)	8190	419	296	2.33	362	690	1031	0.53	0.50	0	1031
8	B(25)	9726	286	202	2.33	324	471	876	0.40	0.50	1	**552**
9	B(26)	5388	337	238	2.33	275	556	780	0.61	0.50	0	780
10	A(70)	5106	161	114	1.65	177	188	401	0.42	0.50	1	224:
11	A(71)	4440	165	117	2.33	171	272	457	0.46	0.50	1	**286**
12	B(30)	5172	212	150	2.33	238	349	565	0.55	0.50	0	565
13	B(32)	6840	272	193	2.33	293	449	734	0.51	0.50	0	734
14	CA	2046	136	96	2.33	132	224	309	0.78	0.50	0	309
15	CB	1434	149	105	2.06	135	217	277	1.13	0.50	0	277
16	AM	1305	158	112	2.06	131	230	285	1.20	0.50	0	285
17	MO	1767	148	105	2.33	125	244	317	0.85	0.50	0	317
18	DA	2040	149	105	2.33	134	245	330	0.79	0.50	0	330
19	WC	1224	160	113	2.06	127	233	284	1.25	0.50	0	284
20	TS	5130	179	127	2.33	215	295	509	0.50	0.50	0	509
21	CO	3768	141	100	2.33	180	232	389	057	0.50	0	389
22	WI	1146	158	112	2.06	122	230	278	1.28	0.50	0	278
23	AB	3102	127	90	2.33	161	209	338	0.62	0.50	0	338
24	NA	1260	155	110	2.06	128	226	278	1.22	0.50	0	278

4.3 Calculation method and result of Target Stock Level (TSL) and order quantity for Periodic review system

A Periodic review system, mostly frequency of place order has a fix time order review such as 1 month, 2 months or 3 months depending on an organization's performance. It is unlike a convenience of place continuous order review in a replenishment system, where this method is easier than fixed order quantity or continuous review. However we are likely to calculate this by using 1 month of the fix time order review which is suitable for this Cosmetics Company, as in the3 example presented in Table 4.5.

Target stock level = (Demand over time + LT) + [Safety stock]

= D*(Tb +LT) + Z(S'd) SQRT (Tb +L)

Order Quantity = Target stock level – Stock on hand – Stock on order

For example:

Average demand rate	D 299 pieces/month
Standard Deviation	(Sd) 170 pieces/month
Fix time between order	(Tb) 30 days
Production lead time	(LT) 15 days
Z(S'd) SQRT (Tb +L)	(SS) Safety stock

$= D*(Tb+LT) + (Z*S'd*\sqrt{(Tb+LT)}$

$= 299*(1+0.5) + (1.89*170*\sqrt{1+0.5}$

= 448 + 1.89*209

= 448+395

= 843 cartons where orders of varying size are placed at regular intervals to raise the stock to a specified level (the target stock level) (see also Table 4.5).

Order quantity = 843 – stock on hand – stock on order

Table 4.5 Result Table of a periodic review system

No.	Code	Average Demand (Carton)	Sd	S'd	Z	Safety stock (SS)	Fix time between order	Production Lead Time (Month)	TSL M*
1	A(27)	299	170	209	1.89	395	1	0.50	**843**
2	A(28)	398	239	293	2.33	683	1	0.50	**1279**
3	A(29)	1095	749	917	3.49	3201	1	0.50	**4843**
4	B(14)	729	490	601	3.49	2096	1	0.50	**3189**
5	B(15)	413	236	289	2.33	674	1	0.50	**1294**
6	B(16)	855	517	633	3.49	2208	1	0.50	**3490**
7	B(19)	683	419	513	2.33	1195	1	0.50	**2218**
8	B(25)	811	286	350	2.33	815	1	0.50	**2031**
9	B(26)	449	337	413	2.33	962	1	0.50	**1636**
10	A(70)	426	161	198	1.65	326	1	0.50	**964**
11	A(71)	370	165	202	2.33	470	1	0.50	**1025**
12	B(30)	684	212	334	2.33	777	1	0.50	**1803**
13	B(32)	517	272	260	2.33	606	1	0.50	**1382**
14	CA	205	136	167	2.33	388	1	0.50	**695**
15	CB	143	149	183	2.06	377	1	0.50	**592**
16	AM	131	158	193	2.06	398	1	0.50	**594**
17	MO	177	148	182	2.33	423	1	0.50	**688**
18	DA	204	149	182	2.33	425	1	0.50	**731**
19	WC	122	160	196	2.06	404	1	0.50	**588**
20	TS	513	179	219	2.33	511	1	0.50	**1281**
21	CO	377	141	173	2.33	403	1	0.50	**969**
22	WI	115	158	193	2.06	398	1	0.50	**569**
23	AB	310	127	156	2.33	364	1	0.50	**829**
24	NA	126	155	190	2.06	392	1	0.50	**581**

From this simulation result Table we compare average inventory level on hand between current, fixed order quantity and periodic review systems. Stock in hand after simulation results in an average inventory level reducing by 78%, 4.7 million baht (5.7-1.0) or 61,912 cartons (75,207-13,295) for fixed order quantity, and reducing by 69%, 4 2 million baht or 55,607 cartons for the periodic review. The average inventory level can be calculated from the example as follows:

Average inventory level = Q*/2 +Z(S'd) or regular stock + Safety stock

For example:

Fixed order quantity	Periodic review
= Q*/2 +SS	= dT*/2+SS
= 162/2 +227	= (299*0.12)/2+395
= 308 cartons	= 412 cartons

