ORDER QUANTITY PLANNING FOR RETAIL BUSINESS UNIT UPON TOP PRODUCT
On The Body Shop Indonesia's Outlet of Semarang Paragon

BACHELOR THESIS

Submitted as a partial requirement
to complete Bachelor Degree (S1)
in the Faculty of Economics
at DiponegoroUniversity

Written by:

RIZZANTIA AFFIATILATIFAH SETIYO BUDI
NIM. C2A006119

FACULTY OF ECONOMICS
DIPONEGORO UNIVERSITY
SEMARANG
2011

APPROVAL

Author : Rizzantia Affiatilatifah Setiyo Budi

Student ID Number : C2A006119

Faculty/Major : Economics/Management

Title : **ORDER QUANTITY PLANNING FOR RETAIL BUSINESS UNIT UPON TOP PRODUCT (on The Body Shop Indonesia's Outlet of Semarang Paragon)**

Supervisor : Dr. Johanes Sugiarto Ph., SU.

Semarang, July 28th 2011

Bachelor Thesis Supervisor,

(Dr. Johanes Sugiarto Ph., SU.)

NIP. 19491212 197802 1001

APPROVAL

Author : Rizzantia Affiatilatifah Setiyo Budi

Student ID Number : C2A006119

Faculty/Major : Economics/Management

Title : **ORDER QUANTITY PLANNING FOR RETAIL BUSINESS UNIT UPON TOP PRODUCT (on The Body Shop Indonesia's Outlet of Semarang Paragon)**

Has passed the bachelor thesis defense on August 9th 2011.

Defense Examiners:

1. Dr. Johanes Sugiarto Ph., SU.   (..)

2. Susilo Toto Raharjo S.E., M.T.   (..)

3. Drs. Bambang Munas Dwiyanto S.E.   (..)

BACHELOR THESIS ORIGINALITY STATEMENT

'I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at Diponegoro University or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at Diponegoro University or elsewhere, is explicitly acknowledged in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.'

Semarang, July 27th 2011

Sincerely,

(Rizzantia Affiatilatifah Setiyo Budi)

NIM. C2A006119

Dedicated to my Mom, my Dad, Sisters and my little Brother

The greatest happiness of life is the conviction that we are loved -- loved

for ourselves, or rather, loved in spite of ourselves

-Victor Hugo-

And I always know that I'm loved . . .

No matter why, no matter how hard your life is. Mom and Dad, your

love is the only thing that makes me stay for this long..

ABSTRACT

Inventory Management is one of essential problem in Supply Chain system. It describes quantity and location of inventory, including raw materials, work-in-progress (WIP) and finished goods. Needs of finished goods for selling purpose become a crucial issue in macro issue on inventory management systems while order quantity decision becomes the crucial one in micro issues on inventory management systems.

This study aims to determine the order quantity planning of finished product on The Body Shop Indonesia's outlet of Semarang Paragon upon top product. Top product determining model engages a decision making tool, Analytical Hierarchy Process (AHP) considering several criteria; Price, demand and availability. This model finds She Body Butter as top product of pertinent outlet. The order quantity planning engages fuzzy logic interference system using Sugeno method. Research design used for this study is adopted and modified from previous study about supply allocation upon fresh vegetables commodity by Hadiguna and Marimin (2007). Research also presents several tests to know performance of the system.

Keywords: *Analytical Hierarchy Process, Expert System, Fuzzy, Order Quantity Planning, The Body Shop Indonesia, Top Product*

ABSTRAK

Inventory management adalah salah sati masalah yang mendasar dalam system rantai pasok. *Inventory management* menjelaskan jumlah dan lokasi dari persediaan, termasuk bahan mentah, barang setengah jadi dan barang jadi. Kebutuhan akan produk jadi untuk tujuan penjualan menjadi isu yang krusial dalam isu-isu makro pada sistem *inventory management*, sedangkan keputusan jumlah pasokan yang dipesan menjadi hal yang krusial dalam isu-isu mikro pada sistem *inventory management*.

Penelitian ini bertujuan untuk menentukan perencanaan jumlah pesanan atas pasokan produk jadi pada The Body Shop Indonesia otlet Semarang Paragon atas produk yang diunggulkan. Penentuan produk unggulan ini menggunakan sebuah alat pengambilan keputusan yang disebut dengan *Analytical Hierarchy Process (AHP)* dengan mempertimbangkan beberapa criteria seperti; Harga, permintaan dan ketersediaan produk. Produk unggulan pada outlet yang bersangkutan yang ditemukan dengan menggunakan model ini adalah Shea Body Butter. Kemudian model penentuan jumlah pesanan untuk pasokan produk tersebut menggunakan sistem interfensi logika *fuzzy* dengan metode Sugeno. Kerangka penelitian yang digunakan dalam penelitian ini diadopsi dengan modifikasi dari penelitian terdahulu tentang alokasi pasokan pada komoditi sayuran segar oleh Hadiguna dan Marimin (2007). Penelitian ini juga menunjukan beberapa ujicoba untuk mengetahui kinerja sistem yang telah dibangun.

Kata Kunci: *Analytical Hierarchy Process, Fuzzy, Perencanaan Jumlah Pasokan, Sistem Pakar, The Body Shop Indonesia, Produk Unggulan*

PREFACE

بِسْمِ اللهِ الرَّحْمَنِ الرَّحِيْمِ

Praise to Allah SWT, my savior and my strength that always blesses me, walk with me each and every day, teaching and helping me with never ending miracles and love. It's only because of Allah's grace that this bachelor thesis titled **ORDER QUANTITY PLANNING FOR RETAIL BUSSINESS UNIT UPON TOP PRODUCT (on The Body Shop Indonesia's Outlet of Semarang Paragon)** can be finished.

Writing this final assignment has given me a lot of learning. It was really challenging, stressing me out yet fun. It helps me to explore a wider horizon about supply chain and company operational which I enjoy so much.

I am also grateful for the presence, support, advices, and love of many people. Therefore, I would like to thank:

1. Dean of Faculty of Economics and Head of Management Major at Diponegoro University Semarang, who has given a lot of support and hard work for the faculty development.

2. Dr. Johanes Sugiarto Ph., SU. who has helped me a lot with his thoughtful advices, ideas, and patience. I do learn a bunch of things about this research and I also appreciate the time and advices you have given to me. Thank you.

3. Drs. Prasetiono, my academic advisor. Thank you for your concern and support since the first semester.

4. Asri Yusuf ARM for your assistance, support and patience, for every second you spent with me. It is your love that toughens me, thank you dear. I love you..

5. Big family, supporters, and mentors, Mega Anjasmoro, Anggi Tria Suci Bandaryanti, Astuti Nur Wulandari, Resha Adi Pradipta, Aditya Firmansyah, Shallisyah Sabiela, Linta Aftukha Royanna, Himaniar Triasdini, Eka Dannyanti, Alfian Tastaftiani, Muhammad Aji, Fitrah Buhari. You're my inspirations guys, stay shine! Love you all, I'll be missing you..

6. Big family of Aiesec Indonesia LC Diponegoro, Ega Wisnu, Weny, Desembo, Vivi, Farid, Tami, Fatma and other Aiesecer. Thank for our wonderful experience guys! Great to be a part of you..

7. Mr. Agus Soemarmo, Mrs. Tri Wulansari and all family of The Body Shop Indonesia, thanks for your cooperation and participation for helping me worked this research and explored about The Body Shop Supply Chain System.

Despite of my best efforts and hard work, I realized that this thesis is still far from perfect. Hopefully, there will be some critics and suggestions to make this thesis better. Finally, I hope this study will bring benefit for the society.

Semarang, July 27th 2011

(Rizzantia Affiatilatifah Setiyo Budi)

NIM. C2A006119

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF PICTURE

Page

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

1.1. Background of the Research

Supply Chain Management is associated with a complete cycle of raw materials from suppliers, to operational activities at the company, continuous to distribution to the consumer. The rationale of this concept is focused on reducing waste and optimizing value in the supply chain related issue.

A supply chain is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer. Supply chain activities transform natural resources, raw materials and components into a finished product that is delivered to the end customer (Wikipedia, 2011).

General business planning activity starts from sales. What product to sale, how many products to sale, and when to sell the product is the initial questions must be answered in supply planning process. Inventories of finished products and finished products at the end of the period become the parameters of sales planning process, while sales prediction as the variable.

