Analysis of Inventory Management of Laptops Spare Parts by Using XYZ Techniques and EOQ Model – A Case Study

Wisam Al-dulaime, Walid Emar
Electrical Engineering department Isra University
Faculty of Engineering Amman, 11622 Jordan
Jordan
{walidemar@yahoo.com}

ABSTRACT: *Inventory control of spare parts is very important to many organizations. Excess inventory and overstocks lead to high holding costs. On the other side stock outs can have a great impact on production or service. The problem of this paper is the shortcomings of the current systems of inventory management and the lack of proper regulation of spare parts using most common manual methods to manage them in inventory. This paper was conducted at Laptop sale company known as UPS company and electrical appliances supply Company in Amman, Jordan as a case study.*

In this paper, the EOQ cost management model and XYZ analysis were implemented using a software system that helps to make the inventory management automatically prepared and organized. Using EOQ model with XYZ analysis and following the procedures of entering the data into the system consequently lead to a process of getting the necessary reports in consistent shape. Using the software system such as the one used in this paper helps facilitating the access to the history of any items that could be managed by such system.

1. Introduction

The definition of inventory management is a continuous process involving organization, planning and inventory control. Its main objective is to minimize the investments that are made within the inventory as they are balanced in terms of supply and demand. In particular, this process involves overseeing the most important procurement, storage, and access to materials, to ensure sufficient supply, minus excess offerings. The most important objective is to develop ways to reduce the amount of inventory through centralization of warehouse sites [1].

The purpose of implementation of the spare parts' inventory management is keeping a balance between the continuous production of spare parts in the industry and the minimum cost incurred. Today, in the World, there is very little paper on the spare parts despite of the inventory management of being very essential for any business that deals with spare items. This means that it is necessary to access a time management system properly to reduce the cost, because any delay should be reduced whether caused by transport, sales movement, or regulation to avoid an increase in cost [2].

With the continuous development of experience in the 21st century, the industrial management system has become more complex in all respects. This leads to widespread criticism about the control of spare parts and their availability. Shortage of spare parts

may cause sudden and unexpected discontinuities, resulting in loss of money [3].

Inventory classification is of great importance for organizations as the number of items kept as inventory makes it difficult to implement a control system for every item. Instead of trying to control every single item, organizations seek to classify them into different groups, whereas the groups are assigned different policies. Since the classification is limited to annual cost usage many crucial factors such as lead time, criticality, inventory cost, obsolescence, commonality, reparability, durability and so on are not taken into account [4].

In the analysis of spare part storage, their specific, often unpredictable nature of demand is an objective problem. Some spare parts have a demand for high level, some very small (one to several years), which greatly complicates anticipating and predicting the level of importance for their replacement. When managing spare parts inventory, the answer to several important questions should be known [5-6]:

• Retention or non-retention of spare parts in inventory? In general, the holding period of the performance parts should be limited but parts are usually stored as much as possible so that customers can use it forever. Comparing the storage (holding) cost to the inventory cost at the time of replacement and supply could give a realistic answer to this question.

• What is the optimal number of pieces to keep in stock? Decisions require annual demand, ordering and storage holding costs.

• The time of asking for a new order? The moment to create a new order is usually called a reorder point. If too many items are in stock, this can lead to high holding cost. On the other hand, too few items can lead to high punitive holding cost. The minimum inventory is determined taking into account the consumption during the lead time. The user or supplier specifies the lead time and the demand is calculated based on the previous time periods and the basis of the known (planned) needs for replacement of parts.

• What is the quantity that is optimal to order just to satisfy external customer or internal requirements for some items? Thus, the decision on making an order is not "how many items or orders?" instead, it is:" Under which conditions does the decision of the company for choosing the right quantity makes it different?"

This work tries to answer the questions above. Therefore, it addresses the question of how to make inventory classification management and the order of magnitude constitutes a major management cost difference and efficient. There are various types of spare parts inventory management techniques and models that could be used for managing parts inventory more effectively. But this paper is focused on the implementation of XYZ analysis with economic order quantity model (EOQ) using software technology. XYZ analysis stands for always best control analysis where inventory items are classified into three categories, namely: X, Y and Z. The items in X category of inventory are closely controlled as steady turnover over time and demand in future can be readily forecast. The items in Y category are characterized by the variability of their demand to a certain extent depending on season factors, product lifecycle, competitor action or economic situations.

A well-known classical formula for making a decision concerning how much quantity of inventory could the company order at any instant of time and when should they ask for the order, economic order quantity (EOQ) can be successfully used [7].

The purpose of this paper, therefore, is to develop a strategy using EOQ model with XYZ analysis through software technology that will facilitate the choice of the inventory strategy and inventory management of spare parts within industrial and sale companies or suppliers. The model aims to reduce inventory holding and carrying costs in order to improve the efficiency and effectiveness of organizations.

This is achieved through:

• Conducting an XYZ analysis in order to access the classification of materials to minimize inventory.

• Conducting the EOQ model to manage inventory costs per order.

• Building a questionnaire to assess current inventory management.

• Building a computerized inventory management system for inventory control in general.

The results of this paper demonstrate the reduction of the total holding and carrying costs by a large amount whilst the efficiency of the service is improved and achieved as required. Even more satisfactorily, the proposed technique is simple and straightforward enough to be implemented by company managers which increases the possibility of its adoption in other or similar industries.

2. Explanation of Inventory Management Techniques

2.1. XYZ Analysis Method
XYZ analysis is one of the most common methods used to organize spare parts in inventory. XYZ analysis is a format that focuses on the quantitative movement of the inventory parts. This analysis is based on clear foundations for leadership in this subject in terms of the nature of their disparity. There is a clear ease in organizing elements of similar patterns and applying appropriate strategies to each group differently.