Table 4.6 Result Table: comparison of average inventory level

No.	Code	AIL Current **(Baht)**	AIL Current (Carton)	AIL Fixed Order Quantity **(Baht)**	AIL Fixed (Carton)	Decrease %	AIL Periodic Review **(Baht)**	AIL Periodic (Carton)	Decrease %
1	A(27)	80,241	659	37,538	308	(53)	50,176	412	(37)
2	A(28)	126,464	1673	38,371	508	(70)	53,611	709	(58)
3	A(29)	329,215	4582	142,967	1990	(57)	237,217	3302	(28)
4	B(14)	250,331	3457	95,841	1324	(62)	156,582	2162	(37)
5	B(15)	106,463	1232	42,662	494	(60)	60,546	701	(43)
6	B(16)	252,693	3495	101,071	1398	(60)	164,893	2281	(35)
7	B(19)	204,967	2822	63,241	871	(69)	90,132	1241	(56)
8	B(25)	157,660	1948	51,194	633	(68)	69,384	857	(56)
9	B(26)	182,796	2524	50,183	693	(73)	72,157	996	(61)
10	A(70)	92,765	653	39,253	276	(58)	49,184	346	(47)
11	A(71)	91,876	965	34,031	357	(63)	46,681	491	(49)
12	B(30)	399,061	6197	42,734	595	(89)	45,580	635	(89)
13	B(32)	445,106	5556	33,646	468	(92)	58,512	815	(87)
14	CA	322,239	4304	21,732	290	(93)	30,136	403	(91)
15	CB	270,007	3570	21,505	284	(92)	29,443	389	(89)
16	AM	278,440	3679	22,360	295	(92)	31,089	411	(89)
17	MO	301,452	4010	23,019	306	(92)	32,881	437	(89)
18	DA	293,494	3907	23,484	313	(92)	33,040	440	(89)
19	WC	279,664	3706	22,387	297	(92)	31,429	416	(89)
20	TS	196,915	2508	31,582	402	(84)	42,222	538	(79)
21	CO	234,302	3106	24,314	322	(90)	31,947	424	(86)
22	WI	285,201	3760	22,090	291	(92)	31,053	409	(89)
23	AB	256,006	3410	21,741	290	(92)	28,607	381	(89)
24	NA	261,684	3484	21,776	290	(92)	30,351	404	(88)
TOTAL		5,699,042	75,207	1,028,722	13,295	(78)	1,506,853	19,600	(69)

Graph 4.1 shows the average inventory level current, fixed order quantity and periodic review system and average demand (Baht). Graph 4.2 shows the average inventory level current, fixed order quantity, periodic review and average demand (Carton). Obviously average inventory level decreased when comparing both fixed order quantity and periodic review.

Figure 4.1 Graph: optimal average inventory level and average demand (Baht)

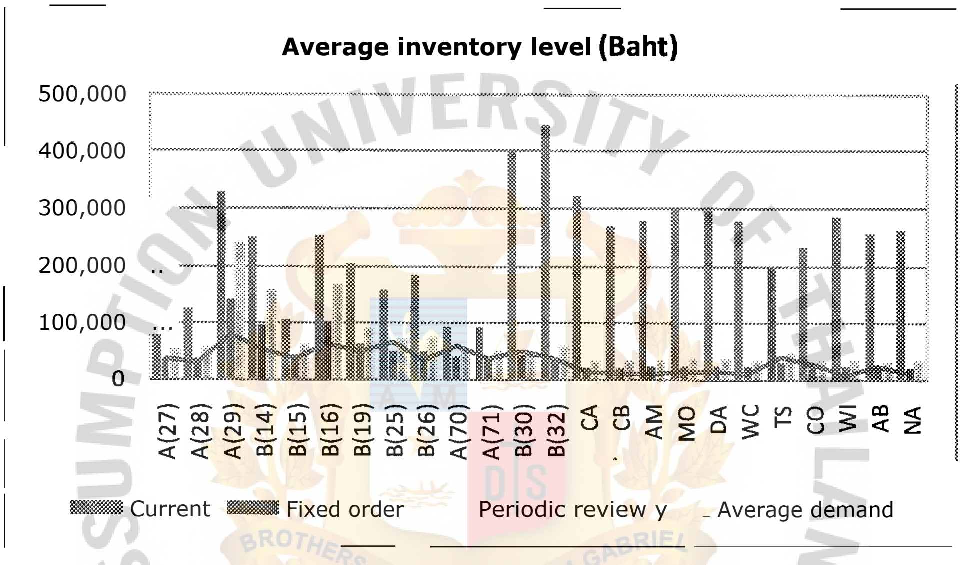
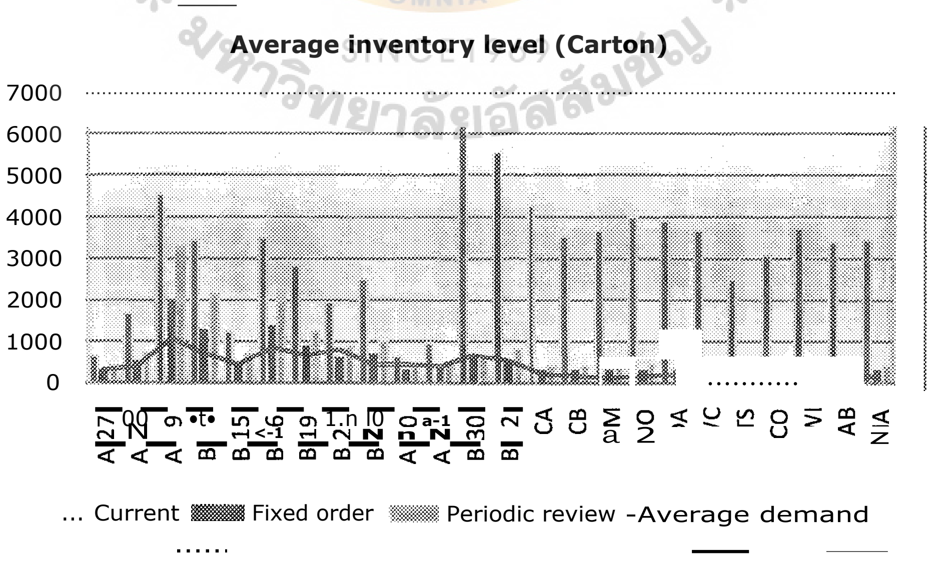


Figure 4.2 Graph: optimal average inventory level and average demand (Carton)



4.4 Result of key performance index measurement

The result of current and new performance in this Cosmetics Company can be measured for the key performance index from the total inventory cost, inventory turnover ratio and customer service level, as follows:

4.4.1 Total inventory cost can be calculate for example item A (27). See Table 4.7 and 4.8 comparing result table total inventory cost as follows:

TC = Total ordering cost **+** Total Carrying cost **+** Total Stock out cost

Fixed order Quantity	Periodic review
TC = (D/Q)*S)+(IC*Q/2)+(ICzs'd)+(D/Q*ks'dE(z))	TC = (D/Q*S)+(IC*Q/2)+(ICzs'd)+(D/Q*ks'dE(z))
=(3585/162)*50)+(30*162/2)+(30*227)+0	=(3585/421)*50)+(30*421/2)+(30*395)+0
= 1105 + 2469+6916	= 425+6408+12010
= 10,490	= 18,848

Table 4.7 Result Table of cost saving total inventory cost (Baht)

