ANALYSIS OF THE INVENTORY MANAGEMENT PROCESS IN TURKISH GENERAL COMMANDERSHIP OF GENDARMERIE AND AN IMPLEMENTATION IN A TROOP THROUGH ANALYTICAL MODELING

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SEPTEMBER 2014

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A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
İZMİR UNIVERSITY OF ECONOMICS

BY
EMRE ÖZDEMİR

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ART

IN

THE GRADUATE SCHOOL OF SOCIAL SCIENCES

WITH THE PERMISSION OF THE TURKISH GENERAL
COMMANDERSHIP OF GENDARMERIE

SEPTEMBER 2014

Approval of the Graduate School of Social Sciences

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I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Art.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Art.

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Logistics is like breathing. You can only notice when it is stopped.

ABSTRACT

ANALYSIS OF THE INVENTORY MANAGEMENT PROCESS IN TURKISH GENERAL COMMANDERSHIP OF GENDARMERIE AND AN IMPLEMENTATION IN A TROOP THROUGH ANALYTICAL MODELING

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September 2014, 102 pages

Turkish General Commandership of Gendarmerie is facing problems with inaccurate inventory levels, which can lead to unnecessarily high inventory carrying costs or unnecessary consumptions. Currently, responsible personnel make the decisions, regarding the timing and the amount of ordering, arbitrarily. These decisions are based only on some brief procurement history and personal experiences. Here, we develop a system that is able to provide the purchaser with support in these and other related decisions. The purpose of this thesis is to give suggestions to the responsible personnel while decisions are being made. Two of the main questions are as mentioned:

- How many orders should be made each time?
- When to place an order?

The classification is based on the value of volume and demand frequency of the products. This will give a good starting point where someone decides which products do require the most effort. It is clear that while examining the two points, listed above, it becomes obvious that there are numbers of additional parameters involved. Examples of which are:

- Safety stock
- Replenishment methods
- Mode of transportation
- Warehouse selection.

All this parameters have some costs, of course. Despite most of them are always be considered, but there are some hidden costs, also. We uncovered them and examined the whole inventory and purchasing process by analytical modelling.

Keywords: Inventory Management, Inventory Costs, Safety Stock, Warehouse, Procurement, Consumption.

ÖZET

JANDARMA GENEL KOMUTANLIĞI'NIN STOK YÖNETİM SİSTEMİNİN ANALİZİ VE ANALİTİK MODELLEME YOLU İLE BİR BİRLİKTE UYGULAMASI

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Eylül 2014, 102 Sayfa

Jandarma Genel Komutanlığı, ihtiyaç dışı envanter bulundurma maliyetlerine ve gereksiz tüketimlere yol açabilecek hatalı stok seviyesi sorunlarıyla ile karşı karşıyadır. Mevcut durumda, "ne zaman?" ve "ne kadar?" sipariş verileceği ile ilgili kararlar sorumlu personel tarafından verilmektedir. Bu sorumlu personelin kararları onların kişisel tecrübelerine ve kısa tedarik geçmişine dayanmaktadır. Biz tedarik ve tedarikle ilgili diğer kararları destekleyebilecek bir sistem geliştiriyoruz. Bu tezin amacı; sistem sorumlu personele karar aşamasında öneriler getirmektir. Ana sorulardan ikisi şu şekilde belirtilmiştir:

• Her bir seferde ne kadar sipariş edilecek?

• Sipariş ne zaman verilecek?

Tezdeki sınıflandırma, ürünlerin hacim değerlerine ve talep sıklığına dayalı olarak seçilmiştir. Bu hangi ürünlerin üzerinde daha fazla durulması kararı ile ilgili iyi bir başlangıç noktası olacaktır. Yukarıda belirtilen iki soru incelendiğinde, herbirinin birçok ek parametreler içerdiği ortaya çıkmaktadır. Bunlara örnek olarak:

- Emniyet stoğu
- Tedarik metodları
- Taşıma usülleri
- Depo seçimi verilebilir.

Tüm bu parametrelerin maliyetleri bulunmaktadır. Bunların çoğunun, her zaman göz önünde tutulmasına rağmen bazı gizli maliyetler de vardır. Biz bu maliyetleri ortaya çıkartıp envanter ve satın alma sürecini analitik modelleme ile inceledik.

Anahtar Kelimeler: Envanter Yönetimi, Envanter Maliyetleri, Emniyet Stoğu, Depo, Satın Alma, Tüketim.

ACKNOWLEDGMENTS

I am using this opportunity to express my gratitude to my father, mother, brother and sister, who supported me throughout all my life. I express sincere appreciation to Asst. Prof. Dr. Muhittin Hakan DEMİR for his guidance and insight throughout the research. Thanks go to the other department member, Asst. Prof. Dr. Özgür ÖZPEYNİRCİ and Yaşar University faculty member Asst. Prof. Dr.Ahmet CAMCI for their suggestions and comments. J.Alb. Murat KINAY for understanding my frequent absences at work and for his advices. I am thankful to Ph.D. M.Deniz ÖZATA, for his invaluably constructive criticism and friendly advices.

To my wife, Funda ÖZATA ÖZDEMİR, I offer sincere thanks for her unshakable faith in me and her willingness to endure with me the vicissitudes of my endeavors.

VITA

Emre OZDEMİR was born in İzmir on July 10, 1979. He received his faculty degree in The Systems Engineering from the Kara Harp Okulu in August 2002. In 2012, he has started Supply Chain and Logistics Management Master Program. Since 2002, he has been working as a manager, in the difference logistics and supply departments in The Turkish General Commandership of Gendarmerie.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

This chapter contains background and purpose of the thesis. Furthermore the restrictions of our work are presented followed by reading directions to make the reading easier.

1. Introduction

All organizations have to keep inventory. “Inventory” includes raw materials of company or institution; work in process, supplies used in operations, and finished goods. Inventory can be simply described as a bottle of glass cleaner used as part of a building cleaning process or described in a more complex way, such as a mix of raw materials and subassemblies used as part of a manufacturing process.

Given that Turkish General Commandership of Gendarmerie keeps inventory for its’ different processes, it has the greatest importance in military. Considering the fact that the success rate would be very low if military did not have correct inventory. As Napoleon said “An army marches on its stomach”. Foça Gendarmerie Commando School and Training Center (FGCS) has a various inventory and it has a quick conversion rate. In the purchasing and inventory systems, there are some hidden costs (like ordering cost) that nobody consider them, when the replenishment plans are made. In this thesis, we examined Foça Gendarmerie Commando School and Training Center’s inventory and purchasing system as an example. This thesis is the first study dealing with the inventory management in Turkish General

Commandership of Gendarmerie, except some researches about the spare parts. If the thesis's results can be applied to the current system, it will provide huge amount of benefits to the Turkish General Commandership of Gendarmerie.

1.1 Background

Since the end of the cold war, there has been a shift in paradigm from large heavy forces to light and reactionary mobile forces. By then, dynamism and the forecasting capability of inventory management has become more and more important. Currently, it has been evident that Turkish General Commandership of Gendarmerie is facing problems regarding inaccurate inventory levels, which can lead to unnecessary inventory carrying costs or unnecessary consumptions. Recently the decisions about when and how many to order are made somewhat arbitrarily by the responsible personnel. And the responsible personnel make the decisions, regarding the timing and the amount of ordering, arbitrarily. Their decisions are based only on some brief procurement history and on personal experiences. This situation would be a possible reason explaining why decisions, made for inventory management, are problematic.

If we compare the meaning of "inventory" within Turkish General Commandership of Gendarmerie literature with the explanation provided above, "Inventory" gets the same meaning, basically. However, there are some differences, of course. The management of the process of procurement and inventory system in Turkish General Commandership of Gendarmerie is subject to the regulations, instructions and orders of Public Procurement Law and Public Procurement Contracts Law. Different inventory procedures have been developed to enhance inventory management in various purposes. With multiple product lines, inventory needs to be classified before making decision about inventory methods. In the current inventory management system, consumable materials are classified into ten sections:

- **i.** Foods and Drinks
- **ii.** Gas and Fuel Oil
- **iii.** Ammunition
- **iv.** Coal
- **v.** Cleaning Goods
- **vi.** Military Equipment
- **vii.** Healthcare Materials
- **viii.** Stationary Goods
- **ix.** Construction Materials
- **x.** Replacement Parts

1.2 Purpose

Here, we aim to develop a system, which is able to provide the purchaser with support in making the optimal ordering decisions. In order to achieve this; there are a large number of issues, which should be taken into consideration. The three main tasks are described below.

Calculate The Optimal Order Quantity: As mentioned above one of the key issues is to decide the optimal order quantity. Instead of having this as a subjective decision, we wish to base it more on facts and figures.

Calculate The Optimal Ordering Point: The timing of placing an order is described as having a big impact on the inventory levels. Since this decision is made in a similar way as the order quantity decision is, the same solution is anticipated – to base it more on facts than it is today.

Warehouse Selection: Another issue, which has to be taken into consideration, is that if an enterprise has more than one warehouse, where the products should be kept. When the product is ordered from the supplier, the decision regarding the shipping must be made. The basic decision concerns whether the product should be kept in only one warehouse or in multiple warehouses. We want to figure out for what products it is most cost effective to store in only one warehouse and for what it will be better to have in multiple warehouses. From the customer service point of view, due to inbound and outbound transportation costs, the decision has to be made for each product and should also be based on facts and calculated more or less automatically.

1.3 Mode of Procedure

In order to find possible suggestions to solve the problems mentioned above, we will explore the contemporary theories concerning these issues in the next chapters. Afterwards, we will discuss how these theories can be adjusted to the framework of Turkish General Commandership of Gendarmerie in a better way. Finally, our own reflections and recommendations for continuous work are presented in the last two chapter of the thesis.

1.4 Restrictions

When managing the process of procurement and inventory system in Turkish General Commandership of Gendarmerie, we have to follow some literature listed below;

I. Public Procurement Law

II. Public Procurement Contracts Law

III. Regulations of Turkish General Commandership of Gendarmerie

IV. Instructions of Turkish General Commandership of Gendarmerie

V. Orders of Turkish General Commandership of Gendarmerie

If we want to give an example of the restrictions, according to Public Procurement Law, unless there is an acceptable natural connection between them, purchase of goods, services and works cannot be consolidated in the same procurement. Procurement of goods, services or works cannot be divided into lots with the intention of avoiding threshold values. The procurement proceedings shall not be initiated unless there is a sufficient budget allocation (Turkish Public Procurement Law, 2014).

CHAPTER 2

2. Theoretical Framework

2.1. Inventory Management

Logistics is all about managing inventory, dealing the questions of whether the inventory is moving or staying, whether it is in a raw state, in manufacturing, or finished goods. Logistics and inventory management are embedded in each other and tied up closely. The “Bill of Rights” that logistics professionals often repeat is to deliver the right product to the right place, at the right time, in the right quantity and condition, and at the right cost. To make it happen, effective inventory management is a cornerstone (Goldsby and Martichenko, 2005).

Inventory management also becomes a fundamental part of supply chain management (SCM) now. A lot of research in SCM over the last two decades can be characterized as so-called “multi-echelon inventory theory” (Quayle, 2003). Supply chain management has become an important way to improve the company’s competitive strength and therefore an important issue for most companies.

In other words, Effective inventory management is essential in the operation of any business. Although logistics does involve internal operations and stretches to up and downstream trading partners in the supply chain, it is fair to say that any definition of logistics will need to involve the management of inventory, whether it is in the form of hard goods (materials, people) or soft goods (information). If there is no inventory to move around, there is no need for logistics.

According to International Journal of Clothing Science and Technology (Lam and Postle, 2006), a summarized definition of the supply chain can be stated as: “All the activities involved in delivering a product from raw material through to the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer and the information systems necessary to monitor all of these activities.”

Supply chain management coordinates and integrates all of these activities into a seamless process. During the process, inventory holding and warehousing play an important role in modern supply chains. A survey of logistics costs in Europe identified the cost of inventory as being 13 per cent of total logistics costs, whilst warehousing accounted for a further 24 per cent (European Logistics Association/AT Kearney, 2004). As well as being significant in cost terms, they are important in terms of customer service, with product availability being a key service metric and warehousing being critical to the success or failure of many supply chains (Frazelle, 2002).

The American Production and Inventory Control Society (APICS) define inventory management as the branch of business management concerned with planning and controlling inventories (Toomey, 2000). Inventory management is a critical management issue for most companies – large companies, medium-sized companies, and small companies. Inventory basically falls into the overall categories of raw materials, finished goods, and work-in-process (Muller, 2011).

Raw materials: Used to produce partial products or completed goods.

Finished product: This is product ready for current customer sales. It can also be used to buffer manufacturing from predictable or unpredictable market demand. In other words, a manufacturing company can make up a supply of toys during the year for predictably higher sales during the holiday season.

Work-in-process (WIP): Items are considered to be WIP during the time raw material is being converted into partial product, subassemblies, and finished product. WIP should be kept to a minimum. WIP occurs from such things as work delays, long movement times between operations, and queuing bottlenecks.

Other categories of inventory should be considered from a functional standpoint:

Consumables: Light bulbs, hand towels, computer and photocopying paper, brochures, tape, envelopes, cleaning materials, lubricants, fertilizer, paint, dunnage (packing materials), and so on are used in many operations. These are often treated like raw materials.

Service, repair, replacement, and spare items (S&R Items): These are after-market items used to "keep things going." As long as a machine or device of some type is being used (in the market) and will need service and repair in the future, it will never be obsolete. S&R Items should not be treated like finished goods for purposes of forecasting the quantity level of your normal stock.

2.2. Inventory Costs

Why should we care about the financial aspects of inventory? Because, inventory is money. Even if you do not have a financial background, it is important to understand and appreciate that inventory information in financial statements can be useful in the operation of your business. A basic understanding of how inventory appears on the balance sheet and its impact on the income statement and cash flow statement will improve your ability to have the right item in the right quantity in the right place at the right time (Muller, 2011).

In making any decision that affects inventory size, the following costs must be considered (Jacobs, 2012):

Holding (or carrying) costs: This broad category includes the costs for storage facilities, handling, insurance, pilferage, breakage, obsolescence, depreciation, taxes, and the opportunity cost of capital. Obviously, high holding costs tend to favor low inventory levels and frequent replenishment.

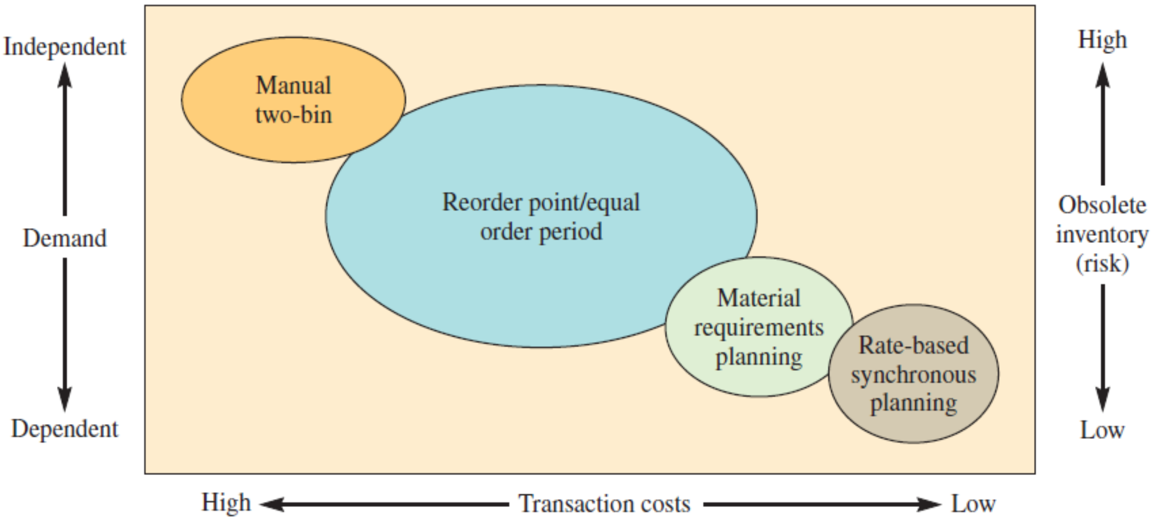
Setup (or production change) costs: To make each different product involves obtaining the necessary materials, arranging specific equipment setups, filling out the required papers, appropriately charging time and materials, and moving out the previous stock of material. If there were no costs or loss of time in changing from one product to another, many small lots would be produced. This would reduce inventory levels, with a resulting savings in cost. One challenge today is to try to reduce these setup costs to permit smaller lot sizes.

Ordering costs: These costs refer to the managerial and clerical costs to prepare the purchase or production order. Ordering costs include all the details, such as counting items and calculating order quantities. The costs associated with maintaining the system needed to track orders are also included in ordering costs.

Shortage costs: When the stock of an item is depleted, an order for that item must either wait until the stock is replenished or be canceled. When the demand is not met and the order is canceled, this is referred to as a stock out. A backorder is when the order is held and filled at a later date when the inventory for the item is replenished. There is a trade-off between carrying stock to satisfy demand and the costs resulting from stock outs and backorders. This balance is sometimes difficult to obtain because it may not be possible to estimate lost profits, the effects of lost customers, or lateness penalties. Frequently, the assumed shortage cost is little more than a guess, although it is usually possible to specify a range of such costs. Establishing the correct quantity to order from vendors or the size of lots submitted to the firm's productive facilities involves a search for the minimum total cost resulting from the combined effects of four individual costs: holding costs, setup costs, ordering costs, and shortage.

In inventory management, it is important to understand the trade-offs involved in using different types of inventory control logic. Figure 2.1 is a framework that shows how characteristics of demand, transaction cost, and the risk of obsolete inventory map into different types of systems.

Figure 2. 1 : Framework Describing Inventory Control Logic



Source: Jacobs (2012). Operations and Supply Chain Management

As we said above, inventory brings with it a number of costs. These costs can include:

- Dollars
- Space
- Labor to receive, check quality, put away, retrieve, select, pack, ship, account for
- Deterioration, damage, and obsolescence
- Theft

Inventory costs are generally divided into ordering and holding costs. Ordering costs come about regardless of the actual value of the goods. These costs include the salaries of those purchasing the product, costs of expediting the inventory and so on.

Holding costs include the cost of capital tied up in inventory (the opportunity cost of money); storage costs such as rent; and costs of handling the product such as equipment, warehouse and stock keeping staff, stock losses/wastage, taxes, and so on (Jacobs, 2012).

2.3. Why do we need inventory?

As discussed, inventory is considered waste or cost. So, why do we need it? In environments where an organization suffers from poor cash flow or lacks strong control over;

(i) Electronic information transfer among all departments and all significant suppliers,
(ii) Lead times, and
(iii) Quality of materials received, inventory plays important roles (Muller, 2011).

The interval between receiving the purchased parts and transforming them into final products varies from industries to industries depending upon the cycle time of manufacture. It is, therefore, necessary to hold inventories of various kinds to act as a buffer between supply and demand for efficient operation of the system. Thus, an effective control on inventory is a must for smooth and efficient running of the production cycle with least interruptions (Kumar, 2008).

According to Max Müller, some of the more important reasons for obtaining and holding inventory are:

Predictability: In order to engage in capacity planning and production scheduling, you need to control how much raw material, parts, and subassemblies you process at a given time. Inventory buffers what you need from what you process.

Fluctuations in Demand: A supply of inventory on hand is protection: You don't always know how much you are likely to need at any given time, but you still need to satisfy customer or production demand on time. If you can see how customers are acting in the supply chain, surprises in fluctuations in demand are held to a minimum.

