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«Inventory control system in a corporate organization»

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ABSTRACT

In inventory control system, demand plays a vital role. According to studies about inventory control models, it is known that there are two types of inventory control models and are named as deterministic and stochastic models. This classification occurs upon the condition when the demand is absolutely known, or not. All over the world, Economic Order Quantity (EOQ) and Economic Production Quantity (EPQ) are the most widely spread models. They are used in deterministic inventory control models.

We can easily analyze the result of assumptions in these models which are unrealistic. So, in real life, there are so many situations and cases which can make problem or required some corrections and they are not mentioned. However, in our present life, there are so many studies which developed new assumptions in order to make a balance between the assumptions of models and real life conditions. In new assumptions, there are many new literatures are mentioned. For example, shortage, inflation and time value of money, effect of learning and so on. I will investigate how new assumptions effect on economy and models. The corrections and reasonable results of these assumptions will be mentioned.

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Introduction

In economic sphere, the growth rate of countries is mainly about their manufacturing ability and increasing profit which is gained from this production period. There are so many ways for assesing the level of development of countries. There is reasonable differentiation among the level of improvement of countries and being successful in manufacturing period is the principal factor.

The concept of manufacture is one of the essential term not only for countries, but also entities. As operating activities begin with production and they are founded for producing goods and service.

Companies face a lot of limitations in their operations about production. These limitations can be under control of companies such as price of product, quality of product, time. On the other hand, it is not under control of companies, for instance, market, changing of costumer needs or changing rate of demand about the same product. So, business management plays a vital role for companies like making a reasonable decision in order to use the current sources for maximizing profit.

Business management consists of many functions such as production control, quality control, inventory control and etc. Among these all functions, inventory control gets a high value in the last years and so many improvements, changes are happened about this function. In inventory control system, companies have to decide their strategies in advance in order to reach their target. So they launch inventory management for making better the inventory control system for entities.

In inventory management, managers must analyze the financial condition and sale rate and have to determine the most economic quantity of inventory and set a goal in order to keep a stable level of inventory. So, the level of inventory and transactions of inventories must be controlled consistently.

Inventory controlling system is principal tool for entities in order to minimizing the cots and maximizing the profit. Because, there are two main cost about inventory, stock: holding cost or stock – out cost. So, inventory management has to make a good decision about how much money should be invested for inventories. In order to determine the most appropriate level of inventory, these two costs have to be balanced. Holding costs are the costs which are happened in the period of holding much more inventory and depreciation and impairment of these inventories. On the other hand, decreasing rate of manufacturing or fail in sales is caused by lack of stock and this is related to stock – out costs. The main goal in inventory controlling system

is to determine the most suitable quantity of order or manufacture which have minimum holding and stock-out costs. There are so many and methods for reaching this goal.

Every company uses their unique inventory control system and techniques according to their inventory policy, type of production, financial position and other factors. These techniques which are used in inventory control system are begin from simple counting and inspection method to some complex software in computer and other techniques like this. The size of entity, costs related to inventories, demand, the importance of stock policy, human capital and rate of information flow play an essential role in the selection process of which technique is appropriate for the company.

In inventory control system has used the fixed order and production quantity models since by 1900s. The easy way of using these methods make these methods the most commonly used methods in inventory control system and some additional functions make these methods much more convenient for their users. These methods are known as Classis Economic Order and Production Quantity models. They are based on variety of hypothesis. In these hypotheses, fixed and constant quantity of demand, orders are free from error, payments are received as a cash on delivery, not focused on inflation rate are main factors. These factors are not enough in order to explain some cases. So that, they are replaced or edited and developed in order to be much more reasonable about real cases in life and develop new models.

Economic Order and Production Quantity models are changed their basic hypothesizes and developed them. So, there are so many new approaches in these models. The most important changes are having defective product in ordering, impairment of inventories, changeable demand, paying much more attention on inflation and letting costumers pay their payments in short delaying period.

In this study, a new model of Economic Order Quantity is being developed from these developments. The developed model discusses the basic assumptions in the classic models that the goods coming out of order are perfect and that the assumption that the payments are made in advance during the delivery of the goods is defective and the payment is allowed to be delayed. In addition, the model is also allowed to stoop. The aim of the study is to obtain a mathematical model that will allow the amount of economic order that will make the most profit under these conditions and make some analysis about the subject. For this purpose, first of all, classical economic order and production quantity models are examined and new developments

made in these models are examined in the field of theory and field. Later, a new model is developed that deals with stock-out, defective products, and delays in payments.

The study consists of two parts. In the first chapter, under the heading of stock control models; inventory concept, inventory varieties, inventory costs, causes of inventory possession, stock control and management, stock control systems and stock control models are mentioned. In addition, the mathematical methods of obtaining classical deterministic stock control models are shown in this section.

In the second part, under new headings in inventory control models; economic order and production quantity models, and the studies on the field related to these developments are given in the summer. Within these expansions, we deal with the situation where the product is very product, the products in the stock are deteriorated with time, the different demand functions, the quantity reduction, the variable speed of production, the time value of money and the effect of inflation, learning effect, delay in payments and defective product it is taken. In particular, the studies on the condition of delayed payment and the case of defective product are examined in detail.

Chapter 2. Literature review

2. Inventory concept.

If the company faced some hardships in production or there were so many reasons which caused barriers in the production period of outputs, the company would have problems about covering their costumers' demand. It can be the reason for declining customer royalty about this product or company. So, this is the best opportunity for rivals to make this company out of game.

Specially, complex structured entities more likely to fix these disruptions. In order to make provisions against these factors, companies are much more sensitive about their stock, inventory. Inventories represent investment which is used for supporting manufacturing process and serving clients.

2.1 Definition of Inventory

Inventory term is commonly used in accounting reports, statements and so on. In the production period, inventory is used for unexpected cases, period of delay. This is like a guarantee for companies in several reasons mentioned above. They are kept in order to use them in necessary cases. They are raw materials, material, alternative product and other resources. For commercial entities, these are some services in order to serve their client in emergency cases.

In some countries, there some strict roles about keeping inventories such as Turkey. These fields are center bearing, retailing and agriculture. However, this obligation is applied for their business in order to make them serve their customers properly. In managerial and economic view, keeping inventories is the great investment for companies. However, these inventories do not have any chance like using for other purposes. So, it caused some hardships and failures about other opportunities.

Inventory control or stock control is the crucial factor, as this is true that keeping much more inventory can cause some losses in profit. Let's imagine that your money is kept as an inventory and you can not earn profit from this money. So, estimating all factors in market and determining the most acceptable inventory order point play a principal role for companies.

There are so many definitions for inventory which are given in literature and we are able to choose some acceptable options in order to define inventory. "Inventories are stockpiles of raw materials, suppliers, components, work in process, and finished goods that appear at numerous points throughout a firm's production and logistics channel" (Ballou 2004:326). Secondly, "inventory or stock is the stored accumulation of material resources in a transformation system. So, a manufacturing company will hold stocks of materials, a tax office will hold stocks of information and a theme park will hold stocks of customers (when it is customers which are being processed we normally refer to the stocks of them as a queues)" (Pycraft et al 2000;419). Finally, in a simple way, inventory is defined as "the stock of any item or resource used in an organization" according to Chase, Jacobs and Aquilano (2004;545).

2.2 Types of inventory

In general, there are 3 main types of inventory which are known from years and are used commonly. These are named as raw materials, work in process, and finished goods. Additionally, we have 2 other types of inventory that are not directly situated in these 3 types of inventory which are mentioned above. They are "scraps and readymade components" (Waters, 1989: 71). However, these additional types have some critical role in manufacturing finished goods.

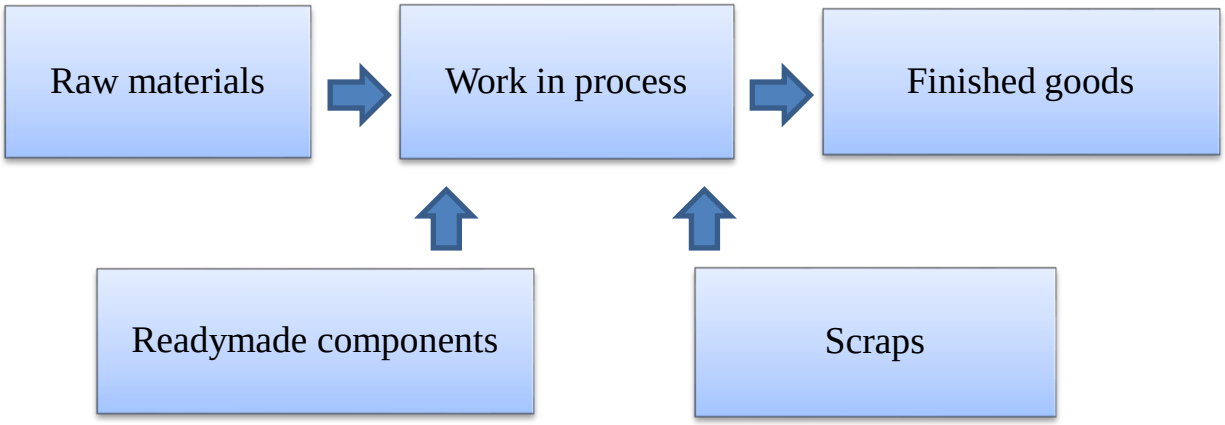

Figure 1. Types of inventory (Waters, 1989: 71.)

2.2.1. Raw materials

Raw materials are the fundamental for production period and also for a company. Entities have to manage their raw material inventory control system in order to reach their production goals. This is combination as a body system, For example, company can have variety of technologies, employees an etc. However, having error in raw material inventory management caused problems for company and is able to make some other hardships in other inventory types. Depend on the function of company, raw materials can be different. For instance, company which manufacture iron need ironstone as a raw material in order to produce iron. However, iron can be a raw material for companies which produce a car or other machines.

2.2.2. Work in process

Work in process (WIP) is a material which is currently in a production level. It means that raw materials are taken in order to use in process and then, technologies or employees convert them other types of materials or inventories which are known as work in process inventories. Work in process inventories in rare cases are like a finish goods. For example, in car manufacturing company, cars are ready, but they need to paint or some other little accessories.

2.2.3. Finished goods

These types of inventory are ready for their customers and are usually managed by distributors of company. Some finished goods can be raw materials for other companies as I mentioned before. However, companies have to make an excellent

relationship with their distributors in order to make a perfect decision about how much output company need. Especially, huge companies as a car manufacturer have to keep in touch their distributors and also their customers in order to find out the most appropriate production quantity.

2.2.4. Readymade components

These components are generally taken from outside, other companies and they become a part of finished goods. We can give some examples for these, bol or loaf can be small readymade components for a company. However, electrical motor or transmissions are complex materials whicah create a part of finished goods.

2.2.5. Scraps

Scrap materials are used in manufacturing process in order to produce finished goods. These materials generally give their value to the finished products in the period of using physical and chemical processes to raw materials in order to reach the last stage of production period. According to the function of companies, these materials can be different. For example, electrician, gas, water, oil, oxygen and coal are scrap products for companies. At the same time, some vitamins, products which create a new color for the finished goods, hydrogen are also scrap materials for those companies which are the producer of biological oil. (Tekin, 2003: 8)

This classification is the general classification of inventory (stock) according to the functions of entities. In additional, in order to achieve their objectives, inventories are classified into other stages such as cycle stocks, safety or buffer stocks, speculation stocks and seasonal stocks. (Martinich, 1997: 663)

Cycle stock is inventory which results from the process of supplying again and is required for the purpose of meeting demand in the period of certainty. That is why, the firm can predict wishes of their customers and times for supplying again (lead times) almost perfectly. For instance, in the event that the ratio for sales for a constant 40 items per day and the appropriate time is always after 20 days and there is not any inventory beyond the cycle stock would like to be required.

Safety or buffer is held in surplus of cycle stock due to the fact that uncertainty in the rate of demand or lead time. The notion is which a level of average inventory should be suitable for covering short-range variations in demand and replenishment time. An average number of inventory at a stock-keeping place which experiences demand or lead time probability is equal to half of the order quantity and the safety stock.

Speculation stock is inventory held for some objectives other than satisfying the present demand. For instance, materials may be ordered in volumes larger than normal in order to get quantity discounts, because of the fact that a forecasted price go up or materials shortage, or in order to protect against the real case of a strike.

Seasonal stock is a type of speculative stock which includes the accumulation of inventory before a season starts in order to maintain a constant labour force and constant production runs or, agricultural products can be a primary example for this, inventory accumulated as the conclusion of a growing season which limits availability in every stage of the year.

2.3. Cost of stock

In the production period, in order to produce some products companies have to keep stock in their stock-keeping location. So, this is so normal that it can be costly for entities. All costs which are appeared in the period of keeping stock are cost of stock. There is a little bit differentiation because of the fact that keeping stock is costly, however, it can be costly for companies when they are out of stock. In every problem of stock control methods, a main goal is achieving the most acceptable point between these two costs. Due to the fact that one part of these costs increases according to increase in quantity of stock, the second part of them decrease and another part of them is free from relations to quantity of stock and remain stable.

Related to increase in quantity of stock, cost of stock begins to increase and opportunity cost, cost of carry, tax and insurance, cost of quality, coordination cost, depreciation and impairment are the examle of cost of stock. As I mentioned before, there are some costs which decrease according to increase in quantity of stock and they are ordering cost, preproduction cost, puchase cost, cost of production. (Dilworth, 1993: 219-221)

It is not matter which field of business entities are, they all face 4 main types of costs. They are ordering or preproduction cost, purchase cost or cost of production, carrying stock costs and stock-out costs. (Chase vd., 1998: 584)

There are some differentiations we have to know. Ordering cost and cost of purchase belong to some specific companies which focus on mainly selling these products without any additional processes. On the other hand, preproduction cost and cost of production are about firms which prefer to produce new products.