No.	Code	Current	Fixed Order quantity	Cost Saving %	Periodic Review	Cost Saving %
1	A(27)	20,332	10,490	(48.41)	18,848	(7.30)
2	A(28)	31,759	10,641	(66.49)	19,316	(39.18)
3	A(29)	82,447	38,057	(53.84)	79,512	(3.56)
4	B(14)	62,709	25,888	(58.72)	52,652	(16.04)
5	B(15)	26,817	11,848	(55.82)	21,924	(18.25)
6	B(16)	63,320	27,350	(56.81)	55,974	(11.60)
7	B(19)	51,387	16,942	(67.03)	32,134	(37.47)
8	B(25)	39,665	14,299	(63.95)	27,241	(31.32)
9	B(26)	45,806	13,526	(70.47)	25,156	(45.08)
10	A(70)	23,582	11,256	(52.27)	20,674	(12.33)
11	A(71)	23,199	9805	(57.74)	17,720	(23.62)
12	B(30)	99,827	9497	(91.47)	22,503	(79.79)
13	B(32)	111,318	11852	(88.13)	17,530	(82.44)
14	CA	80,583	6206	(92.30)	10,868	(86.51)
15	CB	67,522	5909	(91.25)	10,217	(84.87)
16	AM	69,628	6090	(91.25)	10,612	(84.76)
17	MO	75,385	6463	(91.43)	11,492	(84.76)
18	DA	73,400	6631	(90.97)	11,739	(84.01)
19	WC	69,932	6078	(91.31)	10,649	(84.77)
20	TS	49,331	9090	(81.57)	16,797	(65.95)
21	CO	58,636	7125	(87.85)	12,640	(78.44)
22	WI	71,315	5992	(91.60)	10,479	(85.31)
23	AB	64,047	6400	(90.01)	11,167	(82.56)
24	NA	65,439	5935	(90.93)	10,348	(84.19)
TOTAL		1,427,387	283,368	(76)	538,190	(55)

Table 4.8 Result table of comparison between current and new performance of total inventory cost

[illegible]	Ordering cost			Carrying Cost			Stock out cost			Total Cost		
	Current	Fixed	Period c	Current	Fixed	Periodic	Current	Fixed	Periodic	Current	Fixed	Periodic
[illegible]	[illegible]	1 05	425	20060	9384	18422	0	0	0	20322	10490	18848
A	143	1048	[illegible]	31616	9593	18943	0	0	0	31759	[illegible]	19316
[illegible]	143	2315	271	[illegible]	[illegible]	79241	0	0	0	[illegible]	L38057	79512
B	[illegible]	[illegible]	274	62583	23960	52377	0	0	0	62709	25888	52652
B	201	1182	[illegible]	[illegible]	0666	[illegible]	0	0	0	26817	11848	21924
B	147	[illegible]	[illegible]	63173	25268	[illegible]	0	0	0	63320	[illegible]	55974
B	145	[illegible]	[illegible]	51242	15810	31765	0	0	0	51387	16942	32134
B	250	1501	479	39415	[illegible]	[illegible]	0	0	0	39665	14299	27241
B	107	[illegible]	329	[illegible]	12546	24826	0	0	0	45806	13526	[illegible]
A	391	1443	[illegible]	[illegible]	[illegible]	20145	0	0	0	[illegible]	[illegible]	20674
A	230	1297	[illegible]	[illegible]	8508	17287	0	0	0	23199	9805	[illegible]
B	[illegible]	1169	449	[illegible]	10683	[illegible]	0	0	0	99827	11852	17530
B	42	1085	455	111277	8412	22048	0	0	0	111318	9497	[illegible]
[illegible]	[illegible]	773	353	80560	5433	10515	0	0	0	80583	6206	10868
[illegible]	20	[illegible]	[illegible]	67502	5376	[illegible]	0	0	0	[illegible]	5909	[illegible]
	18	500	264	69610	559	10348	0	0	0	69628	[illegible]	[illegible]
MO	22	708	308	[illegible]	5755	[illegible]	0	0	0	[illegible]	6463	11492
DA	26	760	[illegible]	[illegible]	[illegible]	11404	0	0	0	73400	[illegible]	11739
WC	17	481	[illegible]	69916	[illegible]	[illegible]	0	0	0	69932	6078	[illegible]
TS	[illegible]	1 5	[illegible]	49229	7895	1631	[illegible]	0	0	49331	[illegible]	[illegible]
CO	61	1047	[illegible]	58576	6078	12173	0	0	0	58636	7125	12640
	IS	469	242	71300	[illegible]	[illegible]	0	0	0	71315	599	10479
	45	965	449	64002	[illegible]	[illegible]	0	0	0	64047	6400	11167
NA	[illegible]	491	260	65421	5444	10088	0	0	0	65439	5935	10348
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]	257,180	529,425	0	0	0	1,427,387	[illegible]	[illegible]

4.4.2 Inventory Turnover ratio

Inventory turnover ratio can be measured for the current and new performance. We are likely to calculate the following:

Inventory turnover ratio (day) = (Average inventory / Cost of goods sold)*365 which new performance presents the current average inventory of 174 day. Meanwhile fixed order quantity is 26 days and periodic review is 41 days (see Table 4.9).

Table 4.9 Result Table of inventory turnover ratio

No.	Code	Current	Fixed Order Quantity	Periodic Review
1	A(27)	81	38	59
2	A(28)	98	30	45
3	A(29)	103	45	75
4	B(14)	98	37	62
5	B(15)	76	30	46
6	B(16)	101	40	67
7	B(19)	94	29	43
8	B(25)	68	22	32
9	B(26)	125	34	52
10	A(70)	65	28	43
11	A(71)	73	27	41
12	B(30)	236	18	27
13	B(32)	179	19	28
14	CA	279	19	28
15	CB	265	21	35
16	AM	282	23	38
17	MO	278	21	33
18	DA	257	21	31
19	WC	287	23	39
20	TS	111	18	26
21	CO	156	16	24
22	WI	298	23	39
23	AB	187	16	24
24	NA	371	31	51
TOTAL		174	26	41

4.4.3 Customer service level

We can find out the actual customer service level by the following calculation:

Service level = 1- (Expected number of units out of stock annually) / Total annual demand

SL = 1-S'd(E(z)/D

For example: Item A (27) Fixed order quantity and periodic review system

Fixed order quantity	Periodic review
SL = 1-S'$_d$(E$_{(z)}$/D	**SL = 1-S'$_d$(E$_{(z)}$/D**
= 1-(120*0.0113)/3585	= 1-(170*0.0113)/3585
=1.00	= 1.00