The word of "inventory" here, if the domain is finished product inventory then the input is the output of the finished product inventory scheduling process. How many unit to sell becomes the variable of inventory management process, by initial inventories of finished product and final

inventorries as the parameters. While output is how much unit of finished product inventory must be brought in and when it will be brought in.

In this situation, it clearly describes the terminology of Inventory control explains the relationship between planning and inventory control in scheduling process with sales planning. But practically there are so much un-integrated inventory scheduling process happens, and it causes an overstock of ready to sell product that accumulate resulting in low inventory turnover and then makes opportunity cost of the finished product positive. On the contrary, if there is not enough product inventory to meet demand, company will lose the opportunity to gain profits through the sale of that product.

Nowadays we face the a highly competitive business, and a good integrated operations management of a company is needed to fulfill the consumer's need of goods availability and maximizing company's profit by minimizing costs that occurred as operation of the company. Consumers' demand that cannot be exactly and precisely noticed must be anticipated by an inventory management that capable of accommodating both concerns above, consumer's need of goods availability and company's wish to minimize the costs that occurred as those goods inventory.

Supply Chain Management in the other way is an integrating process of materials and services procurement activities, transforming into intermediate inventories and final products, and delivering it to customers. The whole activities include purchasing and outsourcing activities, also other functions that are substantial for the relationship between suppliers and distributors. The purpose of

supply chain management is building a supply chain which concerning to maximize value to consumers.

Systematically, the chain will provide goods movement system, assets and information from initial suppliers to last consumers and on the contrary. Then a chain is made, un-separately linking one part to another as its linkages. The following figure simply shows the chain, it means the chain occurred on normal stuffs.

Figure 1.1
Simplified Supply Chain
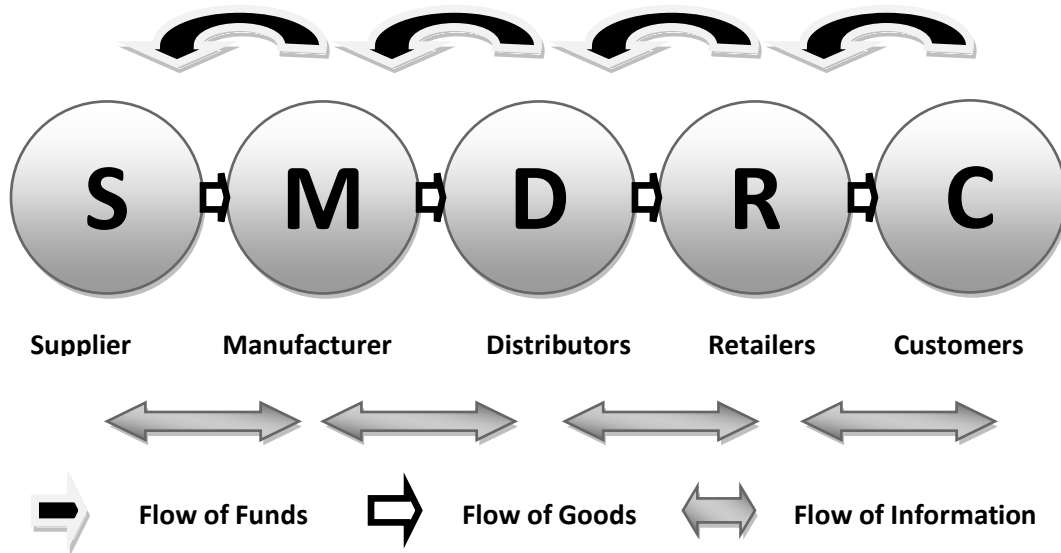
Source : www.ebizzasia.com (modified)

The model above shows that part of supply chain system which directly contacts with customers is retailer or in a company with direct distribution system defines this role as sales or marketing department. Sales department becomes the gateway of fund flow and the information flow about consumer behavior and the

market situation. Sales department as a distribution channel also becomes the point of company's operations that selling the final products to the consumers.

In case of companies having a direct distribution system, final products of these companies are distributed to costumers directly without any second-tier distributor and/or retailer. The distribution function of final products of the company is held by sales or marketing department as discussed above. It is directly run through official outlets which still owned and controlled by the company. In the other word, if the role of final product distributors is run by company itself, that system will be a supply chain system without intermediation or *disintermediation supply chain*. The figure below shows the flow of disintermediation supply chain.

Figure 1.2
Disintermediation Supply Chain
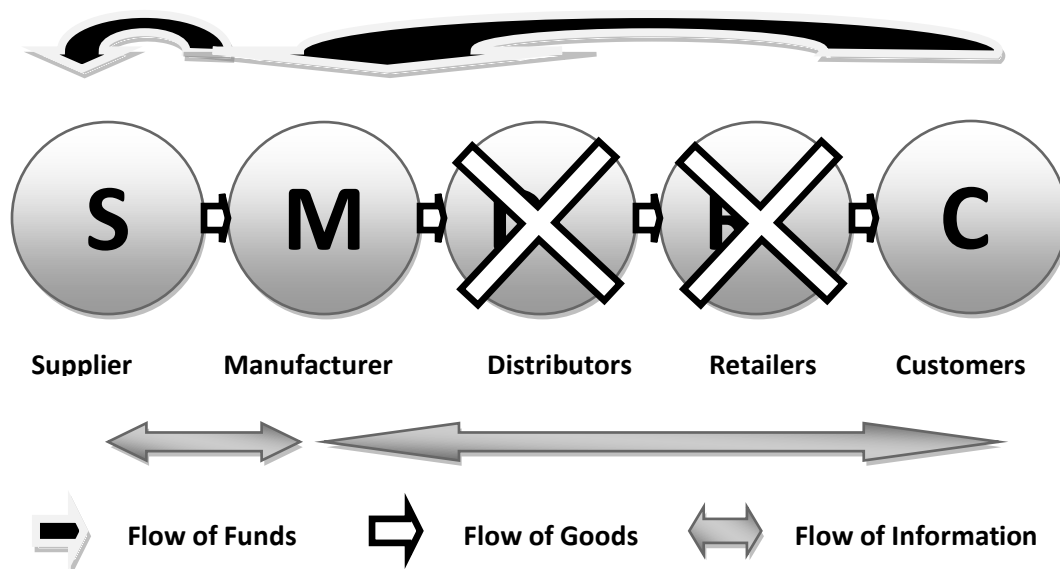
Source : www.ebizzasia.com (modified)

Recently, disintermediation supply chain is chosen as distribution system by big manufacturer companies which produce exclusive products to protect their product exclusivity. This distribution system often used by many famous fashion companies and cosmetics companies in Europe. They sell their products through outlets in famous urban road and/or malls.

In local scale, disintermediation supply chain can be found in the gift (foods and beverages formed) outlets in many cities which have their own brand for their products and several bakery shops in urban or suburban area.

This disintermediation supply chain also used by a company that is discussed in this research, The Body Shop plc. A natural based cosmetic company that becomes one of famous cosmetics company in the world. The Body Shop sells their products exclusively through official outlets. All manufacturing processes, distribution and marketing run by company itself. Products that been produced by The Body Shop is not limited for just one product. In other words, this is a multi products company.

Both companies, with intermediation distribution system or without intermediation, with few competitors or many competitors, must keep their inventories stability in order to fulfil customers need and of course considering all costs that is occurred as these inventories. This situation makes companies optimize the inventory management in order to obtain appropriate inventory level or common defined as optimum inventory. An optimum inventory also includes top product stock, as it has more demands. While an optimum inventory level is gained by ordering proper amount or required supply.

Optimum Inventory assumptions are also applied by The Body Shop Indonesia in supplying product to its outlets throughout Indonesia, including The Body Shop Indonesia's outlet of Semarang Paragon which becomes research object. It is located in a famous shopping centre in Semarang, Paragon Mall Pemuda rd, 118 Semarang. The Body Shop Indonesia's outlet of Semarang Paragon was operated first at April 2010. It applies the optimum inventory assumptions with a same reason, occupying customer's demand of its products under an optimum inventory level.

Almost a year The Body Shop Indonesia operating online ERP which enables headquarter to plan the amount of end product supply based on appointed demand planning. Online ERP also enables headquarter to access daily information and of its outlets through Indonesia such as daily transaction, financial situation, inventory status, loss situation and other information.