Figure 1 shows the division method of the inventory according to this analysis where the (X) represents about 20% percent of the inventory and 80% of the inventory value. The (Y) parts represent about 30% of the inventory and about 15% of the inventory value. The (Z) parts make up about half of the inventory and about 5% of the inventory value [9].
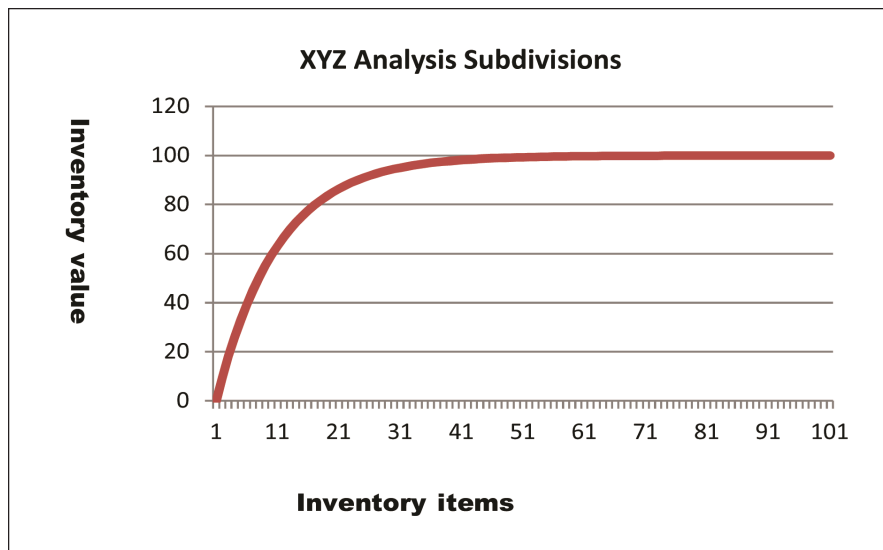

Figure 1. XYZ Analysis Subdivisions

2.2. Economic Order Quantity (EOQ)
This model is known as the EOQ model because it has the most economically advantageous order size to place. It is one of the oldest classic production planning models. With this model, companies can minimize order and storage holding costs. This can be a valuable tool for small business owners who need to make decisions about how much inventory to do, how many items to order every time, and how often to make a reorder to generate the lowest possible cost.

Depending on EOQ, inventory costs can be divided into two most important categories: ordering cost and carrying or shipping cost. Spare parts have two types of costs. The first one is the purchase cost. Each order contains a fixed cost for shipping parts, processing orders, delivery of parts of the inventory, etc. The second type, the cost of retention, is the cost that comes from organizing, arranging and maintaining inventory. When demand and order increase, all fixed costs are divided according to the number of parts in order. While the cost per second per unit is determined, it increases with the time based on the parts that are in inventory. Therefore, increasing the amount of demand means that the parts will remain longer in inventory which means that the cost of maintaining inventory will also increase [10].

2.2.1. Assumptions of the Basic EOQ Model
There are some assumptions required to maintain the basic EOQ model (assume that the unit of time is one year for ease and clarity):

- Demand must be decisive and occur at a steady rate, unchanged.

- If the request of any size (for example, Q units) is incurred, the cost of the order and the preparation are also incurred.

- The timeout for each request is supposed to be zero.

- Shortfall does not exist.

- Cost per unit, Year of seized inventory can be defined (h).

Figure 2 shows inventory variations for different values of Q assuming a constant and continuous demand of certain number of units per month. The average inventory level given by Eq. 1 is estimated just to avoid complete inventory depletion. This helps to trigger an action to replenish that particular inventory stock. It is normally calculated as the forecast usage during the replenishment lead time plus safety stock. • In the EOQ (Economic Order Quantity) model, there is no time lag between ordering process and procuring process of materials. Reorder point is a technique to determine when to order; it does not address how much to order when an order is made [11].

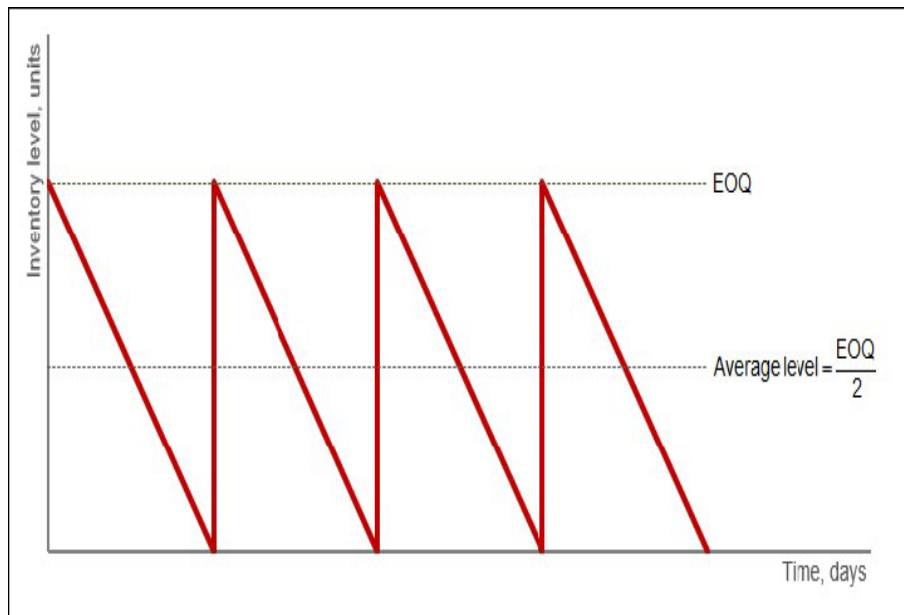$$Average\ inventory\ level = Q/2 \qquad\qquad (1)$$

Figure 2. Time Relationship with Quantity in EOQ

3. Paper Methodology Diagram

This paper is classified into many layers, where layers represent a different set of approaches, methods, strategies, and techniques of data collection. Figure 3 shows a diagram designed in this research to represent the steps used in the paper methodology.

3.1. Case Study Analysis
In this paper, the research work selected two companies as a case study. First, (UPS Company) is one of the largest parcel delivery company in the world. The selection of this company based on its works in inventory management. Second, (PC Mall Suppliers Company) that is one of the largest companies that deal with spare parts of computers. The researcher selected the data of the year 2018 in order to decrease variations in values and factors in a large interval year.