Table 4.10 Result Table of customer service level

No.	Code	Annual Demand	Probability of being in stock	Current	Fixed Order Quantity	Periodic Review
1	A(27)	3585	98%	100%	100%	100%
2	A(28)	4773	99%	100%	100%	100%
3	A(29)	13140	100%	100%	100%	100%
4	B(14)	8748	100%	100%	100%	100%
5	B(15)	4959	99%	100%	100%	100%
6	B(16)	10257	100%	100%	100%	100%
7	B(19)	8190	99%	100%	100%	100%
8	B(25)	9726	99%	100%	100%	100%
9	B(26)	5388	99%	100%	100%	100%
10	A(70)	5106	97%	100%	100%	100%
11	A(71)	'1110	99%	100%	100%	100%
12	B(30)	5172	99%	100%	100%	100%
13	B(32)	6840	99%	100%	100%	100%
14	CA	2046	99%	100%	100%	100%
15	CB	1434	99%	100%	100%	100%
16	AM	1305	99%	100%	100%	100%
17	MO	1767	99%	100%	100%	100%
18	DA	2040	99%	100%	100%	100%
19	WC	1224	99%	100%	100%	100%
20	TS	5130	99%	100%	100%	100%
21	CO	3768	99%	100%	100%	100%
22	**WI**	1146	99%	100%	100%	100%
23	AB	3102	99%	100%	100%	100%
24	NA	1260	99%	100%	100%	100%

That is the demand for item A (27) which can be met 100% of the time. This is somewhat higher than the probability of a stock out during the lead time, of P = 98%

4.4.4 Advantages and disadvantages

From the result of each model, we can summarize the advantages and disadvantages in each model as follows:

Table 4.11 Advantages and disadvantages of fixed order quantity and periodic review

Model	Advantage	Disadvantage
Fixed order quantity	Average stock level on hand lesser than Periodic; Total cost, inventory turnover to minimize cost and minimize days to sell inventory and maximize customer service level. Order quantity is fix size.	Continuous review and always monitor, inconvenience for workload in some companies
Periodic Review System	Convenience determines time, every 1 or 2 months of fix time order review, no need always monitoring to place order	Order quantity varies as order size, total carrying cost is higher than fixed order

CHAPTER V

SUMMARY FINDING, CONCLUSION AND RECCOMENDATIONS

Chapter 4, provides the results and the simulation Tables which compared the replenishment system for each model, with key performance of index for both models. Hence, this chapter deals with a summary of the findings, conclusion, and a recommendation for selecting a suitable model.

5.1 Summary of the findings

The simulation result Tables for both fixed order quantity and periodic review can be summarized as follows:

The total cost comprises ordering cost, carrying cost and stock out cost for the fixed order quantity resulted in cost savings of 76%, or 1.14 million baht of the total cost. Meanwhile, the periodic review system resulted in cost savings of 55%, or 0.89 million baht of the total cost.

However, the ordering cost of fixed order quantity represented a higher cost than the periodic because the fixed order quantity is always continuously reviewed every 15 days. On the other hand, periodic review has a periodic review every 1 month, and will incur high carrying cost as shown in both models.

The periodic review keeps more inventory than fixed order quantity. Fixed order quantity is suitable with right cost and right quantity, as periodic review is the second alternative.

The average inventory level result reduces the excess inventory level as fixed order quantity by 78%, about 4 7 million baht or 61,912 cartons, and periodic review can reduce by 69%, about 4 2 million baht or 55,607 cartons, The fixed order quantity more gives us greater gain than periodic review in terms of optimal stock level on hand.

Inventory turnover ratio or number of day to sell inventory decreased from 174 days of the current system to 26 days of fixed order quantity and 41 days of periodic review.

In terms of the optimal service level, it was 100% for both models as the actual service level did not show the stock out cost.

5.2 Conclusion

From the results, the researcher regards the fixed order quantity system as a suitable model in this study which compares the key performance index with the total inventory cost, inventory turnover ratio and customer service level. It was apparently fixed order quantity which gives more benefit in terms of optimal inventory level, total cost and inventory turnover ratio or number of day to sell inventory; greater than the periodic review system.

The fixed order quantity was suitable for this Cosmetics Company performance in terms of right quantity, right time, minimized cost and maximized service level. However fixed order quantity needs continuous review and perpetual monitoring which places an order every 15 days - the order quantity is fixed size. The periodic review system is suitable with a fixed time order review which places an order every 1 month or 2 months as the company requires depending on the company's lead time as well the order quantity which varies order sizes, depending on the demand planner in each organization and which model he would select to solve the excess inventory.

However, the demand planner needs to make a decision a suitable model for placing orders. It depends on a convenient time for order review in each organization.

5.3 Recommendation and Further research

From this study, top management should realize that the issue is the excess inventory level in the domestic products, and focus on inventory management using a replenishment system of the two models in this Cosmetic Company. That means whenever the company has good performance, an optimal inventory level, it will create a better return on asset and better profitability. Hence, a replenishment system will solve the problems and enhance the company.

In order to reduce the tremendous carrying cost in this Cosmetic Company using mathematical models, the fixed order quantity and periodic review systems are problem solvers which could help the Company to determine how much to order and when to order, so as to reduce the excess inventory to a sustainable level.

For further research, the researcher would like to study the export products of independent demand, the as researcher intended to focus on the 2nd priority using a replenishment system which is likely reduce the excess inventory in export products. The data analysis shows bad performance or a high number of days to sell inventory, the same issue as for domestic products. However the researcher would propose a deeper study in future research.

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APPENDIX A

Data analysis - Domestic and Export products

	Export Products			Domestic Products		Export Products	Domestic Products
	ST	BSCC	PRO	BT	MT	ST,BSCC,PRO	BT,MBT
	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec		
Beginning of inventory	4,752,879.59	11,440,943.78	4,471,845,15	1,112,591,77			
Purchase	7,871,763.72	17,622,530.79	7,693,127.72	7,754,916,00	4,657,287.00		
	12,630,643.31	29.063,474.57	12,164.972.87	8,941,507.77	4,657,287.00		
Ending of inventory	3,694,773.99	8,269,037.89	5,961,113.57	1 952,812 1J	2,734 6`7.81		
Cost of goods sold	8,935,869.32	29,794,436,68	6,203,859.30	6,994,695.63		35,934,165.30	8,917,324.82

	ST	BSCC	PRO	DT	MT		
	Jan'09	Jan'09	Jan'09	Jan'09	Jan'09		
Beginning of inventory	4,752,879.59	11,440,943.78	4.471,845.15	1,192,591,77	....		
Purchase		861,811.32	3,177,139.06	1,750,728.00			
	6,975,303.73	12,302,755.10	7,648,984.21	2,943,319.77			
Ending of inventory	6,929,049.42	12,249,054.11	6,405,35633	1,948,343,38			
Cost of goods sold	46,254.31	53,700,91	1,243,627.48	994,971,39		1,343,582.78	994,971.39