Headquarter of The Body Shop Indonesia accesses the information to decide the amount of end product supply to each outlet. Supply planning and delivering process is determined in every three months or a quarter of a year as a period. But problem is appeared when amount of supply delivered cannot meet the exceeded actual demand then causing a stockout[1]. Table below provides inventory status of The Body Shop Indonesia's outlet of Semarang Paragon on May 10th 2011:

---

[1] *Stockout* means running out of the inventory of an Stock Keeping Unit (wikipedia.org)

Table 1.1
Inventory Status of The Body Shop Indonesia's outlet of Semarang Paragon (May, 10th 2011)

	Product in Variety	**Percentage (100%)**
Stockout	21	6,3
Available	314	93,7
Total	335	100

Source: Primary data, 2011

Figure 1.3
Inventory Status of The Body Shop Indonesia's outlet of Semarang Paragon (May, 10th 2011)
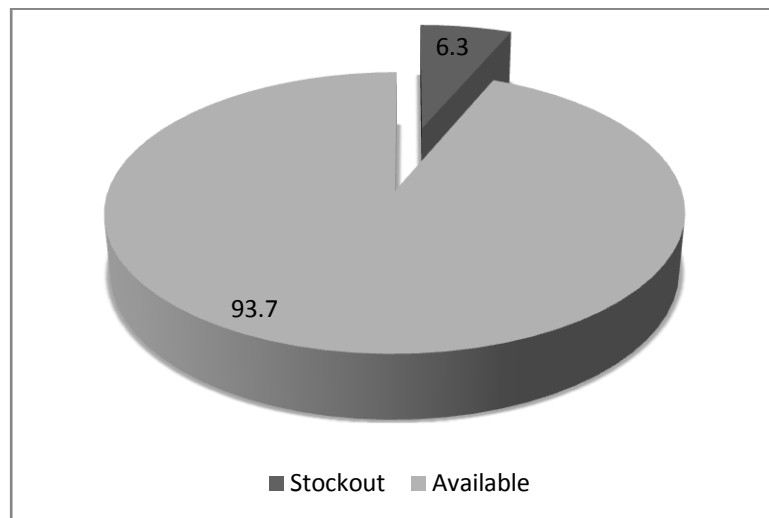
Source: Primary data, 2011

Based on table 1.1, known that stockout level happened in The Body Shop Indonesia's outlet of Semarang Paragon on May 10th 2011 by 6,3% or 21 product variety of 335 product variety in total. It indicates that product availability cannot meet customers' demand perfectly. Of course this situation inflicts a financial loss by drowning out chances to gain profit and also reduces

customer's satisfaction, especially customers who need those under stockout products (Wisner *el al*).

Therefore a study is worked researching about supply planning, an optimal and efficient order planning. This research aims to make a quantity to order or an order quantity planning which able to reflect appropriate supply requirement under actual inventory status and expected demand condition. It must be efficient but able to determine the optimal requirement of final product based on inconstant customers' demand.

1.2.   Problem Statement and Research

Inventory is critical in a supply chain system. How to plan an appropriate inventory is a key to start a good supply chain management. In the case of this study, management of The Body Shop is trying to occupy outlet's needs of product inventory based on its sales planning. Furthermore, stock fulfilment aimed to ensure product availability to customers.

But practically, sometimes supply planning management unable to occupy actual demand and then causing bullwhip effect (Lee *et al*, 1997). According to description and data above, problem found is suppy planning for The Body Shop Paragon Semarang outlet which have been done by management was unable to fullfil whole customer's demand shown by stockout in level of 6,3% of all product variety.

Furthermore, it is necessary to build a new order system, focused on required supply quantity planning or an order quantity planning. In this case,

the order quantity planning built by an efficient cost but able to represent appropriate level of required supply quantity to meet customer's demand.

The order quantity planning in this study is modelled upon the top product determined by Analytical Hierarchy Process (AHP). It needs expert opinions from internal source based on several criteria.

1.3.   Research Objective and Research Benefit

1.3.1. Research Objectives

This study aims to:

1. Determine the top product of The Body Shop Indonesia Paragon Semarang outlet.

2. Implement fuzzy interference system to decide the order quantity planning in supply chain of The Body Shop Indonesia on Paragon Semarang outlet toward its top product.

3. Measure model accuracy so that the company shall apply this model for its real system.

1.3.2.   Research Benefits

This study provides an implementation of model building to make order quantity decisions, which can be used by management as consideration in supply chain activity especially in supply or order quantity planning. Besides, this study also provides a top product decision model.

1.4 Thesis Outline

Outline of the bachelor thesis is described as follows:

- Chapter I Introduction

Chapter I provide the research background, problem discussion, research purposes, and research benefits.

- Chapter II Literature Review

Chapter II contains underlying theories and reviews of the previous study that has a closer relationship to the subject of this study. It also contains theoretical framework of the study.

- Chapter III Research Methodology

Chapter III explains the research methods. This chapter also includes a definition and operational measurement of the variables, data type and data source. This chapter also describes models used and analysis method used in the research.

- Chapter IV Result and Data Analysis

Chapter IV presents company and product information, data analysis and the results.

- Chapter V Concluding Remarks

Chapter V provides the conclusions and implications drawn from the research. It includes the limitations of the study and suggestions.

CHAPTER II

LITERATURE REVIEW

2.1.   Theoretical Background

2.1.1. Supply Chain

A supply chain is a system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer (Wikipedia.org accessed on Feb 2011). Supply chain can be defined as:

> "real world systems that transform raw materials and resources into end products that are consumed by the consumers. Supply chains encompass a series of steps that add value through time, place, and material transformation. Each manufacturer or distributor has some subset of the supply chain that it must manage and run profitably and efficiently to survive and grow". (Pinto)

Supply chain activities transform natural resources, raw materials and components into a finished product that is delivered to the end customer. In many sophisticated supply chain systems, used products may re-enter the supply chain at any point where residual value is recyclable.

A supply chain, as opposed to supply chain management, is a set of organizations directly linked by one or more of the upstream and downstream flows of products, services, finances, and information from a source to a customer. Managing a supply chain is 'supply chain management' (Mentzer *et al.*, 2001).

2.1.2. Supply Chain Management

Oliver and Webber mentioned in their book "Supply-chain management: logistics catches up with strategy" (1982) that the term <u>Supply Chain Management</u> (SCM) was developed in 1980s to express the need to integrate the key business processes, from end user through original suppliers. The basic idea behind the SCM is that companies and corporations involve themselves in a supply chain by exchanging information regarding <u>market fluctuations</u> and production capabilities.

Supply chain management (SCM) is the management of a network of interconnected <u>businesses</u> involved in the ultimate provision of <u>product</u> and <u>service</u> packages required by end customers (Harland, 1996). Supply chain management spans all movement and storage of <u>raw materials</u>, work-in-process inventory, and finished goods from point of origin to point of consumption (<u>supply chain</u>).

The Council of Supply Chain Management Professionals (CSCMP) defines Supply Chain Management as follows:

> "Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance, and information technology."

Another definition is provided by the APICS Dictionary when it defines Supply Chain Management as the:

"design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand and measuring performance globally".

More common and accepted definitions of supply chain management are (Cited from Wikipedia, Feb 2011):

- Supply chain management is the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole (Mentzer et al., 2001).

- A customer focused definition is given by Hines (2004:p76) that supply chain strategies require a total systems view of the linkages in the chain that work together efficiently to create customer satisfaction at the end point of delivery to the consumer.

- Global supply chain forum - supply chain management is the integration of key business processes across the supply chain for the purpose of creating value for customers and stakeholders (Lambert, 2008).

According to Russel and Taylor (2006), Supply Chain Management (SCM) focuses on integrating and managing the flow of goods and services and information through the supply chain in order to make in responsive to customer

needs while lowering total costs. Keys to effective supply chain management are information, communication, cooperation, and trust.

Wisner et al (2005) defined Supply chain management as the integration of key business process from initial raw material extraction to the last customer, including intermediate processing, transportation and storage activities and final sale to the end customer.