Unreliability of Supply: Inventory protects you from unreliable suppliers or when an item is scarce and it is difficult to ensure a steady supply. Whenever possible unreliable suppliers should be rehabilitated through discussions or they should be replaced. Rehabilitation can be accomplished through master purchase orders with timed product releases, price or term penalties for nonperformance, better verbal and electronic communications between the parties, etc. This will result in a lowering of your on-hand inventory needs.

Price Protection: Buying quantities of inventory at appropriate times helps avoid the impact of cost inflation. Note that contracting to assure a price does not require actually taking delivery at the time of purchase. Many suppliers prefer to deliver periodically rather than to ship an entire year's supply of a particular stock keeping unit (SKU) at one time. (Note: The acronym "SKU," standing for "stock keeping unit," is a common term in the inventory world. It generally stands for a specific identifying numeric or alpha-numeric identifier for a specific item.)

Quantity Discounts: Often bulk discounts are available if you buy in large rather than in small quantities.

Lower Ordering Costs: If you buy a larger quantity of an item less frequently, the ordering costs are less than buying smaller quantities over and over again. (The costs of holding the Item for a longer period of time, however, will be greater.) In order to hold down ordering costs and to lock in favorable pricing, many organizations issue blanket purchase orders coupled with periodic release and receiving dates of the SKUs called for.

2.4. Physical Location and Inventory Control Techniques

If you can't find an item you can't count it, fill an order with it, or build a widget with it. This is about setting up a system that allows you to put items where they will do the most good for your organization (Muller, 2003). Let's take it one step further for military; if you can't "count" inventory that is out of "control", if you can't "control" inventory that is you are out of "control". So get it under control first and then you can manage your troop.

The location of your product or raw materials from both a physical and a recordkeeping standpoint is the most important thing for your inventory accuracy. In considering which locator system will work best, you should attempt to maximize:

- Use of space
- Use of equipment
- Use of labor
- Accessibility to all items
- Protection from damage
- Ability to locate an item
- Flexibility
- The reduction of administrative costs

Maximizing all of these at the same time is very difficult, maybe impossible. Often each of these concerns creates conflicts with one or more of the others. For example, you may wish to store all products together in order to utilize the same equipment to handle them or locate them together for ease of getting to and retrieving them. However, if the any nature of the contents of these products prohibits them from being stored in the same area, safety and protection of property concerns overcome other considerations. The stock keeper should select a locator system that provides the best solution given the tradeoffs between conflicting objectives. No any system is "right." What is best will depend on considerations such as:

i. Space available
ii. Location system
iii. Dimensions of product or raw materials stored
iv. Shape of items
v. Weight of items
vi. Product characteristics, such as stackable, toxic, liquid, crushable
vii. Storage methods, such as floor stacked, racks, carousels, shelving
viii. Labor availability
ix. Equipment, including special attachments available

x. Information systems support

The scientific inventory control system strikes the balance between the loss due to non-availability of an item and cost of carrying the stock of an item. Scientific inventory control aims at maintaining optimum level of stock of goods required by the company at minimum cost to the company (Kumar, 2008).

In any organization, depending on the type of business, inventory is maintained. When the number of items in inventory is large and then large amount of money is needed to create such inventory, it becomes the concern of the management to have a proper control over its ordering, procurement, maintenance and consumption. The control can be for order quality and order frequency.

The different techniques of inventory control are:

I. ABC (Always Better Control) analysis,

II. HML (High, Medium, Low) analysis,

III. VED (Vital, Essential, Desirable) analysis,

IV. FSN (Fast, Slow moving and Non-moving) analysis,

V. SDE (Scarce, Difficult, Easy) analysis,

VI. GOLF (Government supply, ordinarily available, local availability and foreign source of supply items) analysis and

VII. SOS (Seasonal and off-seasonal items) analysis.

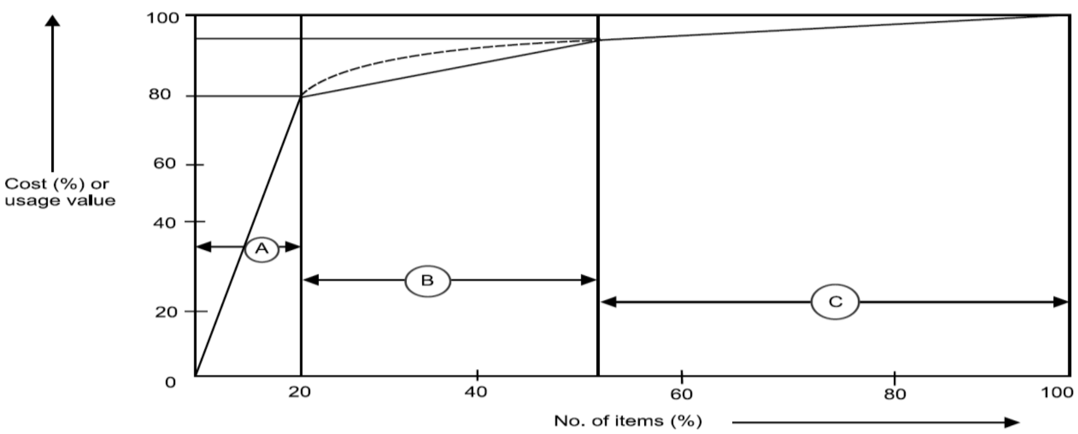
The most widely used method of inventory control is known as ABC analysis. In this technique, the total inventory is categorized into three sub-heads and then proper exercise is exercised for each sub-heads.

ABC analysis: In this analysis, the classification of existing inventory is based on annual consumption and the annual value of the items. Hence we obtain the quantity of inventory item consumed during the year and multiply it by unit cost to obtain annual usage cost. The items are then arranged in the descending order of such annual usage cost. The analysis is carried out by drawing a graph based on the cumulative number of items and cumulative usage of consumption cost. Classification is done as follows:

Table 2. 1 The Classification of ABC Analysis

CATEGORY	PERCENTAGE OF ITEMS	PERCENTAGE OF ANNUAL CONSUMPTION VALUE
A	**10-20**	**70-80**
B	**20-30**	**10-25**
C	**60-70**	**5-15**

Figure 2.2 The Classification Of ABC Analysis Graph



Source: Kumar, Anıl (2008). Production and Operation Management

Once ABC classification has been achieved, the policy control can be formulated as follows:

A-Item: Very tight control, the items being of high value. The control need be exercised at higher level of authority.

B-Item: Moderate control, the items being of moderate value. The control need be exercised at middle level of authority.

C-Item: The items being of low value, the control can be exercised at gross root level of authority, i.e., by respective user department managers.

HML analysis: In this analysis, the classification of existing inventory is based on unit price of the items. They are classified as high price, medium price and low cost items.

VED analysis: In this analysis, the classification of existing inventory is based on criticality of the items. They are classified as vital, essential and desirable items. It is mainly used in spare parts inventory.

FSN analysis: In this analysis, the classification of existing inventory is based consumption of the items. They are classified as fast moving, slow moving and non-moving items.

SDE analysis: In this analysis, the classification of existing inventory is based on the items.

GOLF analysis: In this analysis, the classification of existing inventory is based sources of the items. They are classified as Government supply, ordinarily available, local availability and foreign source of supply items.

SOS analysis: In this analysis, the classification of existing inventory is based nature of supply of items. They are classified as seasonal and off-seasonal items.

For effective inventory control, according to S. Anıl Kumar (2008), combination of the techniques of ABC with VED or ABC with HML or VED with HML analysis is practically used.

2.5. Inventory Control Models (Systems)

Even though there are literally millions of different types of products manufactured in our society, there are only two fundamental decisions that you have to make when controlling inventory (Nagraj, 2013):

- How much to order?
- When to order?

Inventory control is a planned approach of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales (Kumar, 2008). For also S. Anil Kumar, inventory control basically deals with two problems:

- When should an order be placed? (Order level), and
- How much should be ordered? (Order quantity).

These questions are answered by the use of inventory models. As you know, inventory fulfills many important functions in an organization. But as the inventory levels go up to provide these functions, the cost of storing and holding inventory also increases. Thus, we must reach a fine balance in establishing inventory levels. A major objective in controlling inventory is to minimize total inventory costs.

An inventory system provides the organizational structure and the operating policies for maintaining and controlling goods to be stocked. The system is responsible for ordering and receipt of goods: timing the order placement and keeping track of what has been ordered, how much, and from whom. According to Jacobs (2009), the system also must follow up to answer such questions as:

- Has the supplier received the order?
- Has it been shipped?
- Are the dates correct?
- Are the procedures established for reordering or returning undesirable merchandise?

Inventory model is a mathematical description of a system using the objectives, variables, constraints, current and candidate requirements and assumptions of the problem. With various objective functions and constraints, any inventory model can be established according to demands.

Models can be classified according to different criteria. Generally, when we peruse the literature, inventory control models are divided into deterministic models (certain demand) and stochastic (uncertain demand) models. If demand and lead time are known (constant), they are called deterministic models; but if they are treated as random (unknown), they are stochastic. Attention is focused on the distribution of demand during the lead time. The businesses select the appropriate model, according to their different criteria, and use them.

The simplest inventory models assume that the rate of demand is a constant. The economic order quantity (EOQ) model and its extensions are based on this assumption. Variable demand arises in a variety of contexts, including aggregate planning and materials requirements planning.

It is possible for demand to be constant in expectation but still be random. Synonyms for random are uncertain and stochastic. Virtually all stochastic demand models assume that the average demand rate is constant. Random demand models are generally both more realistic and more complex than their deterministic counterparts (Nahmias, 2009).

Figure 2.3.a Deterministic Model

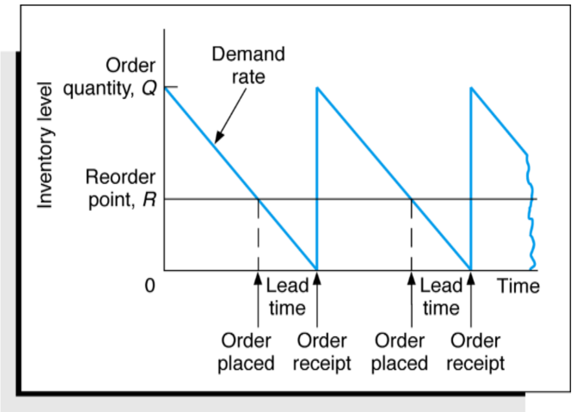
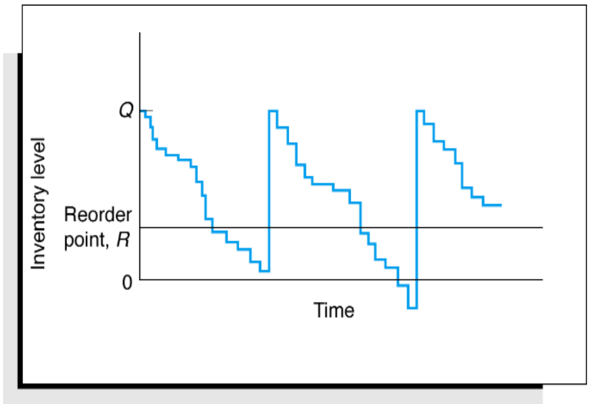


Figure 2.3.b Stochastic Model



2.5.1. The Economic Order Quantity (EOQ) Model

Economic order quantity is the order quantity that minimizes total inventory holding costs and ordering costs. It is one of the oldest classical production scheduling models. The framework used to determine this order quantity is also known as Wilson EOQ Model or Wilson Formula. The model was developed by Ford W. Harris in 1913, but R. H. Wilson, a consultant who applied it extensively, is given credit for his in-depth analysis. The EOQ model is the simplest and most fundamental of all inventory models. It describes the important trade-off between fixed order costs and holding costs, and is the basis for the analysis of more complex systems (Nahmias, 2009).

The single-item EOQ formula finds the minimum point of the following cost function:

Purchase cost : "This is the variable cost of goods: purchase unit price × annual demand quantity."

This is: "c × D"

Ordering cost : "This is the cost of placing orders: each order has a fixed cost K, and we need to order D/Q times per year."

This is: "K × D/Q"

Holding cost : "The average quantity in stock (between fully replenished and empty)" is Q/2, so this cost:

"h × Q/2"

"Total Cost = purchase cost or production cost + ordering cost + holding cost"

$$TC = cD + \frac{(D \times K)}{Q} + \frac{(h \times Q)}{2}$$

To determine the minimum point of the total cost curve, partially differentiate the total cost with respect to Q (assume all other variables are constant) and set to 0:

$$0 = -\frac{DK}{Q^2} + \frac{h}{2}$$

Solving for Q gives Q* (the optimal order quantity):

$$Q *^2 = \frac{2DK}{h}$$

Therefore: $$Q^* = \sqrt{\frac{2DK}{h}}$$

Q* is independent of c; it is a function of only K, D, h. The optimal value Q* may also be found by recognizing that;

$$TC = \frac{DK}{Q} + \frac{hQ}{2} + cD = \frac{h}{2Q} \times \left(Q - \sqrt{\frac{2DK}{h}} \right)^2 + \sqrt{2hDK} + cD$$

Where the non-negative quadratic term disappears for; $Q = \sqrt{\frac{2DK}{h}}$

Which provides the cost minimum: $TCmin = \sqrt{2hDK} + cD$

This technique is relatively easy to use, but it makes a number of assumptions. Some of the more important assumptions follow:

- **i.** Demand is known and constant.
- **ii.** The lead time that is, the time between the placement of the order and the receipt of the order is known and constant.
- **iii.** The receipt of inventory is instantaneous. In other words, the inventory from an order arrives in one batch, at one point in time.
- **iv.** Quantity discounts are not possible.
- **v.** The only variable costs are the cost of placing an order, ordering cost, and the cost of holding or storing inventory over time, carrying, or holding, cost.
- **vi.** If orders are placed at the right time, stock-outs and shortages can be avoided completely.

When we consider the inventory control models which are divided into deterministic models and stochastic models above, we will examine the inventory system as single-period systems and multiperiod systems to explain the inventory system in the Turkish General Commandership of Gendarmerie easier. The classification will be based on whether the decision is just a one-time purchasing decision where the purchase is designed to cover a fixed period of time and the item will not be reordered, or the decision involves an item that will be purchased periodically where inventory should be kept in stock to be used on demand.

2.5.2. A Single Period Inventory Model

A single period inventory model is a scenario that faced by companies that order seasonal or one-time items. There is only one chance to get the quantity right when ordering, as the product has no value after the time it is needed. There are some costs to both ordering too much or too little, and the company's managers must try to get the order right the first time to minimize the chance of loss.

The optimal stocking level, using marginal analysis, occurs at the point where the expected benefits derived from carrying the next unit are less than the expected costs for that unit. Also we have to keep in mind that the specific benefits and costs depend on the problem. Stocking too much of a seasonal item can lead to large losses for a business. In the case of Christmas cards, for example, sales go to zero on the day after Christmas. The company has the choice of destroying the remaining inventory, selling some at huge discounts or storing them until next Christmas. The latter option may save the cost of the inventory, but will cost the company in warehouse and storage fees. Inventory that is dated, such as magazines or royal wedding memorabilia, may have no market after the date.

2.5.3. Multiperiod Inventory Model

There are two types of multiperiod inventory systems: fixed–order quantity models (also called EOQ, and Q-model) and fixed–time period models (also referred to variously as the periodic system, periodic review system, fixed–order interval system, and P-model). Multiperiod inventory systems are designed to ensure that an item will be available on an ongoing basis throughout the year. Usually the item will be ordered multiple times throughout the year where the logic in the system dictates the actual quantity ordered and the timing of the order.

The basic distinction is that fixed–order quantity models are “event triggered” and fixed–time period models are “time triggered.” That is, a fixed–order quantity model initiates an order when the event of reaching a specified reorder level occurs. This event may take place at any time, depending on the demand for the items considered. In contrast, the fixed–time period model is limited to placing orders at the end of a predetermined time period; only the passage of time triggers the model.

To use the fixed–order quantity model (which places an order when the remaining inventory drops to a predetermined order point, R), the inventory remaining must be continually monitored. Thus, the fixed–order quantity model is a perpetual system, which requires that every time a withdrawal from inventory or an addition to inventory is made, records must be updated to reflect whether the reorder point has been reached. In a fixed–time period model, counting takes place only at the review period.

Some additional differences tend to influence the choice of systems (Table 2.2):

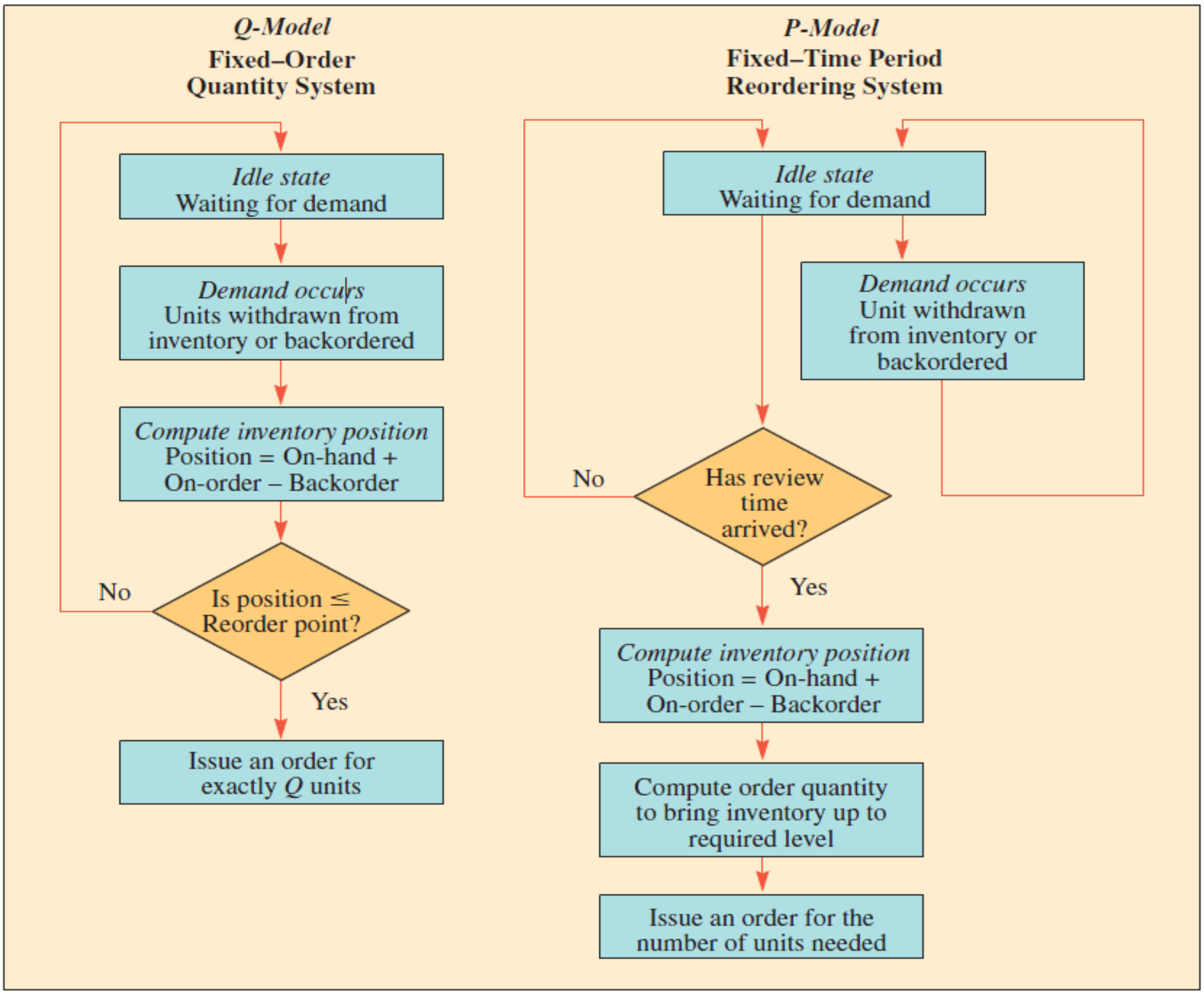
- The fixed–time period model has a larger average inventory because it must also protect against stock out during the review period, T; the fixed–order quantity model has no review period.
- The fixed–order quantity model favors more expensive items because average inventory is lower.
- The fixed–order quantity model is more appropriate for important items such as critical repair parts because there is closer monitoring and therefore quicker response to potential stock out.
- The fixed–order quantity model requires more time to maintain because every addition or withdrawal is logged.