	ST	BSCC	PRO	BT	MT		
	Feb'09	Feb'09	Feb'09	Feb'09	Feb'09		
Beginning of inventory	6,929,049.42	12,249,054.11	6,405,356.73	1,948,348.38			
Purchase	1,659,231.00	13099.90	1,041,143,15	2,240,00	12320,00		
	8,788,280.42	12,387,454.01	7,446,499.88	1.950,588.38	12320,00		
:Ending of inventory	8,630,778.92	10,457,235.26	1,334,581,18	1,285,169.00	12.320,00		
Cost of goods sold	157,501.50	1,930,218.75	109,917.90	665,419,30		2,197,638.15	665,419.38

	ST	BSCC	PRO	BT	MT		
	Mar'09	Mar'09	Mar'09	Mar'09	Mar'09		
Beginning of inventory	8,630,778.92	10,451,235,26	1,336,581,98	1,285,169,00	12,320.00	....	
Purchase	663,304.58	103,145,90	1,103,523.09	1,659,840,00	:5,166,965.00		
	9,294,083.50	10.640,380.26	8.440,105.07	2,945,009.00	3,179305,00.		
Ending of inventory	8,893,536.89	9,417,769.46	8,482,635.59	2,135,286,17	2,695,811.21		
Cost of goods sold	395,546.61	1,222,610.60	42,530.52	809,722.83	483,493.79	1,575,626.69	1,293,216.62

	Export Products			Domestic Products		Export Products	Domestic Products
	ST	BSCC	PRO	BT	MT		
	Apr'09	Apr B9	Apr'09	Apr'09	Apr'09		
Beginning of inventory	8,898,536.89	9,417,769.66	8,482,635.59	2,135,286.17	2,695,811.21		
Purchase	97,580.00	616,63630	153,577,47				
	8,996,116,89	10,034,406,46	3,641,213.06	2,135,236.17	2,695511.21		
Ending of inventory	7,818,569.89	8,292,098.05	8,281 07.59	1,319,131.44	2,657,893.70		
Cost of goods sold	1,177,547.00	1,742,308,41	359,905.47	815,848.73	37317.51	3,279,760.88	853,766.24
	ST	BSCC	PRO	BT	MT		
	May'09	May'09	May'09	May'09	May'09		
Beginning of inventory	7,818,569.89	8,292,098.05	8.281,307.59	"1519,437.44	2,657,893.70	....	
Purchase	241,98000	2,130,156.24	35,850.00	1453,0550	1,476,342.00		
	8,060549.89	10,422,254.29	8,317,157.59	2173,43244	4,134,23510		
Ending of inventory......	7,553,551.88	5,245307,20	8.260,030.99	2,179,105.07	3,985,215.46		
Cost of goods sold	50659831	5,176,347.09	57,126.60	594321.37	09520.24	5,140,471,70	743,347.61
	ST	BSCC	PRO	BT	MT		
	Jun19	Jun19	Jun'09	Jun'09	Jun'09		
Beginning of inventory	7,553,551.88	5,245,907,20	8,2%030.99	2,179,10557	3385,21546		
Purchase	58,980.00	4,816,718.68	58,980.00	2,735,918.00			
	7,612,531.88	10,062,625.88	8,319510.99	4,915523.07	3,985,215,46		
Ending of inventory......	6,845485,10	8,195,727,77	6,490,937.36	4,652,773.41	3386306,20		
Cost of goods sold	767546,78	1,866,898.11	1328573.63	262,249.66	179,209,26	4,462,018 52	441,458.92
	ST	BSCC	PRO	BT	MT		
	Jul'09	Jul'09	Jul%	Jul'09	Jul'09		
Beginning of inventory	6,845,485.10	3,195,727,77	6,490,937.36	4352,773.41	3,806,006,20		
Purchase	59375.00	1,995,07635	411,048.95	12,675,00			
	6,905,460.10	10,190,804.62	6,901,986.31	4,665,448.41	,806,006.20		
Ending of inventory......	5,403,591,10	9,865,504,89	5,744,693,39	4,335,240.02	3,628,655.66		
Cost of goods sold	1,501,868.40	325,299,73	1,157,292,92	330,208.39	177,35054	2,984,461.05	507,558.93

	Export Products			Domestic Products		Export Products	Domestic Products
	ST Aug'09	BSCC Aug%	PRO Aug'09	BT Aug'09	MT Aug'09		
Beginning of inventory	5,403,591.70	9,865,504.89	5,744,69339	4,335,240,02	3,628,655.66	....	
Purchase	1,021,076.00	308,053.00	595,072,00	34,115.00	1,640.00		
	6,424,66/.70	10,173,562339	6,339,165.39	4,369.355.02	3,630,295.66		
Ending of inventory	4,954,200.23	8,921,413,24	5,834,698.11	4,047,997,48	3,487,310.60		
Cost of goods sold	1,474,467.47	1,252,149.65	505.067,28	321,357,54	142,985,06	**3,227,684.40**	**464,342.60**
	ST Sept'09	BSCC Sept'09	PRO Sept'09	BT Sept'09	MT Sept'09		
Beginning of inventory	4,954,200.23	8,921,413.24	5,834,698,11	4,047997.48	3,487,310,60		
Purchase	217,855.00	696,300.00	41,910.00				
	5,172,055.23	**9,617,71324**	5,876,608.11	4,047,99738	3,487,310.60		
Ending of inventory.......	5,142,912.09	7.537,551.00	6,085,579.19	3,519,312,00	3,316,849.95		
Cost of goods sold	29,143.14	2,080,162.24	(208,971.08)	52868538	170,460.65	**1,900,334.30**	**699.146.13**
	ST Oct'09	BSCC Oct'09	PRO Oct'09	BT Oct'09	MT Oct'09		
Beginning of inventory	5,142,912.09	7,537,551.00	6,085,57939	3,519312.00	3,316,849.95		
Purchase	114,051.40	3,472,570.00	58,420,00				
	5256,963.09	11,010.121.00	6,143,999.19	3,519,312.00	3,316,349.95		
Ending of inventor	4 431,178 13	7,469,817.33	5,038,814.68	2,914.037,84	3,116.179.69		
Cost of goods sold	325,734.96	3,540,303.67	1,105,184,51	605,274.16	200,670.26	5,471,273.14	**805,944.42**
	ST Nov'09	BSCC Nov'09	PRO Nov'09	BT Nov'09	MT Nov'09		
Beginning of inventory	4,431,178.13	7,469,817.33	5,038,814.68	**2,914,037,84**	333335,179.69		
Purchase	1,135,316.00	1,311539,00	1,008,524.00	105,405,00			
	5,566,494.13	8,811356,33	6,047,338.68	**3,019,442.84**	3,035.179.69		
Ending of inventory	4,471,057.56	8,599,281.25	6,064,130.42	2,554,198.91	2,96.1,687,47		
Cost of goods sold	1,092,436.57	212,075,03	(16,791143	465,243.93	70,492,22	1,287,719.91	535,736.15
	ST Dec'09	BSCC Dec'09	PRO Dec'09	BT Dec'09	MT Dec'09		
Beginning of inventory	4.474,057.50	8,599,281,25	6,064,130.42	2,554,19 ,91	2,964,687,17	....	
Purchase	185,991.00	1,062,119.00	2,940.00				
	4,600,048.56	**9,661,40025**	**6,067,070.42**	2,554,198.91	2,964,687.47		
Ending of inventory	3,694,773.99	8,269,037,89	5,961,113.57	**1,952,812.14**	2,734,657,81		
Cost of goods sold	965,274.57	1,392,362,36	105,956.85	601,386.77	230,029,06	2,463,593.78	831,416.43