3.2. The Questionnaire Design
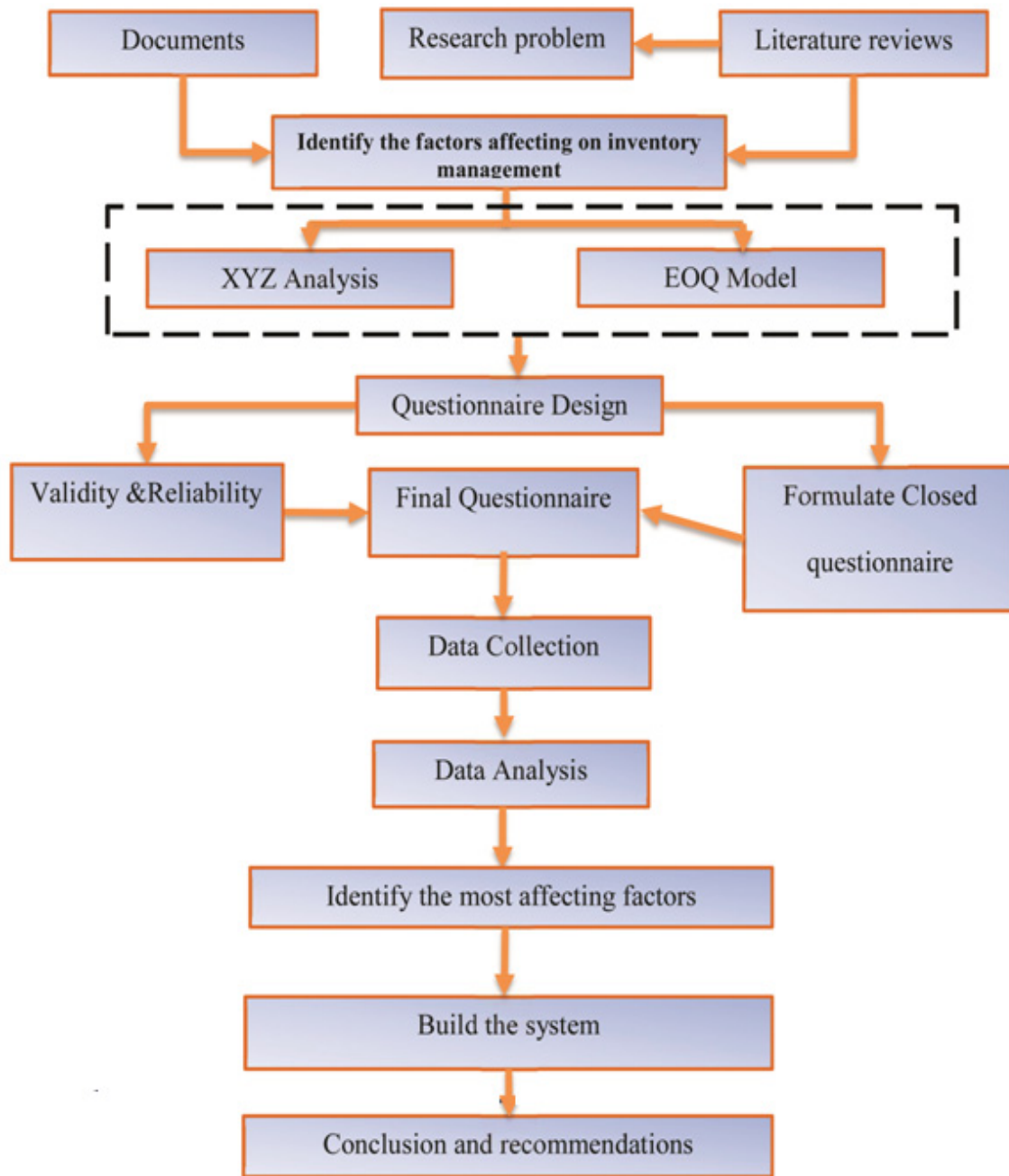
Figure 3. No text of specified style in document.3: Research Methodology (Researcher)

The questionnaire design has been done to take into consideration the main objective of this study with the aim to get useful answers to the research questions. Great efforts and brainstorming were done for doing the questionnaire through meetings with members from the industry. The closed questionnaire questions were selected for factors affecting the inventory management. The sample of the study is specialists of private sector in companies of case study.

The follow-up approach of collecting data was done through telephone calls and subsequent visit to firms and work sites, most of data were collected by this method. Completed forms of the questionnaire were requested to be delivered or sent back to the researcher.

A preliminary version of the questionnaire was prepared and delivered to the judgment committee consisting of four project management specialists. After taking advantage of their observations on the subject, the final version of the questionnaire was prepared.

The Google forms were used in the preparation of the questionnaire. This technique has been used for easy delivery to specialists. The ease of delivery of the questionnaire and the shortening of time are among the most important features of Google forms.

The aim of the questionnaire was to evaluate the current inventory management. The (5- likert scale) method was used for the purpose of knowing the effect of the factors, where (1) represents the strongly disagreed factor and (5) the strongly agreed factor.

3.2.1. Questionnaire Reliability
Pearson correlation coefficients were used as a tool to measure the validity of questionnaire as shown in Table 1. Reliability of questionnaires is that they give the same result if the questionnaire re-distributed more than once under the same circumstances and conditions.

No. Questions	Pearson Correlation	Cronbach's Alpha
The quantity of the demand shall be known accurately and fixed over time.	0.591	0.71
The ordered quantity is received in one package.	0.645	0.89
The company deals with constant agents.	0.588	0.77
Reorder point is selected, systematically.	0.654	0.65
The time required to reach order within three days (constant duration).	0.532	0.69
The cost of transportation from the supplier to the company is constant.	0.611	0.78
The company has its own machinery for transportation.	0.652	0.726
The good policy deals with the presence of pieces is damaged in the case of storage for a long time.	0.421	0.723
The factory retrieves and repairs all damaged items.	0.622	0.811
Spare parts are classified based on sales movement.	0.548	0.441
Spare parts and order process are managed by an easy-to-use integrated computer system.	0.589	0.55
Staff is trained in specific training programs to develop their skills.	0.633	0.56
The cost of production is a major factor affecting inventory management of spare parts laptops.	0.544	0.66
Importing low-quality parts hastens to sell because of low cost.	0.577	0.74

No. Questions	Pearson Correlation	Cronbach's Alpha
The cost of production is a major factor affecting inventory management of spare parts laptops.	0.544	0.66
Importing low-quality parts hastens to sell because of low cost.	0.577	0.74
The staff of inventory management has understanding in principles of inventory management.	0.564	0.68
The behavior of Consumers.	0.594	0.66
Level of technology in population is acceptable.	0.554	0.77
The company divided costs for each order according to inventory management standards	0.625	0.69

Table 1. Pearson Correlation and Cronbach Alpha

Reliability of questionnaires is measured through (Cronbach's Alpha coefficient) as shown in Table 2. Pearson correlation was used to identify the correlation between questions. This correlation scale was divided into three ranges. first range of low correlation is from (0-0.3), second range of medium correlation is from (0.3-0.5), third range of high correlation is from (0.5-1).

Cronbach alpha test was used to determine the stability of the questions in the questionnaire. The results of this test explain that the mean of Cronbach for all questions was (0.6947), this value demonstrates that the stability of questions was acceptable.