Table 2.2 Comparing Q and P Models

FEATURE	Q-MODEL	P-MODEL
	FIXED-ORDER QUANTITY MODEL	FIXED-TIME PERIOD MODEL
ORDER QUANTITY	Q-CONSTANT (THE SAME AMOUNT ORDERED EACH TIME)	q-VARIABLE (VARIES EACH TIME ORDER IS PLACED)
WHEN TO PLACE ORDER	R-WHEN INVENTORY POSITION DROPS TO THE REORDER LEVEL	T-WHEN THE REVIEW PERIOD ARRIVES
RECORDKEEPING	EACH TIME A WITHDRAWAL OR ADDITION IS MADE	COUNTED ONLY AT REVIEW PERIOD
SIZE OF INVENTORY	LESS THAN FIXED-TIME PERIOD MODEL	LARGER THAN FIXED-ORDER QUANTITY MODEL
TIME TO MAINTAIN	HIGHER DUE TO PERPETUAL RECORDKEEPING	
TYPE OF ITEMS	HIGHER-PRICED, CRITICAL OR IMPORTANT ITEMS	

Figure 2.4 shows what occurs when each of the two models is put into use and becomes an operating system. As we can see, the fixed–order quantity system focuses on order quantities and reorder points. Procedurally, each time a unit is taken out of stock, the withdrawal is logged and the amount remaining in inventory is immediately compared to the reorder point. If it has dropped to this point, an order for Q items is placed. If it has not, the system remains in an idle state until the next withdrawal. In the fixed–time period system, a decision to place an order is made after the stock has been counted or reviewed. Whether an order is actually placed depends on the inventory position at that time.

Figure 2. 4 Comparing Q and P Models



Source: Jacobs (2012). Operations and Supply Chain Management

2.5.3.1. Fixed–Order Quantity Models

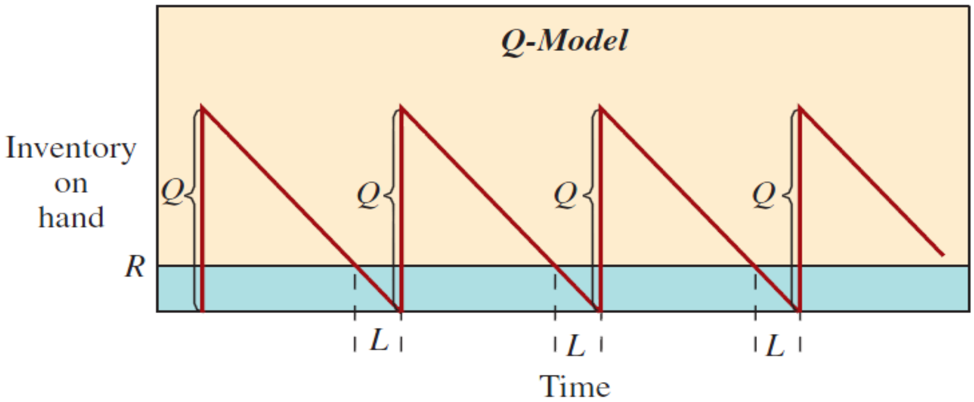
Fixed–order quantity models attempt to determine the specific point, R, at which an order will be placed and the size of that order, Q. The order point, R, is always a specified number of units. An order of size Q is placed when the inventory available (currently in stock and on order) reaches the point R. Inventory position is defined as the on-hand plus on-order minus backordered quantities.

The solution to a fixed–order quantity model may stipulate something like this: When the inventory position drops to 36, place an order for 57 more units. The simplest models in this category occur when all aspects of the situation are known with certainty. If the annual demand for a product is 1,000 units, it is precisely 1,000 not 1,000 plus or minus 10 percent. The same is true for setup costs and holding costs. Although the assumption of complete certainty is rarely valid, it provides a good basis for our coverage of inventory models.

Figure 2.5 and the discussion about deriving the optimal order quantity are based on the following characteristics of the model. These assumptions are unrealistic, but they represent a starting point and allow us to use a simple example.

- Demand for the product is constant and uniform throughout the period.
- Lead time (time from ordering to receipt) is constant.
- Price per unit of product is constant.
- Inventory holding cost is based on average inventory.

Figure 2.5 Q Model Graphics



• Ordering or setup costs are constant.

• All demands for the product will be satisfied. (No backorders are allowed.)

The "sawtooth effect" relating Q and R in figure 2.5 shows that when the inventory position drops to point R, a reorder is placed. This order is received at the end of time period L, which does not vary in this model. In constructing any inventory model, the first step is to develop a functional relationship between the variables of interest and the measure of effectiveness. In this case, because we are concerned with cost, the following equation pertains:

Total annual cost = Annual purchase cost + Annual ordering cost + Annual holding cost

$$TC = cD + \frac{DK}{Q} + \frac{hQ}{2}$$

Where

TC = Total annual cost

D = Demand (annual)

C = Cost per unit

Q = Quantity to be ordered (the optimal amount is termed the economic order quantity (EOQ or Qopt))

K = Setup cost or cost of placing an order

R = Reorder point

L = Lead time

H = Annual holding and storage cost per unit of average inventory (often holding cost is taken as a percentage of the cost of the item, such as H = iC, where i is the percent carrying cost)

On the right side of the equation, DC is the annual purchase cost for the units, (D _ Q) K is the annual ordering cost (the actual number of orders placed, D _ Q, times the cost of each order, K), and (Q _2) H is the annual holding cost (the average inventory, Q _2, times the cost per unit for holding and storage, H). These cost relationships are graphed in figure 2.9.

The second step in model development is to find that order quantity Q opt at which total cost is a minimum. In figure 2.8, the total cost is minimal at the point where the slope of the curve is zero. Using calculus, we take the derivative of total cost with respect to Q and set this equal to zero. For the basic model considered here, the calculations are;

$$TC = \frac{DK}{Q} + \frac{hQ}{2} + cD = \frac{h}{2Q} \times \left(Q - \sqrt{\frac{2DK}{h}} \right)^2 + \sqrt{2hDK} + cD$$

$$Q = \sqrt{\frac{2DK}{h}}$$

Because this simple model assumes constant demand and lead time, neither safety stock nor stock-out cost is necessary, and the reorder point, R, is simply;

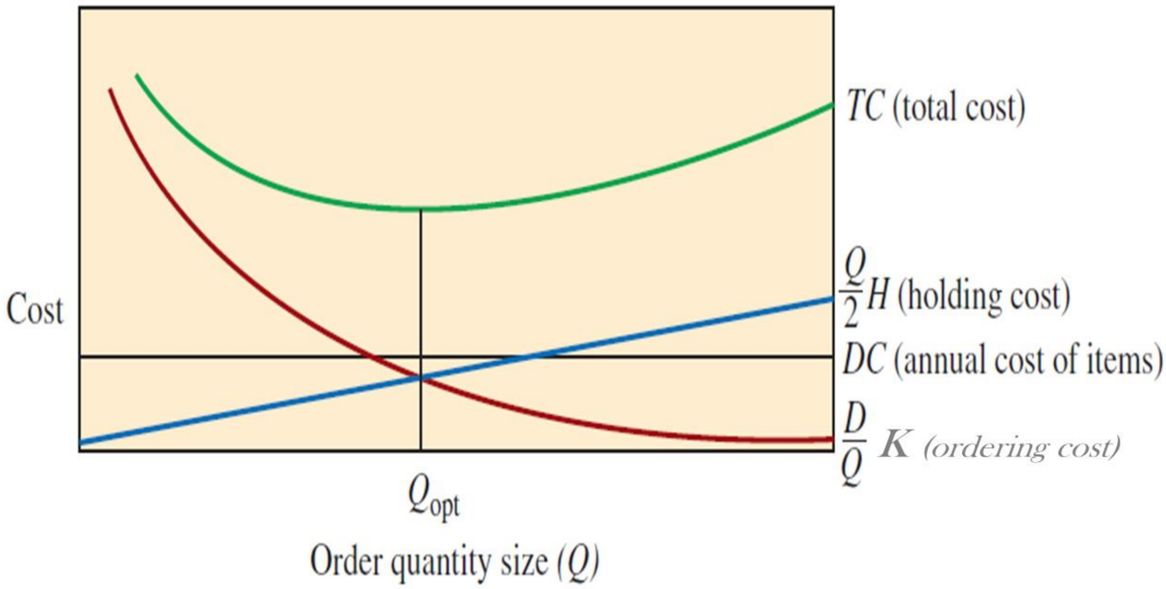
$$R=d*L$$

Where;

d= Average daily demand (constant)

L= Lead time in days (constant)

Figure 2. 6 Order Quantity Size



2.5.3.2. Fixed–Time Period Models

In a fixed–time period system, inventory is counted only at particular times, such as every week or every month. Counting inventory and placing orders periodically are desirable in situations such as when vendors make routine visits to customers and take orders for their complete line of products, or when buyers want to combine orders to save transportation costs. Other firms operate on a fixed time period to facilitate planning their inventory count; for example, Distributor X calls every two weeks and employees know that all Distributor X's product must be counted.

Fixed–time period models generate order quantities that vary from period to period, depending on the usage rates. These generally require a higher level of safety stock than a fixed–order quantity system. The fixed–order quantity system assumes continual tracking of inventory on hand, with an order immediately placed when the reorder point is reached. In contrast, the standard fixed–time period models assume that inventory is counted only at the time specified for review. It is possible that some large demand will draw the stock down to zero right after an order is placed. This condition could go unnoticed until the next review period. Then the new order, when placed, still takes time to arrive. Thus, it is possible to be out of stock throughout the entire review period, T, and order lead time, L. Safety stock, therefore, must protect against stock outs during the review period itself as well as during the lead time from order placement to order receipt.

In a fixed–time period system, reorders are placed at the time of review (T), and the safety stock that must be reordered is:

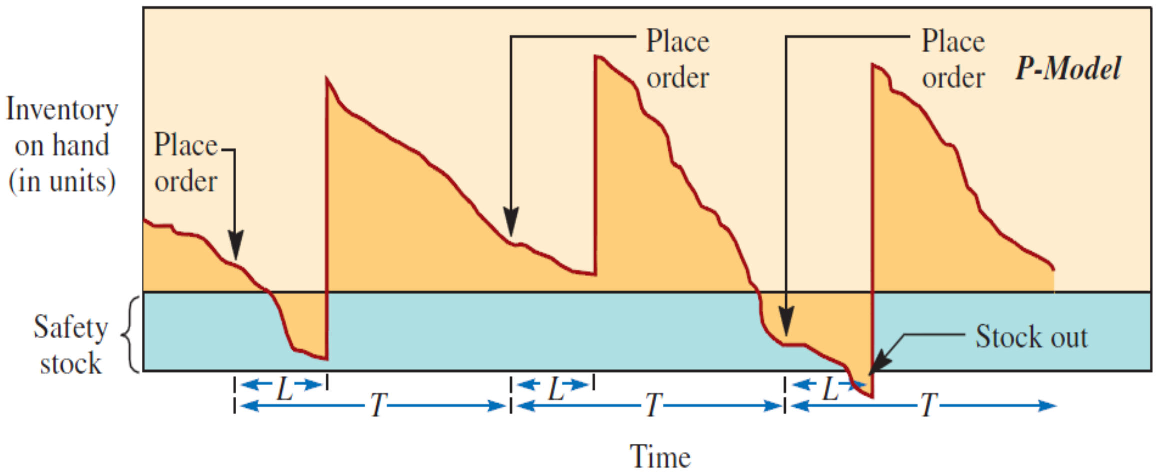
$$\text{Safety stock} = z\sigma_{T+L}$$

Figure 2.10 shows a fixed–time period system with a review cycle of T and a constant lead time of L. In this case, demand is randomly distributed about a mean d. The quantity to order, q, is:

$$\text{Order quantity} = \text{Average demand over the vulnerable period} + \text{Safety stock} - \text{Inventory currently on hand (plus on order, if any)}$$

$$q = \bar{d}(T + L) + z\sigma_{T+L} - I$$

Figure 2. 7 Fixed Time Period Model



Where

q = Quantity to be ordered

T = The number of days between reviews

L = Lead time in days (time between placing an order and receiving it)

$\bar{d}$ = Forecast average daily demand

z = Number of standard deviations for a specified service probability

σ_{T+L} = Standard deviation of demand over the review and lead time

I = Current inventory level (includes items on order)

Note: The demand, lead time, review period, and so forth can be any time units such as days, weeks, or years so long as they are consistent throughout the equation. In this model, demand (d) can be forecast and revised each review period if desired, or the yearly average may be used if appropriate. We assume that demand is normally distributed. The value of z is dependent on the probability of stocking out.

2.5.4. Reorder Point : Determining When to Order

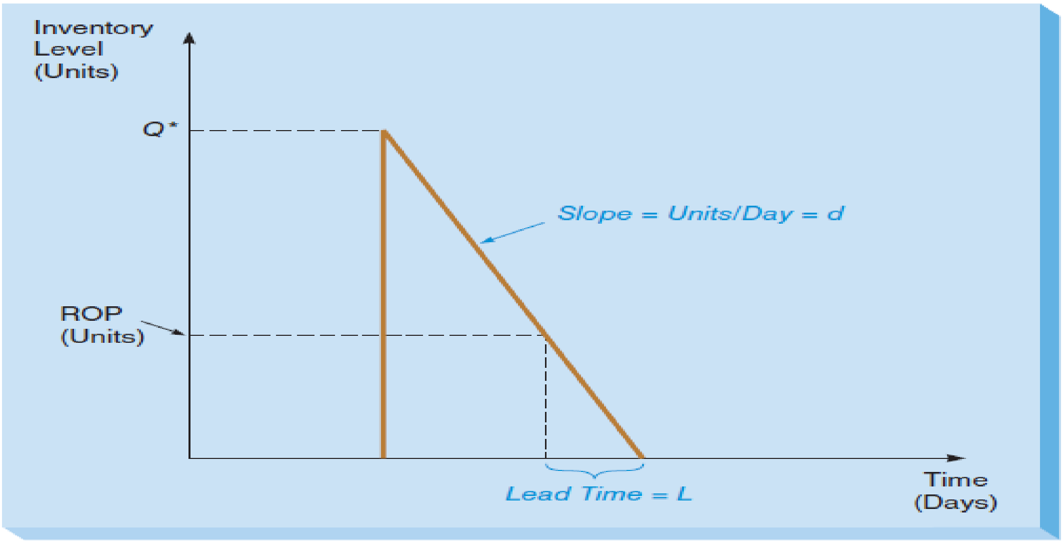
Now that we have decided how much to order, we look at the second inventory question: when to order. In most simple inventory models, it is assumed that we have instantaneous inventory receipt. That is, we assume that a firm waits until its inventory level for a particular item reaches zero, places an order, and receives the items in stock immediately. In many cases, however, the time between the placing and receipt of an order, called the lead time, or delivery time, is often a few days or even a few weeks. Thus, the when to order decision is usually expressed in terms of a reorder point (ROP), the inventory level at which an order should be placed. The ROP is given as

$$\text{ROP} = \text{Demand per day} * \text{Lead time, in days}$$

$$= d * L$$

Figure 2.11 shows the reorder point graphically. The slope of the graph is the daily inventory usage. This is expressed in units demanded per day, d. The lead time, L, is the time that it takes to receive an order. Thus, if an order is placed when the inventory level reaches the ROP, the new inventory arrives at the same instant the inventory is reaching zero.

Figure 2. 8 Reorder Point



Order point formulae are used to determine how much of a given item needs to be ordered where there is independent demand. In these formulae a reorder point (ROP) is set for each item. The ROP is the lowest amount of an item you will have on hand and on order before you reorder.

Order point formulae are based on some relatively simple concepts. Imagine that all of a particular SKU are kept in a single bin. If no reorder point was set, then the entire batch would be used up without any order being placed. The organization would then be unable to sell or use that item during whatever time frame was required to order and bring the SKU in—the lead time. It would therefore make sense to adopt a two-bin system with Bin 1 containing working stock and Bin 2 containing working reserve. The amount of product in Bin 2 would be equal to your usage rate during that item's lead time. In a two-bin system, if all goes as it should, then immediately upon using the first item from Bin 2, you would reorder a quantity equal to both Bins 1 and 2. As you use the last item in Bin 2, the order arrives and you refill both bins. This assumes that lead time is exact, there are no vendor stock outs or backorders, and that there are never any defects. That assumption is, of course, often false.

Therefore, a true order-point system is a three-bin system, with the Bin 3 containing safety stock. Bin 3, safety stock, relates to Bin 2 since Bin 3 is to make up for uncertainties in lead time and defects. Mathematically safety stock is 50 percent of working reserve. (The average between having nothing in Bin 2 and having it at 100 percent full is 50 percent.) However, companies adjust safety stock levels to coincide with their actual experience. Bins can be mathematically created or can reflect actual physical separation of items in the stockroom. A simple formula for determining the ROP reflects the above concepts.

$$(\text{Usage} \times \text{Lead Time}) + \text{Safety Stock} = \text{ROP}$$

CHAPTER 3

3. Inventory Management in the Turkish General Commandership of Gendarmerie

3.1. The Conceptual Difference

The main difference between literature and Turkish General Commandership of Gendarmerie in inventory management is that; only some of the military troops, like sewing factory or printing press, are creating inventory for raw materials and work in process. For all others inventory usually be used to buffer consumption from predictable or unpredictable demands.

Given that there is not any producing in the Foça Gendarmerie Commando School and Training Center (FGCS), we have no raw material for inventory. Inventory uses for "finished products", "consumables" and for "S&R items" in FGCS. This inventory is used for the all needs of soldiers and trainees, like water, rice, medicine, and pen etc. According to the "Guideline Logistics Services (2013)", military goods are examined in five sections;

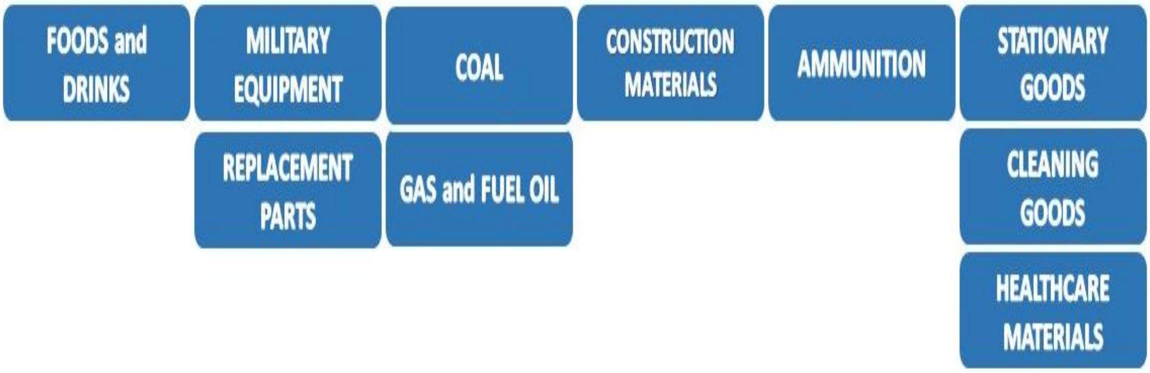
First Class Replenishment Materials	: Foods and Drinks.
Second Class Replenishment Materials	: Clothing Goods, Vehicles, Equipment, Guns and Replacement Parts.
Third Class Replenishment Materials	: Coal, Gas and Fuel Oil.
Fourth Class Replenishment Materials	: Construction Materials.
Fifth Class Replenishment Materials	: Ammunitions.