Figure 2.1
Generic Supply Chain

Product & Service flow

Recycling & Returns

End-product manufacturer (or local firm)

Raw Material suppliers

Intermediate components manufacturers

Wholesalers, distributors

Retailers

End Customer

Transportation & Storage activities

Information/planning/activity integration
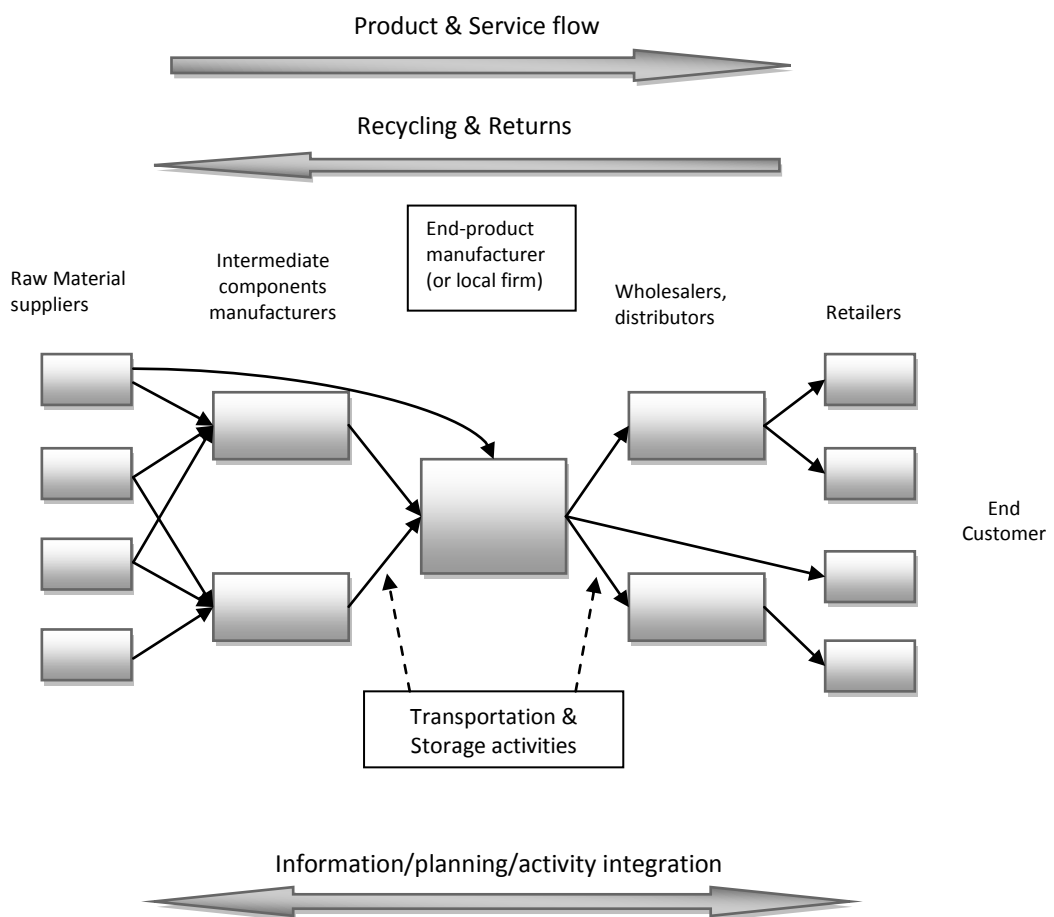
Source: Wisner et al (2005) "Principles of Supply Chain Management" (modified)

Wisner et al also put important elements of Supply Chain Management in their book, these are:

➢ Purchasing Elements

Purchasing is an extremely important element in supply chain management, since incoming material quantity, delivery timing, and purchase price are dependent on the buyer-supplier relationship and the capabilities of supplier. Problems with suppliers will ultimately cause end-product customers to get less and pay more. Important issues of purchasing elements are: Suppliers alliances, supplier management and strategic sourcing.

➢ Operations Elements

Internal operations elements become important in assembling or processing the item from purchased material and components into finished product. Controlling or managing inventory is one of the most important aspects of operations and certainly valuable to the firm. Firms can and typically do have some sort of material requirement planning (MRP) software system for managing their inventory.

➢ Distribution Elements

When products are completed, they are delivered to the customers through a number of different modes of transportation. The distribution elements are transportation, warehousing, break-bulk or repackaging services etc.

➢ Integration Elements

The final step and certainly the most difficult in supply chain management are to coordinate and hopefully seamlessly integrate these practices among the supply chain's participants.

From Wikipedia.org (Feb 2011), supply chain management must address the following problems:

- Distribution Network Configuration: number, location and network missions of suppliers, production facilities, distribution centers, warehouses, cross-docks and customers.

- Distribution Strategy: questions of operating control (centralized, decentralized or shared); delivery scheme, e.g., direct shipment, pool point shipping, cross docking, DSD (direct store delivery), closed loop shipping; mode of transportation, e.g., motor carrier, including truckload, LTL, parcel; railroad; intermodal transport, including TOFC (trailer on flatcar) and COFC (container on flatcar); ocean freight; airfreight; replenishment strategy (e.g., pull, push or hybrid); and transportation control (e.g., owner-operated, private carrier, common carrier, contract carrier, or 3PL).

- Trade-Offs in Logistical Activities: The above activities must be well coordinated in order to achieve the lowest total logistics cost. Trade-offs may increase the total cost if only one of the activities is optimized. For example, full truckload (FTL) rates are more economical on a cost per pallet basis than less than truckload (LTL) shipments. If, however, a full truckload of a product is ordered to reduce transportation costs, there will be an increase in inventory holding costs which may increase total

logistics costs. It is therefore imperative to take a systems approach when planning logistical activities. This trade-offs are key to developing the most efficient and effective Logistics and SCM strategy.

- Information: Integration of processes through the supply chain to share valuable information, including demand signals, forecasts, inventory, transportation, potential collaboration, etc.

- Inventory Management: Quantity and location of inventory, including raw materials, work-in-progress (WIP) and finished goods.

- Cash-Flow: Arranging the payment terms and methodologies for exchanging funds across entities within the supply chain.

It can be found that Inventory management is one of essential problem in a supply chain system.   Supply chain execution also means managing and coordinating the movement of materials, information and funds across the supply chain. The flow is bi-directional.

2.1.3. Inventory Management

Inventory Management is one of essential problem in supply chain management. In the USA and Canada the term has developed from a list of goods and materials to the goods and materials themselves, especially those held available in stock by a business; and this has become the primary meaning of the term in North American English, equivalent to the term "stock" in British English. In accounting, inventory or stock is considered an asset.

From investopedia (Feb 2011), inventory is defined as the raw materials, work-in-process goods and completely   finished   goods   that   are

considered to be the portion of a business's assets that are ready or will be ready for sale. Inventory represents one of the most important assets that most businesses possess, because the turnover of inventory represents one of the primary sources of revenue generation and subsequent earnings for the company's shareholders/owners.

Based on Texas State Auditor's Office, Methodology Manual (rev. 5/94), Inventories include goods purchased for resale, internal usage, or consumption. Inventory management is a complex matter, involving governing laws, operating rules and regulations, administrative law rulings, recommended practices, designated procedures, and specific conflict-of- interest provisions. In addition to all of these compliance issues, the entity must also ensure that "enough but not too much" inventory is available. Management controls over the recording, reporting, and safeguarding of inventory items are also necessary.

From the same source, inventory management is a part of the materials management process, which includes procurement, fixed assets, maintenance, and transportation as well. See the modules on Procurement and Fixed Assets for further information

According to wikipedia.org (Feb 2011), Inventory management is primarily about specifying the size and placement of stocked goods. Inventory management is required at different locations within a facility or within multiple locations of a supply network to protect the regular and planned course of production against the random disturbance of running out of materials or goods. The scope of inventory management also concerns the fine lines between

replenishment lead time, carrying costs of inventory, asset management, inventory forecasting, inventory valuation, inventory visibility, future inventory price forecasting, physical inventory, available physical space for inventory, quality management, replenishment, returns and defective goods and demand forecasting.

There are three basic reasons for keeping an inventory:

1. Time - The time lags present in the supply chain, from supplier to user at every stage, requires that you maintain certain amounts of inventory to use in this "lead time."

2. Uncertainty - Inventories are maintained as buffers to meet uncertainties in demand, supply and movements of goods.

3. Economies of scale - Ideal condition of "one unit at a time at a place where a user needs it, when he needs it" principle tends to incur lots of costs in terms of logistics. So bulk buying, movement and storing brings in economies of scale, thus inventory.