Limitation of Pearson	Description	No. of Questions
0-0.3	Low relationship	Nothing
0.3-0.5	Medium relationship	8
0.5-1	High relationship	1, 2, 3, 4, 5, 6, 7, 9, 10, 11,12, 13, 14, 15, 16, 17, 18

Table 2. No text of specified style in document.1: Questions in Pearson Correlation Interval

4. Study Population and Sample Size

The survey was conducted with engineers and staff from private and public sector of inventory management of companies. The data were analyzed using relative importance index, ranking and simple percentages. The Sample study focuses on inventory management of laptop spare parts in a group of companies in the private sector. The studied target population includes owners, managers and engineers, where the number of engineers involved in inventory management in the companies of research case study is about (100) engineers. Equation 2 is used to obtain the statistical representative sample of the population:

$$n = \frac{N \times p \times (1-p)}{(N-1) \times \frac{d^2}{z^2} + p \times (1-p)} \tag{2}$$

Where n: Sample Size; N: Population Size; Z: Standard Score Corresponding to the Significance Level (0.95), which is equal to (1.96); d: Standard Error of the Sampling Distribution which is equal to (0.05); p: Value of the Population Proportion which is being estimated.

Eqs. 3 and 4 show that if the value of p is unknown, then the suggestion value of (p) would be chosen as (0.5) so that a sample size that is at least as large as required to be obtained. Here, the research used (95%) of confidence level and (5%) of significance level.

The sample size of the population is approximately given as follows:

$$n = \frac{100 \times 0.5 \times (1-0.5)}{(100-1) \times \dfrac{0.05^2}{1.96^2} + 0.5 \times (1-0.5)} = 79.51 \tag{3}$$

Table Error! No text of specified style in document.3: Significance Levels

Level	Interval of Mean	Description
5	4.2-5	Very high
4	3.4 – 4.2	High
3	2.6 – 3.4	Neutral
2	1.8 – 2.6	Low
1	1-1.8	Very low

Table 3. Shows the significance levels for each selection per factor, and for analyzing data

5. Data Analysis and System Development

Certain efforts have been made to curtail the importance of the inventory management, this research work attempts to identify, investigate, and rank factors perceived to affect the inventory process with respect to their relative importance so as to proffer possible ways of coping with this project. To achieve this objective, researcher invited engineers and experts, comprising a statistically representative sample to participate in a structured questionnaire survey. Brain storming was taken into consideration, through which a number of rank factors were identified in inventory management and data collection. After completion of the data collection and processing phase, the stage of analyzing the documents and the data obtained from the questionnaire survey prepared at previously mentioned companies for the purpose of comprehensive evaluation of inventory management has been included in this stage. The researcher found a need to build a system that can deal with the factors that were not taken into consideration in the current inventory management of companies [12-14].

6. Questionnaire Analysis

Assessment of feedback from questionnaire survey was made. Analysis was carried out for one hundred responses to identify major contributing factors. Analysis is discussed in details, on the basis of which recommendations to construct inventory management were made. Totally, one hundred factors and questions were short-listed to be made part of the questionnaire survey and were identified and categorized into eighteenth major categories. Answers were analyzed to determine the statistical parameters which include mean, standard deviation and Z-scores with confidence level of 95%. All parameters are shown in Table 4. A systematic random sample was selected to ensure a representative sample of all targeted factors using the following equations:

$$\overline{x} = \frac{\sum X_i F_i}{\sum F_i} \tag{4}$$

$$S = \sqrt{\frac{(X_i - x)^2 F_i}{n-1}} \tag{5}$$

Where: n: sample size; $\overline{x}$: mean of sample; x_i: scale of Likert; f_i: frequency for each scale; and S: standard deviation of samples.

Based on the above equations mean value and standard deviation have been calculated in order to study the importance and the effect of all factors and items on the inventory management process. For all factors, Z-score has been calculated to comprise this value with the value of Z at 95% confidence level as shown in Table 4.

NO.	Question	Mean	D.S	Z	Rank
1	Reorder point is selected, systematically.	1.73	0.89	-12.8	1
2	Spare parts are classified based on sales movement.	1.91	1.07	-9.1	2
3	Spare parts and order process are managed by an easy-to-use integrated computer system.	1.94	1.22	-7.84	3
4	Level of technology in population is acceptable.	2.02	1.17	-7.49	4
5	The company divided costs for each order according to inventory management standards	2.05	1.18	-7.24	5
6	The time required to reach order within three days (constant duration).	2.15	1.29	-5.96	6
7	The staff of inventory management has understanding in principles of inventory management.	2.16	1.32	-5.73	7
8	Staff is trained in specific training programs to develop their skills.	2.25	1.21	-5.6	8
9	The good policy deals with the presence of pieces is damaged in the case of storage for a long time.	2.27	1.33	-4.92	9
10	Importing low-quality parts hastens to sell because of low cost.	2.31	1.31	-4.75	10
11	The company deals with constant agents.	2.33	1.32	-4.54	11
12	The ordered quantity is received in one package.	2.38	1.34	-4.15	12
13	The quantity of the demand shall be known accurately and fixed over time.	3.02	1.56	0.143	13
14	The cost of production is a major factor affecting inventory management of spare parts laptops.	3.04	1.36	0.246	14
15	The cost of transportation from the supplier to the company is constant.	3.53	1.4	3.42	15
16	The company has its own machinery for transportation.	3.67	1.48	4.045	16
17	The behavior of Consumers.	3.9	1.28	6.333	17
18	The factory retrieves and repairs all damaged items.	4.07	1.2	8.043	18

Table 4. Statistical Analysis

Ranking process of factors and categories was demonstrated according to their relative importance level on inventory management. After completing the calculation of all variables mentioned above, all factors that have Z score more than (1.96) have been

rejected which perfectly highlights the importance of the system development. Factors which have a rank from (1-14) have not been taken into consideration which causes the need for developing an inventory management system [14-16].

6.1. EOQ Model Calculations
Equations for EOQ model as following from [11]:

$$\text{Number of order annual} = \frac{D}{Q} \tag{6}$$

$$\text{Annual ordering cost} = \frac{D}{Q} C_o \tag{7}$$

$$\text{Annual holding cost} = \frac{Q}{2} C_h \tag{8}$$

$$\text{Total cost} = \frac{D}{Q} C_o \frac{Q}{2} C_h \tag{9}$$

$$EOQ = Q^* = \sqrt{\frac{2DC_o}{C_h}} \tag{10}$$

$$\text{Reorder point} = ROP = d \times L \tag{11}$$

Where Q is the number of pieces of order, EOQ (Q^*): optimal number of pieces to order, D: annual demand in units for the inventory item, Co: ordering cost of each order, C_h: holding or carrying cost per unit per year, d: Daily demand, L: lead time [17-20].