However if we examine the materials, which are in the current inventory management system in Turkish General Commandership of Gendarmerie, in comparison with the inventory literature, we have to make some changes in classification of the materials. Because classifying the materials in five section is about making the planning and management easier. But in inventory management process there are some differences.

For “Foods and Drinks”, “Construction Materials” and “Ammunitions”, there is no any difference in classifying. But when we consider the second class replenishment materials, as an audit offices, we do not have any inventorial or managing decision for vehicles, clothing goods, military equipment and guns. Commandership of Logistics in Ankara does the whole materials management. In this section, we can only separate the inventory of replacement parts (Table 3.1).

There is another difference in third class materials. We have to separate them in two sections, which are “coal” and “gas and fuel oil”, if we want to manage this inventories easier. In addition to these, we also add “stationary goods”, “cleaning goods” and “healthcare materials”, which have a role in our inventory management process. Although their role in inventory management system is not much, the impact should not be underestimated.

Table 3. 1 - Inventory Sections in FGCS

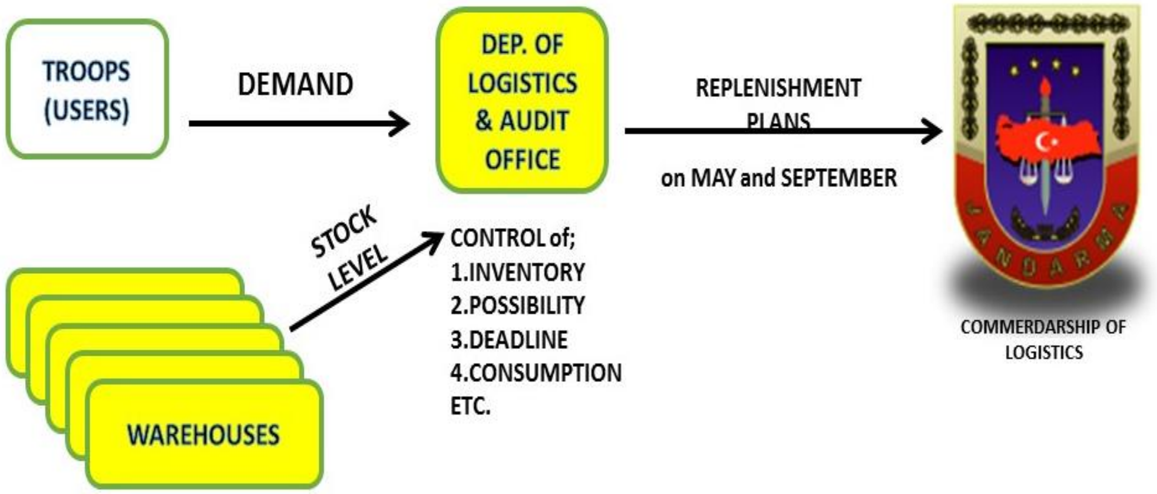


3.2. Overview

Foca Gendarmerie Commando School and Training Center has three main troops regarding the inventory management. One of them is 7th Gendarmerie Training Regiment, which is stationed at Yenifoca, has approximately 3.500 soldiers for training. The other one is Gendarmerie Commando School, which is stationed in Foca, has approximately 1.000 trainees. And the last one is Command of Supporting Activities, is also stationed in Foca and has 500 soldiers.

The "Replenishment Plan" is done by the Department of Logistics and Audit Office prior to budget year, according to the demands of these three troops and the stock level of the warehouses. And the decision regarding "What we need?" is taken for the next year. Afterwards, it is sent to the Commandership of Logistics in Ankara (Figure 3.1.a).

Figure 3. 1. a - Inventory Process Chart in FGCS



Later Commandership of Logistics shares the approvals (Approvals are given by the Ministry of Interior) and transfers cash or sends the demanded items directly. As shown in figure 3.1.b, Audit Office and Department of Logistics receives or buys the sent items that will be used during the whole year. The purchase of Foods and Drinks, Gas and Fuel Oil, Coal, Cleaning Goods, Stationary Goods, Construction Materials and Replacement Parts are subject to the approval sent from The Commandership of Logistics. However at this point, there is an important difference. Since “Foods and Drinks”, “Gas and Fuel Oil”, and “Coal” are the materials that we should always have, there is no budget-restriction in this sections. However the other budgets are constant and we use these budgets for all the year. Military Equipment, Healthcare Materials and Ammunitions are directly sent by The Commandership of Logistics.

Generally items taken or buy with hire purchase, because of the warehouse capacity. The warehouses, which are shown in figure 3.1.b, are the Audit Office’s warehouses. The Audit Office and Department of Logistics distributes the items to the troops, according to their demands according to the rules.

Figure 3. 1. b - Inventory Process Chart in FGCS

Troops use items during the whole year and send the consumption report to the audit office in every month. The audit office controls the consumptions, whether they are suitable for laws or not. Audit office is authorized to reject the consumption reports and to perform criminal investigations. At the beginning or end of the budget year, The Court of Accounts' inspectors perform announced and unannounced inspections on the audit office, in order to control the activities conformance with laws, regulations, instructions and orders (Figure 3.1.c).

Figure 3. 1. C - Inventory Process Chart in FGCS

In the Foca Gendarmerie Commando School and Training Center, there are three different groups of people –soldiers, trainees, and staff– because of who keep inventory. During the whole year, we spare inventory for approximately five thousand people and for their trainings.

3.3. Inventory Control Techniques in Foca Gendarmerie Commando School and Training Center

As we said before, "You don't always know how much you are likely to need at any given time, but you still need to satisfy customer or production demand on time." In FGCS we can consider trainees as customers. The amount of consumption and the need for consumption can be named as demand. Sometimes the number of the trainees and soldiers can change in a week or in ten days before the course. We have to be ready with their demands in these situations. If you see as an activity before in the supply chain, surprises in fluctuations in demand are held to a minimum.

"For effective inventory control, combination of the techniques of ABC with VED or ABC with HML or VED with HML analysis is practically used", said when we were examine inventory control techniques. In Turkish General Commandership of Gendarmerie, the classification of inventory is made like "SDE analysis". So, the classification of inventory is based on the kind of items. Almost all items are stocked in a different warehouse according to their sections. As an example; clothing goods are not in the same warehouse with healthcare materials or foods.

Given that while we stock the products, we have to consider not only kind of the items, but also annual consumptions, criticality and supply of items, combination of FSN, VED; with SOS is used as a technique inner sections. For example, we have to take into account of consumption of foods and cannot store pickles on front rice, if we have to store them side-by-side. The reason for the fact is that rice consumption rate is nearly four or five times more than pickles. On top this, we have to consider the storage ahead in order not to do extra work and waste time. However it is not enough of course. We also have to consider the season in which we do not prefer to serve pickles at lunch or dinner during summer days. Consuming the opened installment rice before the unopened installment one is another important point in obeying the rules of FIFO.

In Foca Gendarmerie Commando School and Training Center, inventory management has an important role especially in "Gas and Fuel Oil" and "Foods and Drinks" sections. Because we do not use coal and all of the other sections budgets are managing from the Commandership of Logistics in Ankara, and control before the budget year by replenishment plans and before year consumptions.

But other two sections are managed by the troop and if there is any mistake it can only be noticed after it is done. So inventory management has a very important role for this section. This study is the first scientific examination regarding the inventory management In Turkish General Commandership of Gendarmerie and because of the importance of this sections' inventory management processes ("Gas and Fuel Oil" and "Foods and Drinks") we will model only this sections.

3.4. Inventory Costs in Foca Gendarmerie Commando School and Training Center

3.4.1. Holding Costs

In Gendarmerie Commando School and Training Center, holding expenses only includes the costs for breakage, spoilage and obsolescence. Due to the fact that lifetime is very important constraint during the stocking for nearly all products that we examine in this thesis. We can only keep gas and fuel oil out of it. For example for “Daily Foods”, (which includes fresh vegetable and fruits, meat, chicken, yogurt, etc.) Lifetime is the main object when we manage inventory. As we can see in the example holding cost like “holding risk” in Gendarmerie Commando School and Training Center. And the provision of this risk is sometimes invaluable. Nevertheless, we have to have safety stock. Because we cannot say “we don’t have enough vegetable for lunch or dinner” at any time. So, in comparison to warehousing costs, holding costs are variable and depend mainly on the inventory level. Our warehouses consists of a safety stock and a cycle stock. The holding costs can in other words be expressed as proportional to the estimated annual demand quantity and the size of the safety stock.

3.4.2. Warehousing Costs

The costs incurred are proportional to service and material handling facilities provided in the warehouse. Warehousing costs can be divided into fixed or variable costs. Variable costs often but not always increase and decrease in correlation with the sales revenue of the firm. Variable cost include labor, material, packing, utilities, transportation and those operating expenses that enables the business to run. Fixed costs are the expenses that remain constant regardless of activity or production volume. Capability of separating fixed and variable cost is essential for the company to be able to compare the costs and savings in the warehouse alternatives. (Kapoor and Kansal, 2005)

In FGCS, warehousing costs are usually mainly fixed. Examples of costs of this kind are equipment, buildings and personnel. Since these costs are not directly influenced by fluctuations in the inventory level, the costs remain the same. Furthermore, there is no clearly cost for handling, storage, operations administration and general administrative expenses. Our warehouses should provide right stocks at right times and the space in the warehouses should be utilized efficiently and according to the predictable demands. On the other hand overstocks increase costs and risks, can reduce the profitability. In comparison to company operating private warehouse it is more difficult to determine the fixed and variable costs of warehousing. According to article Understanding Warehouse Costs and Risks by Ph.D. Thomas W. Speh published in Warehouse Forum (2009) all companies with warehouses incur the same elements of cost but compile them differently depending on if the firm is whether buying or selling warehouse services or a firm providing warehouse service for its own organization. The article presents a model that enables to isolate and analyze costs of warehousing and to compare price to actual value of the services rendered with another or one company to others regardless of being about wholesale distributor or logistics service provider. But despite all costs and risks, we can’t outsourcing warehousing in military.

3.4.3. Ordering Costs

These costs refer to the managerial and clerical costs to prepare the purchase or production order. These costs, in FGCS, especially known as a hidden cost. In procurements, we cannot compare the price between “in one lump sum” and “with installments”. Because we wrote the specification, before the procurement. And have no chance to determine an order cost. But of course there is an order cost and the supplier put it into the price. Because of that reason, in this thesis, ordering cost will be defined as virtual.

In fact, we have to pay attention to order risk with the order cost. In Gendarmerie Commando School and Training Center, according to laws and regulations, we have to establish commissions for the purchases of goods and inspections of them. And in every other installment, these commissions meet each other. If we take into account that all the persons in these commissions do their duties as an additional duties (all of them are company/ battalion commander or commander teacher), we have a real hidden cost for all installments. Because when they meet for this job, they move away from their real job. So, this situation creates an amateurism and therefore lots of probable risks.

Also with all installment, we have a reject probability and if a product is rejected by the inspection committee or laboratory, suppliers have a right to appeal. This process usually take months and all the procurement plan is affected negatively.

According to the civilian companies, ordering cost is like a hidden cost in Gendarmerie Commando School and Training Center. Because of these reasons that we said below, “minimize the order numbers” is the objective function of our thesis.

3.4.4. Shortage Costs

There are approximately five thousand people In Gendarmerie Commando School and Training Center, and we have to identify their requirements, which are needed whole day. We procure the items during their trainings, store them, control the consumptions, and check if they are proper according to the laws. In this process we cannot say “postpone your requirements” or “do not do your training”. Because of that we have to have safety stock and ensure the stock is not out.

For only supersede products, it can be an exception. Like spaghetti and rice. If your spaghetti inventory is out, you can give rice in lunch or dinner. But of course you cannot give rice to the people every day. That´s why shortage costs are our most important costs and “not to be stock out” is our other objective in this thesis.

3.5. The Assessment of the Inventory in Foca Gendarmerie Commando School and Training Center

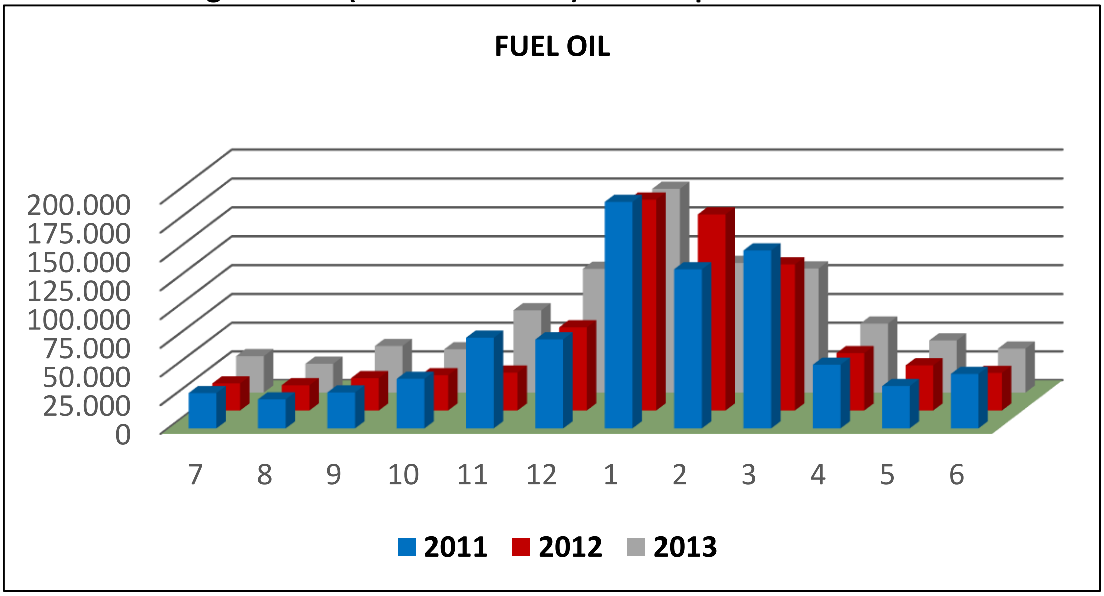
In the current inventory system, materials are classified into ten sections (Table 3.1), in General Commandership of Gendarmerie. Here, we want to explain which ones are used in FGCS, in which we implemented an analytical modeling, with their objectives, constraints and assumptions.

3.5.1. Fuel Oil, Gasoline, Diesel and LPG

We can examine fuel oil, gasoline, diesel and LPG in this section, together. Because all of them are have the same rules and similar processes. A tender is done at the May of each year and the unit price for twelve months is determined. Then, from 01 July to next year 30 June, according to tank capacities, when the products run out, orders are given to the suppliers.

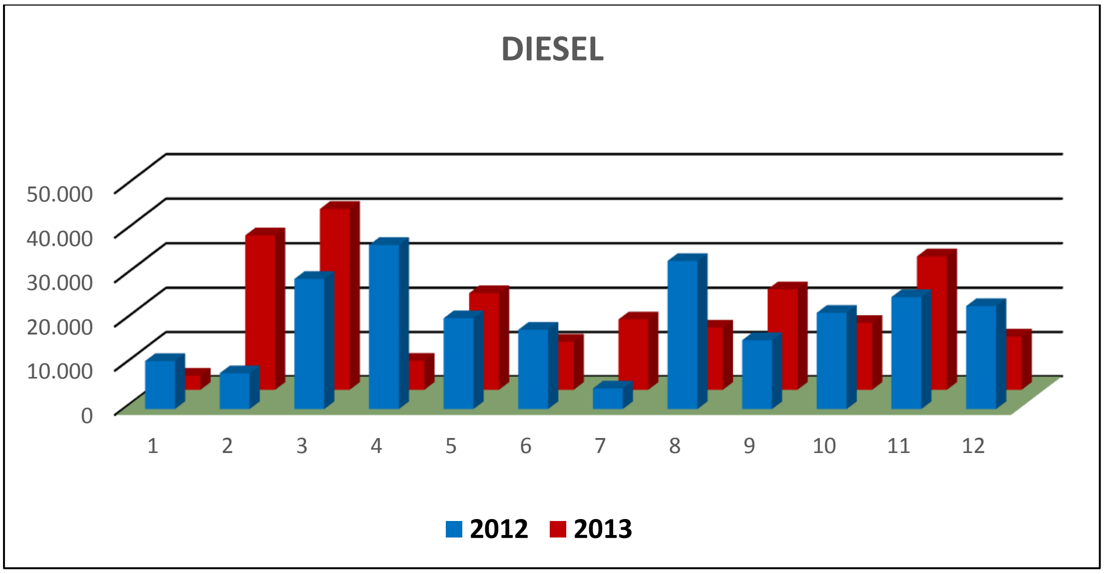
But in consumptions, there is a difference between fuel oil and the others (diesel, gasoline and LPG). In FGCS, fuel oil is used for heating systems and of course on winter day's consumption is very higher than summer days. Because it is used only for hot water on summer. On figure 3.2 we can see the last three year's (2011-2012-2013) consumptions of fuel oil. When we look this chart, we can see the regular dispersion of consumption.

Figure 3. 2 - (2011-2012-2013) Consumptions of Fuel Oil



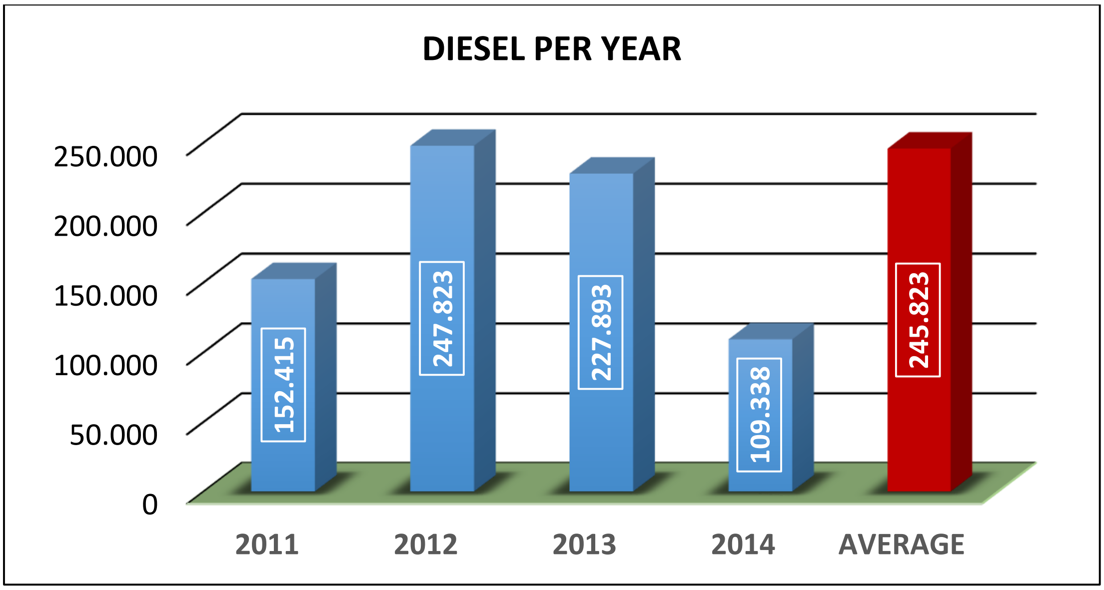
But for gas, diesel and LPG we cannot say similar things. Because uses of this items is changing by the number of person and missions in FGCS. A monthly consumption can be 34.000 liters, when it was 8.000 lt. at the same month of the last year (Figure 3.3). (In this figure we use only two years, because of that we have last six months of 2011 and first six months of 2014's consumption rates. So it can be give wrong to see this twelve months as a year.)