According to Heizer and Render (1999), inventory can serve several functions that add flexibility to a firm's operations. Here are the four functions of inventory:

1. To "decouple" or separate various parts of the production process. For example, if a firm's supplies fluctuate, extra inventory may be necessary to decouple the production process to suppliers.

2. To decouple the firm from fluctuations in demand and provide a stock of goods that will provide a selection for customers. Such inventories are typical in retail establishment.

3. To take advantages from quality discount, because purchases in larger quantities may reduce the cost of goods or their delivery.

4. To hedge against inflations and upwards price charges.

Melnyk and Dezler (1996) defined Inventory as physical resources that a firm holds in stock with the intent of selling it or transforming it into a more valuable state. Then they mentioned the general category of inventories includes several more specific types of inventories, those were:

1. Raw Materials Inventories hold resources purchased as inputs to the transformation process that have not yet begun that process.

2. Work-in-process inventories or WIP inventories, hold resources currently undergoing transformations into more valuable state.

3. Finished goods inventories, hold completed products for later sale to customers. Firms hold finished goods at various locations: at the plants that make them, at the warehouse or distribution center, in vehicles where it transit, and at retail outlets. In some cases, a firm may maintain finished goods at customer's site to await sale or consignment.

4. Maintenance, repair or operating (MRO) inventories also include incidental resources purchased to support ongoing activities. Firms also calls these inventories as *supplies or consumables.*

Melnyk & Denzler also added the functional roles of inventory, they argued that a well-run organization identifies a purpose for every action and an action for every purpose. To avoid wasting organizational resources on unneeded inventories, an operations manager must set out a specific role for each type of

inventory. A functional classification scheme can aid this process by defining a number or general roles for inventories.

- Transit Inventories. Items counts as inventories as they move from one physical location to another, usually in trucks, rail cars, ships, barges, aircraft or pipelines.

- Buffer inventories. Despite the principle of just-in-time manufacturing, many firms hold inventories to protect against disruption due to unplanned event like unexpectedly high demand, delayed shipments or equipment breakdowns.

- Seasonal inventories. Through careful planning, operation managers try to accommodate mismatches between when they want to provide goods and when buyers need them.

- Decoupling inventories. This inventory accommodates differences between the rate or pattern of production and the rate or pattern of demand.

- Speculative inventories. Some conditions may justify purchasing goods prior to need to avoid likely future price increases or supply shortages. In periods of high inflation, a firm may wisely invest surplus funds in tangible commodities that probably increase rapidly in value.

- Lot sizing or cycle functions. Although the operation manager would typically build only what is needed, in many case this is not possible. Significant changeover or set up costs may be incurred.

- Mistakes. Almost all systems accumulate goods as a result of poor decision. Demand forecasts sometimes prove too high. Operations manager may produce a component as engineers bring them a new design. Completed products may not meet quality specification, but staff members still hope to find uses from them. Retail business deal effectively with their mistakes; they send the goods back if they can, or they mark down the prices until someone buys the unneeded products.

2.1.4. Issues in Inventory Management

According to Melnyx and Denzler (1996), when a company dealing with inventory, operations manager must work at two levels. At the micro level, emphasized to the point, the operations managements are making item-by-item decisions and it is very detailed. The other one, macro level is much broader and deals with issues that have strong implications for both the type of value delivered by the system and the strategic stance of the company.

Macro Issues in inventory management systems are:

a. Needs for finished goods inventories

b. Ownership of inventories

c. Specific contents of inventories

d. Locations of inventories

e. Tracking inventories

f. Responsibility for key inventory decisions

While micro issues in inventory management systems are:

a. Order Quantity decisions

b. Order timing decisions

Both macro and micro issues elements need a lot of concerns by company and the operations manager especially. From the explanation above, it can be found that needs for finished goods for selling purpose become a crucial issue in macro issue in inventory management systems while order quantity decision becomes the crucial one in micro issues in inventory management systems.

2.1.5. Order Quantity

Cited from Melnyx and Denzler, "In the operations management literature, Harring addressed this issue first as early as 1913[2]". They explained that Harris focused on the familiar problem of balancing the cost of setting up for production runs against the cost of holding the inventories that large production runs create. They also argue that today's operations managers deal this trade off by applying the Economic Order Quantity (EOQ) formula.

Cost that we discussed above becomes one of value added through inventories according to Melnyx and Denzler from the same book. They explained that inventories affected both direct and indirect cost. The firm incurs direct costs to purchase, deliver and manufacture a product. While the indirect costs include the inventory holding costs and stockout costs.

✓ Inventory holding costs include funds, physical resources, and personnel that a firm ties up by maintaining inventories and also

[2] D. Erlenkotter, "Ford Whitman and the Economic Order Quantity Model," *Operations Research* 38, no.6 (November-December 1990), p. 937

include expenses for people and systems to track and manage inventories.

✓ Stockout costs measure the effect of failure to provide the products that customers want, leading to lost sales and reductions and goodwill.

One of basic inventory management model is Economic Order quantity as Melnyx and Denzler argued above. This model determines how much to order an item with independent demand to minimize the total cost of holding this inventory. Melnyx and Denzler also define that the problem statement of EOQ assumes constant annual demand and instantaneous replenishment. The EOQ inventory cycle is provided below:

Figure 2.2
EOQ Inventory Cycle
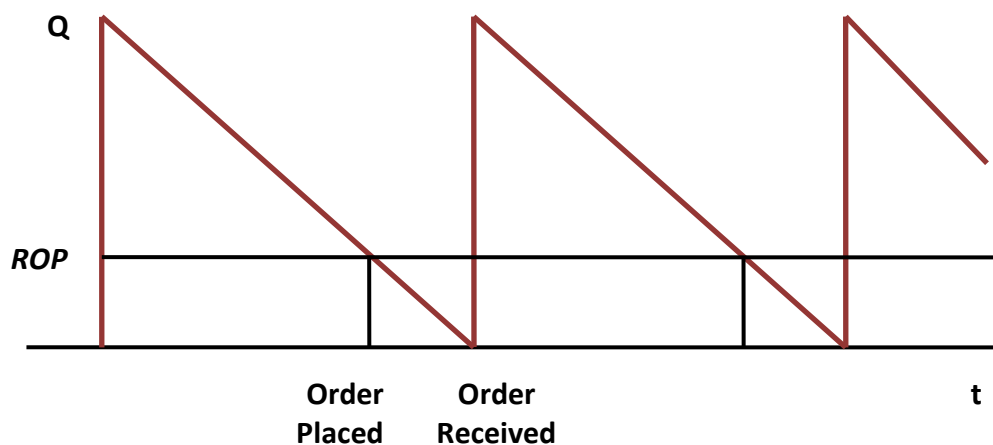
Source: Melnyx & Denzler (1996) *"Operations Management: A Value-Driven Approach"*

There are several assumptions to use this EOQ model according to Heizer & Render (2008):

1. Demand is known, constant, and independent

2. Lead time-that is, the time between placement and receipt of the order-is known and constant.

3. Receipt of inventory is instantaneous and complete. In other words, the inventory from an order arrives in one batch at one time

4. Quantity discounts are not possible

5. The only variable costs the cost of setting up or placing an order (setup cost) and the cost of holding or storing inventory over time (holding or carrying cost).

6. Stockouts (shortages) can be completely avoided if orders are placed at the right time.

According to EOQ assumptions above, it cannot be used to handle this research since demand is not constant and holding cost can not exactly defined. The assumption of constant demand simplifies a second potential decision variable, ROP, the reorder point which the quantity simply determined by multiplying the order lead time by the demand rate.

While Heizer & Render (2008) defines lead time as a time between placing an order and receiving it; in production systems, the wait, move, queue/ setup and run times for each components produced. Simple inventory models assume: (1) that a firm will place an order when the inventory level for that particular item reaches zero (2) that it will receive the order item immediate

2.1.6. Outlet

According to Wikipedia (accessed on March 2011) an outlet store or factory outlet is a brick and mortar or online retail stores in which manufacturers sell their stock directly to the public.

There may be variances in quality and price when comparing true factory stores with general outlet stores. The latter may have higher instances of manufacturers' "overruns" and unmarked seconds and blemished merchandise. Factory stores usually mark any seconds and blemished merchandise as such, and tend to offer newer models.

The American Heritage Dictionary defines outlet as a store that sells the goods of a particular manufacturer or wholesaler.