On the other side, entities which engaged with production area, cost of ordering which is for supplying raw materials and scrap materials is also classified as ordering

cost. (Scholder, 1993: 584) As I mentioned before, ordering cost is mainly about firms which prefer to sell their product without any additional works. However, ordering cost of entities which are in production area is preproduction cost. Otherwise, the total cost for such companies have to keep either ordering or preproduction costa t the same time.

2.3. 1. Ordering cost

Ordering cost is a cost which is appear in a period from ordering new products to acceptance of product. Ordering costs are total of these costs: bookkeeping about regulation of order, salaries, registration fees, cargo, order follow-up and payment of invoices and also costs which appear in acceptance process such as control, transportation, acceptance and registration costs. (Tekin, 2003: 10)

Ordering cost is stable for every order. However, cost for every unit decrease when the quantity of product which is ordered begin to increase. Sometimes, companies take advantages of ordering larger quantity. This advantage is discount in total price. At that time cost per unit becomes lower because of discount. So that, ordering large quantity of product gives benefits to company as getting quantity discount and reducing the total quantity of order due to the fact that in the case of ordering large quantity rather than necessary amount, they do not need to order in a while. At the same time, ordering large quantity make some additional costs such as carrying stock and storage cost. (Kobu, 2005: 346)

2.3. 2. Preproduction cost

Entities which are engaged with production area have this type of costs. In order to manufacture a new product, firms need some machines, equipment and facilities which have to be prepared for production process. So, all such costs which are appeared in preparing period are preproduction costs. In installing a new machines and testing all of them, there are some employees who are not able to do work at that time. However they should be paid for those hours and also all expenses in testing and installing period record as preproduction costs. (Eroglu, 2002: 2) In additional, costs which occur in the ordering process of raw materials, scrap materials and operating equipment are recorded as preproduction costs. (Schroeder, 1993:585)

2.3. 3. Purchase cost

In order to purchase a new product, the unit is variable cost. (Winston, 1991:815) In the event that the company wants to buy products from market, money which is paid for every unit will be purchase cost. Specially, purchase cost plays a

great role in statement of companies which are engaged with wholesale and retail sale.

2.3.4 . Cost of production

In order to produce a product, the necessary unit is variable cost. Two types of costs appear in production period. They are fixed and variable costs. Raw materials and other production expenses are variable cost of product and they will begin to increase when quantity of product go up. When the stock policy was identified, they need to calculate variable costs in purchase cost additional to fixed costs. (Tersine, 1988:14)

2.3.5. Carrying costs

Carrying costs are the one of the common costs in entities. Carrying cost would appear when the company decided to store some inventories in a specific period. Then, carrying cost has a direct relation with the amount of stock. It means that when the company added some additional amount of stock to storage, carrying cost related to these inventories would begin to increase.

Opportunity cost of capital, insurance and tax, breakage, impairment, obsolescence, outage and storing cost are the main cost items of carrying cost and they create it in accounting period. (Chase vd., 1998: 584)

Opportunity cost of capital which is invested to stocks or inventories is cost of capital. If the company made a decision and it was really into to invest its money to stocks, company would lose some benefits. It means that company could invest its money to another thing and could make money and this amount of money create cost of capital for the company for the reason that the company had other options or opportunities to gain a profit. However, this entity chose to invest its money to stocks. For example, amount of investment could be deposited in banks. Then, profit from banks according to amount of deposit became a base for cost of capital. Specially, in inflation period, this is much more costly for company to invest their capital to stocks. Opportunity cost plays the biggest role in carrying cost and it makes 10-15 % share in value of stock. (Martinich, 1997:664; Karaoz, 2003; 66)

Storing cost is also important for a company. Necessary level of heating, rent, lighting and salaries related to employees of storage are cost items of storing cost. If company owned the place which was used for storing inventory, opportunity cost would be calculated for this company. Because the company had an opportunity to use this place for other purposes in order to generate a profit. One part of the storing

costs is fixed, another part is variable costs. Variable costs are used for analyzing rather than fixed costs. (Dilworth, 1993: 585)

According to the long period of keeping inventories in storage, the most of inventories begin to impair. Impairment and outage can be different according to the nature of inventory. There is a period for products which determine how much time this product can be kept in storage. This period is so important for entities and named retention period. Impairment and out age for products which have a little retention period are essential. Obsolescence of product, foods which have a little useful life and stolen goods make a cost for company. So, these costs are recorded as impairment and outage cost. (Schroeder, 1993: 585)

Inventories (stocks) have a big share in investment of capital. So, companies are really into to insure their stocks. Expenditures which are spent in order to insure their stocks are recorded as insurance costs. In additional, taxes which are paid for storing inventories are also involved to carrying cost. These taxes are varied according to value and amount of stock. (Tekin, 2003: 9)

2.3.6. Sock-out costs

Companies have a great amount of costumer base and get a lot of order. However, there are so many companies which have a lack of costumer. Stock-out costs will be appeared when companies are not able to cover their customers' need. The reason for this is that they do not have necessary amount of stock in their storages. Decrease in sales for result of do not covering customers' need, problems which are occurred in period of delay and it caused cost of delay and cost of losing brand loyalty are recorded as stock-out costs. (Nahmias, 1993: 219)

On the other hand, there are so many firms which are engaged with producing materials and use raw materials. So, they have raw material storage with inventories. It means that stock-out costs in these entities can be much more. As they need to fill their stock up properly. If there was any delay or lack of stock, it would cause decrease in production level. Then, it would have a result as not to cover their customers' demand. All of these are recorded in stock-out costs (Top,2001: 195; Martinich, 1997: 665)

The main objective of inventory control system is to make a balance between carrying costs and stock-out costs. This is crucial for every company all over the world.

All entities face such a problem. They become in a common situation. This situation is about to choose keeping stock in inventory or being out of stock. There are so many reasons why companies choose to carrying their stock.

2.4. Reasons about carrying stock in companies

Entities keep so different types of stock accoring to their field of business. After a several time, entities face some hardships in order to make a balance between necessary amount of inventory and inventory which is kept in storage. However, purpose of inventory control system is to have a necessary amount of stock in company in order to cover company's need. In companies which prefer to produce new material, they need to have a necessary amount of inventory in order to produce properly, without any delay in production period. In wholesale and retail sale companies, customers have to be satisfies and be provided what they require. This is the main goal for those business fields. (Karaoz, 2003: 62)

Companies can suffer from lack of stock in their inventory and it caused some costs for them. On the other hand, having much more materials in inventory caused some other costs. So, every company would like to make an inventory control policy in order to have at least minimum necessary amount of stock. At that point, there are so many reasons for keeping necessary amount of stock in company. It is obligation for entities and differentiation between demand and supply in a short term is in the top of these reasons. Changes between demand and supply caused long term differentiation for every entity (also for companies which produce according to just in time philosophy) and it is fundamental reason for keeping necessary amount of stock in company. (Waters, 1989: 69-70)

On the other hand, every entity benefits from scaly of economics, being ready for uncertainties, making profit at the result of speculation and to continue their business without any delay. Those factors make the company to keep necessary amount of stock. In additional, having much more inventory in the company for delivering to a big distance and saving some seasonal foods for the same demand (seasonal demand) are also reasons for having inventory in the company. (Martinich, 197: 661-663; Nahmias, 1993:213-215; Chase vd., 1998: 583-584)

2.4.1. To be prepared against uncertainties

One of the most important reasons for keeping stock in entities is uncertainties. Uncertainties arise especially in the period of demand, offer and supplying products. Apart from these, the enterprises face uncertainty problems in labor supply, factor

prices and as well as the uncertainty about interest rates as the cost of capital. (Nahmias, 1997: 213-214)

Under such uncertainties, production continues uninterrupted or demanding extra stock in the operator's hands so that they can be met without being out of stock. These stocks that are in need of uncertainty are also called safety stock. (Schroeder, 1993: 413)

One of the uncertainties which is faced by businesses is sudden increases in demand in products which are produced in entities. A trowel and sudden demand increases that are unpredictable and companies are not able to meet due to be out of stock. In the result of this problem, companies suffer from the loss of sales and the loss of customers. (Karaoz, 2003: 63) For this reason, businesses need to stock more than their existing products in order to meet customer requests on time and not to lose their customers need to stock more than their existing products.

Another one of the major uncertainties is uncertainty in supply and supply shocks. For example, reduction of petroleum supply due to oil shocks or disasters such as drought temporary contractions that may occur for some reason cause supply uncertainties. Moreover, each supply has a limited capacity, responding to changes is also limited. For this reason, against for limitations and uncertainties in supply, companies need to keep much more stock win their hand. (Karaoz, 2003: 63-64)

Another uncertainty that businesses may encounter is all about the duration of product supply. During the delivery of goods which are ordered from outside, confronted with the depletion of stocks due to possible delays so that the customer can be satisfied in such a case enterprises constantly have extra safety stock. So that, in the result of this stock the demands can be met without falling into out of stock. (Nahmias, 1997: 186)

2.4.2. Benefiting from Scale Economies

To benefit from the advantages of economies of scale, companies prefer to order much more at once or to produce more amount of material caused keeping much more stocks in entities.

There is an independent cost related to each order for orders-driven businesses. Therefore, when the amount of orders which is given in each order increases the order cost per unit will be decreasing. As a result, businesses taking advantage of ordering more than necessary and they keep them as more inventories in company.

However, when the company decided to keep much more inventories, there is a stock keeping cost. (Martinich, 1997: 661)

On the other hand, production line for every different good production for the enterprises that manufacture has to be changed and rearrange the machines in order to produce new products. Machines need to be prepared. Preparation (installation) jobs for each product have a huge amount of cost. So, a business has to produce in such quantities that are folded to make the cost rational. Another reason is that companies must produce large batches of volumes in exchange for each production line which means less preproduction cost per unit. (Nahmias, 1997: 213)

As the result of these, business can save money at some costs going to fall by holding more stocks by doing more orders at once or more production. In order to make having too much inventory reasonable, this decrease in costs due to scale economies needs to be more than cost which occurs in the period of keeping stock.

2.4.3. Reasons which have Speculative Purpose

Businesses should be prepared for uncertainties and benefiting from economies of scale. However, there are so many reasons for keeping stock. Especially future expectations, it affects directly decisions of managers. For example, in expectation of increasing in the prices of raw materials or finished goods, companies will not be affected by the price increase or to increase profit they may have more stock than usual. (Vonderembse and White, 1991: 627)

2.4.4. Providing Continuity of Business Activities

Beyond all these reasons, businesses have to keep some stock to make their production continuously. Otherwise, in case of any trouble in any of them which I mentioned above will be the subject to sale cuts and disruptions in production . In this case, businesses will have to take stop or supply the intermediate goods from other entities with more price rather than usual. This situation will increase the operating costs of businesses. So, in every case, it is necessary to keep some amount of goods in stock. (Karaoz, 2003: 64-65)

For all these reasons that are mentioned above, businesses have to keep much more stocks rather than necessary amount. However, how much stock should be kept, is determined by the inventory control system used in company.

2.5. Inventory Control and Management

Stock control: stock quantities and types according to operator's procurement, production, sales and their financial means to be determined in the most rational and economical way and management. (Tatar, 1973: 51)

In recent years, there have been significant changes and improvements in inventory control system. According to the increase of the place and the importance of stocks in the production system in enterprises, a successful stock policy that takes stock of control only is impossible. For this reason, there was a need for stock management that was covered extensively. As a result of this situation, stock management concept is used instead of inventory control concept. In this sense, inventory management is actually an improved version which incorporates functions in a more comprehensive and relevant way. (Tekin, 2003: 2)

A well-planned inventory management for successful management in the business is necessary. The stocks raw material that the operator will use for production are not enough, it causes a stop in production. To keep excess stock in a high interest environment, it makes decrease in economic profit and increases inventory holding and storage costs. It is important to have inventory management in order to continue its activities. (Tekin, 2003: 4)

As a result, it does not matter what type of business they are in, they have to keep stocks for the reasons discussed before. According to inventory control systems and models, companies can determine how much of these stocks should be kept.

2.6. Inventory Control Systems

In general, the purpose of inventory control is to provide and to keep stocks at the lowest cost. Organization structure related to amount of stock to be obtained and determination of policies are provided by inventory control system. (Chase vd., 1998: 585)

In terms of size, management and organization, production type, financial position and many other factors, each company has their own inventory control system. In determining the appropriate inventory control system, the claim structure of demand which companies are dealing with plays a distinctive role. (Dilworth,1993: 201)

There are two types of demand: independent demand and dependent demand in stock management in enterprises. Independent demand is a demand for product by non-business buyers (such as the demand for the final product). The other type of demand is dependent demand, is a demand for another product such as demand for

raw material, semi-finished product and emerging within the enterprise. Independent demand operations are determined by external factors, while the dependent demand is cut off a structure of dependent. This difference in structure of demand will be the reason for being different of applied inventory control system and its methods. (Schroeder, 1993: 586)

Inventory control systems which are applied in case of independent demand have three main titles. These are: fixed order quantity, fixed order period and maximum-minimum system. In case of dependent demand, Materials Requirement Planning (MRP) is the most common stock control system.