Figure 4 obtained from [11] shows the relationship between cost and quantity. The total cost is equal holding cost plus ordering cost annually. Usually, the holding cost increases constantly but ordering cost decreases according to the non-linear relationship. At the point, when the annual holding cost becomes equal annual ordering cost, the quantity value is called optimal value of quantity (Q^*). as shown in equation (4-9).

$$\text{Optimal Point} \quad \frac{Q}{2} C_h = \frac{D}{Q} C_o \tag{12}$$
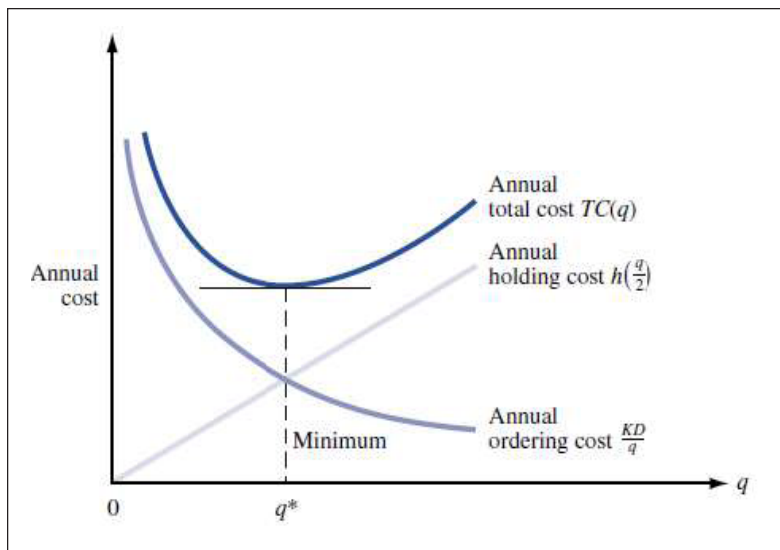

Figure 4. Cost Trade-Off between Holding Cost and Ordering

After mentioned the most important equations used in the EOQ model, the researcher applies the model to the data obtained from two international companies from private sector in Jordan that were targeted as a sample for the study.

The researcher assumed that the demand has a constant value for both companies while other factories have been left as given. The data of UPS Company have been first collected, and then professionally processed and analyzed through EOQ model. Hence, the researcher based on previously mentioned mathematical calculations and equations, estimated for the given model the total cost, the order cost and the holding cost. This calculation finally leads to the required optimal point. In addition to all variables that are related to order, reorder point is dependent on the daily demand which represents the inventory point that the order must reach. All calculations are demonstrated in Table 5.

NO.	Items	Demand	Cost Price	Quantity	Holding	Total cost
1	PWR SPLY, MT,240W, EPA,BRZ	290	19.54	25	7.816	27.356
2	SVC, PLN, I76500,4G, 5459, W8.1H	325	381.11	26	152.444	533.554
3	SVC, PLN, I56200U, 2, SKL	207	299.74	48	119.896	419.636
4	ASSY, DVD+/-RW,HLDS	208	30.05	75	12.02	42.07
5	SVC,PLN,DSV,I7-4600,TRPM,E5540	181	530.77	95	212.308	743.078
6	ASSY,PLMRST,U,ALL,WW,E7240,V1	343	33.23	5	13.292	46.522
7	HD,1T,S3,5.4K,2.5,512E,AQU-B	533	36.2	74	14.48	50.68
8	LCD,15.6HDF,TL,FL,EDP1.2,BOE	381	28.8	65	11.52	40.32
9	SVC,PLN,I5-5200U,D1,W8.1/10P	337	215.07	25	86.028	301.098
10	SSDR,256G,S3,7MM,HYNIX,SC308	299	76.5	16	30.6	107.1
11	SVC,PLN,TRPM,I75600U	161	498.66	14	199.464	698.124
12	HD,1TB,5.4,2.5,7,SM,SGT-RSWA	248	36.2	25	14.48	50.68
13	HD,1TB,5.4,2.5,7,SM,SGT-RSWA	213	36.2	35	14.48	50.68
14	LCD,15.6FHD,IPS,AG,EDP1.2,LGD	196	39.8	48	15.92	55.72
15	HD,500G,S3,7.2K,512E,PH-OASIS	552	31	75	12.4	43.4
16	ASSY,PWA,PLN,I5-7200U,2G,GKBL	249	305.96	96	122.384	428.344
17	HD,500G,S3,5.4K,512E,7MM,AQU-B	181	31	64	12.4	43.4
18	SVC,PLN,TRPM,I55300U,U	441	361.85	74	144.74	506.59
19	SSDR,128,S3,2280,SAMSUNG,PM851	510	46	100	18.4	64.4
20	LCD,14.0FHD,AG,EDP,LGD	473	56.5	30	22.6	79.1
21	SVC,PLN,NBK,U,B5V,E5550	179	360.27	50	144.108	504.378
22	SVC,PLN,U,I7V,GT,E5550	184	448.39	40	179.356	627.746
23	PWA,PLN,T,UMA,KI5-7200U,5480	269	326.06	60	130.424	456.484
24	DIMM,4GB,2400,1RX16,8G,DDR4,S	326	36.25	85	14.5	50.75
25	LCD,15.6HDF,EDP1.2,TLF,INX	412	28.8	75	11.52	40.32
26	SVC,PLN,I3-4005U,U,CEDARH	495	217.6	95	87.04	304.64

27	ASSY,KYBD,W/PLMRST,ARA,5368	261	37.37	41	14.948	52.318
28	SVC,PLN,I3S-5005U,U,W8.1/10P	332	189.79	62	75.916	265.706
29	PWR SPLY,SFF,180W,EPA	374	20.04	45	8.016	28.056
30	ASSY,PLMRST,SEC,SP,GMLK14	468	33.6	26	13.44	47.04
31	LCD,15.6HDF,TL,FL,EDP1.2,SEC	413	28.8	86	11.52	40.32
32	LCD,14.0FHD,AG,EDP1.3,BOE	400	56.5	45	22.6	79.1
33	SVC,PLN,TRPM,MT,V2,3020	353	51.9	23	20.76	72.66
34	SVC,PLN,I5-5200U,D,W7	368	280.99	54	112.396	393.386
35	ASSY,LCD,FRM,FHD,WWAN,M-	309	146.58	75	58.632	205.212
36	SVC,PLN,D-MS,I7V,U,E5570	363	575.32	84	230.128	805.448
37	HD,500,S3,7.2,512E,7,ST,YRX-RF	361	32.7	95	13.08	45.78
38	SVC,PLN,DSV,I7-4600,TRPM,E5440	347	525.8	62	210.32	736.12
39	PWA,PLN,T,GMR,KI7-7600UV,5580	319	530.69	63	212.276	742.966
40	ASSY,ENCL,CTL,ISCSI,MD38X0I,4G	330	1,584.	26	52 633.704	2217.964
41	ASSY,PWA,PLN,RJ45,5010,W8,TPM	398	82.24	41	32.896	115.136
42	LCD,15.6FHD,AG,EDP1.2,INX	295	34.7	52	13.88	48.58
			8722.83	**2326**	**3489.132**	

Annual Holding cost	5681004.72
Annual Demand	13884
Annual order cost	52066.97
EOQ (Q*)	263.48
Expect no. order	52.70
Expect Time between order	4.55
d: (Daily Demand)	57.85
Rod: (Reorder Point)	289.25
Average (cycle stock) inventory	131.74
Total cost	12211.96

Table 5. EOQ Calculations for UPS Company

Here, Figure 5 presents the behavior of the UPS Company from the cost aspect. As it is shown from the figure, the cost curve demonstrates a certain bias between intersection point and minimum total cost which means an incorrect policy of the company or a problem in the record management. Table 6 demonstrates the data analysis of Suppliers Company. As shown in the previous analysis, all variables related to EOQ model have been estimated and graphically represented based on the given mathematical relations.