While Collins English Dictionary – Complete and Unabridged describes it as a commercial establishment retailing the goods of a particular producer or wholesaler.

Then there is one more definition of outlet described in Webster's New World College Dictionary that an outlet is a store, agency, etc. that sells the goods of a specific manufacturer or wholesaler.

2.1.7. Operation Management Toolkit

Operation management toolkit described as a basic set of conceptual tools and techniques for completing the activities of operation management (Melnyx & Denzler, 1996).

The operations management tools are:

1. Total Cost Analysis

Total cost analysis is a decision-making techniques in which managers identify all costs associated with asset of decisions and then choose the one with the lowest total cost

2. Trade-off analysis

It is a technique for choosing among decision alternatives based on the indifference point between them.

3. Deming Cycle (plan-do-check-act)

The Deming Cycle is also called the Deming wheel or the PDCA (plan-do-check-act) cycle, it is defined as a sequence of plan-do-check-act designed to stabilize an OM system and identify opportunities for continuous improvement.

4. Cause-and-Effect Diagrams

A cause-and-effect diagram is a problem solving tool that visually represents relationships between symptoms and their root causes.

5. Pareto Analysis

Pareto analysis is a problem-solving tool that sets management priorities based on the assumption that 80 percent of any gap between expected and actual performance results from 20 percent of operation.

6. Check Sheets

A check sheet is a widely used method for collecting data by defining categories and making a mark for each event in each category.

7. Model Building

Model is an abstract representation of reality that simplifies actual events or situations. Model building can help operations manager to overcome many of the obstacles in their problem solving

Model building can be used for completing operations activities according to them. Therefore, it can also used in determining the order quantity planning for supply chain.

2.1.8. Model Building

An effective model can help a problem solver to answer several questions:[3]

- ✓ *What*

  A model identifies important elements in a problem or situation, separating factors that decision makers should consider from those that they can ignore and exclude from the model

- ✓ *How*

  A model also helps to specify relationship between elements for a situation, especially causes and effects. Model often designate independent variables to represent causes of particular symptoms. Dependent variables represent events that are influenced by independent, causal variables.

- ✓ *Why*

  Some models even explain reasons for the relationship between causes and effects.

- ✓ *Under What Conditions*

---

[3] id

Models specify conditions such as when event occur, where they occur, and who makes things happened.

Melnyx and Denzler also defined some different types of models, benefits and building a model. Some different types of models are:

Physical Model vs. Conceptual Models

The physical models are model that built in another physical form and usually in a smaller version of the actual thing. While a conceptual model is an abstract representation of logical mathematical relationships in some system or process.[4]

Prescriptive vs. Descriptive Models

A prescriptive model might help to formulate a problem and arrive at a feasible solution to close a gap between the current and desired future situation. In contrast, descriptive model would simply illustrate or describe system behavior, ex: a cause-and-effect diagram.

Analytical vs. Simulation Models

Analytical models created by specifying mathematical equations to represent a real situation. While a simulation model is a numerical exercise that shows how specific inputs affects measures of output or performance.[5]

Benefits of models are:

- Models help managers to control manipulate the large number of details that surround problems or issues. A model clarifies the

---

[4] Averill M.Law and David Kelton, Simulation Modeling and Analysis, 2d ed. (New York: McGraw-Hill, 1991),p. 5.

[5] Id p.6.

distinction between critical elements that require close attention and extraneous factors often distort or confuse real relationships between inputs and outputs.

- Models allow managers to experiment with changes to see what effect they would have in real life.

- Models can help problem solver to evaluate the effectiveness and efficiency of various alternatives, separating poor solutions from better ones.

- Models can improve communications, as mangers often discuss systems using models.

- Models help to focus information gathering-activities. By identifying the key factors of a real situation, a model directs manager's attention to information that they need to make decisions.

Models are basic to operations management. Discussions of inventory, scheduling, and quality all rely on models. Managers use them to set inventory levels, design factory layouts, and identify the most appropriate levels of quality or lead times for a product.

Building a model. The basic process for building a model involves addressing four questions:

- ➢ What real-life problem must the model builder solve? The answer to this question identifies the scope of the model and its purpose.

- ➢ What elements of the real situation are important and how are they related? The answer to this question specifies what the model must

represent and how it must portray that information. The choice of key elements to model depends on the real-world problem or objective.

➢ What data does the model require? An effective model must include certain inputs for dependent variables, and collected data must accurately measure key elements.

➢ What major assumptions (implicit and explicit) does the model make? Are those assumptions reasonable? The answer to these questions determined how much the solutions or description implied by the model depend on potentially faulty assumption.

2.2. Previous Research

Researches about inventories and order quantity decision and also research about determining top product have been done by some researchers, mentioned at table hereunder:

Table 2.1
Previous Researches

No.	Researchers	Title	Year	Conclusion
1.	Entin Hendartin and Marimin	*Optimasi Jumlah Produksi dan Pemilihan Produk Unggulan di PT. Inhutani I*	2001	This research determined top products engaged AHP methods. Product determination was based on financial criteria, management criteria, product criteria, supply, human resources and marketing production. Questionnaires were addressed to company stakeholder under perception that all data is valid. The research revealed the top product of PT Inhutani I.

Table 2.1 (Continued)
Previous Researches

No.	Researchers	Title	Year	Conclusion
2.	Rika Ampuh Hadiguna and Marimin	*Alokasi Pasokan Berdasarkan Produk Unggulan Untuk Rantai Pasok Sayuran Segar*	2007	This research determined amount of supply on agricultural business upon top products. Top product determination model used exponentially comparison method engaged three criteria, price, inventory and demands. To determine required supply numbers engaged weighted average of intervention fuzzy system by Sugeno Method, this model able to take some related decision to the problem.

Source: Journal Compilation

2.3. Research Design

Research design depicts supply planning on only one kind of product which is giving biggest contribution in sales. In this case, the criteria which used for this research to determine the top product are adopted from Rika Ampuh Hadiguna (2007) research.

Figure 2.3
Research Model
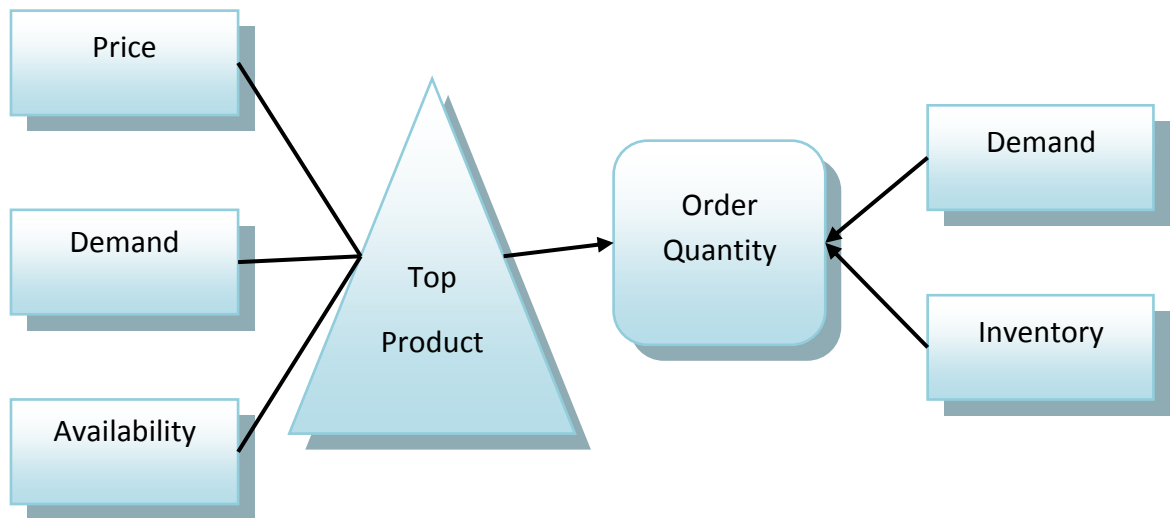
Source: Hadiguna and Marimin (2007) modified

CHAPTER III

RESEARCH METHODS

3.1.   Operational Definition

Analysis of this research reveals only one decision variable, order quantity planning of top product that is determined by selected criteria. Accordingly, 2 models are built to gradually define precise order quantity. Those models are top product determining model and then be continued with supply requirement of finished product as quantity to order of previous chosen product.