In this part of the work, brief information about these systems which fall under the scope of stock control is given.

2.6.1. Inventory Control Systems under Independent Demand

Stock control systems which are used in case of independent demand are examined under the terms of fixed order quantity, fixed order period and maximum-minimum system. These systems also use some methods in themselves. In the selection of methods its personnel status, information flow system, machinery and equipment factors such as state, building and storage capacities must be taken into account. (Kobu, 2005: 351)

2.6.1.1. Fixed Order Quantity System

In the fixed order quantity system, the stocks have a predetermined stock amount. When it falls to such level, it is ordered at fixed rate. In this method, it is not known beforehand when order will be made. However how much order was fixed from the beginning. In the case of the period when demand ratio is not very fluctuating, the fixed order quantity system which is a suitable system in this case, it must be monitored continuously. (Waters, 1989: 73)

The entity which uses the fixed order quantity system has different methods used in the application according to the type and amount. The simplest method is the two-bin method, and for more complicated structures, the mathematical Models are available.

Two-Bin method: S mall businesses where the amount of stock is small, however types of stock are more use the two-bin method. There are two boxes, one of them is the main, another one is alternate. When the stock in the main box is exhausted orders are placed and demand is met by the another, alternative box up to

orders are received. For this reason, the quantity of stock which is held in the spare up to the next order of supply, uncertainties have to take into account. When the stock in the original box is full, a fixed amount of stock is ordered. This method is handled as an application of the fixed order quantity system. (Schroeder, 1993: 608)

2.6.1.2. Fixed Order Period System

In the fixed order period system, stocks are at certain times - fixed time, for example every week or every month, are monitored and predetermined the order quantity is given in consideration of a certain stock level. In this method, when to place an order, in another word, when it is certain, the time between orders, the given amount of order for each period is different due to the rate of demand.(Gaither, 1992: 415-416) For this reason, the amount of safety stock is higher than the fixed order quantity system. This system is used when periodical customer visits with wholesalers and transportation common in situations where orders are combined to save costs. (Chase vd., 1998: 599)

The methods which are used in this system are for example visual inspection and single-box method

Visual inspection method: Especially in small businesses, a stock control method applied by persons who are responsible for warehouse and ambassador. Stocked goods constantly observed by the person or persons and are ordered when there is a decrease in stocks. Easy, simple and cost-effective production capacity is visually controlled in small enterprises and retail enterprises. This method is widely used. (Tekin, 2003: 12)

Single-box method: The place or shelves which are described as a box in the single box method are periodically checked and filled. This is an example for this method, filling tanks in petrol stations, supermarket shelves are followed by staffs, boxes may contain with small parts in factories. In this method, the shelves are filled with stock as much as they are periodically received, there is no record for the output. (Schroeder, 1993: 608) This method, which has a very high risk of falling to out of stock. This method is easy, simple and cheap as a visual inspection method.

2.6.1.3. Maximum-Minimum System

In the fixed order period system, some orders which are placed in order in a fixed period, some amount of orders given in cases can be very small. In this situation, the maximum-minimum system applied to remove system, some features of the fixed-order quantity and fixed order period system make more rational stock

policy which can be followed. (S, s) In this system, which is also known as system, the desired maximum stock level (S) and the minimum stock level (s) are determined in advance. Stocks are kept at fixed time intervals, for example every two weeks, and the amount of stock is below from a predetermined minimum level then is ordered. If the stock amount is not below from the minimum level, stock is not provided. Because in this case, the quantity of stock on hand is most likely enough and will be at the level of the next turn and the amount to be ordered is very small. (Dilworth, 1993: 204)

2.6.2. Inventory Control Systems and MRP in Dependent Demand

The most widely used inventory control methods under independent demand method is MRP (Material Requirement Planning) Method. MRP is an inventory control system used for the planning of all manufacturing activities of entities. In this system, the demand for materials, parts and semi-finished products depends on the demand about the final product. When the demand for final product was known, sub-assembly required during production and quantity of parts forming product would be fully calculated. (Chelikchapa, 1999: 139)

Many types of MRP have been developed, tested and applied in different countries production processes. Common point in all applications, production hours and materials and parts and required amount of energy to be heard is programmed on a chart. In this program, every product and the parts that make up it are immediately needed to stockpile since it is produced or supplied in advance. O, this also remove keeping stock in entities. Thus, the amount of intermediate stock in the production phase decreased and the cost of stockpiling will also be reduced. (Ayanoglu, 2005: 354)

Chapter 3. Inventory Control Models

3.1. Inventory Control Models

To continue the operations of the enterprises, to respond to all customers' needs and wishes companies have to keep some amount of stock in relevant place. The purpose in all stock control problems, to make the total cost minimum, how much to order for each product, and to determine when to place orders. (Gaither, 1992: 411)

Many methods and models have been developed to answer these questions. These methods and techniques, which form a wide spectrum from visual control to computer-solved complex models, improved stock control models have an important place.

The main determinant in the classification of stock control models is variable in demand. According to the classification made according to the structure of demand; inventory control models, deterministic and probabilistic models. This classification according to structure of demand is given in Figure 1.2.

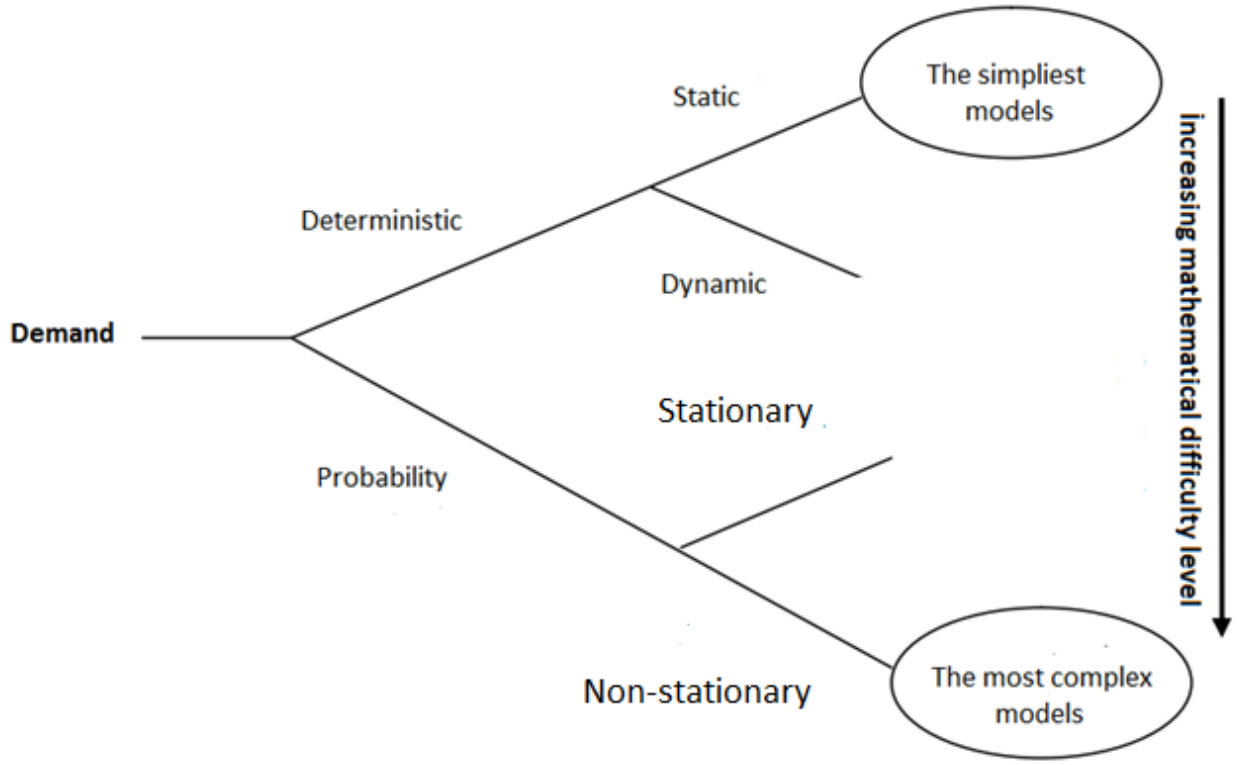

Figure 1.2. Inventory Control Models by structure of demand

(Eroglu, 2003: 6)

According to this classification, when the amount of demand was absolutely known, deterministic models would be mentioned and when the amount of demand was not known in advance, probability models would be mentioned.

The deterministic demand, it means, the consumption rate, is constant over time, Models that deal with the state are known as deterministic static models,

whereas demand rate is fluctuating from one period (period) to the other Models are defined as deterministic dynamic models are mentioned.

In case of possible demand, if the probability function of the demand did not change, the stationary models would be used, if the probability function of the demand changed time by time, the non-stationary models are mentioned. (Eroglu, 2003: 5-6)

Within these models, the simplest and simplest models are deterministic static models. Classical economic order quantity and economic production quantity models are among the commonly used deterministic static stock control models. However, the assumptions in these models are not enough to make the solution to many real life problems due to the insufficiency, due to the problematic structure, many new models have been developed by expanding assumptions. (Eroglu, 2003: 125) In these models, considered as new expansions, the defective product status, allowing payments to be delayed, factors such as inflation and learning effect is considered.

In order to obtain the amount of a new economic order model under the new expansions of this study model, in this part of the study, stock control models and in particular from the classical deterministic stock control models are mentioned according to the demand structure. Classical economic order and mathematical derivation of production quantity models are also covered in this section. New expansions brought to the stock control models are in the second part of the study are examined together with review of literature.

3.1.1. Deterministic Static Inventory Control Models

In the deterministic stock control models, the demand ratio is definitely known. When the demand ratio does not change from one period to the others, the stock control models obtained in this case where they are fixed are known as deterministic static models. The most common of these models Models are Classic Economic Order and Production Models.

3.1.1.1. Classical Economic Order Quantity Model

The oldest and most widely used model in stock control models is Economical Order Quantity model. First in 1915 by Ford W. Harris brought this term to economy and this model is based on the many models used today form. This technique, which is very easy and simple to use, has many assumptions in it. (Zipkin, 2000: 178; Heizer and Render, 2001: 481)

The purpose of the economic order quantity model is to decide how much to order in order to minimize the total cost. In this model, the change over time is shown in Figure 1.3.

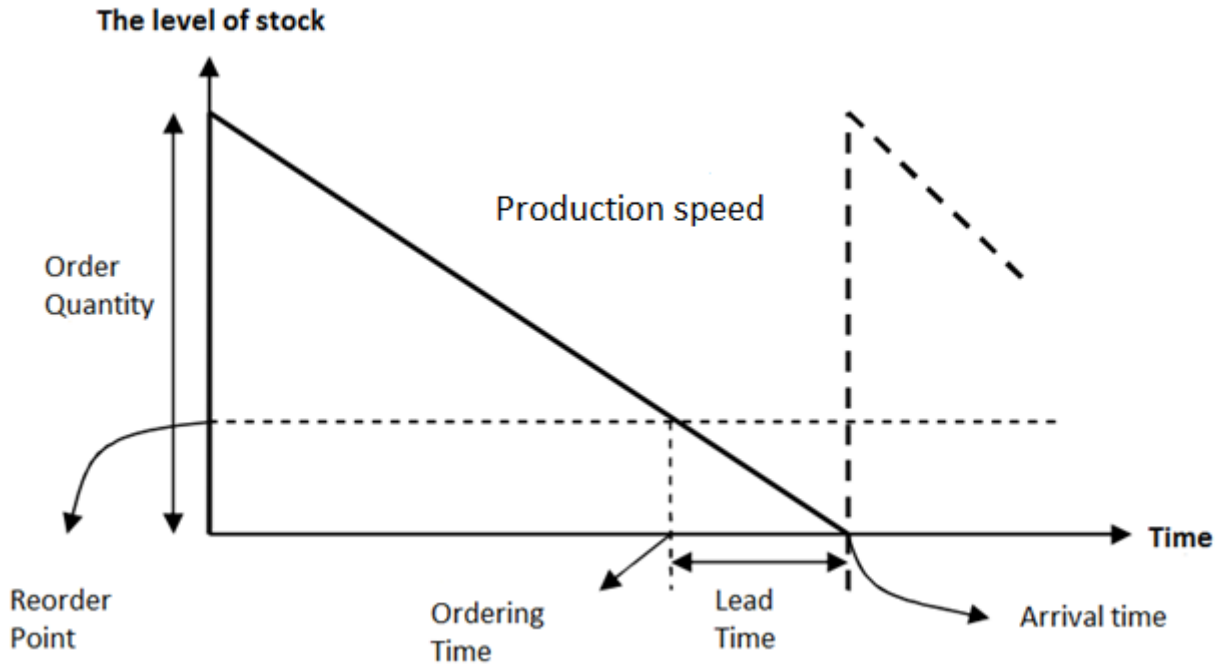

Figure 1.3. Classical Economic Order Quantity Model

(Stevenson, 1993: 594)

In the Economical Order Quantity model orders are received in batches and in one part. Then, this stock is reduced with a constant demand rate. Order is reordered at the reorder point before the order is finished. The inventory on hand is running out until the orders arrive. Reorder point, it is just before the lead time when the stocks in hand will end. In some models, the assumption is made that the supply period in these models is zero, delivery point crosses with the time when the orders end. So, in this case, the assumption is about that the goods will be delivered at the same time when the goods will be ordered.

Detailed information about this model and how it was obtained will discuss in the future.