Ending inventory of Domestic and Export product Jan-Dec'09

Packaging Material Million (Baht)

PM													AVG cost Export	AVG cost Domestic
PRO-Export	2.906	3.260	3.349	3.081	1084	2.641	2.336	2.377	2.606	1.821	2311	2.111		
BSCC-Export	6.025	4.792	3.885	1611	3.798	4.254	5.229	4,254	3.095	2.772	3.190	2.905		
ST-Export	3.159	3.207	3.532	3.135	3.157	2.844	2.271	2.083	2.134	1.882	1.778	1.504		
Total	12.15	11.20	10.77	9.83		9.74	9.94	8.71	1.84	0,48	7.28	6.52	9.20	
BEAUTEEN-Domestic	0.079	0.123	0.082	0.007	0.095	0.084	0.080	0.079	0.072	0.061	0.107	0.092		
MenBT-Domestic	0.000	0.012	0,006	0.006	0.006	0.006	0.006	0.007	0.007	0.007	0.006	0.006		
	0.08	0.14	0.09	0.07	0,10	0.09	0.99	0.09	0.08	0,07	0.11	0.10		0.09

Raw Material Million (Baht)

PRO-Export	1.558	1.576	1.560	1.148	1.125	0.836	0.751	1.056	0.732	0.591	1.127	0.559		
BSCC-Export	3.500	2.018	1.988	1.807	0.939	3.247	2.735	1.870	0.795	3.811	3.356	2.426		
ST-Export	1.771	3.131	3.005	2.513	2.302	1.894	1.170	1.174	0.953	0.733	1.280	0.755		
Total	6.93	7,32	6,55	5.47	437	5,90	4.66	4.10	2.48	5.13	5.76	174	5.20	

Work in process Million (Baht)

WIP									81300					
PRO-Export	1.881	2.501	3.573	3.759	3.757	2.722	2.658	2.402	2.748	2.0081	2.008	2.674		
BSCC-Export	0.497	0.871	0.466	0.806	0.508	0.69	0.760	0.781	0.767	0.8871	0.689	1.081		
ST-Export	1.837	1.652	2.211	2.075	1.873	2.020	1.789	1.609	1.778	1.395	1.235	1.349		
Total	4.22	5.02	0.25	0.04	6.14	5.44	5.21	4.79	.29	4.29	3.93	5.10	5.19	

FINISHED GOOD Million (Baht)

lea														
PRO-Export	0.000	0.000	0.000	0.293	0.293	0.293	0.000	0.000	0.000	0.618	0.618	0.618		
BSCC-Export	2.226	2.176	3.080	2.067	0.000	0.000	1.141	2.017	2.880	0.000	1.364	1.857		
ST-Export	0.162	0.641	0.150	0.096	0.221	0.088	0.174	0.088	0.278	0.421	0.181	0.087		
Total	239	232	3.23	2.40	0.51	0.38	1.32	2.10	3.10	1.94	2.10	2.06	2.01	
BEAUTEEN-Domestic	1.809	1.162	2.054	1.252	2.085	4.569	4.255	3.969	1448	2.853	2.447	1.861		
MenBT-Domestic	0.000	0.000	2.689	2.651	3.979	3.800	3.622	3.480	3.310	3.109	2.958	2.729		
Total	1.87	1.16	4.74	3.90	6.06	8.37	7.09	7,45	0:76	5.96	5.41	4,59		5.35

Summary Cost Report Mil ion (Baht)

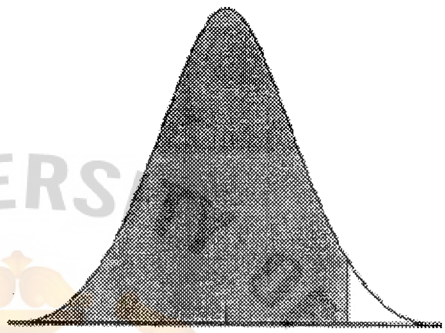
Total		0907.												
PRO-Export	6.41	7.34	8.48	8.28	826	6.49	5.74	5.83	6.09	5.04	6.06	5.96		
BSCC-Export	12.25	10.46	9.42	8.29	5.25	8.20	9.87	8.92	7.54	7.47	8.60	8.27		
ST-Export	6.93	8.63	8.90	7.82	7.55	6.85	5.40	4.95	5.14	4.43	4.47	3.69		
Total	25.58	26,42	26.00	24.39	21.06	21.53	21.01	19,71	10,77	16.94	19.14	17.92	21.81	
BEAUTEEN-Domestic	1.95	1.29	2.14	1.32	2.18	4.65	4.34	4.05	3.52	2.91	2.55	1.95		
MenBT-Domestic		0.01	270	2.66	3.99	3.81	3.63	3.49	3.32	3.12	2.96	273		
Total	1.95	1.30	4.63	3.99	6.16	0,480	7,96	1.54	6.84	6.03	5.52	4,69		5.44

APPENDIX B

Normal Distribution

Area under the standardized normal distribution

A table ttry is the proportion the area under curve from of 0 to a positive ' alue of To find the area from z a nega five. si tact the he from 1.