These models research supply planning in The Body Shop Indonesia's outlet of Semarang Paragon only. Quantity to order refers to order from certain outlet to The Body Shop Indonesia head office in Jakarta. Either inventory status and supply chain in head office are not being part of this research.

On top product determination model, appraisal is directly obtained from the insider source about several criteria or indicators. There are 1) Price, by observing the official price issued by The Body Shop. 2) Demand volume, referring to sales level according to insider sources and official data. 3) Product availability, measured by hollow frequency.

The next model is supply planning determination considering two variables, those are 1)Demand, measured by sales planning from demand forecast for certain period that is directly observed on sales report/data. 2)Inventory Status, measured by inventory level for certain period that is directly obtained from

inventory report. While the quantity of order or supply planning is determined
from the amount of product which is required by outlet.

Table 3.1
Operational Definition

Variable	Definition	Indicator	Parameter
Top Product	Kind of product which is giving biggest contribution in sales (Hardiguna, 2007)	Price	Official price issued by The Body Shop Indonesia
		Demand volume	Average level of product sales entire single period according to internal source
		Product Availability	Frequency of stockout situation of single product based on operations manager's opinion
Order/ supply planning	From a seller's point of view, it expresses the intention (product) to sell (Wikipedia, 2011)	Order Quantity	Amount of required product to sell
Demand	The amount of a particular economic good or service that a consumer or group of consumers will want to purchase at a given price (Investorwords.com, 2011)	Demand Level	Average amount of sold product entire single period

Table 3.1 (Continued)
Operational Definition

Variable	Definition	Indicator	Parameter
Inventory (of finished product)	A company's merchandise, raw materials, and finished and unfinished products which have not yet been sold (investowords.com, 2011)	Inventory Level	Average amount of inventories in the end of previous period.

3.2.   Types and Source of Data

3.2.1. Primary data

Primary data usually obtained by field survey using all original data collecting methods (Kuncoro, 2001). Individuals, focus groups, and a panel of respondents specifically set up by researcher whose opinions may be sought on specific issues from time to time are examples of primary data sources (Sekaran, 2000). This data which in the form of information obtained through sample respondent in the form of answers from questions submitted in questionnaire, direct interview and also observation related to research variables.

3.2.2. Secondary data

Secondary data is data which has been collected by data compiler (institute) and published to public and data user. The availability of secondary data would make the study easier and quickens the research (Kuncoro, 2001). Company resource or archives, government publications, industry analysis offered by the media, web sites, the internet, and so on are included in secondary data

(Sekaran, 2000). In this research, secondary data obtained by collecting data from books, magazines article, journal, and also websites related to variables which has been selected.

3.3. Data Collecting Method

3.3.1. Field Research

A field research is a research which directly research in the company or plant that is being the subject of the research to gain data and information, and also clearly observe the real situation in it. The definition of field itself was is "'Fields' that is circumscribed areas of study which have been the subject of social research" (Burges, 1984)

Field research is necessary in this research to collect information, especially primary data related to (1) sales activity, (2) inventory, (3) price of each kind of product, (4) availability of each product to meet customer's demand and (5) order or supply planning and process. Those data were gained by:

a. Interview and Group Discussion

An interview is a conversation where somebody is trying to get information from another person (Wikipedia, accessed on April 23rd 2011). In this research, the information gaining is run by asking some questions related to research objects above to the person in charge in the relevant outlet, store supervisor as the store top managerial and executive board in The Body Shop Indonesia.

b. Observation

Observation is an activity of an intelligent living being (e.g. human), which senses and assimilates the knowledge of a phenomenon in its framework of previous knowledge and ideas (Cambridge Advanced Learner's Dictionary). In this research, the observation is done by some direct observations to the research object in the pertinent outlet.

3.3.2. Literature Study

Literature study was done by collecting information from books, journals, magazines, and internet which has correlation with research.

3.4. Analytical Techniques

3.4.1. Qualitative Analytical Methods

Qualitative analysis is analysis which is not applies mathematical model, statistic model, econometrics or other certain models. Data analysis done limited to data processing technique, such as data and tabulation checking -in this case simply reading tables', charts, or numbers which is available, then do the breakdown and interpretation- (Hasan, 2002).

3.4.2. Quantitative Analytical Methods

Quantitative analysis is analysis utilizing analyzer having the character of quantitative. Analyzer having the character of quantitative is analyzer using models, like mathematics model, statistical model, and econometrics. The result presented in the form of numbers then explained and interpreted in a description (Hasan, 2002).

3.5.   Model Formulation

3.5.1. Top Product Determining

In this research, the top product of The Body Shop outlet which is observed is determined by using an Analytical Hierarchy process (AHP). AHP is one of decision-making model with multiple criteria. This method was developed by *Thomas L. Saaty* in the 1970s to solve complex problem where statistical data and information from that problem is very little. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.

According to Forman and Gass (2001), decision situations to which the AHP can be applied include:

- Choice - The selection of one alternative from a given set of alternatives, usually where there are multiple decision criteria involved.

- Ranking - Putting a set of alternatives in order from most to least desirable

- Prioritization - Determining the relative merit of members of a set of alternatives, as opposed to selecting a single one or merely ranking them

- Resource allocation - Apportioning resources among a set of alternatives

- Benchmarking - Comparing the processes in one's own organization with those of other best-of-breed organizations

- Quality management - Dealing with the multidimensional aspects of quality and quality improvement

- Conflict resolution - Settling disputes between parties with apparently incompatible goals or positions.[6]

The procedure for using the AHP can be summarized as (Saaty, 2008):

1. Model the problem as a hierarchy containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives.

2. Establish priorities among the elements of the hierarchy by making a series of judgments based on pairwise comparisons of the elements. For example, when comparing potential real-estate purchases, the investors might say they prefer location over price and price over timing.

3. Synthesize these judgments to yield a set of overall priorities for the hierarchy. This would combine the investors' judgments about location, price and timing for properties A, B, C, and D into overall priorities for each property.

4. Check the consistency of the judgments.

5. Come to a final decision based on the results of this process

---

[6] Saaty, Thomas L.; Peniwati, Kirti (2008). Group Decision Making: Drawing out and Reconciling Differences. Pittsburgh, Pennsylvania: RWS Publications

3.5.1.1 Problem the Model as Hierarchy

The first step in the Analytic Hierarchy Process is to model the problem as a *hierarchy*. A hierarchy is a stratified system of ranking and organizing people, things, ideas, etc., where each element of the system, except for the top one, is subordinate to one or more other elements. Though the concept of hierarchy is easily grasped intuitively, it can also be described mathematically (Saaty, 2010).

Figure 3.1
Hierarchy Diagram
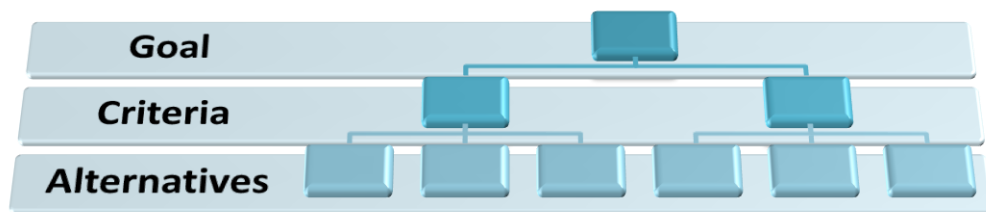
Source: Wikipedia, accessed on March 2011

The analyze method of top product on The Body Shop Indonesia's outlet of Semarang Paragon is using three criteria adopted from Hadiguna (2007) research, those criteria are :

    a. Price

    b. Demand

    c. Availability

The alternative products are all products which claimed as best-seller products according to The Body Shop Indonesia's official site.[7] Those best-seller

---

[7] http://www.thebodyshop.co.id, accessed on April 23rd 2011

means best-seller products based on average selling from all outlet in Indonesia, not refers to one certain outlet.

3.5.1.2 Establish Priorities among the Elements (Comparative Judgment)

Appraisal method from criteria against each product alternative requires expert opinion from internal source of relevant outlet. This appraisal source is claimed represents the objectivity and validity of the information. From obtained opinions, then the appraisal of importance are made in some levels that related with its above levels. This appraisal is the main core from AHP because it is influential to elements prior to those mentioned criteria. This valuation creates a degree of benefits that differs in every part.