3.1.1.2. Classical Economic Production Quantity Model

Economic Production Quantity model is the inventory control model obtained as a result of adaptation Economic Order Quantity model to the production enterprises. In this model, in the economic order quantity model, all the goods are delivered at the same time under the assumption that goods are produced in-house rather than assumed of the production needs to be done. Production speed is always more than demand and the increasing stocks in the production process will use to cover customers' demand. Production is resuming when there is no stock in hand. Change in stock amount over time in the model of economic production model is seen Figure 1.4.

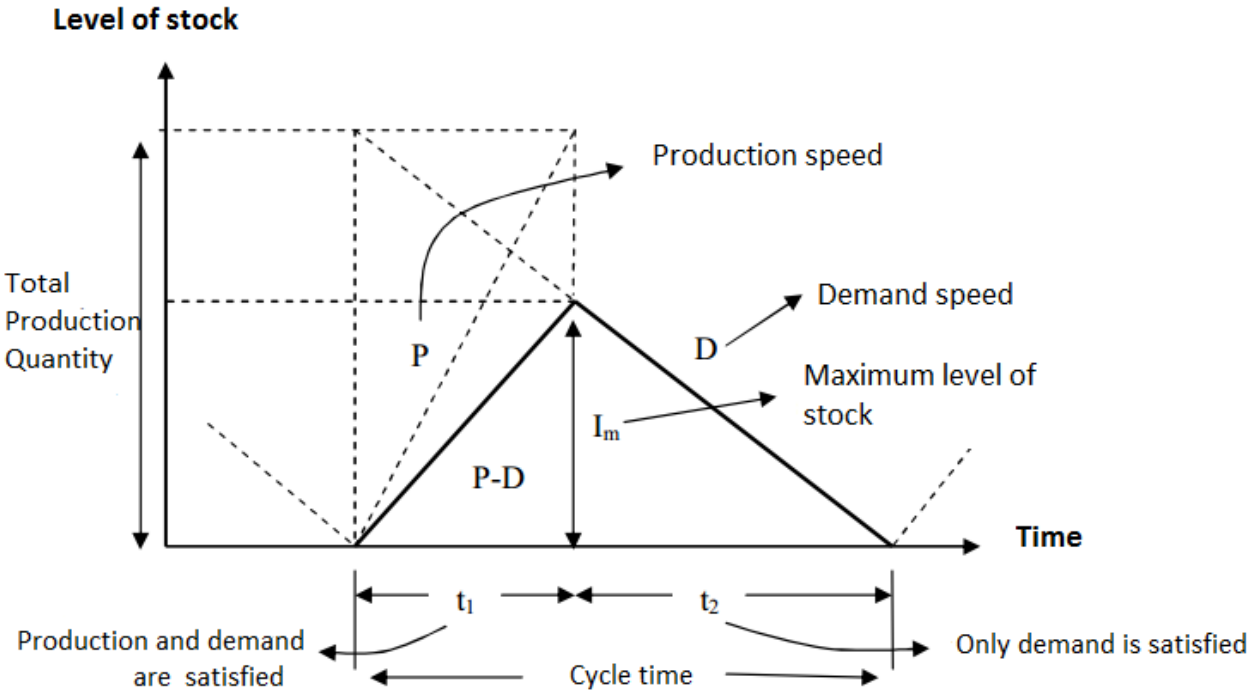

Figure 1.4. Classical Economic Production Model

(Stevenson, 1993: 599l; Eroglu, 2003: 10)

In this model, a cycle time consists of two phases. In the first phase, with the production, the demand that is generated in that period is satisfied. At the end of this phase, company reached maximum stock-out point and production is stopped. In the second phase, accumulated demand is met by surplus production in the first phase. Detailed information about this model and the derivation topic will be future part of this chapter.

The change of production technology, due to the inclusion of the economic life of the computer, many assumptions that are incompatible with today's conditions Economic Order and Production Quantity models in stock politics has become insufficient. On top of this by expanding the basic assumptions of the models and adding new assumptions which are higher real life representation power have been developed. These models, known as new expansions are described in detail in the second part of the study.

3.1.2. Deterministic Dynamic Stock Control Models

Inventory control models are static (unchanging) or dynamic (variable) according to demand ratio which is varied over time from one period to the next. In static models, demand is constant. The quantity of demand for dynamic models varies from one period to the next. In this case, in response to the question of how many orders should be made per period, three approaches are recommended. (Silver vd., 1998: 200-201) They are:

1. Using the classical economic order quantity model
2. Use mathematical models that are developed according to the situation and give definite result
3. Using intuitive methods that give the most appropriate solution

Using the classical economic order quantity model. The easiest solution is to determine the fixed order quantity for each period by using the average demand which has been creating during the planning period. However it is clear that it will give the appropriate solution for the demand which is used in this path when the variability is very low. The reason is that when the variability of the demand rate is very low, it has not been too much (significant) violation in the assumption where the rate of demand in each period is constant.

Use mathematical models that are developed according to the situation and give definite result. Disconnected time under non-allowance to stock-out period, some specific assumptions which give an optimum result for dynamic demand inventory control models with variable demand such as the Wagner-Whiten algorithm as a solution method the algorithms to be obtained under cluster exact amount of order can be calculated. (Eroglu, 2003: 21)

Using intuitive methods that give the most appropriate solution. As far as possible, but with do not do complex calculations intuitive methods that allow users to understand relatively easily and can be reached to the result in a short time. Along

with not giving a definitive conclusion, these intuitive methods can be used within reasonable limits and solving seems to give the closest results. The most important issue developed in this regard heuristic methods; Silver-Meal intuitive, Lot-for-Lot (L4L) and lowest unit cost is intuitive. (Ho vd., 2006: 1005-1013; Chase vd., 1998: 650-653)

3.1.3. Probabilistic Stock Control Models

In stock control models, one of two basic variants is demand. According to the structure of demand, stock control models are divided into two groups as deterministic and probabilistic models. Deterministic models in the case of demand which is known in advance and with this model, it is quite easy to set the delivery time and the optimal order quantity. However, in real life, it is impossible to know exact quantity of demand in advance. Therefore, random changes in demand cause them to be out of stock and in order to prevent this, the extra stock in their hands. (Ayanoglu, 2005: 350)

It is also known that you have both stockpiling and stocking too much and the cost increases. This is the reason that companies have to develop their own inventory control model in order to prevent the probability function of demand. Today's modern enterprises give preference to demand in probabilistic stock control models, demand is random variable and is defined with the help of a probability distribution. In order to determine the function of the amount of demand, past demand data is used to discover. Periodic and continuous overhaul of proposed stock control models are classified according to their status. Periodic oversight models also have their own classification. It is divided into single period and multi period. (Martinich, 1997: 686-692; Chase and Apuilano, 1998: 475-489)

Since the scope of this study is deterministic models, it seems enough so much explanation about probabilistic models. The next part of study is about mathematical deduction of deterministic classical stock control models and derivation.

3.2. Derivation of Deterministic Static Stock Control Models

Basic assumption in deterministic static stock control models, planning the amount of demand is strictly known throughout the period and the rate of speed of demand is fixed. In these models, the planning period consists of equal cycle times. It is given an equal amount of orders per cycle (procurement or production order). Goal is that the economic order amount which makes the total cost minimum, in other

words, to find the volume of the party and therefore the time between orders cycle time. (Eroglu, 2002: 7)

Within deterministic static stock control models, there are four basic models known as classical models. These:

I. Economic Order Quantity Model
II. Economic Production Quantity Model
III. Economic Order Quantity Model in the case of Stock Disposal
IV. The Economical Production Quantity Model in the case of Stock Disposal

All these models are based on two important functional relationships. (Tersine, 1998: 94, Karaoz, 2003: 79-80) They:

I. Stock level is a function of time. That is, at a fraction of the time, the business stores goods with order or production and consumes them over time.
II. Total cost; the factors affecting the order size and production speed. For a cycle time, the total cost function is created by taking into account the cost elements that occur over time and the cycle time is calculated with the order / production amount that makes this cost minimum.

Under these two functional relationships, the mathematical derivation of the four classic stock control models which are mentioned above is carried out in this part of the study.

3.2.1. Economic Order Quantity Model

The Economy Order Quantity model is the most basic and simple model of all the stock control models. This model is based on a balance between fixed order cost and availability costs and is the basis for more complex models. In the model, the quantity ordered is received at the beginning of each cycle period, and the demand during the cycle period is fully covered from this stock. The following assumptions are made in the Economic Order Quantity model:

1. Supply duration is fixed or zero and independent of order quantity.
2. Demand is constant and continuous.
3. The purchase price (unit variable cost) is fixed.
4. Cost of inventory is a linear function of stock quantity.
5. Order cost is fixed for each order and independent from the order quantity.
6. Being out of stock is not allowed.

Demonstration of the Economic Order Quantity Model is shown in Figure 1.5. At the beginning of each cycle period, Q units are ordered and orders are delivered immediately (supply period is zero). This stock is then used to meet incoming demand and D is steadily declining at constant demand. The stock is reordered when the stock level drops to zero.

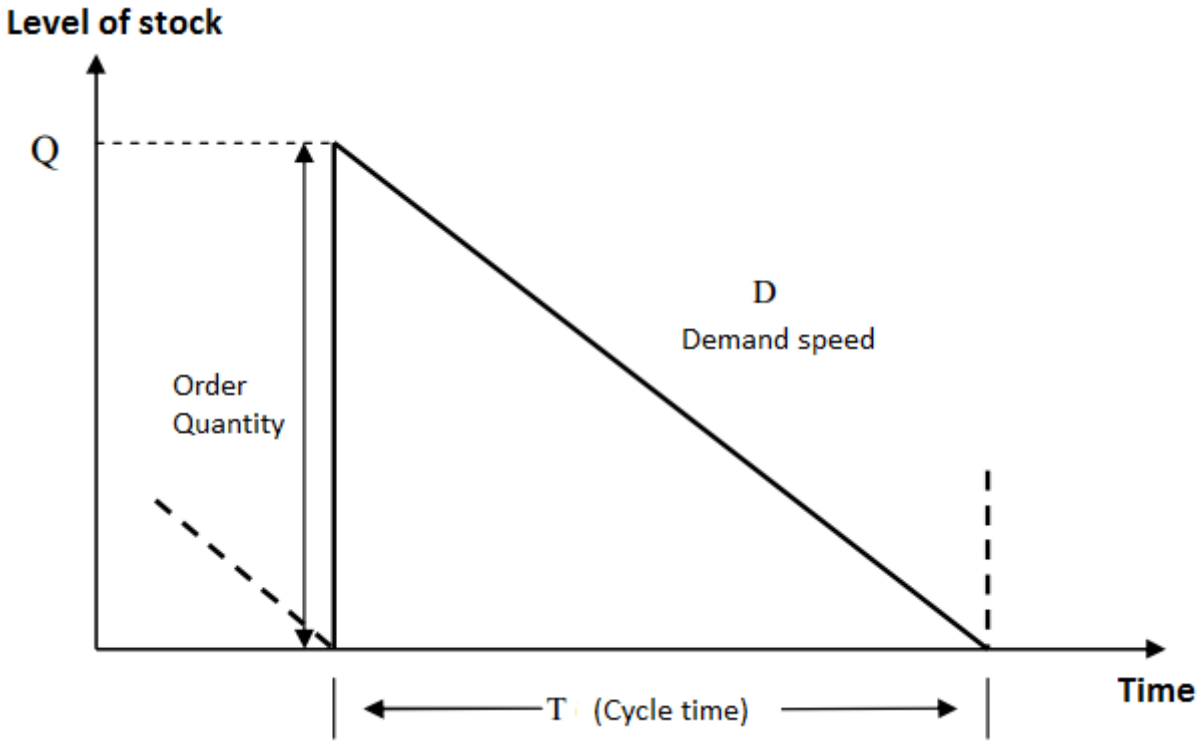

Figure 1.5. Change of Stock Level in Economic Order Quantity Model over Time

(Eroglu, 2003: 8)

The symbols used in the model are:

Q	Quantity ordered (units)
D	Demand speed (unit / unit time)
T	Conversion time (unit time)
c	Unit variable purchase cost

K	Order cost
h	Unit cost of stock keeping
T	C Total cost
TCU	Total cost in unit time
Q*	Optimal order quantity
T*	Optimal cycle time

The aim is to find the amount of the economic order and cycle time which makes the total cost minimum.

Total cost consists of order cost, purchasing cost and stock carrying cost.

$$TC = \binom{Order}{Cost} + \binom{Purchasing}{Cost} + \binom{Carrying}{Cost}$$

3.2.2. Economic Production Quantity Model

In batch type production systems, the production of the same kind of products is done collectively in a certain volume. When planning production in the enterprises; the amount of goods produced at each party and to minimize production costs are taking into account in order to calculate the relevant data such as demand, inventory level and production rate to determine the most suitable size of batch. (Tersine, 1998: 121; Karaoz, 2003: 86)

The Economic Order Quantity model assumes that the total amount of stock is instantaneously obtained at a certain point in time. This assumption applies to all inventories purchased from outside or supplied from other parts of the enterprise. If an operation can be met at the moment of production (or if the production rate is too high for the demand rate), the Economic Order Quantity model is used in the planning. In the Economic Production Quantity model, unlike the Economic Order Quantity model, it is considered that inventories occur within a certain period of time. The production is going on in a certain period of time, and while some of the products produced in order to meet the demand, the remaining part is stored to meet future demands.