	00	0		.03	.			07		
		0.5040	0.5080	05120	0.5160	0.5199	0.5239		0. 319	
	0.53	.5438								
	0.5793	0.5832	0.5871	05910	0		0.6026		0.61	0.61
0.3	0.6179	0.6217	0.6255		0.6331	0.6368		0.6443	0.6480	
US	**0.b 4**	**0.49**	0.6628	0.6 4	6700	0.6736	0672	OM	0.6844	0.6879
0.5	0015	0.6950	0.6985	0.7019	0.7054	0.7088	0.n 23	0.7157		0.7224
	0.7257	{172	0.7 24	0.7357	0	0.7422	07494	0.7486	0.7517	0.7549
		0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0:794	0.7823	0.7852
		0.7910	0.7939	0.7967	0.7995	....	0.8051	0.8078	0.8106	0.81 13
	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
	0.8413	0.8438		0.8485	0.8508	0.8531	0.8554	0.8577	n599	0.8621
1.1	0.8643	0.8665	0.8686	0570.8	03729		05770		0.8810	0.8830
1.2	0.8849	0.8869	C	0.8907	05929	0.8944		**93**	0.8997	9015
1.3	01032	0.9049	0.9066	0.9092		0.911			0.9162	9177
IA	0.9192	0.9207		0.9236		0.9265	0.9279	0.9292	0.9306	

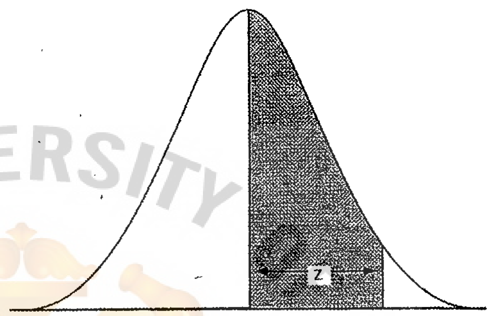
(cont.)

2		.01				.05	116	.07	.08	.09
15	0.9332	0.9345	0,9357	0.9370	.382	09394	0.9406	09418	0.9429	0.9441
1.6	0,9452	0.9463	0.9474	09484	0.9495	0.951:5	0.9515	09525	0.9535	0.9545
1.7	09554	0.9564	0.9573	09582	0.9591	09.,9	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0 9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	09706
19	0.9713	0 9719	0.9726	09732	0.9738	0.9744	0.9750	0,9756	0.9761	0.9767
2.0	0.9772	09728	0.9783	0.9788	0,9793	09798	0.9803	0.9808	0.9812	09817
2.1	0 9821	0 9826	0.9830	09834	0.9838	09842	0.9846	09850	0.9854	0.9857
2.2	0.9861	09864	0.9868	09871	0.9875	09878	0.9851	09884	0,9887	0.9890
2	0.9893	0.9896	0.9898	0 9901	03994	0 9906	0.9909	09911	0.9913	0.9916
2.4	0.9918	0:9920	0.9922	0.9925	0.9927	09929	0.9931	0.9932	0.9934	0.9936
25	0.9938	0.9940	0,9941	09943	0.9945	09946	0.9948	0.9949	0.9951	09952
2.6	0.9953	09955	0:9956	09957	09959	09960	0.9961	0992	0.9963	099M
2.7	0.9965	(19966	0.9967	0.9968	0.9969	0.9970	09971	0.9972	0.9973	0.9974
2.8	0.9974	09975	0.9976	0.9977	0,9977	09978	0.9979	0,979	0,9980	09981
29	0.9981	0.9982	0.9952	0.9983	0.9984	0 9984	0.9985	0.9985	0.9986	89986
3.0	0.9987	0.9987	0.9937	0.9988	0.9988	0.9989	0.9989	0.999	0.9990	09990
31	0,9990	09991	0.9991	09991	0.9992	0 9992	0.9992	09992	0.9993	09993
	0.9993	0 9993	0.9994	09994	0.9994	0 9994	0.9994	0.9995	0.9995	09995
33	0.9995	0 9995	09995	0.9996	099)6	099%	0,9996	099%	0.9996	0.997
3.4	0 9997	09997	0.9997	09997	0 9997	1)0997	0.9997	0 9997	0.9997	00999

APPENDIX C

Unit Normal Loss Integrals1

Examples:
$E_{(z)}$ $E_{(0.85)} = 0.1100$
$E_{(-z)}$ $E_{(-1.79)} = 1.8046$



z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
-3.4	3.4001	3.4101	3.4201	3.4301	3.4401	3.4501	3.4601	3.4701	3.4801	3.4901
--3.3	3.3000	3.3101	3.3201	3.3301	3.3401	3.3501	3.3601	3.3701	3.3801	3.3901
-3.2	3.2001	3.2102	2.2202	3.2302	3.2402	3.2502	3.2602	3.2701	3.2801	3.2901
-3.1	3.1003	3.1103	3.1202	3.1302	3.1402	3.1502	3.1602	3.1702	3.1802	3.1902
-3.0	3.0040	3.0104	3.0204	3.0303	3.0403	3.0503	3.0603	3.0703	3.0803	3.0903
-2.9	2.9005	2.9105	2.9205	2.9305	2.9405	2.9505	2.9604	2.9704	2.9804	2.9904
-2.8	2.8008	2.8107	2.8207	2.8307	2.8407	2.8506	2.8606	2.8706	2.8806	2.8906
-2.7	2.7011	2.7110	2.7210	2.7310	2.7410	2.7509	2.7609	2.7708	2.7808	2.7908
-2.6	2.6015	2.6114	2.6214	2.6313	2.6413	2.6512	2.6612	2.6712	2.6811	2.6911
-2.5	2.5010	2.5119	25219	2.5318	2.5418	2.5517	2.5617	2.5716	2.5816	2.5915
-2.4	2.4027	2.4126	2.4226	2.4325	2.4424	2.4523	2.4623	2.4722	2.4821	2.4921
-2.3	2.3037	2.3136	2.3235	2.3334	2.3433	2.3532	2.3631	2.3730	2.3829	2.3928
-2.2	2.2049	2.2148	2.2246	2.2345	.2.2444	2.2542	2.2641	2.2740	2.2839	2.2938
-2.1	2.1065	2.1163	2.1261	2.1360	2.1458	2.1556	2.1655	2.1753	2.1852	2.1950
-2.0	2.0085	2.0183	2.0280	2.0378	2.0476	2.0574	2.0672	2.0770	2.0868.	2.0966
-1.9	1.9111	1.9208	1.9305	1.9402	1.9500	1.9597	1.9694	1.9792	1.9890	1.9987
-1.8	1.8143	1.8239	1.8336	1.8432	1.8529	1.8626	1.8723	1.8819	1.8916	1.9013
-1.7	1.7183	1.7278	1.7374	1.7470	1.7566	1.7662	1.7758	1.7854	1.7950	1.8046
-1.6	1.6232	1.6327	1.6422	1.6516	1.6611	1.6706	1.6801	1.6897	1.6992	1.7087
-1.5	15293	1.5386	1.5480	1.5574	1.5667	1.5761	1.5855	1.5949	1.6044	1.6138

(cont.)