Figure 3. 3 - (2012-2013) Consumptions of Diesel



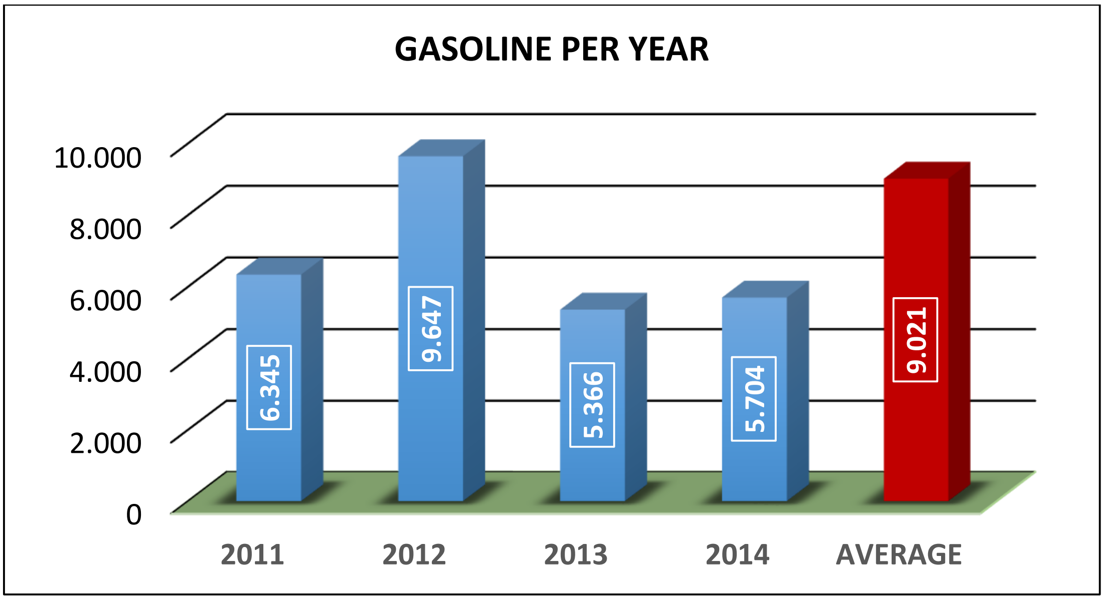
As we can see on figure 3.5, in Foca Gendarmerie Commando School and Training Center, approximately 850.000 kg fuel oil is used in a year for steam boilers, heating system and hot water. Also approximately 245.000 lt diesel (Figure 3.4), 9.000 lt gasoline (Figure 3.5) are used for vehicles in a year, in FGCS. (In both chart, 2011's second six months and 2014's first six months are taken.)

Figure 3. 4 – Average Diesel Consumption



(Last 8 months' consumption of 2011 and first 6 months' consumption of 2014)

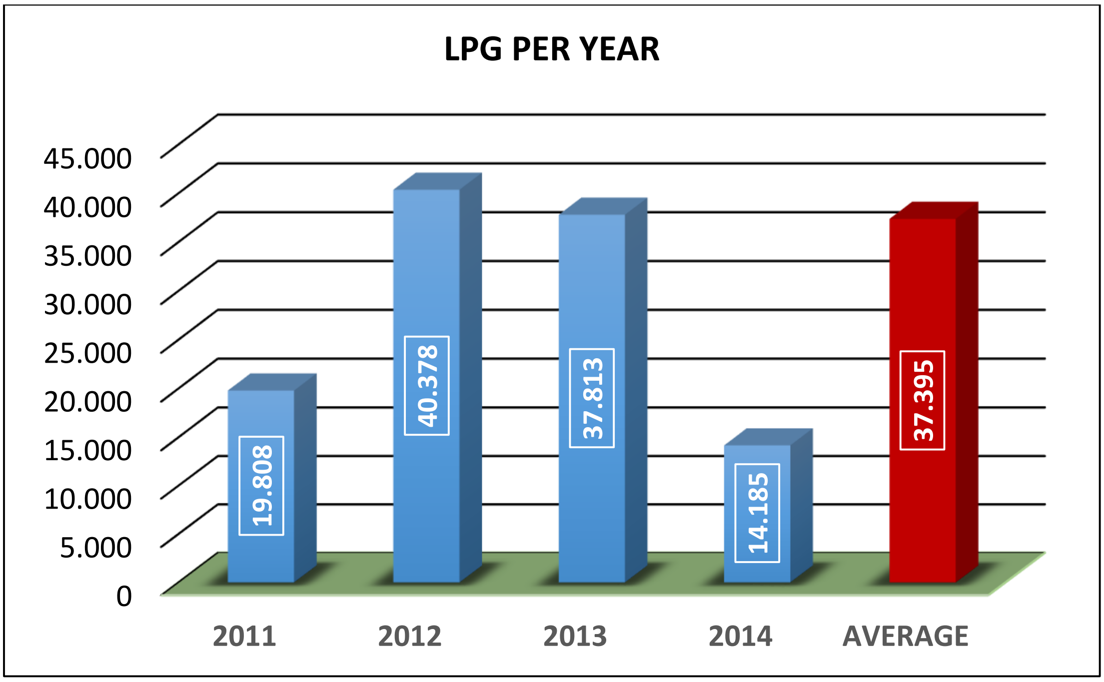
Figure 3. 5 – Average Gasoline Consumption



(Last 8 months' consumption of 2011 and first 6 months' consumption of 2014)

At the same time, approximately 37.000 kg LPG is used for cooking facilities (Figure 3.6). We stock up diesel in 3 tanks (totally 52.000 lt), gas in an 8.000 lt tank and LPG in 3 tanks (capacities ranging between 3.000 kg and 10.000 kg, totally 23.000 kg). The purpose of the inventory for “Gas and Fuel Oil” is to maintain them above safety stock. In this section, tank capacities and irregularity of the consumption (demand) are our constraints. The products in this section have no expiration date.

Figure 3. 6 – Average LPG Consumption

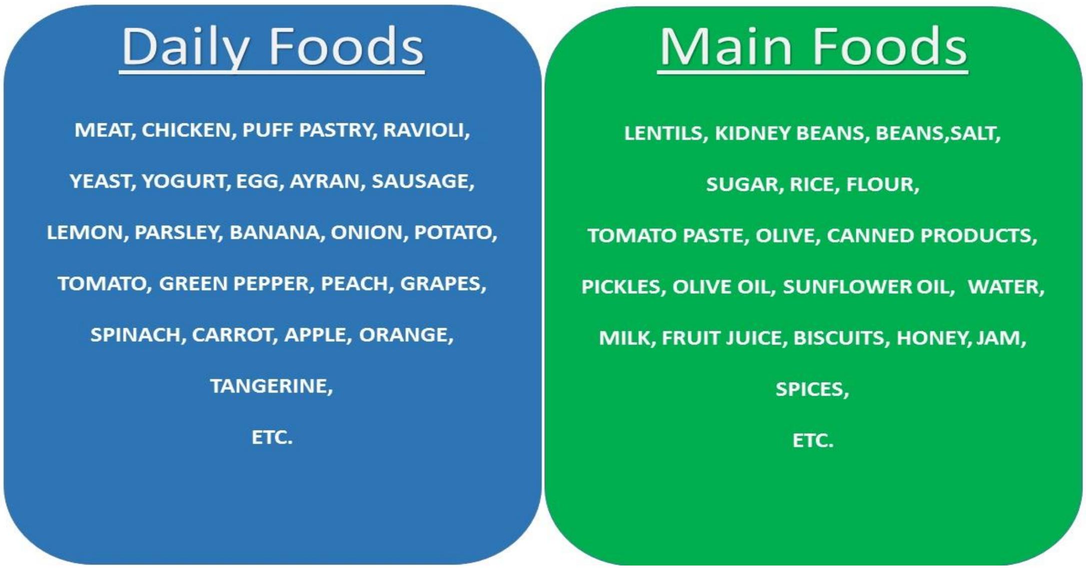


(Last 8 months’ consumption of 2011 and first 6 months’ consumption of 2014)

3.5.2 Food and Drinks

In FGCS, we can examine foods in two parts. One of them is “Daily Foods”, which are have short lifetime, includes fresh vegetable and fruits, meat, chicken, egg and yogurt, etc. And the other is “Main Foods”, that have long lifetime includes pulses, oils, drinks, canned goods, for breakfasts, etc. (Figure 3.10). At the moment, in FGCS, we stock all these eatable items in 11 freezers and 4 normal warehouses. This warehouses are located in Foça and Yenifoça area.

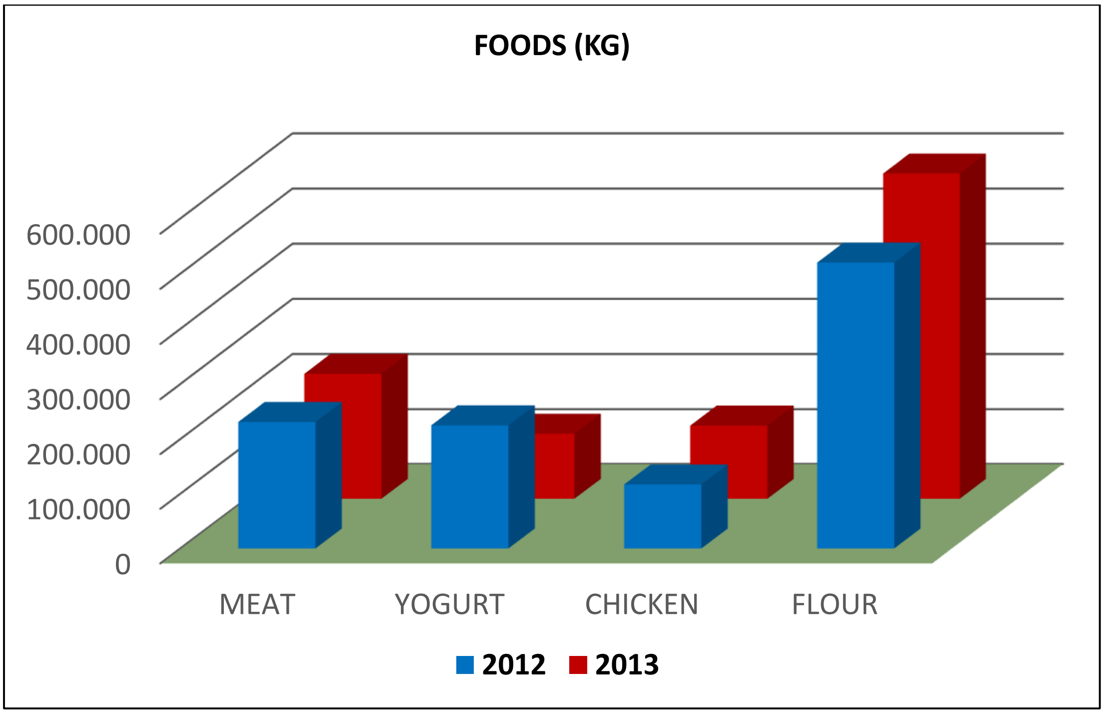
Table 3.2 – Foods Sections



Orders are given in two ways according to the characteristics of the products. Seasonal products are ordered (fruits and vegetables) every six months, others every twelve months. Currently the decisions about when and how many to order are made somewhat arbitrarily by the responsible personnel. Their decisions are based only on some brief procurement history and on personal experiences. Because we cannot know the number of personal in next year and we have no any research for "ordering how much and when?"

Seasonal products, which have short lifetime like meat, egg, chicken etc., are delivered twice a week, on Monday and Thursday, by suppliers. After the inspection, they are stored in the warehouses. Other ones are brought according to the chart of installments, which is given by audit office. Troops send the roll calls to the audit office daily and for these roll calls, audit office give the goods to the kitchens.

Figure 3. 7 – Annual Consumptions of Some Foods (2012-2013)



In FGCS, there is an important food circulation. As an example average 225.538 kg meat, 194.804 kg yogurt, 116.259 kg chicken and 545.329 kg flour is consumed in a year (Figure 3.7). The purpose of the inventory for "Foods and Drinks" is not to be stock out. All persons in FGCS, soldiers and trainees, have to be feed all time. Because of this "not to be below safety stock" is very important. (But of course we cannot take safety stock for daily foods, because of the expiration dates.) In this section, our constraints are; warehouse capacities, irregularity of the consumption (demand) and the expiration date of products. Lead time is ranging between 15 and 60 days, according to product.

3.5.3 Ammunition, Military Equipment, Healthcare Materials

As you can imply from its name, Foca Gendarmerie Commando School and Training Center, there are lots of exercises and trainings. So, every time we need lots of kinds and numbers ammunitions. As a FGCS, we can give only an order before the beginning of the year (we can give more orders in the year, but it’s not preferred) and Gendarmerie Commandership of Logistics sends them to us. We stock up them in 4 underground warehouses and give to the consumption for troops’ need.

Given that Training is a constant activity in Gendarmerie Commando School and Training Center, and you cannot say, “We have no ammunition that you need, the purpose of the inventory is to be maintain it above safety stock. It’s also the same for military equipment and healthcare materials. Objective is not to be stock out. Our constraints are; warehouse capacities, irregularity of the demand and the lifetime. In Turkish General Commandership of Gendarmerie, ammunitions, military equipment and healthcare materials are sent by The Commandership of Logistics to the troops, according to their demands. After the consumptions, month by month, Commandership of Logistics control the inventory and sent the items if we need. Because of that we will not examine them in this thesis.

3.5.4 Coal

In Turkish General Commandership of Gendarmerie, lots of troops use coal for their heating systems. In spite of that, in Gendarmerie Commando School and Training

Center, because of the “Law on Protection of Cultural and Natural Assets” we cannot use coal. So, we will not examine coal in this thesis.

3.5.5 Cleaning Goods, Stationary Goods

According to inventory management, Cleaning Goods and Stationary Goods are the same. Because, both of them have the same process. Before the budget year, the audit office, send the needs to Commandership of Logistics in Ankara, according to the probable demands of the troops, which is determined by the last year’s usage, and the stock level of the warehouses. Than the Commandership of Logistics send the allowances, if the budget is suitable. We buy the cleaning and stationary goods by tenders. Orders can be one or more installments according to suitability of warehouses.

3.5.6 Replacement Parts, Construction Materials

For replacement parts, process is the same with cleaning goods. But in Gendarmerie Commando School and Training Center, there are lots of kind vehicles, machines and durable goods. Because of that you cannot stock any replacement part and only use the allowance for repairing activities.

Construction materials’ management is a little bit different. As we said, before the budget year, the “Replenishment Plan” is done by the audit office. In this plan, we determine which constructions and restorations will be made. According to this plan, The Commandership of Logistics sends the allowance, if the budget is suitable. Because of that reasons, for replacement parts and construction materials there isn’t any clear inventory management. We won’t examine them in this thesis, either.

CHAPTER 4

4. Mathematical Analysis with Consider Multiple Inventory Models

As we explain above, in section 3.4 “inventory costs in FGCS”, our main subject in inventory management is “not to be stock out”. Because in this process we cannot say “postpone your requirements” to anybody, in anytime.

“Minimize the order numbers” is the objective function of our thesis as we said below, in “ordering costs”. Because our proposition is that in FGCS, there are lots of hidden costs in procurement process. In procurements, we cannot compare the price between “in one lump sum” and “with installments”, because we buy our needed by tenders. So our objective function must be to minimize the order number. This is also will reduce risks, which are not seen clearly, unless you look exhaustive.

EOQ is one of the oldest classical production scheduling models. Economic order quantity is the order quantity that minimizes total inventory holding costs and ordering costs. Because of that reasons, and also to lay out the foundations of our models, we will make an examples with EOQ model with the sections that we will model.

4.1 Examples with Economic Order Quantity

In FGCS, last 38 months, 616.879 kilograms yogurt were consumed. Average annual demand is approximately 194.800 kg. Our ordering cost is 250 TL per order and

Holding Cost is 0, 05 TL per unit per year. A kilo of yogurt av. cost is 2, 48 TL and lead time is 5 days (Costs are default except yogurt's cost). What quantity should be ordered? (At the time of review, there is no yogurt on inventory.)

The optimal order quantity is ; $Q = \sqrt{\frac{2DK}{h}}$ and $Q = \sqrt{\frac{2(194.800*250)}{0,05}} = 44.136\ kg.$

Reorder point is ; ROP = d * L

$= \frac{194.800}{365} * 5$

= 2.669 kg.

The inventory policy is as follows: When the inventory position drops to 2.669 kg., place an order for 44.136 kg more.

The total annual cost will be ;

$TC = \frac{DK}{Q} + \frac{hQ}{2} + cD = \frac{(194.800*5)}{44.136} + \frac{(0,05*44.136)}{2} + 2,48 * 194.800$ = 506.275 TL

Solutions with "Economic Order Quantity Model" that we found for quantity to be ordered is 44.136 kg. As we say before, the purpose of the inventory for "Foods and Drinks" is not to be stock out. But also there is an important constraints that we have to obey. ; These are warehouse capacities and the expiration date of products. If we think about with the example, our quantity orders neither suitable for our warehouse capacity, nor suitable for “yogurt’s 7 days lifetime”. Because of the reasons that we have necessarily constraints, we have to create our model for calculating order quantities, order period times, safety stocks etc.

As another example; In FGCS, last 38 months, 737.469 liters diesel were consumed. Average annual demand is 184.367 liters. Our ordering cost is 2.000 TL per order (20.000 liters) and holding Cost is 0, 05 TL per liter per year. A liter’s av. cost is 4, 00 TL and lead time is 5 days (Costs are default except diesel cost). What quantity should be ordered? (At the time of review, 2500 liters in stock. If only a 1 percent risk of stocking out is acceptable.)

The optimal order quantity is; $Q = \sqrt{\frac{2DK}{h}}$ and $Q = \sqrt{\frac{2(184.367*2.000)}{0,05}} = 121.447$

Reorder point is ; ROP = d * L

$= \frac{184.367}{365} * 5$

= 2.526

The inventory policy is as follows: When the inventory position drops to 2.526, place an order for 121.447 liters more.