While the cost of each unit purchased in the Economic Order Quantity model is expressed as the unit purchase cost while in the Economic Production Quantity model, the unit production cost is the unit purchase cost as the goods are directly

produced by the enterprise. In addition, in the Economic Production Quantity model, the production cycle time is taken as the production lead time and the production ordering cost is taken as the production lead cost. (Karaoz, 2003: 86)

In the Economic Production Quantity model, the change in inventory level according to time is shown in Figure 1.6. In the model of economic production quantity; each cycle time consists of two phases. The first phase (t1) is the time interval during which the production is made, and the second phase (t2) is the period when the production is not performed. In the first phase, demand is met from production and more demand is kept in stock. The basic assumption here is that the speed of production is faster than the speed of demand. In the second phase, the demand is met from the inventory. The stock is exhausted at the end of the cycle and is passed to the other period.

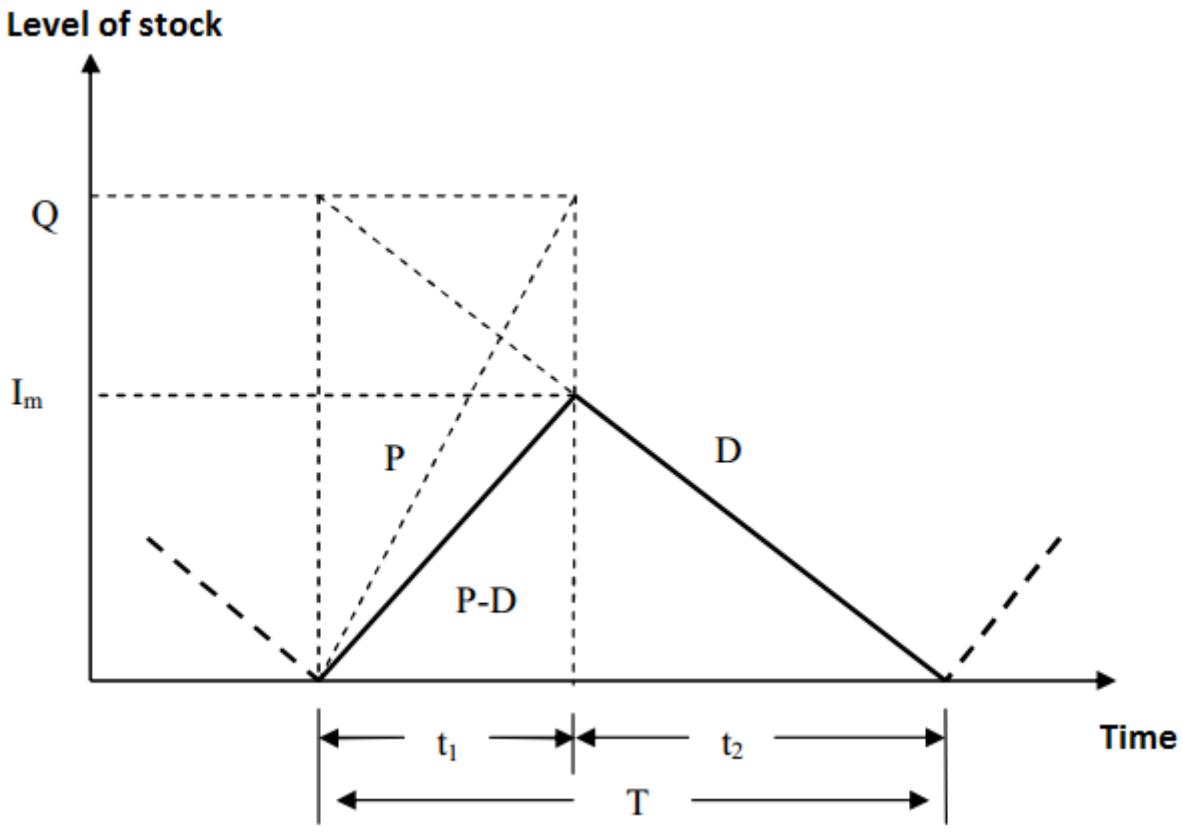

Figure 1.6. Change of Stock Level in Economic Production Quantity Model by Time

(Eroglu, 2003: 10)

3.2.3. Economic Order Quantity Model in the case of Stock Disposal

In the simplest economic order / production quantity models, being out of stock is not allowed. In other words, when inventory does not have any goods, the demand is fulfilled from this order and production as soon as new order or production goes into effect. In economic life, however, it is not always possible to meet demand, or allowing a certain amount of stagnation is more advantageous in terms of cost. With this in mind, the unacceptable part of a claim that occurs within a cycle is deferred to be met in the next cycle.

The function of the Economic Order Quantity model, which permits being out of stock, is shown in Figure 1.7.

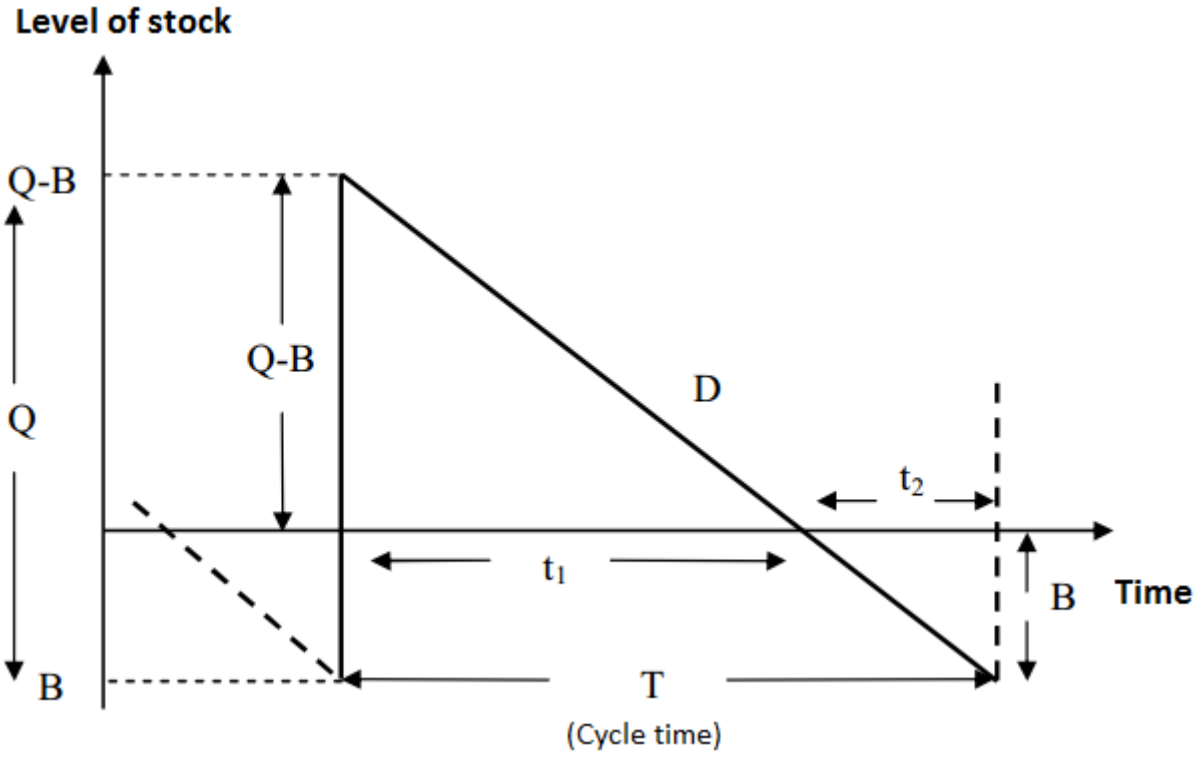

Figure 1.7. Change of Stock Level in Economic Order Quantity Model over Time in the Case of Stock Depletion

(Eroglu, 2003: 13)

In the model, a cycle consists of two phases. In the first phase, the demand is met from the stock, while in the second phase the entire demand is deferred to be met at the beginning of the next cycle.

3.2.4. Economic Production Quantity Model in the case of Stock Disposals

In the case of stock depletion, the function of the Economic Production Quantity model is shown in Figure 1.8.

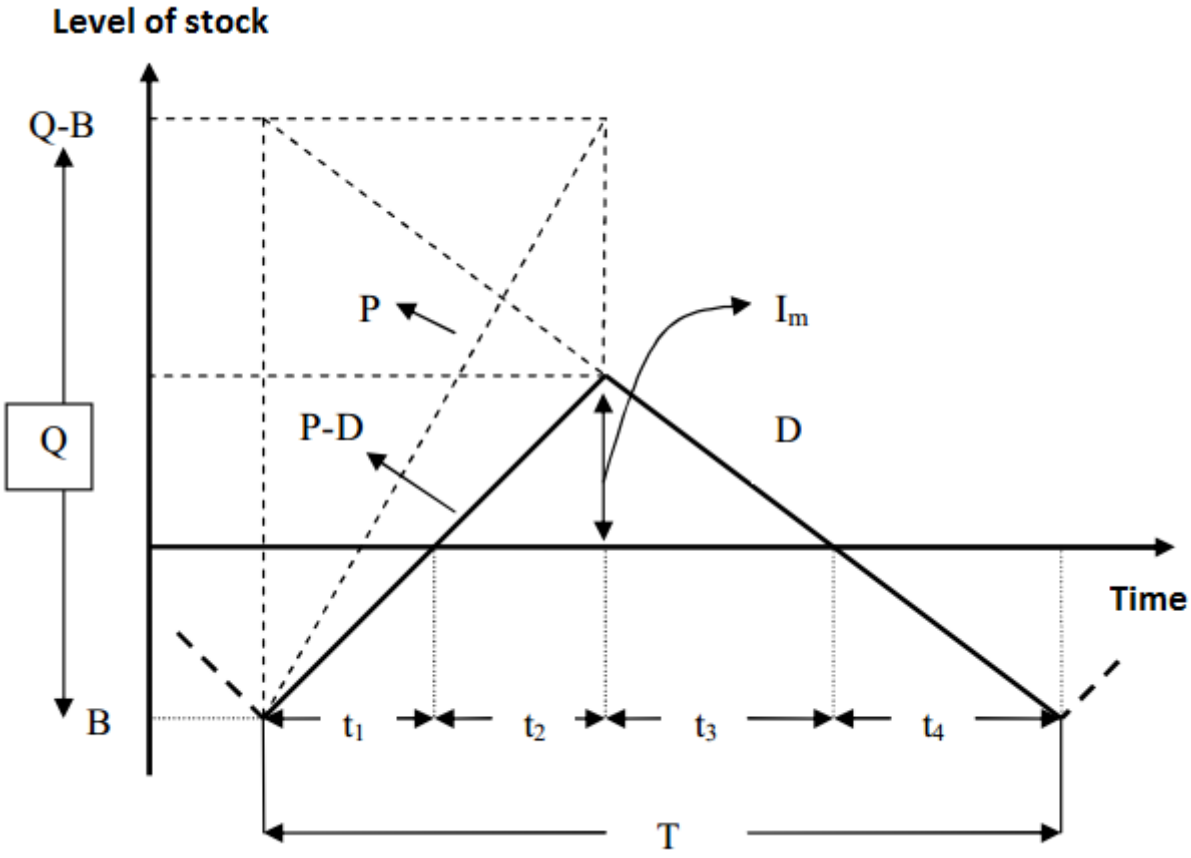

Figure 1.8. Change of Stock Level in Economic Production Quantity Model in Time of Stock Depletion

(Eroglu, 2003; 17)

In the model, a cycle time consists of four phases. The first and second phases cover the time intervals at which production is made, and the third and fourth phases

cover the time intervals at which production is interrupted. In the first phase (t_1), when the production is done, firstly the demand that is generated is covered and then deferred demand is satisfied during the previous cycle from the demanded production.

At the end of this phase, the entire deferred demand has been met during the previous cycle. In the second phase (t_2), the demand is met from the production and the production surplus is kept on demand. At the end of this phase the maximum stock level is reached. In the third phase (t_3), when production is not performed, demand is met from stock, and at the end of this phase, the stock in hand is exhausted. In the fourth phase (t_4), the resulting demand is postponed to be met in the next cycle. At the end of this phase, maximum level of stock-out is reached.

3.3. Relations between Deterministic Static Inventory Control Models

The optimal order and production quantities, the optimal cycle time and the maximum allowable amount of being out of stock quantities obtained from the derivation of deterministic static stock control models are summarized in Table 1.1.

Table 1.1. Optimal Values Obtained in Deterministic Static Stock Control Models

Economical Order Quantity Model (O Model)	Economic Production Quantity Models (P Model)
$Q_O^* = \sqrt{\frac{2KD}{h}}$ $T_O^* = \sqrt{\frac{2K}{hD}}$	$Q_P^* = \sqrt{\frac{2KD}{h\left(1-\frac{D}{P}\right)}}$ $T_P^* = \sqrt{\frac{2K}{hD\left(1-\frac{D}{P}\right)}}$
Economic Order Quantity Model in the case of Stock Disposal (SDO Model) $Q_{SDO}^* = \sqrt{\frac{2KD}{h}}\sqrt{\frac{h+\pi}{\pi}}$ $B_{SDO}^* = \sqrt{\frac{2KDh}{\pi(h+\pi)}}$ $T_{SDO}^* = \sqrt{\frac{2K}{hD}}\sqrt{\frac{h+\pi}{\pi}}$	Economic Production Quantity Model in the case of Stock Disposals (SDP Model $Q_{SDP}^* = \sqrt{\frac{2KD}{h\left(1-\frac{D}{P}\right)}}\sqrt{\frac{h+\pi}{\pi}}$ $B_{SDP}^* = \sqrt{\frac{2KDh}{\pi(h+\pi)}\left(1-\frac{D}{P}\right)}$ $T_{SDP}^* = \sqrt{\frac{2K}{hD\left(1-\frac{D}{P}\right)}}\sqrt{\frac{h+\pi}{\pi}}$

In the next part of the study, new expansions emerged in stock control models are discussed. Particularly, the studies that allow delay in payment and address the situation of defective product are examined in detail and in the last part a new model proposal is made.