z	.00	.01	.02	.03	.04	.05	,06	.07	.08	.09
-1.4	1.4367	1.4459	1.455:1	1.4643	1.4736	1.4828	1.4921	1,5014	1.5107	1.5200
-1.3	1.3455	1.3546	13636	1.3727	1.3818	.1.3909	4,4000-	1.4092	1.4118	1.4275
-1.2	:1.2561	1.2650	1.2738	1.2827	1.2917	1.3006	1.3095	1.3:185	:1.3275	1.3365
-14	1.1686	1.1773	1.1859	1.1946	1.2034	1.2121	1.2209	1.2296	1.2384	1.2473
-1.0	1,0883	1.0917	1.1002	1.1087	1.1172	1.1257	1.1342	1.1428	1.1514	1,1600
-0.9	1.0004	1.0086	1.0168	1,0250	1,0333	1.0416	:1.0499	1.0582	1.0665	1,0749
-0.8	0.9202	0.9281	0.9361	0.9440	0.9520	0.9600	0.9680	0.9761	0,9842	0.9923
-0.7	0.8429	0.8505	0.8581	0.8658	0.8734	0,8812	0.8889	0.8967	0,9045	0.9123
-0.6	0.7687	0.7759	0.7833	0.7906	0.7980	0.8054	0.8128	0.8203	0.8278	0.8353
-0.5	0.6978	0.7047	0,7117	0.7187	0.7257	0.7328	0.7399	0.7471	0.7542	0,761.4
0.4	0,6304	0.6370	0.6436	0.6503	0.6569	0.6637	0.6704	0.6772	0.6840	0.6909
-0.3	0.5668	0.5730	0.5792	0.5855	0.5918	0.5981	0.6045	0.6109	0.6174	0,6239
-0.2	0.5069	0.5127	0.5:186	0.5244	0,5304	0.5363	0.5424	0.5484	0.5545	0.5606
"0.1	0.4509	0.4564	0.4618	0,4673	0.4728	0.4784	0.4840	0,4897	0.4954	0.5011
-0.0	0.3989	0,4040	0.4090	0.4141	0.4193	0.4244	0.4297	0.4349	0.4402	0.4456
0.0	0.3989	0.3940	0.3890	0.3841	0.3793	0.3744	0.3697	0.3649	0.3602	0.3556
0.1	0,3509	0.3464	0.3418	0.3373	0.3328	0.3284	0.3240	0.3197	0.3154	0.3111
0.2	0.3069	0.3027	0.2986	0.2944	0.2904	0.2863	0.2824	0.2784	0.2745	0.2706
0.3	0.2668	0.2630	0,2592	0.2555	0,2518	0.2481	0.2445	0.2409	02374	0.2339
0.4	0.2304	0.2270	0,2236	0.2203	0.2169	0.2137	0.2104	0.2072	0.2040	0.2009
0.5	0.1978	0.1947	0.1917	0.1887	0.1857	0.1828	0.1799	0.1771	0.1742	0.1714
0.6	0.1687	0.1659	0.1633	0.1606	0.1580	0.1554	0.1528	0.1503	0,1478	0.1453
0.7	0.1429	0.1405	0.1381	0.1358	0.1334	0,131.2	0.1289	0.1267	0.1245	0.1223
0.8	0.1202	0.1181	0.1160	0.1140	0.1120	0.1100	0.1080	0.1061	0.1042	0.1023
0.9	0.1004	0.0986	0,0968	0.0950	0.0933	0.0916	0.0899	0.0882	0.0865	0.0849
1.0	0.0833	0.0817	0.0802	0.0787	0.0772	0.0757	0,0742	0.0728	0.0714	0.0700
1.1	0.0686	0.0673	0.0660	0.0647	0.0634	0.0621	0.0609	0.0596	0.0584	0,0573
1,2	0.0561	0.0550	0.0538	0.0527	0.0517	0.0506	0.0495	0.0485	0.0475	0.0465
1.3	0.0455	0.0446	0.0436	0.0427	0.0418	0.0409	0.0400	0.0392	0.0383	0.0375
1.4	0.0367	0.0359	0.0351	0,0343	0.0336	0.0328	0.0321	0,0314	0,0307	0.0300
1.5	0.0293	0.0287	0.0280	0.0274	0.0267	0,0261	0,0255	0.0249	0.0244	0.0238
1.6	0.0232	0.0227	0.0222	0.0217	0.0211	0.0206	0.0202	0.0197	0.0192	0.0187
1.7	0.0183'	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146
1.8	0.0143	0.0139	0.0136	0.0132	0.0129	0.0126	0.0123	0.01.20	0.0116	0.0113
1.9	0.0111	0.010%	0.0105	0.0102	0.01.00	0.0097	0.0094	0.0092	0.0090	0.0087

	.00					.00 ..	.06	07	.08	... .09
2.0	0.0085	0.0053	0.0081	00075	0.0076	00074	0.0072	0.0070	0.0068	0.0067
21	00%5	0.0063	0,0361.	0.0060	0 0058	0.0056	0.0055	3.0053	0.0052	0.0050
22	0.0049	00048	0.0046	0.0045	0.0044 •	0.0042	0.0041	0.0040	0.0039	0.0038
2,3	0,0037	0.0036	0,0035	00034	0.0033	0.0032	0.0031	0.0030	M029	0.0028
24	0.0027	0.0026	0,00.26	00025	00023	04)024	00023	0m22	0.0021	0,0021
2.5	0.0020	0.0019	0.0019	0.0018	0,0018	00017	0.0017	0.0016	0.0016	0.0015
2.6	0.0015	0.0014	0.0014	00013	0.0013	0.0012	0.0012	0002	0,0011	0.0011
27	0,0011	0.0010	0,0010	0.0010	0.0009	0.0009	0.0009	0.0008	0.0008	0.0008
2.8	0.0008	0.0007	0.0007	0.0007	0.0007	0.0006	0.0006	0.0006	0.0006	0.0006
2.9	0.0005	0.0005	0.0005	00005	0.0005	0.0005	0.0004	0,0004	0.0004	0.0004.
3.0	0,0004	0,0004	0.0004	0.0003	0,0003	0.0003	0,0003	0.0003	0.0003	0.0003
3,1	0.0003	0.0003	0.0002	0.0002	0,0002	00002	0,0002	0.0002	00002	0,0002
3.2	0.0002	0.0002	00002	0.0002	0.0002	0.0002	00001	0.0001	0.0001	00001
3.3	0,0001	0.0001	0.0001	0.0001	0.0001	00001	0.0001	0.0001	00001	0.0001
3.4	0.0001	0.0001	0.000.1	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
3.5	0.0(01	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

The table ... be approximated from when ... positiv