As shown in Figure 6, the behavior of Suppliers Company seems to be better than the behavior of UPS Company. Moreover,
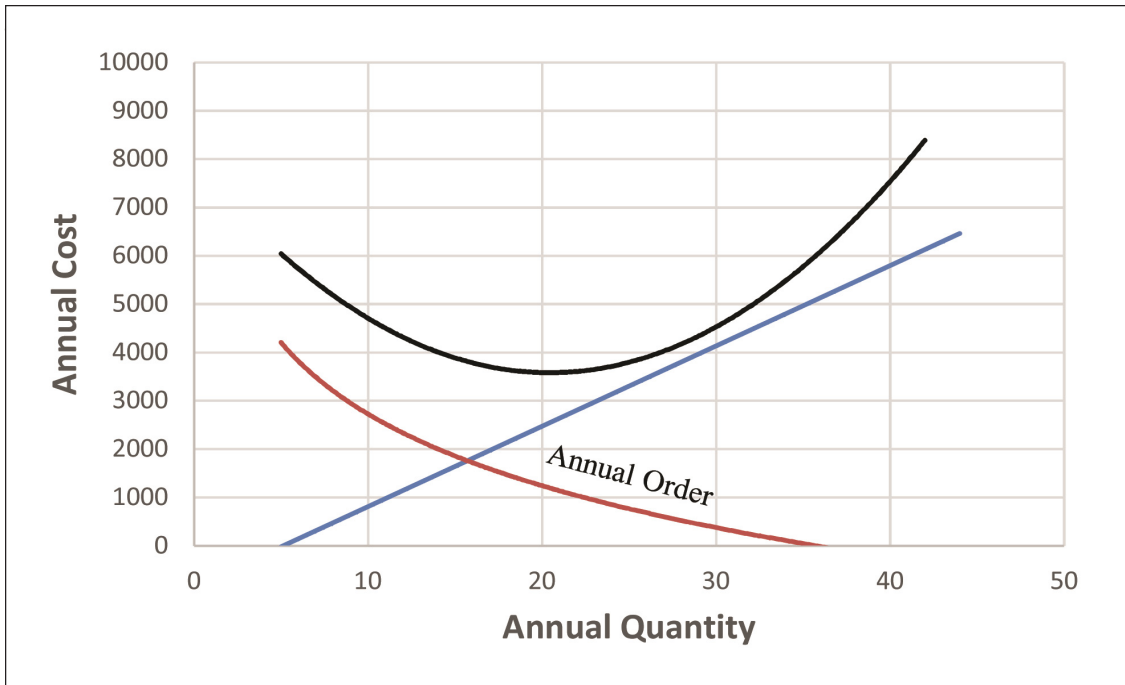
Figure 5. The Behavior of UPS Company

NO.	Items	Category	Demand	Cost Price	Quantity	Holding	Total cost
1	BAT 3634U	TOSHIBA	290	14.607	25	5.8428	20.4498
2	BAT 3465	TOSHIBA	325	14.597	39	5.8388	20.4358
3	BAT 840,1015	DELL	207	16.152	26	6.4608	22.6128
4	SCREEN 17	DELL	208	24.775	33	9.91	34.685
5	BAT 3680	ACER	181	14.597	50	5.8388	20.4358
6	KEY G62	HP	343	7.5	23	3	10.5
7	KEY D255	ACER	533	6	43	2.4	8.4
8	KEYPAD	DELL	381	13	38	5.2	18.2
9	KEYPAD	TOSHIBA	337	15	53	6	21
10	(CPU)	TOSHIBA	299	44	66	17.6	61.6
11	(USB)	TOSHIBA	161	7	45	2.8	9.8
12	Fuser units	TOSHIBA	248	23	35	9.2	32.2
13	Memory	TOSHIBA	213	15	70	6	21
14	Internal Hard	TOSHIBA	196	45	40	18	63
15	chargers	TOSHIBA	552	15	60	6	21
16	Mouse	TOSHIBA	249	3	90	1.2	4.2
18	LCD screens	TOSHIBA	181	25	45	10	35

19	External hard	TOSHIBA	441	29	50	11.6	40.6
20	(CPU)	ACER	510	37	30	14.8	51.8
21	(USB)	ACER	473	5	20	2	7
22	Fuser units	ACER	179	19	19	7.6	26.6
23	Memory	ACER	184	10	30	4	14
24	Internal Hard	ACER	269	40	30	16	56
25	chargers	ACER	326	12	40	4.8	16.8
26	Mouse	ACER	412	2	30	0.8	2.8
27	External hard	ACER	495	23	50	9.2	32.2
28	(CPU)	HP	261	40	40	16	56
29	(USB)	HP	332	7	60	2.8	9.8
30	Fuser units	HP	374	23	25	9.2	32.2
31	Memory	HP	468	15	40	6	21
32	Internal Hard	HP	413	45	40	18	63
33	chargers	HP	400	15	60	6	21
34	Mouse	HP	353	5	100	2	7
35	External hard	HP	368	25	50	10	35
36	(CPU)	DELL	309	39	50	15.6	54.6
37	(USB)	DELL	363	9	120	3.6	12.6
38	Fuser units	DELL	361	25	30	10	35
39	Memory	DELL	347	13	50	5.2	18.2
40	Internal Hard	DELL	319	43	45	17.2	60.2
41	chargers	DELL	330	13	120	5.2	18.2
42	Mouse	DELL	398	5	120	2	7
43	External hard	DELL	295	23	60	9.2	32.2
			825.228	**2090**		**330.091**	
	Annual Holding cost					60365.4	
	Annual Demand					13884	
	annual order cost					5482.04	
	EOQ (Q*)					995.849	
	Expect no. order					13.9419	
	Expect Time between order					17.2143	
	daily demand (d)					57.85	
	Rod (Reorder Point)					289.25	
	Average (cycle stock) inventory					497.924	
	Total cost					1155.32	