Chapter 4. New Expansions in Stock Control Models

4. New Expansions in Inventory Control Models: Allowing Delays in Payments and Defective Product Status

The Economic Order and Production Quantity models used by enterprises to determine their production and order decisions have been widely used since the early 20th century. However, this model has many weaknesses. The weakest part of these models is assumptions that do not reflect real life. Some of these assumptions; demand and production speed are fixed and known, products are not deteriorated and there are no defective products, it is the only product, time value of money, inflation and learning effect are neglected, and payments are made in advance during the delivery of the goods.

From the point of view of today's businesses, it seems that the model to be established with these assumptions is far from representing real life. As a result of this situation, studies on Economic Order and Production Quantity models were carried out under conditions that can be represented by real life by expanding these assumptions or adding new assumptions, and a large literature has emerged.

In this part of the study, these new developments are first discussed in general and the studies carried out are mentioned. Later on, the model developed in this study examines in detail with the permissible delay conditions, the defective product status and the work done in this topic is analyzed.

4.1 New Assumptions

The classical assumptions in the deterministic static inventory control model and the new expansions resulting from the relaxation of these assumptions are summarized in Table 2.1.

Table 2.1. Basic Assumptions of Economic Order and Production Models and New Developments in These Models

	Basic Assumptions	**New Developments**
1	There is only one product.	New models are being developed for multiple products.
2	Being out of stock is not allowed.	Being out of stock is allowed.
3	No deterioration of the products in the stock is possible.	The products in the stock are deteriorating over time.
4	The amount of demand is fixed, continuous and definite.	Different claim functions are discussed, where the claim is variable.
5	Quantity is not reduced.	The amount is reduced.
6	Production speed is constant.	Production speed changes.
7	The time value of the money and the effect of inflation are not considered.	The time value of the money and the inflation effect are taken into consideration.
8	The learning effect is not included in the model.	Learning effect is included in the models.
9	Payments are not allowed to be delayed.	Payments are allowed to be delayed for a certain period of time.
10	Commodities arriving after the order or produced are perfect and error-free.	Commodities arriving after the order or produced goods contain defective products in a certain order.

Although all new developments and approaches are not limited to these tablatures, detailed information on these initiatives, which form the basis of the essence, are given below.

4.1.1 Multi Product

Many inventory control models deal with the problem of determining the stock policy for only one product. The most common and simplest economic order and production models for use and implementation are based on this basic assumption.

However, in real life, many businesses make decisions about hundreds or even thousands of products. In this case, it is difficult or even impossible to develop a separate model for each product and bring them together to follow a stock policy. For this reason, different approaches have been developed for multiple products. These are the limited resource models. Another approach is to determine the inventory control policy by grouping the products or by making a general aggregation. (Nahmias, 1997: 242)

In multi-product stock control models under resource constraint, stock problem is considered as constrained optimization model and solved using Lagrange multiplier method. Raw material constraints, storage space constraints, machine and labor capacity and stock investments are considered as resource constraints in these problems. In many applications, these models are used under one or two constraints. (Siper and Bulfin, 1997: 234)

Rosenblatt and Rothblum (1990), Maloney and Klein (1993) and Ziegler (1982) can be considered for solving multi-product stock control problems under a single constraint. Haksever and Moussourakis (2005) and Bretthauer vd. (2006) have developed an algorithm for the general solution of very limited and multi-product stock control models.

The ABC method is the most commonly used method for grouping and controlling the products. With this method, a small portion of the stock items with a high share in value is identified as more important and more controlled. On the other hand, the minority, which constitutes the majority of the inventory items but contains very little of the stock value, is less important. The main purpose of dividing the products into groups in this way is to determine the importance level for each product. Thus, businesses can save inventory control functions at a lower cost than controlling products one by one, saving both time and cost. (Chase and Aquilano, 1981: 490)

4.1.2 Allowing Stock-out

Being out of stock is not allowed in the classic economic order and production quantity models. In reality, in most cases, the demands are not able to meet on time and the being out of stock is reduced. There are two results of the being out of stock. These are that the loss of sales after all claims which are not met are deferred to meet in the future or the claim is never met. In practice, these two extremes, and as a combination of them, in the case of stock-out, some demand is postponed to be met in the future and some customers are lost. (Silver vd., 1998: 234; Demir and

Gumushoglu, 1998: 600) This situation is treated as partial stalking or partial deferral in the literature.

When the studies dealing with the stock-out are examined; As an example of models that deal with the full postponement situation; Elsayed ve Teresi (1983), Grubstrom and Erdem (1999), Cardenas-Barron (2001) and Eroghlu and Ozdemir (2007) studies can be given. Partial deferral cases are Abad (1996; 2001), Wee (1999), Skouri and Papachristos (2002), Giri vd. (2005), San Jose vd. (2005) and Dye (2007) studies. The loss of sales is addressed in two separate studies by Sandbothe and Thompson (1990: 1993). Padmanabhan and Vrat (1990) and Abad (2000, 2003) have discussed being out of stock and loss of sales together.

Whatever the outcome, there is a cost of not having stock, and the cost items such as loss of sales, loss of customers and loss of prestige are among these cost items. In practice, it is difficult to calculate these costs and most businesses prefer not to fall into being out of stock. The reason is that their size is not predicted. These locations have a stockpile of stocks called safety stocks. So, they do not fall into situation when companies are out of stock. According to the faulty product release, deficiencies in demand forecasts, disruptions in distribution, and other unexpected reasons. Thus, these enterprises are able to avoid the cost of stowage, which they are not able to accurately determine and save on the cost of holding a certain stock. (Waters, 1989: 77)

However, in cases where the cost of holding stocks is very high, allowing a stock-out is a result as a policy choice. For example, some requests may be postponed to be met in the future because it is not possible for the car salesman to have a car of his customers' choices.

In the economic order and production quantity models that address the stock-out situation, the total cost also includes the cost of being out of stock. The model also assumes that in the event of a stock-out, the customer does not withdraw his claim and waits for the next order to arrive. So, in this case, all unmet demand is met at the beginning of the next period and there is no loss of sales. (Evans, 1993: 467-468)

The change in stock level according to the time in the economic order quantity models is shown in Figure 2.1 if the being out of stock is allowed.

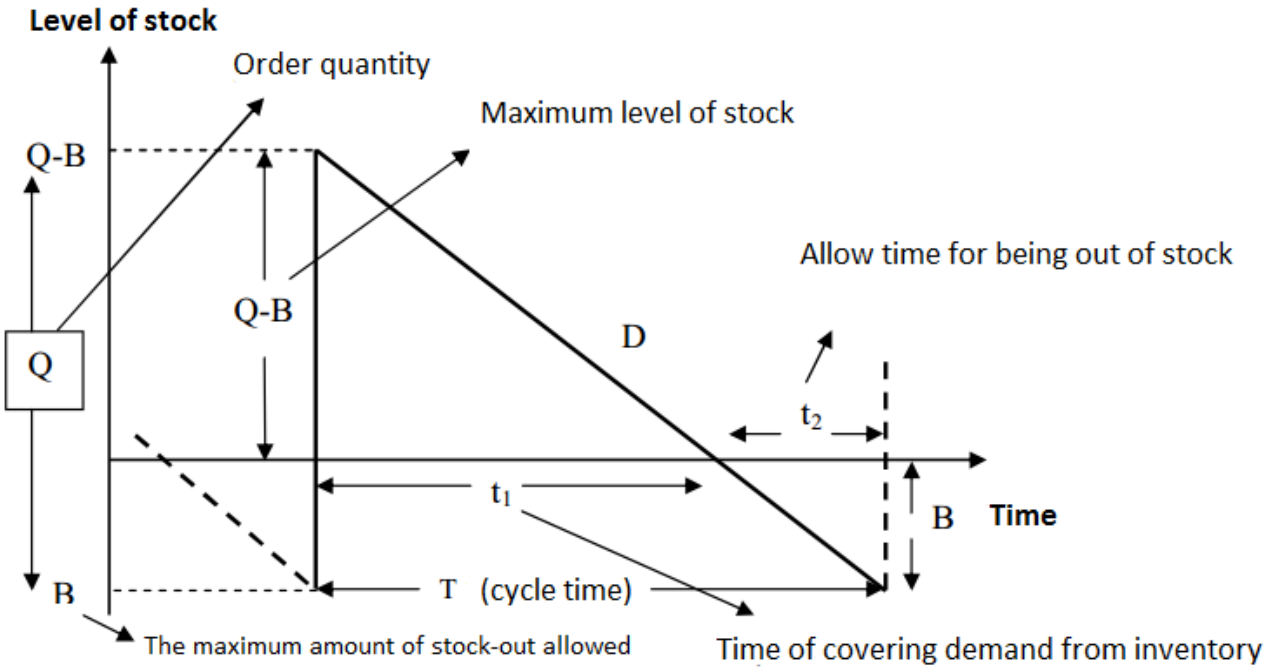

Figure 2.1. Change of Stock Level According to Time under the Condition of Allowing Stock-out

(Eroglu, 2003: 13)

A cycle time consists of two parts, if the stock-out is allowed. In the period t_1, demand is normally provided from the stocks in hand, and at the end of this period, the stock in hand is depleted. In the period t_2, the demand is delayed to meet the next order. When the next order arrives, the demand that was deferred due to the stock-out from the previous period is used as the maximum stock amount for the demand received during that period.

4.1.3 Deteriorating of Stock in Time

Classic inventory control models assume that goods can be stored intact to meet future demands. However, some types of goods may deteriorate over time or become out of fashion by passing through fashion. For example, goods such as fruits and vegetables, meat, perfume, alcohol, gas, photographic films that have a short life span are deteriorating in normal shelf life. For this reason, if the rate of deterioration is not small enough, the effect of the deterioration on the economic order quantity models will also be important. Therefore, this situation should be included in the stock control models. (Goyal and Giri, 2001: 1)

In the models dealing with deterioration, stocks are grouped into three main categories: obsolescence, deterioration and others. Being out of fashion mode is that

the rapid change in technology for a product or the loss of the value of entering into a new product market; product damage, deterioration, drying and evaporation. These deformed products have the maximum life span of goods such as green vegetables, blood, photographic film, and these goods are easily perishable goods. There is no shelf life for goods such as alcohol, gas and radioactive, and these goods are called deteriorating goods because they are decreasing in quantity over time. The goods whose shelf life is uncertain are entering the group outside of deterioration and fashion. (Goyal and Giri, 2001: 1-2)

Since there is no reordering for the finished products, too many inventory control models have not been developed for these goods. Cobbaert and Oudheusden (1996) and Beek vd. (1985) developed some works and these can be example for this situation.

The time chart of stock level in the economic order quantity models under deterioration condition is shown in Figure 2.2

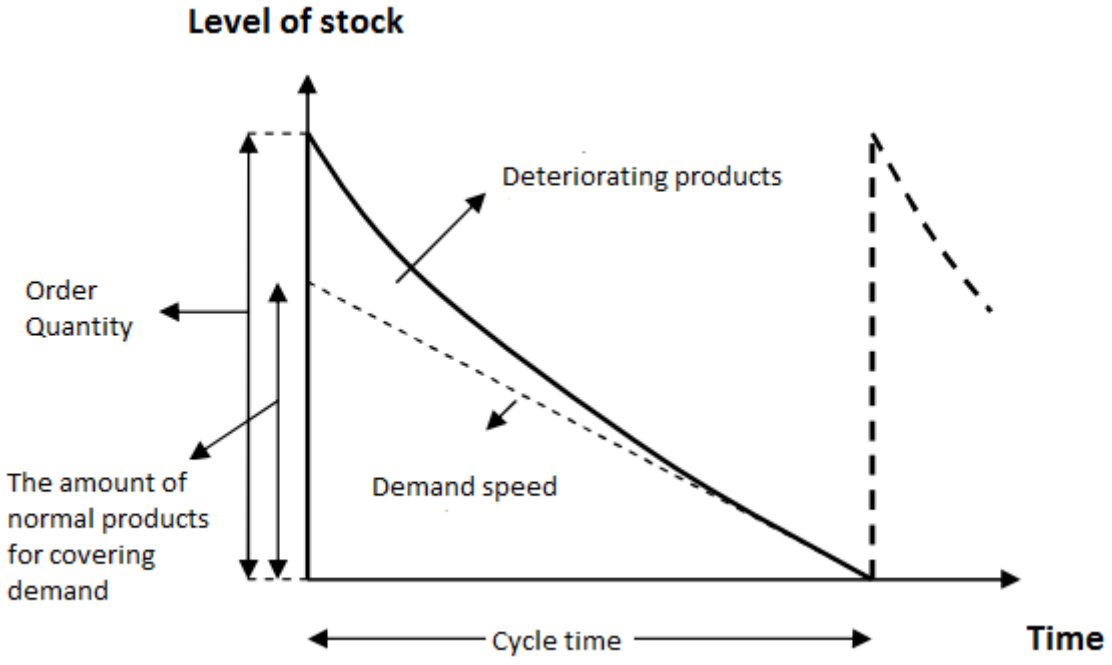

Figure 2.2. Change of Stock Level According to Time under Deterioration

(Hwang and Shinn, 1997: 541)

According to this figure, some of the products that arrive at the end of order are deteriorating with time. The current demand is met by products that remain intact

after the deterioration. The demand rate is indicated by a dashed line, while the decrease in stock level is indicated by a dark curve line.