To get relatives concerns, then the criteria matrix is built or in other words, comparison of pairwise matrix. For example: Matrix A, the number in the i-line and j-column is a relative importance of Ai compared to Aj. Using preference scale interpreted as follows:

Table 3.2
Preference Table

Score	Preference Level
1	Same preferred
2	Same to preferred enough
3	Preferred enough
4	Enough to intense preferred
5	Intense preferred
6	Intense to very intense preferred

Table 3.2 (Continued)
Preference Table

Score	Preference Level
7	Very intense preferred
8	Very intense to extremely preferred
9	Extremely preferred

Source: Sugiono, Unpublished AHP modul

3.5.1.3 Synthesis of Priorities

In every pairwise matrix comparison, the eigenvector values can be determined to get local priorities. As the pairwise matrix comparison exists in every level, so the global priority can be obtained by doing some synthesis between local priorities. The procedures to do synthesis of priorities are different to their hierarchical process. The elements sorting is based on their relatives interests through the synthesis procedures is called setting priority.

3.5.1.4 Check the Consistency

Decision-making in AHP using a preferences scale, so it requires many comparisons (3 or more). That is why the previous statement can be ruled out. Furthermore, the validity and the consistency of the statement is an important matter (the compare between statements must be consistent).

To count the Consistency, this method uses Consistency Index (CI)

$$CI = (\lambda - n) : (n-1)$$

Where:

CI   = Consistency Index

λ　　= Average value of comparison vector multiplication score from each criteria and its weighted score

n　　= Total element in matrix

To measure satisfaction level from consistency and progress of research models with Analytics Hierarchy Process, tool which can be used is Consistency Ratio. Consistency Ratio is a comparison between Consistency Index and Random Index.

Conditions applied are :

1. If the value of CR is < 0,10 hence Consistency Level is quench, successful model

2. If the value of CR is > 0,10 hence there is a serious inconsistency, failure model and it need to start all over again.

3.5.1.5 Final decision based on the results of this process

The last section is making the decision based on the result of the previous processes. The decision that made is depends on the initial goal. In this research, the goal of using AHP is finding the top product of The Body Shop Paragon Semarang outlet.

3.5.2. Order Quantity Planning

3.5.2.1 Fuzzy Logic Implementation on Supply Chain

This research uses artificial intelligence implementation with fuzzy logic system to determine order quantity planning which is expected to meet the customer's demand. Fuzzy logic is a kind of artificial intelligence method to map an input space into an output space (Hardiguna and Marimin, 2007). Actually

there are several ways or methods to gain output from certain input, such as linear system, neural web, expert system, differential equation, multi-dimension interpolate table ansd so on (Kusumadewi, 2002). Founder of fuzzy logic, Lotfi A. Zadeh said "In almost all cases, we can make output without fuzzy logic, but using fuzzy logic will be much much quicker and cheaper[8].

Fuzzy logic has been used in management and decision making policy, like database management based on fuzzy logic, facility location decisions based on fuzzy logic, and fuzzy model for complex marketing systems[9]. This method also has been applied by several researchers to solve supply chain situation in an uncertainty environment (Hardiguna and Marimin, 2007). According to Petrovic *et al*. (1999), fuzzy logic implementation in supply chain management was reasonable enough because it had computing ability which was required to deal with uncertain situation as the bullwhip effect. Lee *et al.* (1997) mentioned four major causes of bullwhip effect, as demand forecast, order batching, price fluctuation and supply capability.

Lee and Yao (1999) used fuzzy theory with extension principle method in developing Economic Order Quantity (EOQ) model without considered any backorder where the shape of the order quantity level was triangle numbered fuzzy. Yao and Shu (2008) used signed distance deffuzzification in developing the inventory model which considered the backorder where total of demand and total of inventory were interpreted in triangle numbered fuzzy.

---

[8] *Id*
[9] *Id*

Many reasons for implementing fuzzy logic (Kusumadewi, 2002), as follows:

- Concept of fuzzy logic in easy understanding using simple mathematic concept

- Fuzzy logic is very flexible

- Fuzzy logic has tolerance to inappropriate data

- Fuzzy logic able to mode very complex nonlinear functions

- Fuzzy logic able to build and directly apply the expert's experiences without any training process

- Fuzzy logic can cooperate with control techniques conventionally

- Fuzzy logic is based on natural language

3.5.2.2 Assumptions

This model uses several assumptions as follows:

1. Inventory decision prefer on safety strategy than JIT

2. Time to order (ROP) is determined in a quarter of a year (3 months)

3. Result of quantity to order includes buffer stock

4. Product counted by item or pc/s

5. Stock holding costs in outlet level are not being main factor in supply planning determination, as:

   - Stock holding costs in each outlet are different and cannot be exactly defined.

   - Stock holding costs in outlet level cannot affect official price issued by headquarter.

3.5.2.3 Procedures of Working the Model

Steps for working the order quantity planning engages fuzzy programming method summarized as follows:

1. Collecting related data, consists of inventory level, sales and expected demand of resulted top product.

2. Creating fuzzy assemblage

3. Applying the implication function. On Sugeno method, the implication functions used are min and probor.

4. Averment (*defuzzy*), averment process *(defuzzyfication)* engages weighted average method run by *matlab*[10] 5.3 program.

5. Finding and concluding the result

3.5.2.4 Involved Variables

The main purpose for building this model is discovering order quantity level based on certain demand level and inventory status. Defuzzification uses weighted average with fuzzy interference system engages the Sugeno method. While the main input is the result of previous key product determination using analytical hierarchy process model.

Affiliation function types which are commonly engaged in supply chain were triangle formed, S curve and trapezium formed (Petrovic *et al*, 1999). In this research, each involved variable engages affiliation type as follows:

---

[10] A *numerical computing environment and fourth-generation programming language developed by MathWorks (Wikipedia, 2011)*

3.5.2.4.1 Demand

Demand level engages S-curve or *sigmoid* curve formed affiliation. This curve defined by engaging 3 parameters (Kusumadewi, 2002):

- Zero membership level (α)

- Inflection spot or crossover (β), domain is 50% true

- Perfect membership level (γ)

In this model, demand variable has two fuzzy assemblages that are demand 'RISE' and demand 'DOWN', by their membership functions as:

RISE

$$S(x;\alpha,\beta,\gamma) = \begin{cases} 0 & \rightarrow x \leq \alpha \\ 2((x-\alpha)/(\gamma-\alpha))^2 & \rightarrow \alpha \leq x \leq \beta \\ 1 - 2((\gamma-x)/(\gamma-\alpha))^2 & \rightarrow \beta \leq x \leq \gamma \\ 1 & \rightarrow x \geq \gamma \end{cases}$$

DOWN

$$S(x;\alpha,\beta,\gamma) = \begin{cases} 1 & \rightarrow x \leq \alpha \\ 1 - 2((\gamma-x)/(\gamma-\alpha))^2 & \rightarrow \alpha \leq x \leq \beta \\ 2((x-\alpha)/(\gamma-\alpha))^2 & \rightarrow \beta \leq x \leq \gamma \\ 0 & \rightarrow x \geq \gamma \end{cases}$$

Source: Kusumadewi, 2002

3.5.2.4.2 Inventory

Inventory level engages triangle and trapezium formed affiliation function. Trapezium used on inventory 'LOW' and 'HIGH', by their membership function as:

$$\mu[x] = \begin{cases} 0; & x \leq a \text{ or } x \geq d \\ (x-a)/(b-a); & a \leq x \leq b \\ 1; & b \leq x \leq c \\ (d-x)/(d-c); & x \geq d \end{cases}$$

While triangle formed used on inventory 'NORMAL', by its membership function as:

$$\mu[x] = \begin{cases} 0; & x \leq a \ or \ x \geq c \\ (x - a)/(b - a); & a \leq x \leq b \\ (b - x)/(c - b); & b \leq x \leq c \end{cases}$$

Source: Kusumadewi, 2002

3.5.2.4.3 Order Quantity

Quantity to order engages linear affiliation function. This is the simplest form and becomes a good solution to approach less clear concept.[11] As the order quantity becomes the output variable, then its membership functions depend on parameters of decision rule on every order quantity condition that are: 'FEW', 'NORMAL', and 'MANY' obtained by discussing it with management of the outlet.

---

[11] *Id*