Table 6. EOQ Calculations for Suppliers Company

based on Figures 5 and 6, the comparative study done between both companies for a year of 2018 gives a priority for the behavior of Suppliers Company due to the more stability that it has in the cost management of the company.
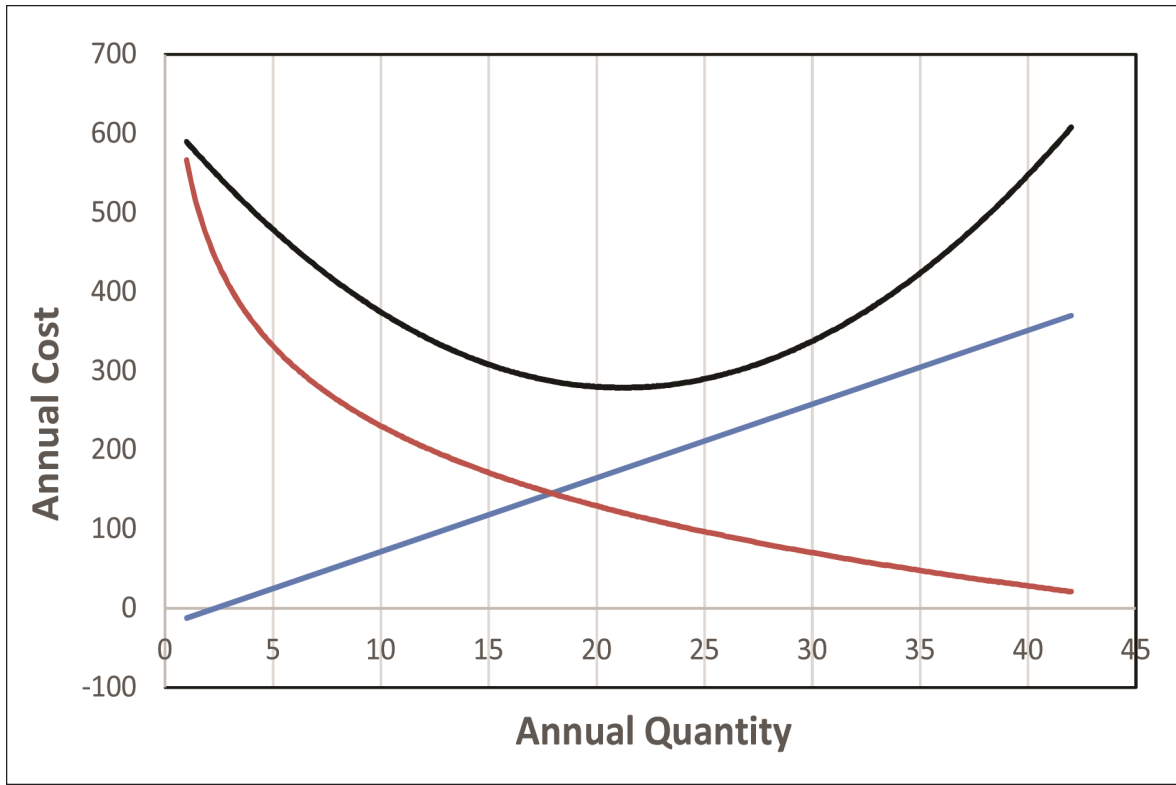

Figure 6. The Behavior of Suppliers Company

6.2. XYZ Analysis Calculations
In the XYZ analysis the researcher used the following Equations derived from (Kulkarni, 2016):

$$Mean\ (Average)\ Demand = \frac{D1 + D2 + ... + Dn}{n} \tag{16}$$

$$\sigma D = \sqrt{\frac{(D-D1)2 + (D-D2)2 + \cdots (D-Dn)2}{n-1}} \tag{14}$$

$$C.V = \frac{\sigma D}{D} \tag{15}$$

6.2.1. Steps of Formulation
In order to reach the XYZ analysis, many steps are followed. Firstly, the annual demand and average demand are calculated. Then, Standard deviation (S.D), Coefficient variation (C.V) and XYZ classification have been reached. Finally, Percentage for items and inventory are graphically presented and shown. Furthermore, the demand for both companies that has been obtained for a time period of six months is obtained. All calculations of XYZ analysis for UBS Company are shown in Table 7. The important results of this stage are classified in such a manner in order to obtain the indication of movement for each item [15-16].

The flow of items according to XYZ analysis is shown in Figure 7. the relationship between Coefficient variation (C.V) and accumulative percentage of items is demonstrated in such a manner, where (C.V) is represented along X-axis to show the distribution of items movement, while the Y-axis represents the accumulative percentage of items depending on the demand. The trend curve is represented by the deviation along X-axis in direction of increasing (C.V).