4.1.4 Having Different Demand Functions

There are many models that are developed under different functions of the claimant which is the main determining variable in stock control models. In classic models, the quantity of demand is known definitely, it is constant and continuous in all periods. In practice, the demand function can be variable, intermittent and probable.

In stock control models, demand is a variable that takes values depending on the time, and it shows a time series feature in this direction. Therefore, elements such as level, trend, seasonality, cyclical movements and random change that are found in a time series are also valid for demand, and the demand is among the reasons why a period is different and probable. (Gaither, 1992: 74) On the other hand, as in the case of material requirements planning, where the raw material and semi-finished goods are tied to the final goods demand, the demand has a partly structure.

Since the case of demand which has disruption and possibility is not included in the study, here only the case where the demand is continuous is discussed.

Many deterministic economic order and production quantity models have been developed under different demand functions as a consequence of the variability of the demand structure (with the assumption that the demand is constant). These developed models can generally be grouped under three headings. (Karaoz, 2003: 101-102) They are:

- Models that assume that demand depends on the selling price of the goods
- Models that claim demand depends on time
- Models that assume demand depends on stock level

4.1.4.1. Models that assume that demand depends on the selling price of the goods

Under the assumption that the demand is tied to the selling price of the goods, the issue of price reduction of the seller in case of placing orders over a certain amount was taken into consideration and it was seen that the low price increased the customers' order quantity.

As an example of economic order and production quantity models that consider demand quantity as a function of selling price of goods; Wee (1997), Wee and Law (2001), Chen and Chu (2001), Mondal vd. (2003), You (2006), Dye vd. (2007).

4.1.4.2. Models that claim demand depends on time

Many studies have addressed the problem of changing over time because it is a time series feature of a property. Regardless of the source of this change, different inventory models have been developed as a result of the claim being treated indirectly as a function of time.

Examples of studies on this subject are Wee (1995), Hariga (1995a, b), Teng (1996), Giri vd. (2000), Sana and Chaudhuri (2000), Khanra and Chaudhuri (2003).

4.1.4.3. Models that assume demand depends on stock level

In some cases demand is also considered as a function of stock level. Especially the amount of goods exhibited for the customer's viewing and the presence of many items on the shelf in the supermarket or supermarket are thought to affect the purchasing preference of the customer positively.

Inventory models developed for the case where demand depends on stock level. Bhunia and Maiti (1998), Giri and Chaudhuri (1998), Chung vd. (2000), Chung (2003), Zhou and Yang (2005), and Urban (2005) are mentioned this in their study.

4.1.5 Amount Discount

In classical economic order quantity models, it is assumed that the unit variable or cost of purchase is constant regardless of the order quantity. However, when a large quantity is ordered, the supplier (seller) can go to the price reduction. This price reduction is in two different forms. These are the normal price for the buyers who place orders over a certain amount, and the lower price after this amount. In the latter case, it is the buyer who orders over a certain amount to give all the products at a lower price. (Zipkin, 2000: 55-57)

The most important and expected effect of the price discount on the stock control model is to increase the order quantity. The reason for the supplier to offer such an alternative is to take advantage of the increased order quantity economics of the aftermarket economies. Thus, while price reductions provide an attractive opportunity for new customers, existing customers are encouraged to place more orders at the same time. Despite being handled in many studies, comparing price

reductions with alternatives such as allowance for late payments policy, there was no consensus on the real reasons for price reduction in practice. (Zipkin, 2000: 58)

Looking at the work done in this regard, Kim and Hwang (1988), Abad (1988), Hwang vd. (1990), Burwell vd. (1991), Tersine and Barman (1991) have discussed traditional price and quantity reduction. The policy of being allowed to delay payments later is considered and evaluated as an alternative approach to quantity reduction. Arcelus vd. (2003; 2001), Sheen and Tsao (2007), Sana and Chaudhuri (2008) are comparing the price reduction and the delay in payment.

4.1.6. Variability of Production Rate

In classical models, it is assumed that the unit production rate during the period is constant, especially in the economic production quantity models. Many new models have been developed with the fact that the speed of production may vary due to the relaxation of this hypothesis since real life does not fully reflect. In these models, the speed of production is assumed to change with learning, over time, stock level and student dependent. (Karaoz, 2003: 98)

When these studies on stock control models are examined, the situation that the production speed depends on time is taken into consideration in the studies of Balkhi and Benkherouf (1996), Balkhi (1999), Goyal and Giri (2003).

Chowdhury and Sarker (2001), Sharma (2006; 2004) and Silver (1995) studied the situation that production changed depending on the student. Bhunia and Maiti (1998; 1999), Kar vd. (2001) and Su and Lin (2001) have developed economic production quantity models in the sense that the production rate depends on demand and the stock level in hand.

The effects of the learning on the production rate have also been studied in many studies. (Jaber and Bonney, 1999, 2003, Alamri and Balkhi, 2007) In these studies, unit production costs are assumed to be reduced over time due to learning in production, so that it is emphasized that learning is inevitable and unit production speed is not fixed due to learning effect.

4.1.7. Time Value of Money and Effect of Inflation

The effects of inflation and time value of money are not taken into consideration in classical stock control models. The reason for this is that inflation is not so much affected by the cost and prices. (Ray and Chaudhuri, 1997: 171). However, the fact that many countries, especially after the financial crises in our

country and in Asia, Russia and South America, are influenced by high inflation and the inflow of money in these countries, the inflation and the time value of money, has led to the work being done on this issue. (Chung and Lin, 2001: 68)

The effects of inflation on economic order quantity models were first addressed by Buzacott (1975) and Misra (1975; 1979). Later on, many researchers have developed many new models under different circumstances, such as time value of money, different inflation rates, end supply situation, deterioration and stoke, from these studies. In these studies, Sarker and Pan (1994), Hariga and Ben-Daya (1996), Moon and Lee (2000), Moon vd. (2005), and Hou (2006).

By using approaches such as net present value and discounted cash flow used in the present value of future cash flows, cost and price elements are eliminated from interest and inflation effects. (Eroglu 2002: 31)

4.1.8. Learning Effect

In classical stock control models, the effect of learning is not included in models, especially in economic production models. In these models, it is assumed that the preparation and unit production times are fixed and independent of the production quantity. This assumption applies only when production is made only by machines. But in a production system, besides machines, human labor is also used and it is observed that the performance of a worker in repeated jobs improves with time. This is described as a learning curve and is described as the reduction of effort required to produce each unit in repeated operations. In other words, as the amount of production increases, there is a decrease in the preparation and unit production periods and hence the cost of learning. (Eroglu 2002: 49)

The effect of learning on models of economic production quantities was first addressed by Keachie and Fontana (1966), and much work has been done to present.

Sule (1978) developed a new model considering the effect of learning in the model of economic production quantity, as well as the effect of forgetting. Salameh vd. (1993) used the Wright learning curve to analyze the effects of learning on total cost and order quantity. Jaber and Bonney (1996) developed this study by adding effects of forgetting. Later, Jaber and Bonney (1999) conducted a comprehensive literature search on the studies of the learners' effects on the inventory control models. Karaoz (2003) developed five different models of economic production under the influence of learning. Apart from these studies, Jaber and Bonney (2003)

and Alamri and Balkhi (2007) studies can be used to study the learning effect in stock control models.

4.1.9. Allowing Delays in Payments

In the Classic Economic Order and Production Quantity models, it is assumed that the payments were made in advance during the delivery of the goods. In practice, some delays are allowed in payments.

The fact that payments are allowed to be delayed has been studied in many works in the literature with simple and different assumptions. One of the basic assumptions of the model developed in this study, the studies and results about allowing the delay in payments are discussed in detail in this section.

4.1.10. Defective (Faulty) Product

One of the basic assumptions in the Classic Economy Order Quantity model is that all of the finished products are perfect and error-free. However, in real life, this hypothesis is not fully achieved. This is because some of the products resulting from the negativities arising during transportation both during production phase and after production fall into defective and faulty conditions.

Defective product status has been discussed in many studies in the literature. In this study, the study and results of the second stage of the model developed and the defective product status which constitutes the basic assumption are discussed in detail in the next sections.

4.2 Delay in Payments and Defective Product Status: Literature Review

There are many basic assumptions that are dealt with in the classical economic order quantity models and are not acceptable for real life. One of them is that the payments are made in advance during the delivery of the goods, and the other products are orderly and normal. However, in real life payments are allowed to be delayed for a certain period of time and incoming orders contain defective products in a certain order. As a consequence of this situation, in many studies the delay in payment and the defective product status have been handled separately, and many studies have been carried out separately (Zipkin, 2000: 58, Salameh and Jaber, 2000: 60; Huang, 2007: 911, Eroglu and Ozdemir, 2007: 544) As a consequence of this situation, many studies have been delayed in payments and the defective product status has been dealt with separately and new models have been developed with many

special cases in mind. There is only one study and model that deals with both the delay in payments and the state of the defective product.

In this part of the study, studies are being undertaken that deal with delayed payments and address defective product status.

4.2.1 Delay in Payments

Many studies have been made under the assumption that payments are delayed for a certain period of time by expanding the assumption that the payments are made in cash during the delivery of the goods, which are dealt with in the classical economic order quantity models.

In all these studies, it is assumed that payments are allowed to delay for a certain period of time. In this case, which often happens in practice, sellers allow customers to delay their debts by a certain amount of time (say 30 days). Generally, no extra payment or interest accrues to the payments of customers who have paid debts during this period. Therefore, buyers earn an income by investing the money they have earned from the sales they have made during the period in the income-generating business, for example. For this reason, buyers postpone their payments until the end of the allowed delay period. However, if all of the payments are not paid by the end of this period, interest is charged at a specified interest rate on the remaining amount. (Chung, 1998: 49)

There are many benefits for both seller and buyer to allow delay in payments.

One of the two important benefits that payment to let sellers allow for delay in payments; allowing payments to be delayed is to attract new customers. Because this delay for the customers, such as price reduction type, a kind of cash advance offers the opportunity to get a term. In this case, customers will place more orders once they buy more at once, since they will indirectly reduce their purchasing costs. (Liao and Chen, 2003: 245) Furthermore, since receivers paying for the benefit of the allowable delay in payments will make their payments more regularly, the seller will be able to more easily collect his money on the receivers. Thus, unpaid sales will also be reduced.

The second reason for letting buyers delay payments is that it is the most possible to reduce the fluctuations in the demand by this policy. That is, seasonal and periodic fluctuations in demand can be avoided by keeping demand alive by allowing payments to be delayed in periods where demand is low. (Chang and Teng, 2004: 471)

However, there is also a risk dimension that allowing a delay in payments is a cost of the seller - the opportunity cost of the capital - as well as the cost of this money - as the money is not collected. (Teng, 2002: 915)

From the point of view of the buyers, they receive interest income at a certain rate by evaluating them in the account of the income deposits obtained from the goods they sold because they did not pay within the allowed delay period. For this reason, buyers want to keep their payments at the highest level, postponing their payments until the end of the allowed delay period. (Huang, 2007: 911-912)

In addition, allowing payments to be delayed indirectly reduces the cost of purchasing and stocking of buyers. Because the payment for capital stock held in this period and the capital investment are postponed, the opportunity cost of the capital will be less.

On the other hand, the cost to the buyer to allow delay in payments is that at the end of the loan period, if the payments are not made at the end of the loan period. (Huang, 2006: 1578; Ouyang vd., 2005: 292Teng, 2002: 916; Chung, 1998: 49-50)

The next part of the study will focus on models of economic order and production quantities developed under the condition that payments are allowed to be delayed from the beginning of the 1970s until this time.

The issue of allowing delay in payments has been subject to examination under different expressions in the literature. A lot of work has been done in the last 30 years on this topic, which is regarded as a trade credit, a credit period or a credit policy and permissible delay in payment. These studies, which are conducted under these two approaches, which address the same theme as the essence, are discussed below.

The model of economic order quantities under the credit period or credit policy was first dealt with by Haley and Higgins (1973). In the case of Halley and Higgins (1973), they developed a new economic order quantity model, assuming that the buyer has a loan policy for investing in additional stock, if the demand is fixed. In this case, in terms of cost minimization, they show that the order amount and the payment time should be modeled simultaneously. In the model, a certain period of time is not assigned for the credit period, and the payment time and optimal order quantity are considered as dependent variables.

Later, Kingsman (1983) suggested that the buyer may have two ways to pay the order amount. According to him, payments must either be made within a certain period of time (within 30 days after delivery of the goods) or until a certain day of the

month following the delivery of the goods (for example, if the delivery of goods is made in any month in March, payments are due until 15 April). Thus, the bills to be arranged in terms of the seller are preferred on the same day of every month. It is more appropriate for the buyer to order the orders on a monthly basis. Kingsman (1983) developed a model that would help determine the order policy under the second case, which is frequently encountered in practice but is not overworked. The optimal order quantity is increased if the model is allowed to delay payments. The model, when considered in terms of total cost, provides an important contribution in that it is more consistent with the application, while not providing much savings compared with the classical models, and is a model that does not need rigid assumptions in the classical models.