The total annual cost will be ;

$$TC = \frac{DK}{Q} + \frac{hQ}{2} + cD = \frac{(184.367*2.000)}{121.447} + \frac{(0,05*121.447)}{2} + 4,00 * 184.367 = 743.540 \text{ TL}$$

Solutions with "Economic Order Quantity Model" for quantity to be ordered is 121.447. As we say before, the purpose of the inventory for "Gas and Fuel Oil" is not to be stock out. But also there is an important constraints that we have to obey. These are warehouse capacities and the objective function is "minimum order number". If we think about with the example, our first quantity order is not suitable for our tanks capacities, other one is not answer the constraint. Because of the reasons that we have necessarily constraints, we have to create our model for calculating order quantities, order period times, safety stocks etc.

4.2 Mathematical Programming Model

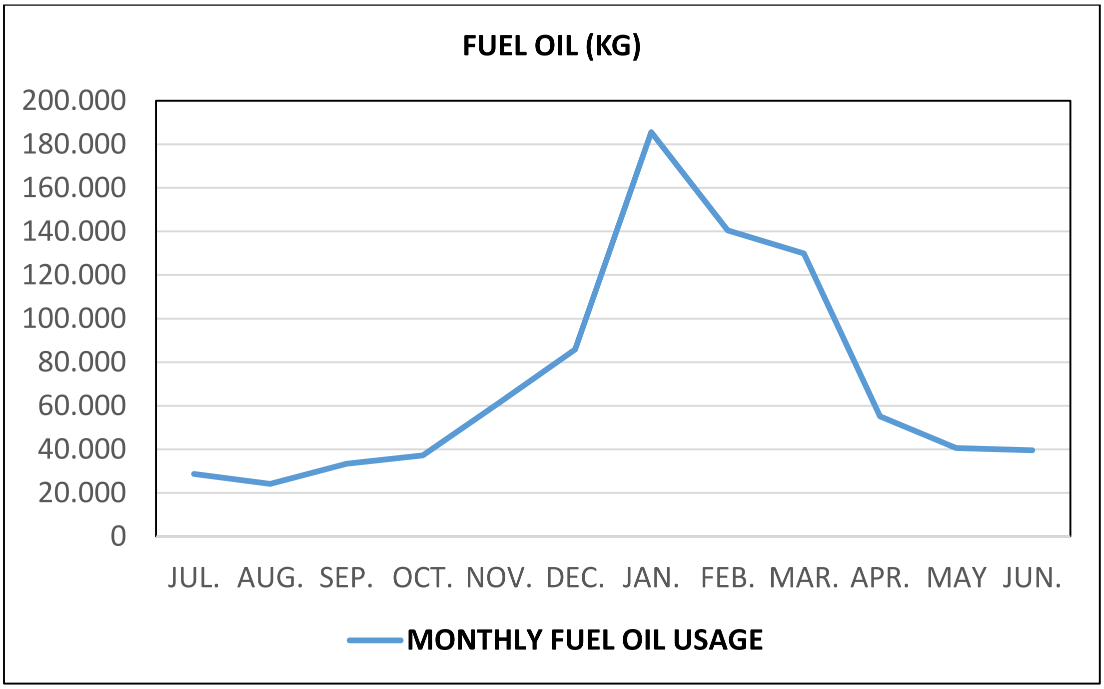
4.2.1 Fuel Oil, Gasoline, Diesel and LPG

We will model all items one by one because of their tanks. All items purchasing processes is the same but consumptions and tanks (also capacities) are different.

4.2.1.1 Fuel Oil

In Foça Gendarmerie Commando School and Training Center, approximately 850.000 kg fuel oil is used in a year for steam boilers, heating system and hot water. On July approximately 28.700 kg fuel oil is used. But in January this number increase to 185.642 kg, cause of winter (Figure 4.1).

Figure 4. 1 – Monthly Average Fuel Oil Usage



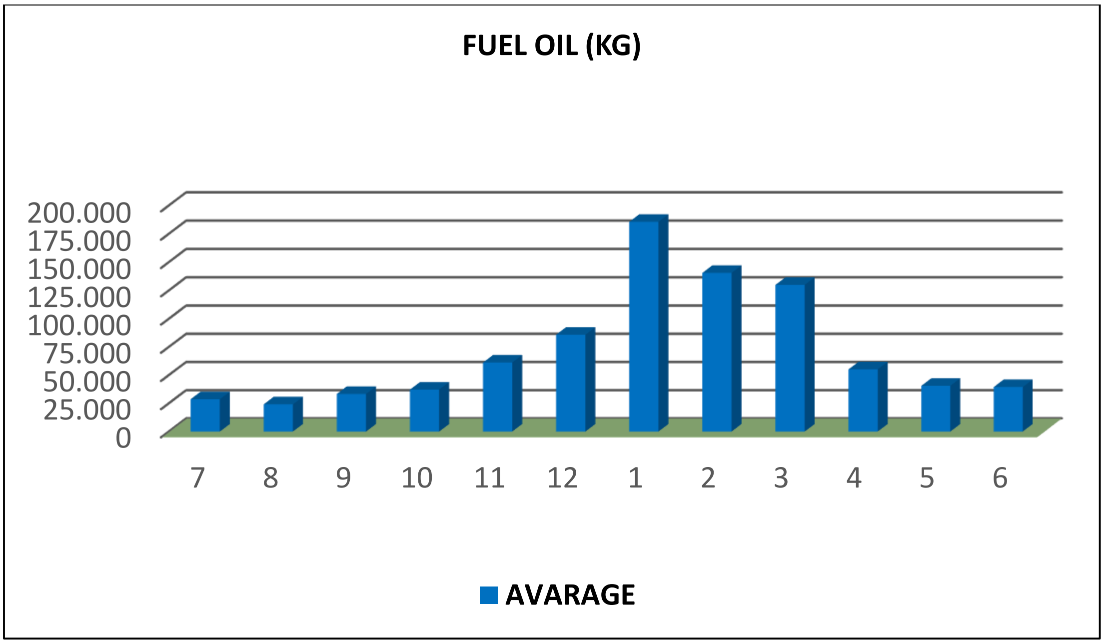
We stock up fuel oil in 12 tanks that capacities are changing between 2.000 kg and 80.000 kg (Figure 4.2). Suppliers' tanker capacities are constant, 20.000 kg. We can order one or more tanker for each time and all tankers can evacuate their fuel oil one or more depots. There is no any difference in process for FGCS, between to buy one or more tanker.

Table 4.1 – Fuel Oil Tank Capacities

FUEL OIL TANK CAPACITIES (KG)					
1	TANK A	60.000	7	TANK G	60.000
2	TANK B	10.000	8	TANK H	80.000
3	TANK C	10.000	9	TANK I	70.000
4	TANK D	5.000	10	TANK J	36.000
5	TANK E	3.000	11	TANK K	6.000
6	TANK F	7.000	12	TANK L	2.000

Because of the reason that; there is no big differences in consumption of fuel oil in one day than before or next day, "week" is taken as the unit of time. This choice will be more useful for also administration, if we consider the whole purchasing process in FGCS. Weekly consumptions are been determined by the dividing the monthly average consumptions (Figure 4.2).

Figure 4. 2 - Average Fuel Oil Consumption



In point of that reasons, our safety stock will be all depots' next week estimated consumption in our model. The objective function is to minimize the number of installments in a year (minimum order time), because we have hidden costs and risks for all each installment.

Model of "Fuel Oil":

Sets

d demand points depots /1*12/ (we have 12 tanks to put fuel oil in our troop. (Table 4.1)) t time (weeks) /1*52/ (Our time unit is "week". We have 52 weeks that we use fuel oil.)

Variable

f objective

Binary Variable

y(t) to denote whether a tanker arrives in day t

Integer Variable

G(t) number of tankers that arrive on day t

Positive Variable

E(d,t) amount (in tons) replenished to depot d in day t

X(d,t) amount (in tons) of stock in depot d at the beginning of day t;

Objective function is to minimize order numbers:

objective .. f =e= sum(t,y(t));

Model has to obey to the capacity:

obeycapacity(d,t).. X(d,t) =l= cap(d);

Model has to balance the inventory. The inventory in week "t" has to be equal before week's inventory minus before week's usage plus before day replenished:

```
inventorybalance(d,t) $(ord(t)>1) .. X(d,t) =e= X(d,t-1) - k(d,t-1) + E(d,t-1);
```

Beginning inventory has to be equal to tank capacity:

```
beginninginv(d).. X(d,'1') =e= cap(d);
```

Tanker capacity is equal to capacity of a tanker multiply the number of tankers:

```
tankercapacity(t).. sum(d,E(d,t)) =l= captanker*G(t);
```

If a tanker doesn’t arrive in specific month, we cannot make a replenishment.

```
notankernoreplenish(t).. G(t) =l= 100*y(t);
```

Finishing inventory has to be equal to tank capacity:

```
finishfull(d) .. X(d,'52') =e= cap(d);
```

Totally replenished has to be equal to annual consumption:

```
maxamount(d) .. sum(t,E(d,t)) =l= sum(t,k(d,t));
```

Maximum replenishment is equal to capacity minus amount of the stock plus two weeks demand.

```
maxreplenish(d,t) .. E(d,t) =l=tank  cap(d)-X(d,t)+2*k(d,t);
```

Safety stock is equal to next week’s demand.

```
safetystock(d,t) .. X(d,t) $(ord(t)<52) =g= k(d,t+1);
```

```
option optcr = 0.0;

Model kalyak /all/ ;

Solve kalyak using MIP minimizing f;

display G.l;

display y.l;

display E.l;
```

Results:

In Foca Gendarmerie Commando School and Training Center, the troops report their requirements to the audit office, when they have a week or ten days-use fuel oil. The audit office combine the requirements and give an order to the supplier. After that suppliers sent their tankers to the FGCS and the staff on issue fulfill the tanks. We modelled whole process, and the result was found in 3 seconds with GAMS.

Table 4. 2 – Fuel Oil Order Weeks

DEPOTS	FUEL OIL ORDER WEEKS TABLE (kg)					
	13	25	29	33	37	51
1	27.638	39.738	40.074	34.122	60.000	59.878
2	3.968	9.111	9.512	7.274	10.000	8.498
3	0	3.020	6.216	5.106	10.000	9.974
4	0	3.244	3.398	2.946	5.000	3.202
5	761	2.634	2.896	2.612	3.000	2.214
6	0	0	0	79	7.000	2.156
7	0	0	0	7.759	60.000	17.090
8	0	0	7.236	22.930	80.000	17.270
9	0	0	18.031	24.026	70.000	30.066

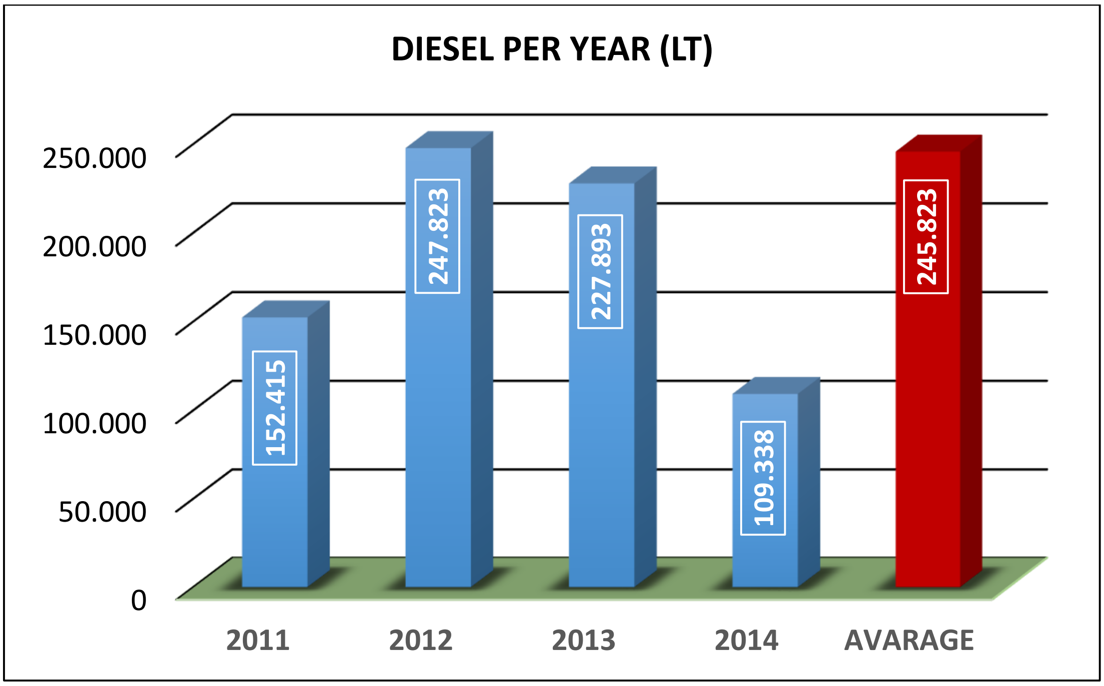
10	**6.850**	**13.733**	**12.670**	**11.036**	**36.000**	**33.982**
11	**0**	**1.331**	**3.334**	**2.026**	**6.000**	**2.304**
12	**0**	**0**	**953**	**0.452**	**2.000**	**256**

As we can see on the figure 4.4, according to our model, we have to give six orders in a year. In 13th, 25th, 29th, 33rd, 37th and 51st weeks we have to give order in totally 38.456 kg, 71.811 kg, 101.918 kg, 118.637 kg, 348.994 kg and 186.634 kg. 1st, 2nd, 5th and 10th depots will be filled every six time. 3th, 4th and 11th depots will start to be filled in 2nd order week (25th week); 8th, 9th and 12th depots will start to be filled at 3rd week (29th week); 6th and 7th depots will start to be filled at 4th week (33rd week). In the current system, annual requirement of fuel oil is met with average 20 or 25 purchasing. If we can obey to the model, we can met this needed with 6 purchasing. So, the model achieves our requirements which is to minimize ordering costs and risks.

4.2.1.2 Gasoline, Diesel and LPG

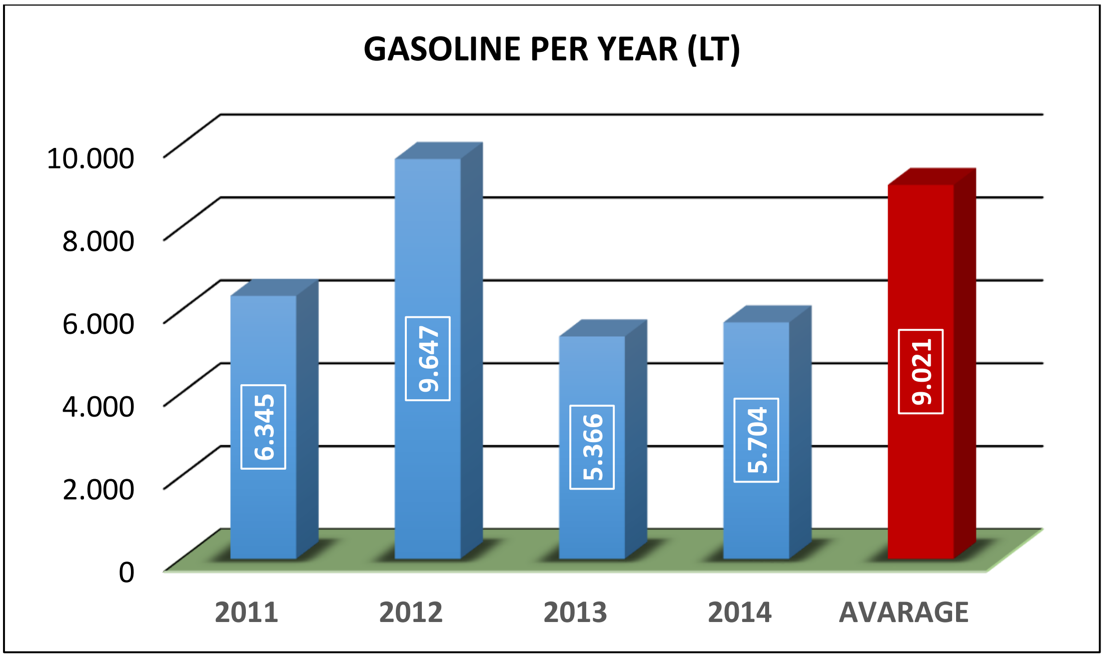
In Foca Gendarmerie Commando School and Training Center, approximately 245.000 lt diesel (Figure 4.5), 9.000 lt gasoline (Figure 4.6) are used for vehicles in a year, in FGCS. At the same time, approximately 37.000 kg LPG is used for cooking facilities (Figure 4.7). We will model “Gasoline”, “Diesel” and “LPG”, the reason that their unpredictable monthly demands, average monthly demand which we found by dividing annual average demand to twelve.

Figure 4. 3 Average Diesel Consumption



(Last 8 months' consumption of 2011 and first 6 months' consumption of 2014)

Figure 4. 4 Average Gasoline Consumption

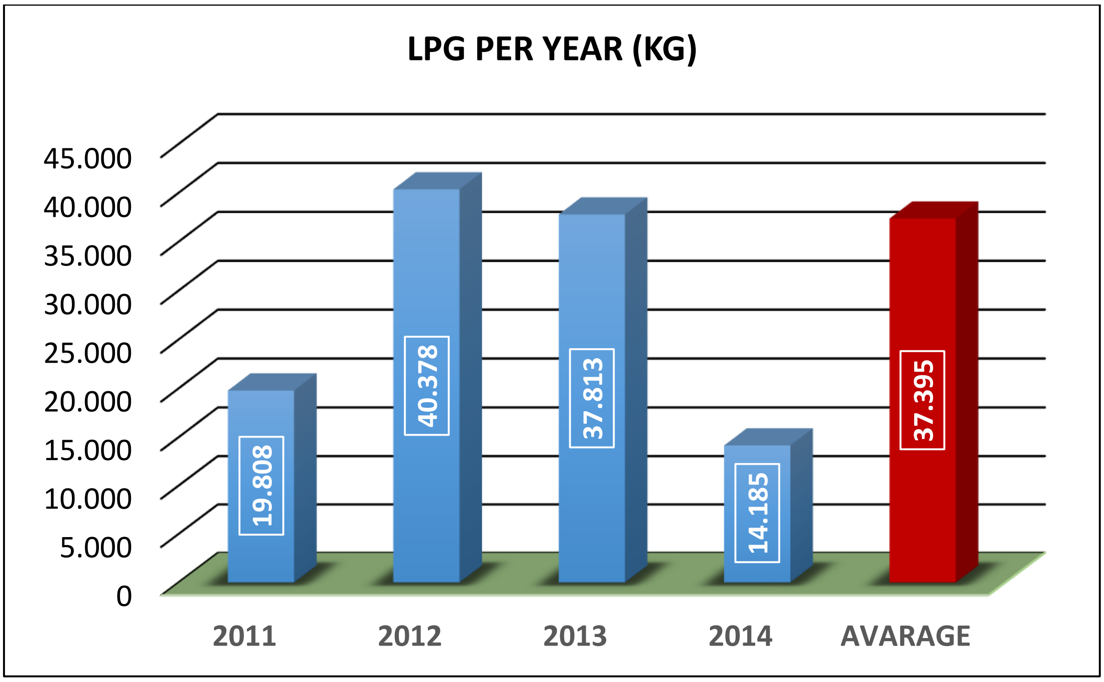


(Last 8 months' consumption of 2011 and first 6 months' consumption of 2014)

We stock up diesel in 3 tanks (totally 52.000 lt), gas in an 8.000 lt tank (Figure 4.8) and LPG in 3 tanks (capacities 3.000 kg, 10.000 kg and 10.000 kg, totally 23.000 kg).