Goyal (1984) made some corrections in his study of Kingsman (1983). One of these corrections is that the borrowing and lending interest rates, which are equally different in the Kingsman (1983) model, are different from each other, and that the cost of non-opportunity costs is also included in the cost elements other than the opportunity cost.

Chapman vd. (1984) make some notes in Kingsman's (1983) studies and give comments to the importance of credit policy in stock control models and some contributions to the model. As a result of the analysis of the length of the credit period for four different situations, the length of the credit period shows that the total cost has decreased and the optimal order amount has increased.

Davis and Gaither (1985) and Arcelus and Srinivasan (1992) have developed a mode for determining the optimal order quantity for certain commodities, or when it is allowed to delay on a one-off payments for receivers that order more than normal. Davis and Gaither (1985), in which the optimal order quantity is analyzed under six scenarios, is quite sensitive to the cost of stock keeping and the changes in demand but not to the extent of the changes in the ordering cost and unit purchase cost. They also show that the lending of loans for one time reduces the unit purchasing cost, the optimal cycle time.

Daellenbach (1986), Halley and Higgins (1973), Kingsman (1983) and Chapman vd. (1984) studies can be applied under certain conditions and the results they find are not always valid, but only when certain conditions are met. According to Daellenbach (1986), the optimal order quantity in the case of credit policy is not higher than the values obtained in classical models, unlike the results obtained in the above studies.

Later, Ward and Chapman (1987), Daellenbach (1986), responded to criticisms of previous studies and explained the points of error. On this study, Daellenbach (1988), Ward and Chapman (1987) responded to three different criticisms of the 1986 study separately, explaining the reasons for misunderstanding.

Goyal (1985) is the first person who has a study to theoretically examine and examine the effects of the allowable lag time on payments on the quantity of economic order model. With this model, Goyal (1985) concluded that the allowable delay time for payments was reduced by the total cost of increasing the optimal order quantity. Goyal (1985) study assumes unit purchase cost equals unit sales price. Dave (1985) objected to the Goyal (1985) model, stating that this assumption is not very realistic and that the selling price is always somewhat greater than the purchase price. The same situation was later addressed in the article of Teng (2002), but this viewpoint of Dave (1985) was not noted and mentioned in the literature.

Chand and Ward (1987) re-examined Goyal (1985) in the classic EOQ framework and obtained different results.

Shah vd. (1988) developed a new model by developing Goyal (1985) model to allow stoichiometry.

In Mandal and Phaujdar (1989) Goyal (1985), sales have developed new models of economic order quantities that allow for late payments, taking into account the resulting interest income.

Chen and Chuang (1999), Bregman (1992), Rachamadugu (1989) and Chung (1989) used the discounted cash-flow approach to determine optimal stock policy under the credit period.

Allowance for delay in payments is dealt with in many studies with deterioration. These include; Shah (1993) and Aggarwal and Jaggi (1995) have also developed the Goyal (1985) model to include deterioration. Chu vd. (1998), Aggarwal and Jaggi (1995) as a correction to the study of the total cost functions in stock models. From this, it is proved that the aggregate cost function of Aggarwal and Jaggi (1995) model has a piecewise-convex property.

Kim vd. (1995), Shinn (1997), and Abad and Jaggi (2003) have developed an optimum credit policy for buyers and sellers to maximize profits when the demand is a function of selling price. Kim vd. (1995) considered that lending and borrowing costs are equal in their work, Shinn (1997) concludes that the assumption is relaxed and that the borrowing rate, which is more common in practice, is equal to or higher

than the borrowing rate and the length of the loan period affects the order quantity is reached. Abad and Jaggi (2003) evaluated the same problem in the context of buyer-seller collaboration and obtained a more comprehensive model.

Khouja and Mehrez (1996), under the deterioration situation, have referred to the effects of the vendor's different credit policies on the optimal order quantity. In the credit policies they deal with for four different situations, the policy preference has examined the two situations in which the loan period is independent of the order quantity or is a function of the order quantity of the loan period.

Shah and Sreehari (1996) developed a new model for degraded products when storage capacity is limited and payments are allowed to delay.

Jamal vd. (1997) have also added to the modeling of Aggarwal and Jaggi (1995) to allow being out of stock and have obtained a new model. In the model they have developed, as the allowable delay time increases, the optimal order amount and cycle time increases and the total cost decreases with the maximum allowable amount of stock-out.

4.2.2. Defective Product

One of the basic assumptions in the Classical Economic Order and Production Quantity model is that all of the products that come to the end of the order or that are produced in-house are flawless and free from error. However, in real life, this hypothesis is not fully achieved. Because of both the reasons arising from the uncertainties in the production phase and the negativities that arise during transportation and transportation after production can be the result of defective and faulty products.

When studies on inventory control models up to this time are examined, there are many studies dealing with the defective product status. Most of these studies focus on the production of defective products due to defects in the production process and the monitoring and maintenance of the production process to remove this situation.

In this part of the workshop, brief information is given about the models and expansions that deal with the defective product and production status and developed up to this time.

It is inevitable that some of the goods produced as a result of the production process are defective and faulty. Because the production process is normally perfect

for a certain period of time, the quality and the low efficiency due to uncertainty and the machine and hardware failures are starting to produce defective products from the end point. These defective products may be reprocessed or they may become defective and become defective or sold at low price or completely useless. Optimal economic production quantities in most of the studies carried out in this area together with optimal monitoring and maintenance planning of the process are evaluated together.

Rosenblatt and Lee (1986) developed a new model of economic production under the assumption that the production system produces perfect products for a period of time (which is a random variant), but then begins to produce defective products at certain times. It is assumed that the system is out of control and exponentially distributed until it starts to produce defective products. In addition, defective products can be recycled at a certain cost in the same production process. The optimal economic output obtained from the model was found to be lower than the value obtained in the conventional economic production quantity model.

Porteus (1986) assumes that the process is likely to be out of control during the production of a unit product in the study of the effects of defective products on the classical economic order quantity. Porteus (1986) concluded that lowering the cost of preparation and increasing the quality of the process resulted in the reduction of the order quantity, the amount of defective product produced, and therefore the annual cost, in a study of process quality improvement and reduction of production preparation cost. Chand (1989) developed the model of Porteus (1986) to include effects on learning preparation frequency and process quality.

Lee and Rosenblatt (1987) developed a new model by adding continuous monitoring and maintenance to their studies of imperfect production. In the model, the control and monitoring schedule for the maintenance of the system and the determination of the economic production quantity are obtained simultaneously. This model deals with the problem of determining the optimum amount of production and the intervals at which the system should be watched. The result is that the tracking schedule and timing should be done in equal periods.

Cheng (1991) has obtained a new economic order quantity model for the situation under faulty production and the dependence of unit production cost on demand. For the problem formulated as geometric programming, Cheng (1991) obtained optimal solution values in closed form.

Hariga and Daya (1998) obtained distribution-specific and range-independent limit values for the overall distributions for the period until the system was out of control, plus optimal cost values. They then showed the validity of these values for both the exponential distribution and the Weibull distribution and conducted sensitivity analyzes.

Similarly, Kim and Hong (1999) have developed the Rosenblatt and Lee (1986) model by adding the assumption that the distribution of saline until the system starts to produce defective products out of control can match any distribution.

Lin (1999), as a model of economic production, deals with both the defective product situation in production and the resource constraint on raw materials. The aim of the model is to find the economic production amount which will make the cost of raw materials and finished products minimum. The model also assumes that the average time to system out-of-control is a function of the production preparation cost of the defective product ratio.

Hayek and Salameh (2001) hypothesized that the rate of defective products is the product of unit disintegration and that defective products are reprocessed into flawless products. The defect rate in the model they developed is a random variant and the defective products that are produced during production are processed again after production is stopped to perfection. Also, the model allows stoichiometry.

Ouyang vd. (2002) have addressed the issue of quality improvement under the conditions of production preparation cost and shortening of supply period. In the model that allows partial stoichiometry, the supply time is variable and optimal values are obtained for this case with normal distribution and independent from distribution.

Chung and Hou (2003), Rosenblatt and Lee (1986) and Kim and Hong (1999) have developed a new model based on their work. The model they have developed is also allowed to be stooped. In this model, where the optimal cycle time and the limit values for this time are obtained, it is assumed that the system is out of control. Chen and Lo (2006) have obtained a new model by adding the same warranty for repair warranties and warranty costs for defective products.

Wang and Sheu (2003) rethink the model of economic output under the stochastic condition and assuming that the system for the out-of-control system suits the general distributions and obtained the basic properties and limit values for optimal batch volume under different circumstances.

Chan vd. (2003) developed three models of economic production for the defective production state; produced products pass through 100% inspection and sorting process and are divided into perfect products, defective products and defective products. This separation process is based on the assumption that products are normally distributed. Accordingly, products whose quality specifications are outside the specified limits are considered defective. Those who stay outside the upper limit are left in the free market and those staying below the lower limit are returned to the state of quality products. The products whose quality specifications are within the specified limits but which are defective are sold at a low price. In this respect, this study is separated from other studies by showing the situation of separating to free, selling at low price and reprocessing in a single model.

Chiu (2003), Hayek and Salameh (2001) found some additions to the model. In the Chiu (2003) model, it is assumed that some of the defective products have been reprocessed and some of them have been reprocessed, and some of them have been sold at discounted prices without any treatment.

Eroglu vd. (2004) have developed a new model of economic production, stating that it is better to sell defective products at discounted prices instead of reprocessing them. This model assumes that the defect rate is uniformly distributed and that defective products are sold at a reduced price when production is stopped and that being out of stock is allowed.

Hou and Lin (2004), Rosenblatt and Lee (1986) have also introduced a new model of quality improvement. In this model, the quality of the capital investment for quality improvement and the effects on the cycle time are examined.

Lee and Rosenblatt (1989), Lin vd. (1991), Lee and Park (1991), and Liou vd. (1989) have proposed the optimal maintenance and monitoring schedule and the economical production model to regain control of the system in the event that the production process produces defective products. (2001), Ben-Daya and Makhdoum (1998), Wang and Sheu (2001), and Makis and Fung (1998) , Sheu and Chen (2004) and Lin vd. (2003).

In order to regain control of the system in the event that the production process produces defective products, the issue of optimal maintenance and monitoring charts and the economical production model is also discussed by Lee and Rosenblatt (1989), Lin vd. (1991), Lee and Park (1991), Liou vd. (2001), Ben-Daya and Makhdoum (1998), Wang and Sheu (2001), and Makis and Fung (1998) , Sheu and Chen (2004) and Lin vd. (2003).

The interruption of the production process for some reasons and the disruptions experienced in the final production are also covered within the scope of defective production. According to this, many models of economic production have been developed under the subjects which cause production failure such as machine malfunction and repair. As an example of these models, it is preferred to look at studies of Groenevelt vd. (1992a; 1992b), Berg vd. (1994), Srinivasan and Lee (1996), Chung (1997), Liu and Cao (1999) and Chakraborty (2008).

Conclusion

In order for an enterprise to work effectively and efficiently, it is necessary to supply the materials and materials that are used in production in time and in the required amount. Every business has to have some materials and materials available to them in order to perform production or to respond to the customers' request, based on their field of activity. In the most general sense, the stock is referred to as the stock of materials and materials that the operator has in his possession. The more important the production management function is within the functions of the operator, the more important is the stock control and management within the production functions.

Each business has different types of stocks according to its business activity. Inventory control and planning have a very vital proposition in inventory management, which is based on the cost of operating and the balance of non-inventory holding provided for production and sale or as post-production final product. In this framework, the main purpose of inventory control and planning is to determine the stock policy, which shows the quantity and timing of stocks. It is necessary to determine and use the methods necessary for achieving this purpose. Factors such as the nature of stocks, demanding characteristics, duration of supply, shed light on the determination of the stock system and methods to be applied. The best inventory management system foresees to have a stable stock according to the objectives of the operator and to meet the needs of the operator.

It can be said in this framework that businesses have to hold a certain amount of stock in order to carry out their business activities, to respond to customer requests and needs instantly, and to make profits in the end. In all stock control problems, the goal is to determine how much to order from each product and when to place these orders, making the total cost minimum.

Many methods and models have been developed to answer these questions. These methods and techniques, which range from simple methods such as visual control to complex models solved by computer, are subjected to different classifications. Among these methods and techniques developed for inventory control, inventory control models developed for solving complex problems have an important place.

The main determinant in the classification of stock control models is demand. According to the classification made according to the talebine structure, stock control models are divided into two as deterministic and probable models. The most

commonly used deterministic models are the economic order and production quantity models.

Many new models have been developed with additional assumptions or relaxation of existing assumptions, depending on the problem structure, since the assumptions in the classical economic order and production quantity models are insufficient to solve many real life problems. These approaches, which are dealt with as new expansions, are analyzing different situations such as many products, imperfect products, allowing payments to be delayed, deterioration of products in stock, learning, inflation and time value effects of money.

In this study, a new model of economic order quantity is developed from these new developments. The study consists of two parts. In the first chapter, stocks and stock control models under the heading of enterprises; inventory concept, inventory varieties, inventory costs, causes of inventory possession, stock control and management, stock control systems and stock control models are mentioned. In addition, this section also shows how to obtain mathematical models of classical deterministic stock control models.

In the second chapter, under the title of new opening to stock control models, economic orders and production quantities models, and studies on these developments. These expansions address the situation where the product is very productive, the goods in the stock are deteriorated with time, the different demand functions, the quantity reduction, the variable rate of production, the time value of money and the inflation effect, learning effect, delay in payment and the product being defective . Particularly, studies on the condition of delayed payment and the situation of defective product are examined in detail.

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