But there is a definite rule here, that we cannot fill the gas tanks more than %50 and LPG tanks more than %80. The purpose of the inventory for “Gas and Fuel Oil” is to maintain them above safety stock. Safety stock means lead time stock for us. In this section, tank capacities and irregularity of the consumption (demand) are our constraints. The products in this section have no expiration date. Our objective function in this section is “minimum order time”. In Foca Gendarmerie Commando School and Training Center, the audit office control the tanks week by week and give an order to the supplier for gas, diesel and LPG. After that suppliers sent their tankers to the FGCS and the staff on issue fulfill the tanks.

Figure 4. 5 Average LPG Consumption



(Last 8 months’ consumption of 2011 and first 6 months’ consumption of 2014)

Table 4. 3 Tank Capacities

DIESEL AND GASOLINE TANK CAPACITIES (LT)					
1	TANK GASOLINE	8.000	3	TANK DIESEL	12.000
2	TANK DIESEL	20.000	4	TANK DIESEL	20.000

Model of "Gasoline, Diesel and LPG":

Sets

d demand points depots /1/

t time (months) /1*52/

Objective function is to minimize order numbers:

objective .. f =e= sum(t,y(t));

Variable

f objective

Binary Variable

y(t) to denote whether a tanker arrives in day t

Integer Variable

G(t) number of tankers that arrive on day t

Positive Variable

E(d,t) amount (in tons) replenished to depot d in day t

X(d,t) amount (in tons) of stock in depot d at the beginning of day t;

Model has to obey to the capacity (For gasoline max. capacity can be %50, for LPG %80):

```
obeycapacity(d,t).. X(d,t) =l= cap(d);
obeycapacity(d,t).. X(d,t) =l= cap(d)*0.50;
obeycapacity(d,t).. X(d,t) =l= cap(d)*0.80;
```

Model has to balance the inventory. The inventory in week “t” has to be equal before week’s inventory minus before week’s usage plus before day replenished:

```
inventorybalance(d,t) $(ord(t)>1) .. X(d,t) =e= X(d,t-1) - k(d,t-1) + E(d,t-1);
```

Beginning inventory has to be equal to tank capacity (For gasoline beginning inventory is %50 of the capacity, for LPG %80 of the capacity):

```
beginninginv(d).. X(d,'1') =e= cap(d);
beginninginv(d).. X(d,'1') =e= cap(d)*0.50;
beginninginv(d).. X(d,'1') =e= cap(d)*0.80;
```

Tanker capacity is equal to capacity of a tanker multiply the number of tankers:

```
tankercapacity(t).. sum(d,E(d,t)) =l= captanker*G(t);
```

If a tanker doesn’t arrive in specific month, we cannot make a replenishment.

```
notankernoreplenish(t).. G(t) =l= 100*y(t);
```

Finishing inventory has to be equal to tank capacity:

finishfull(d) .. X(d,'52') =e= cap(d);

Totally replenished has to be equal to annual consumption:

maxamount(d) .. sum(t,E(d,t)) =l= sum(t,k(d,t));

Maximum replenishment is equal to capacity minus amount of the stock plus two weeks demand.

maxreplenish(d,t) .. E(d,t) =l=tank cap(d)-X(d,t)+2*k(d,t);

Safety stock is equal to next week’s demand.

safetystock(d,t) .. X(d,t) $(ord(t)<52) =g= k(d,t+1);

option optcr = 0.0;

Model mazot /all/ ;

Solve mazot using MIP minimizing f;

display G.l;

display y.l;

display E.l;

Results:

The result was found in approximately in 1, 5 seconds with GAMS for these three items. Full results is on appendix. As we can see on the figure 4.9, according to our model, we have to give three orders in a year. In 20th, 30th and 51st weeks we have to give order in totally 1.700 lt., 4.000 lt. and 3.990 lt. In the current system, annual requirement of gas is met with 2 or 3 purchasing. The same with our model. So, the model achieves our requirements which is to minimize ordering costs and risks.

Table 4. 4 Gasoline Order Weeks

DEPOTS	GASOLINE ORDER WEEKS TABLE		
	20	**30**	**51**
1	**1.700**	**4.000**	**3.990**

On the figure 4.10, we can see that we have to give six orders in a year for diesel. In 10th, 20th, 25th, 35th, 45th, and 51st weeks we have to give order in totally 45.140 lt., 24.285 lt., 48.570 lt., 48.570 lt., 52.000 lt. and 29.142 lt. In the current system, annual requirement of diesel is met with approximately 10 or 11 purchasing. If we can obey to the model, we can met this needed with 6 purchasing. So, the model achieves our requirements which is to minimize ordering costs and risks.

Table 4. 5 Diesel Order Weeks

DEPOTS	DIESEL ORDER WEEKS TABLE (lt)					
	10	**20**	**25**	**35**	**45**	**51**
1	**45.140**	**24.285**	**48.570**	**48.570**	**52.000**	**29.142**

As we can see on the figure 4.11, according to our model, we have to give two orders in a year. In 26th and 51st weeks we have to give order in totally 18.400 lt. and 17.750 lt. In the current system, annual requirement of LPG is met with 5 or 6 purchasing. If we can obey to the model, we can met this needed with 2 purchasing. So, the model achieves our requirements which is to minimize ordering costs and risks.

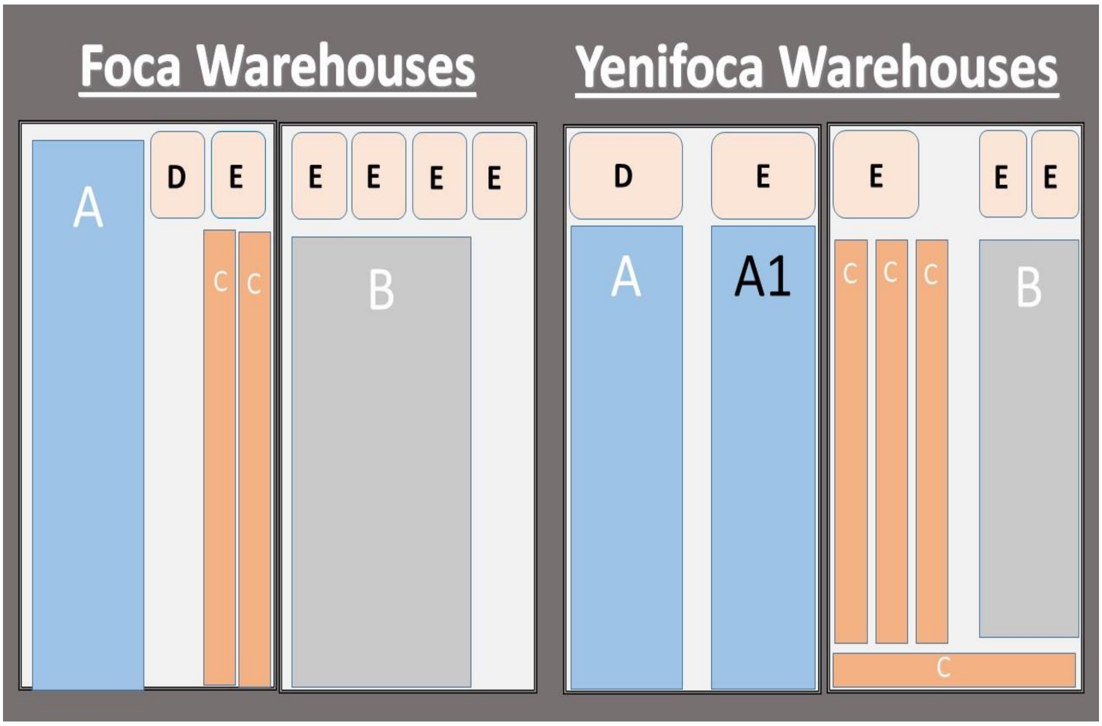
Table 4. 6 LPG Order Weeks

DEPOTS	LPG ORDER WEEKS TABLE (KG)	
	26	51
1	18.400	17.750

4.2.2 Foods and Drinks

We examined foods and drinks in two parts in chapter 3. Without ignoring this review, we will examine this section in four parts in mathematical modelling. This are separated into sections by their warehouses. “Pulses, Canned Foods, Package Foods, -18 Frozen Foods, +4 Foods.” All of these sections contain not only daily foods, which are have short lifetime; but also main foods, which are have long lifetime. In FGCS, we stock all these items in 11 freezers and 4 normal warehouses (Figure 4.6).

Figure 4. 6 Warehouse Location



In figure 4.12 section “A” is pulses, “B” is canned foods, “C” is package foods, “D” is -18 frozen foods and section “E” is +4 frozen foods warehouses. (This picture is generic and is made to show all our warehouses with their nearly capacities in one figure.)

4.2.2.1 Pulses

In all warehouses the total capacity of this section, which is for pulses, 370 pallets. We can see in figure 4.6, with capital A and A1. Section A is for fifteen pulses like sugar, rice, spaghetti, beans, peas, etc. which are have no substitutes for meals, in 220 pallets capacity. Section A1 is for flour and only located at Yenifoça, because of the bakery’s location. Section A1 has a 150 pallets capacity. We can use the section A for flour and the section A1 for pulses. So, we have totally 370 pallets capacity. In our model, we want to use our warehouses in optimum capacity, which provide to obey the shelf life that is 12 months for all items except flour (6 months). We want also no stock out with minimizing the order time. Current system all of these products are ordered with two installments except flour which is ordered with 10 installments. In other words, totally we give 38 orders in a year and take order costs and risks for 38 times.

<u>Model of “Pulses”:</u>

In the model we have 15 items and time unit is month.

Sets

j items /1*15/

t time (weeks) /1*12/

Objective function is to minimize order numbers:

objective .. f =e= sum((j,t),y(j,t));

Parameter d(j) demand (in kg) per month of item j ;

1	1.856		6	2.553		11	686
2	1.368		7	242		12	2.034
3	1.184		8	79		13	7.865
4	1.168		9	4.741		14	821
5	2.701		10	642		15	45.444

Parameter k(j) kgs per pallet of item j

1	1.000		6	700		11	750
2	1.000		7	750		12	700
3	1.000		8	750		13	1.400
4	1.000		9	1.000		14	1.000
5	1.000		10	750		15	1.000

Variable

f   objective

Binary Variable

y(j,t) to denote whether we receive a replenishment for item j in month t

Integer Variable

P(j,t) space (in pallets) occupied by item j in month t

Positive Variable

Q(j,t) amount (in kgs) of item j in depot at the beginning of month t

E(j,t) amount (in kgs) of item j replenished in month t

R(t)

Model has to balance the inventory. The inventory in month “t” has to be equal before month’s inventory minus this month’s usage plus before month replenished:

inventorybalance(j,t) $(ord(t)>1) .. Q(j,t) =e= Q(j,t-1) - d(j) + E(j,t-1);

Beginning inventory has to be equal to safety stock, which is equal to monthly demand of an item:

beginninginv(j) .. Q(j,'1') =e= s(j);

safetystock(j,t).. Q(j,t) =g= s(j);

Ending inventory has to be equal also to safety stock:

endstock(j) .. Q(j,'12') =g= 2*s(j);

Shelf life’s of items is a constraint that we must to obey: (for flour 6 months, all others 12 months)

shelflife(j,t) .. Q(j,t) =l= L(j)*d(j);

Each amounts of the items must be on a pallet:

enoughpallets(j,t).. k(j)*P(j,t) =g= Q(j,t);

enoughpallets2(j,t).. k(j)*P(j,t) =l= Q(j,t) + k(j);

Model has to obey to the capacity (370 pallets):

obeycapacity(t) .. sum(j,P(j,t)) =l= totalcap;

If a product doesn’t arrive in specific month, we cannot make a replenishment.

```
notankernoreplenish(j,t).. E(j,t) =l= 10000000*y(j,t);


option optcr = 0.0;

Model gida1 /all/ ;


Solve gida1 using MIP minimizing f;

display y.l;

display P.l;

display E.l;
```

Results:

We modelled whole process, and the result was found in 2 seconds with GAMS. As we can see on the table 4.7, according to our model, we have to give only one order in a year for 12 products. First product, which is lentils, is ordered twice (1st and 6th months) and 13th product, which is sugar, is ordered twice (1st and 3rd months) also. The flour is ordered 11 times in a year that is not ordered only in 12th month.

If we compare the current system with model; in the current system, annual requirement of pulses are met with 38 purchasing. But if we can obey to the model, we can met this needed with 27 purchasing. For first looking it can be seen like no big difference, but with the model we can purchase 12 items with one instalment. So, the model achieves our requirements which is to minimize ordering costs and risks.

Table 4. 7 Pulses Order Weeks

PULSES ORDER TABLE												
PRODUCT	MONTHS											
	1	2	3	4	5	6	7	8	9	10	11	12
1	9.856	0	0	0	0	12.416	0	0	0	0	0	0
2	16.416	0	0	0	0	0	0	0	0	0	0	0
3	14.208	0	0	0	0	0	0	0	0	0	0	0
4	14.016	0	0	0	0	0	0	0	0	0	0	0
5	32.412	0	0	0	0	0	0	0	0	0	0	0
6	30.636	0	0	0	0	0	0	0	0	0	0	0
7	2.904	0	0	0	0	0	0	0	0	0	0	0
8	948	0	0	0	0	0	0	0	0	0	0	0
9	56.892	0	0	0	0	0	0	0	0	0	0	0
10	7.704	0	0	0	0	0	0	0	0	0	0	0
11	8.232	0	0	0	0	0	0	0	0	0	0	0
12	24.408	0	0	0	0	0	0	0	0	0	0	0
13	20.465	0	73.915	0	0	0	0	0	0	0	0	0
14	9.852	0	0	0	0	0	0	0	0	0	0	0
15	45.444	45.444	45.444	45.444	45.444	45.444	45.444	45.444	45.444	45.444	45.444	0

4.2.2.2 Canned Foods

In this section we examine 10 products that includes; olive, olive oil, sunflower oil, tomato paste, water, pickles, etc. In two warehouses which are Foça and Yenifoça, we have 170 pallets capacity. We can see in figure 4.6, with capital B. These products, that we named “canned foods” also have no substitutes. In our model, we want to use our warehouses in optimum capacity, which provide to obey the lifetime and no stock out with minimizing the order time. Current system all of these products are ordered with two installments except water which is ordered with 5 installments. In other words, totally we give 23 orders in a year and take order costs and risks for 23 times.

Model of "Canned Foods":

In the model we have 10 items and time unit is month.

Sets

j   items /1*10/

t   time (months) /1*12/

Objective function is to minimize order numbers:

objective .. f =e= sum((j,t),y(j,t));

Parameter d(j) demand (in kg) per month of item j ;

1	889
2	2.753
3	1.103
4	2.337
5	675

6	399
7	301
8	1.039
9	8.704
10	13.517

Parameter k(j) kg per pallet of item j

1	1.000
2	1.000
3	787
4	810
5	787

6	787
7	787
8	1.392
9	1.392
10	720

Variable

f   objective

Binary Variable

y(j,t) to denote whether we receive a replenishment for item j in month t

Integer Variable

P(j,t) space (in pallets) occupied by item j in month t

Positive Variable

Q(j,t) amount (in kgs) of item j in depot at the beginning of month t

E(j,t) amount (in kgs) of item j replenished in month t

N(j,t) replenishment in terms of pallets

R(t)

Model has to balance the inventory. The inventory in month “t” has to be equal before month’s inventory minus this month’s usage plus before month replenished:

```
inventorybalance(j,t) $(ord(t)>1) .. Q(j,t) =e= Q(j,t-1) - d(j) + E(j,t-1);
```

Beginning inventory has to be equal to safety stock, which is equal to monthly demand of an item:

```
beginninginv(j) .. Q(j,'1') =e= s(j);
safetystock(j,t).. Q(j,t) =g= s(j);
```

Ending inventory has to be equal also to safety stock:

```
endstock(j) .. Q(j,'12') =g= 2*s(j);
```

Shelf life’s of items is a constraint that we must to obey: (for waters 6 months, all others 12 months)

```
shelflife(j,t)  .. Q(j,t) =l= L(j)*d(j);
```

Each amounts of the items must be on a pallet:

```
enoughpallets(j,t).. k(j)*P(j,t) =g= Q(j,t);
enoughpallets2(j,t).. k(j)*P(j,t) =l= Q(j,t) + k(j);
```

Model has to obey to the capacity (170 pallets):

```
obeycapacity(t) .. sum(j,P(j,t)) =l= totalcap;
```

If a product doesn't arrive in specific month, we cannot make a replenishment.

```
notankernoreplenish(j,t).. E(j,t) =l= 10000000*y(j,t);
```

```
option optcr = 0.0;
Model gida2 /all/ ;

Solve gida2 using MIP minimizing f;
display y.l;
display P.l;
display E.l;
display R.l;
display N.l;
```

<u>Results:</u>

We modelled whole process, and the result was found in 3 seconds with GAMS. As we can see on the table 4.8, according to our model, we have to give 16 orders in a year. One order in a year for 6 products. Two orders for three products and four orders for 10th product, which is water that we have to order. If we compare the current system with model; in the current system, annual requirement of canned foods are met with 23 purchasing. But if we can obey to the model, we can met this needed with 16 purchasing. So, the model achieves our requirements which is to minimize ordering costs and risks.

Table 4. 8 Canned Foods Order Weeks

CANNED FOODS ORDER TABLE												
PRODUCTS	MONTHS											
	1	2	3	4	5	6	7	8	9	10	11	12
1	10.668	0	0	0	0	0	0	0	0	0	0	0
2	2.753	30.283	0	0	0	0	0	0	0	0	0	0
3	16.818	0	0	0	0	0	0	0	0	0	0	0
4	12.000	0	0	0	22.622	0	0	0	0	0	0	0
5	10.292	0	0	0	0	0	0	0	0	0	0	0
6	6.084	0	0	0	0	0	0	0	0	0	0	0
7	4.590	0	0	0	0	0	0	0	0	0	0	0
8	8.957	0	0	0	0	0	0	0	0	0	0	0
9	34.253	0	0	0	0	40.782	0	0	0	0	0	0
10	58.774	0	0	76.321	0	0	0	76.868	0	0	13.321	0

4.2.2.3 Package Foods

In “Package Foods”, we examine 35 products which are milk, fruit juice, biscuits, honey, jam, spices, etc. In two warehouses which are Foca and Yenifoca, we have totally 300 pallets capacity. We can see in figure 4.6, with capital C. These products especially use in breakfasts and operations. In our model, we want to use our warehouses in optimum capacity, which provide to obey the lifetime and no stock out with minimizing the order time. Current system all of these products are ordered with two installments. So, totally we give 70 orders in a year and take order costs and risks for 70 times.

Model of "Package Foods":

In the model we have 35 items and time unit is month.

Sets

j items /1*35/

t time (months) /1*12/

Objective function is to minimize order numbers:

objective .. f =e= sum((j,t),y(j,t));

Parameter d(j) demand (in kg) per month of item j ;

1	1.713
2	2.867
3	2.732
4	1.943
5	2.732
6	5.919
7	6.615
8	3.811
9	373
10	8.258
11	15.694
12	2.980

13	21.514
14	22.313
15	15.113
16	45.236
17	17.136
18	8.909
19	10.400
20	9.564
21	16.720
22	2.633
23	1.667
24	2.167

25	2.027
26	108
27	433
28	444
29	224
30	791
31	28
32	852
33	670
34	618
35	570

Parameter k(j) kg per pallet of item j

1	2.880
2	4.032
3	2.880
4	2.880

5	2.880
6	4.032
7	4.032
8	4.032

9	2.880
10	4.032
11	4.400
12	864

13	4.400
14	14.400
15	14.400
16	14.400
17	14.400
18	10.368
19	10.368
20	10.368

21	10.368
22	10.368
23	10.368
24	10.368
25	10.368
26	360
27	320
28	320

29	320
30	60
31	360
32	500
33	500
34	500
35	360

Variable

f objective

Binary Variable

y(j,t) to denote whether we receive a replenishment for item j in month t

Integer Variable

P(j,t) space (in pallets) occupied by item j in month t

Positive Variable

Q(j,t) amount (in kgs) of item j in depot at the beginning of month t

E(j,t) amount (in kgs) of item j replenished in month t

N(j,t) replenishment in terms of pallets

R(t)

Model has to balance the inventory. The inventory in month "t" has to be equal before month's inventory minus this month's usage plus before month replenished:

```
inventorybalance(j,t) $(ord(t)>1) .. Q(j,t) =e= Q(j,t-1) - d(j) + E(j,t-1);
```

Beginning inventory has to be equal to safety stock, which is equal to monthly demand of an item:

```
beginninginv(j) .. Q(j,'1') =e= s(j);
safetystock(j,t).. Q(j,t) =g= s(j);
```

Shelf life's of items is a constraint that we must to obey: (for milk 4 months, Dried fruits and spices 6 months, all others 12 months)

```
shelflife(j,t)  .. Q(j,t) =l= L(j)*d(j);
```

Each amounts of the items must be on a pallet:

```
enoughpallets(j,t).. k(j)*P(j,t) =g= Q(j,t);
enoughpallets2(j,t).. k(j)*P(j,t) =l= Q(j,t) + k(j);
```

Model has to obey to the capacity (300 pallets):

```
obeycapacity(t) .. sum(j,P(j,t)) =l= totalcap;
```

If a product doesn't arrive in specific month, we cannot make a replenishment.

```
notankernoreplenish(j,t).. E(j,t) =l= 10000000*y(j,t);
```

```
option optcr = 0.0;
Model gida2 /all/ ;

Solve gida2 using MIP minimizing f;
display y.l;
```

display P.l;

display E.l;

display R.l;

display N.l;

Results:

We modelled whole process, and the result was found in 4 seconds with GAMS. Full result is on appendix. As we can see on the table 4.9, according to our model, we have to give 48 orders in a year. One order in a year for 24 products. Two orders for 9 products and three orders for 2 products. If we compare the current system with model; in the current system, annual requirement of canned foods are met with 70 purchasing. But if we can obey to the model, we can met this needed with 48 purchasing. So, the model achieves our requirements which is to minimize ordering costs and risks.

Table 4. 9 Package Foods Order Weeks

PACKAGE FOODS ORDER TABLE												
PRODUCTS	MONTHS											
	1	2	3	4	5	6	7	8	9	10	11	12
1	18.843	0	0	0	0	0	0	0	0	0	0	0
2	31.537	0	0	0	0	0	0	0	0	0	0	0
3	30.052	0	0	0	0	0	0	0	0	0	0	0
4	21.373	0	0	0	0	0	0	0	0	0	0	0
5	30.052	0	0	0	0	0	0	0	0	0	0	0
6	65.109	0	0	0	0	0	0	0	0	0	0	0
7	6.615	66.150	0	0	0	0	0	0	0	0	0	0
8	41.921	0	0	0	0	0	0	0	0	0	0	0
9	4.103	0	0	0	0	0	0	0	0	0	0	0
10	16.516	0	74.322	0	0	0	0	0	0	0	0	0

11	47.082	0	0	62.776	0	0	0	14.267	0	0	0	0
12	8.940	0	0	11.920	0	0	0	13.796	0	0	0	0
13	64.542	0	0	172.112	0	0	0	0	0	0	0	0
14	245.443	0	0	0	0	0	0	0	0	0	0	0
15	166.243	0	0	0	0	0	0	0	0	0	0	0
16	45.236	452.360	0	0	0	0	0	0	0	0	0	0
17	188.496	0	0	0	0	0	0	0	0	0	0	0
18	97.999	0	0	0	0	0	0	0	0	0	0	0
19	114.400	0	0	0	0	0	0	0	0	0	0	0
20	105.204	0	0	0	0	0	0	0	0	0	0	0
21	183.920	0	0	0	0	0	0	0	0	0	0	0
22	28.963	0	0	0	0	0	0	0	0	0	0	0
23	18.337	0	0	0	0	0	0	0	0	0	0	0
24	23.837	0	0	0	0	0	0	0	0	0	0	0
25	22.297	0	0	0	0	0	0	0	0	0	0	0
26	1.188	0	0	0	0	0	0	0	0	0	0	0
27	1.732	0	0	0	3.031	0	0	0	0	0	0	0
28	4.884	0	0	0	0	0	0	0	0	0	0	0
29	2.464	0	0	0	0	0	0	0	0	0	0	0
30	8.701	0	0	0	0	0	0	0	0	0	0	0
31	308	0	0	0	0	0	0	0	0	0	0	0
32	4.260	0	0	0	0	5.112	0	0	0	0	0	0
33	3.350	0	0	0	0	4.020	0	0	0	0	0	0
34	3.090	0	0	0	0	3.708	0	0	0	0	0	0
35	2.850	0	0	0	0	3.420	0	0	0	0	0	0

4.2.2.4 -18°C Frozen Foods

In this section we examine meat, chicken, ravioli and puff pastry. In two warehouses which are Foca and Yenifoca, we have 25 pallets capacity. We can see in figure 4.6, with capital D. These products have no substitutes. In our model, we want to use our warehouses in optimum capacity, which provide to obey the lifetime and no stock out with minimizing the order time. Current system -18°C frozen foods are ordered two times in a week. So, totally we give 104 orders for each products in a year and take order costs and risks for 104 times for each products.

Model of "-18°C Frozen Foods":

In the model we have 5 items and time unit is day.

Sets

j   items /1*5/

t   time (days) /1*360/

Objective function is to minimize order numbers:

objective .. f =e= sum((j,t),y(j,t));

Parameter d(j) demand (in kg) per day of item j ;

1	626
2	323
3	33
4	129
5	0*

(*5th product is sheep meat that we use only in holy days.)

Parameter k(j) kg per pallet of item j

1	500
2	1.500
3	1.500
4	1.500
5	1.500

Variable

f   objective

Binary Variable

y(j,t) to denote whether we receive a replenishment for item j in month t

Integer Variable

P(j,t) space (in pallets) occupied by item j in month t

Positive Variable

Q(j,t) amount (in kgs) of item j in depot at the beginning of month t

E(j,t) amount (in kgs) of item j replenished in month t

N(j,t) replenishment in terms of pallets

R(t)

Model has to balance the inventory. The inventory in day "t" has to be equal before day's inventory minus this day's usage plus before day replenished:

```
inventorybalance(j,t) $(ord(t)>1) .. Q(j,t) =e= Q(j,t-1) - d(j) + E(j,t-1);
```

Beginning inventory is zero:

```
beginninginv(j) .. Q(j,'1') =e= 0;
```

Shelf life's of items is a constraint that we must to obey: (for meat and chicken 14 days; for ravioli 90 days and for puff pastry 30 days)

```
shelflife(j,t)  .. Q(j,t) =l= L(j)*d(j);
```

Each amounts of the items must be on a pallet:

```
enoughpallets(j,t).. k(j)*P(j,t) =g= Q(j,t);

enoughpallets2(j,t).. k(j)*P(j,t) =l= Q(j,t) + k(j);
```

Model has to obey to the capacity (25 pallets):

```
obeycapacity(t) .. sum(j,P(j,t)) =l= totalcap;
```

If a product doesn't arrive in specific month, we cannot make a replenishment.

```
notankernoreplenish(j,t).. E(j,t) =l= 10000000*y(j,t);
```

```
option optcr = 0.169;

Model gida8 /all/ ;

Solve gida8 using MIP minimizing f;

display y.l;

display P.l;

display E.l;

display R.l;
```

Results:

We modelled whole process, and the result was found in 4 seconds with GAMS. Full result is on appendix. As we can see on the table 4.9, according to our model, we have to give 40 orders for meat; 39 orders for chicken, 13 orders for ravioli and 20 orders for puff pastry. If we plus that with 2 sheep meat orders, annual requirement of frozen foods are met with 114 purchasing in a year. So, the model achieves our requirements which is to minimize ordering costs and risks.

Table 4. 10 -18°C Frozen Foods Order Weeks

-18°C FROZEN FOODS ORDER TABLE KG/DAY										
	1	**13**	**24**	**25**	**34**	**42**	**52**	**53**	**61**	**62**
1	7.512	7.512	3.130	6.886	7.512	0	3.130	6.886	1.292	1.292
2	3.876	3.553	3.553	0	4.522	3.876	0	0	0	0
3	396	2.178	0	0	0	0	0	0	2.064	0
4	1.548	3.483	0	0	3.483	0	0	0	0	0
	68	**78**	**85**	**94**	**96**	**104**	**106**	**108**	**116**	**125**
1	8.138	1.878	5.634	5.008	3.756	6.886	0	0	7.512	6.260
2	4.522	3.230	3.553	0	0	1.292	1.292	4.199	0	3.230
3	0	1.683	0	0	0	0	0	0	0	2.409
4	0	2.064	0	2.451	0	0	0	0	1.677	3.096
	134	**135**	**142**	**152**	**160**	**172**	**174**	**182**	**191**	**192**
1	8.764	0	0	4.382	8.764	9.390	0	0	5.008	3.130
2	323	3.553	1.938	4.845	1.938	1.292	1.292	3.876	1.938	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	2.580	0	1.806	0	2.709	0	0
	200	**202**	**207**	**217**	**225**	**226**	**236**	**244**	**254**	**262**
1	7.512	0	3.756	3.756	8.138	0	5.008	7.512	7.512	0
2	3.230	0	4.845	0	1.615	3.876	4.845	0	1.938	1.292
3	66	66	528	660	0	0	957	0	0	0
4	0	0	903	3.483	0	0	0	1.290	1.677	1.548
	263	**270**	**278**	**279**	**286**	**295**	**304**	**314**	**324**	**326**
1	0	5.008	5.634	0	5.634	5.634	7.512	4.382	7.512	0
2	1.292	3.553	646	3.553	0	3.230	3.230	3.553	1.292	3.876
3	0	759	0	0	0	1.815	0	0	0	0
4	0	0	1.806	0	774	3.612	0	0	2.580	0
	334	**344**	**352**							
1	3.756	8.138	1.252							
2	4.199	0	1.615							
3	0	330	0							
4	0	1.677	0							

4.2.2.5 +4°C Foods

We examine "+4°C foods" in two section. One of them is "vegetables and fruits" and the other that includes; three kind of cheeses, buttermilk, egg, ayran, sausage and yogurt. In 9 warehouses which are Foça and Yenifoça, we have 80 pallets capacity.

We can see in figure 4.6, with capital E. Two of these warehouses, which have totally 20 pallets capacity, are for vegetables and fruits. Because of the rule that we have to consume this products fresh, two times in a week we purchase this products. So we will not model vegetables and fruits in this thesis. In our model, we want to use our warehouses in optimum capacity, which provide to obey the lifetime and no stock out with minimizing the order time. Current system yogurt, ayran, egg, yeast and sausage are ordered two times in a week. So, totally we give 104 orders in a year and take order costs and risks for 104 times for each products. Kinds of cheese and buttermilk are ordered two times in a year.

Model of "+4°C Foods":

In the model we have 10 items and time unit is week.

Sets

j items /1*10/

t time (weeks) /1*52/

Objective function is to minimize order numbers:

objective .. f =e= sum((j,t),y(j,t));

Parameter d(j) demand (in kg) per day of item j ;

1	689
2	364
3	3.981
4	445
5	8.622

6	9
7	156
8	3.476
9	19.222
10	7.315

Parameter k(j) kg per pallet of item j

1	1.800
2	1.200
3	36.000
4	1.280
5	36.000

6	300
7	720
8	960
9	10.800
10	1.280

Variable

f   objective

Binary Variable

y(j,t) to denote whether we receive a replenishment for item j in month t

Integer Variable

P(j,t) space (in pallets) occupied by item j in month t

Positive Variable

Q(j,t) amount (in kgs) of item j in depot at the beginning of month t

E(j,t) amount (in kgs) of item j replenished in month t

N(j,t) replenishment in terms of pallets

R(t)

Model has to balance the inventory. The inventory in week “t” has to be equal before week’s inventory minus this week’s usage plus before week replenished:

```
inventorybalance(j,t) $(ord(t)>1) .. Q(j,t) =e= Q(j,t-1) - d(j) + E(j,t-1);
```

Beginning inventory is zero:

```
beginninginv(j) .. Q(j,'1') =e= 0;
```

Shelf life's of items is a constraint that we must to obey: (for 3 kind of cheese and buttermilk 180 days; for sausage 30 days and for egg, yogurt and ayran 7 days)

```
shelflife(j,t)  .. Q(j,t) =l= L(j)*d(j);
```

Each amounts of the items must be on a pallet:

```
enoughpallets(j,t).. k(j)*P(j,t) =g= Q(j,t);
enoughpallets2(j,t).. k(j)*P(j,t) =l= Q(j,t) + k(j);
```

Model has to obey to the capacity (60 pallets):

```
obeycapacity(t) .. sum(j,P(j,t)) =l= totalcap;
```

If a product doesn't arrive in specific month, we cannot make a replenishment.

```
notankernoreplenish(j,t).. E(j,t) =l= 10000000*y(j,t);
```

```
option optcr = 0.04;
Model gida7 /all/ ;

Solve gida7 using MIP minimizing f;
display y.l;
display P.l;
display E.l;
```

display R.l;

display N.l;

Results:

We modelled whole process, and the result was found in 7 and a half minutes with GAMS. Full result is on appendix. As we can see on the table 4.10, according to our model, we have to give 3 orders for white cheese, cream cheese, pan oil and buttermilk; 4 orders for yellow cheese; 11 orders for sausage and yeast; 26 orders for yogurt; 27 orders for egg and 28 orders for ayran. Annual requirement of +4 foods are met with approximately 400-450 purchasing in a year. If we obey the model order number will decrease to 115. So, the model achieves our requirements which is to minimize ordering costs and risks.

Table 4. 11 +4°C Foods Order Weeks

+4°C FOODS ORDER TABLE KG/WEEK							
	1	**3**	**5**	**6**	**7**	**9**	**10**
1	8.268	0	0	0	0	0	0
2	4.368	0	0	0	0	0	0
3	47.772	0	0	0	0	0	0
4	2.225	0	0	1.335	0	1.780	0
5	103.464	0	0	0	0	0	0
6	108	0	0	0	0	0	0
7	780	0	0	624	0	0	468
8	6.952	6.952	6.952	0	6.952	6.952	0
9	38.444	38.444	38.444	0	38.444	38.444	0
10	14.630	14.630	14.630	0	14.630	14.630	0
	11	**13**	**15**	**17**	**18**	**19**	**20**
1	0	15.158	0	0	0	0	0
2	0	4.368	0	0	0	0	0
3	0	71.658	0	0	0	0	0
4	0	1.780	0	2.225	0	0	0
5	0	146.574	0	0	0	0	0
6	0	216	0	0	0	0	0
7	0	780	0	0	780	0	0
8	6.952	6.952	6.952	6.952	0	6.952	0
9	38.444	38.444	38.444	38.444	0	38.444	0

10	14.630	14.630	14.630	14.630	0	7.315	14.630
	21	**22**	**23**	**24**	**25**	**26**	**27**
1	0	0	0	0	0	0	0
2	0	0	0	0	8.736	0	0
3	0	0	0	0	0	0	0
4	0	2.225	0	0	0	0	2.225
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	0	0	780	0	0	0	0
8	6.952	0	6.952	0	6.952	0	6.952
9	38.444	0	38.444	0	38.444	0	38.444
10	0	14.630	0	14.630	0	14.630	0
	28	**29**	**30**	**31**	**32**	**33**	**34**
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	83.601	0	0	0
4	0	0	0	0	2.225	0	0
5	0	0	189.684	0	0	0	0
6	0	0	0	0	0	0	0
7	624	0	0	0	780	0	0
8	0	6.952	0	0	0	6.952	0
9	0	38.444	0	6.952	38.444	0	38.444
10	14.630	0	14.630	19.222	14.630	0	14.630
	35	**36**	**37**	**38**	**39**	**40**	**41**
1	11.713	0	0	0	0	0	0
2	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
4	0	0	2.225	0	0	0	0
5	0	0	0	0	0	0	0
6	0	0	135	0	0	0	0
7	0	0	780	0	0	0	0
8	6.952	0	6.952	0	6.952	0	6.952
9	0	38.444	0	38.444	0	38.444	0
10	0	14.630	0	14.630	0	14.630	0
	42	**43**	**44**	**46**	**47**	**48**	**49**
1	0	0	0	0	0	0	0
2	0	0	0	0	0	0	1.092
3	0	0	0	0	0	0	0
4	2.225	0	0	0	2.225	0	0
5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
7	780	0	0	0	780	0	0
8	0	3.476	6.952	6.952	0	6.952	0
9	38.444	0	38.444	38.444	0	38.444	0
10	14.630	0	14.630	14.630	0	14.630	0
	50						
1	0						
2	0						
3	0						
4	0						
5	0						
6	0						
7	0						

8	6.952						
9	38.444						
10	14.630						

As a result if we can adapt our model to real life, nearly all order numbers will be reduced by half. This means that our ordering costs and risks will be minimized and the purchasing and inventory process will be easier to manage.

CHAPTER 5

5. Conclusion and Future Work

Currently, in Turkish General Commandership of Gendarmerie, we purchase our needs according to the Turkish Public Procurement Law, by tenders. Because of the process that we said above, when we make our purchasing plans, we only consider our warehouse capacities and the shelf life of our needed items. So, our ordering costs and ordering risks be unobserved. With another say, we never know an item's price difference between 3 installments and 5 installments. Because when we composing the specification write this topic and cannot compare the price differences. Also, each one more installment creates one more risk for the person who works in the commission of inspection as an additional duties.

We started at that point and examined Foça Gendarmerie Commando School and Training Center's inventory system with comparing the inventory systems in literature. We reached to the conclusion that in our inventory and purchasing management system, we do not consider "ordering costs" and do not give the orders in correct number. After that we made a mathematical model of the "Gas and Fuel Oil" and "Foods and Drinks" sections to find the best answers of these questions:

1. How much to order?
2. When to order?

We used last 38 months consumption data in our model. And we think that we reached the best solutions for Foça Gendarmerie Commando School and Training Center's inventory management system. In the current system, approximately 40 orders are given for "Fuel Oil, Gasoline, Diesel and LPG" section, in a year. For "Foods and Drinks" section annual order numbers reach approximately 931 orders. But if we can obey to the analytical modelling that we made in this thesis, order numbers will decrease approximately 17 orders for "Fuel Oil, Gasoline, Diesel and LPG" section and 321 orders for "Foods and Drinks" section. The total annual budgets of "Gas and Fuel Oil" and "Foods and Drinks" sections reach 20 million Turkish Liras in Foça Gendarmerie Commando School and Training Center. And with this thesis we think an approximately 2 or 3 percent benefits that will be obtained from the order costs. Also so many possible risks that we explained in chapter 3, will be minimized, of course.

This thesis can be used for another troops by changing the constraints and assumptions. The other sections, that we didn't examine like cleaning goods, can be examined and modelled in future. Also, this thesis can be a start point for using mathematical models before the decisions in the Turkish General Commandership of Gendarmerie, for reducing inventory or purchasing costs.

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