NO.	Items	Demand	Average	S.D	C.V	Category
1	PWR SPLY,MT,240W,EPAA	332	55.33	21.13	0.38	Y
2	SVC,PLN,I76500,4G,5459,W8.1H	276	46.00	14.78	0.32	Y
3	SVC, PLN, I56200U, 2, SKL	385	64.17	28.83	0.45	Y
4	ASSY, DVD+/-RW, HLDS, BLK	354	59.00	20.81	0.35	Y
5	SVC,PLN,DSV,I7-4600,TRPM,	335	55.83	30.40	0.54	Z
6	ASSY,PLMRST,U,ALL,WW,E7240	249	41.50	27.14	0.65	Z
7	HD,1T,S3,5.4K,2.5,512E,AQU-B	300	50.00	22.17	0.44	Y
8	LCD,15.6HDF,TL,FL,EDP1.2,BOE	329	54.83	24.09	0.44	Y
9	SVC,PLN,I5-5200U,D1,W8.1/10P	297	49.50	23.26	0.47	Y
10	SSDR,256G,S3,7MM,HYNIX,SC308	286	47.67	26.37	0.55	Y
11	SVC,PLN,TRPM,I75600U	254	42.33	17.23	0.41	Y
12	HD,1TB,5.4,2.5,7,SM,SGT-RSWA	324	54.00	27.12	0.50	Y
13	HD,1TB,5.4,2.5,7,SM,SGT-RSWA	350	58.33	26.23	0.45	Y
14	LCD,15.6FHD,IPS,AG,EDP1.2,LGD	357	59.50	27.07	0.45	Y
15	HD,500G,S3,7.2K,512E,PH-OASIS	463	77.17	21.41	0.28	X
16	ASSY,PWA,PLN,I5-7200U,2G,GKBL	385	64.17	26.30	0.41	Y
17	HD,500G,S3,5.4K,512E,7MM,AQU-B	383	63.83	10.01	0.16	X
18	SVC,PLN,TRPM,I55300U,U	445	74.17	14.21	0.19	X
19	SSDR,128,S3,2280,SAMSUNG	363	60.50	25.86	0.43	Y
20	LCD,14.0FHD,AG,EDP,LGD	351	58.50	20.92	0.36	Y
21	SVC,PLN,NBK,U,B5V,E5550	292	48.67	21.61	0.44	Y
22	SVC,PLN,U,I7V,GT,E5550	296	49.33	22.01	0.45	Y
23	PWA,PLN,T,UMA,KI5-7200U,5480	311	51.83	17.48	0.34	Y
24	DIMM,4GB,2400,1RX16,8G,DDR4,S	397	66.17	27.60	0.42	Y
25	LCD,15.6HDF,EDP1.2,TLF,INX	347	57.83	28.26	0.49	Y
26	SVC,PLN,I3-4005U,U,CEDARH	368	61.33	25.43	0.41	Y
27	ASSY,KYBD,W/PLMRST,ARA,5368	292	48.67	29.81	0.61	Z
28	SVC,PLN,I3S-5005U,U,W8.1/10P	361	60.17	25.42	0.42	Y
29	PWR SPLY,SFF,180W,EPA	269	44.83	19.07	0.43	Y
30	ASSY,PLMRST,SEC,SP,GMLK14	271	45.17	27.01	0.60	Z
31	LCD,15.6HDF,TL,FL,EDP1.2,SEC	297	49.50	22.84	0.46	Y
32	LCD,14.0FHD,AG,EDP1.3,BOE	266	44.33	16.98	0.38	Y
33	SVC,PLN,TRPM,MT,V2,3020	354	59.00	28.73	0.49	Y
34	SVC,PLN,I5-5200U,D,W7	316	52.67	23.09	0.44	Y
35	ASSY,LCD,FRM,FHD,WWAN,M	457	76.17	16.34	0.21	X
36	SVC,PLN,D-MS,I7V,U,E5570	279	46.50	25.62	0.55	Z

37	HD,500,S3,7.2,512E,7,ST,YRX-RF	336	56.00	27.81	0.50	Y
38	SVC,PLN,DSV,I7-4600,TRPM,E5440	331	55.17	25.82	0.47	Y
39	PWA,PLN,T,GMR,KI7-7600UV,5580	273	45.50	15.54	0.34	Y
40	ASSY,ENCL,CTL,ISCSI,MD38X0I,4G	293	48.83	18.88	0.39	Y
41	ASSY,PWA,PLN,RJ45,5010,W8,TPM	325	54.17	25.25	0.47	Y
42	LCD,15.6FHD,AG,EDP1.2,INX	293	48.83	22.03	0.45	Y

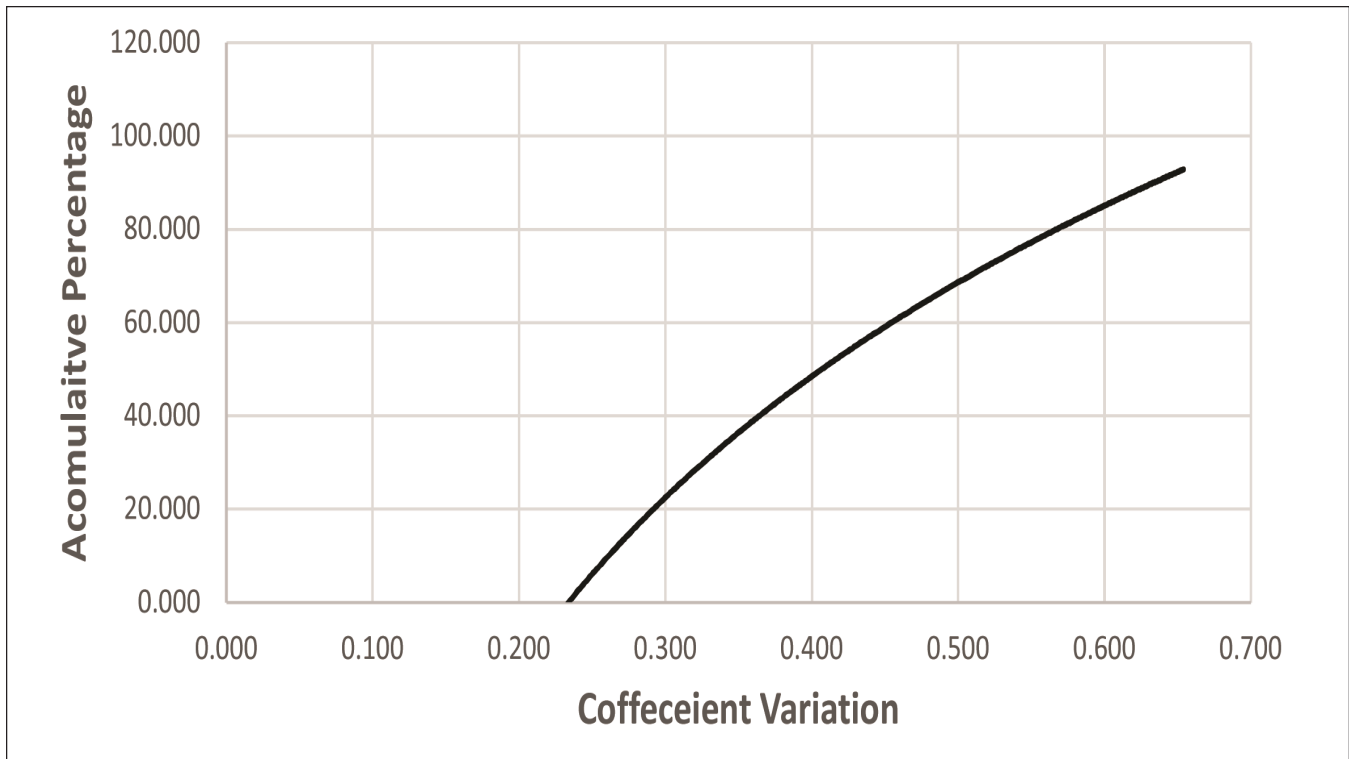Table 7. XYZ Analysis for UBS Company

Figure 7. Relationship between (C.V) and Cumulative of Item Percentage for UBS Company

Simply, Table 8 shows the percentage of demand and the items represented in Figures 8 and 9. According to the results obtained by the researcher in Table 8, the percentage of category (X) is acceptable, the percentage of category (Y) is very high and the percentage of (Z) is very low. That means the behavior of this company is not acceptable according to the standard of XYZ analysis.

Category	Demand	% Demand	Item Used	% Item Used
X	1748	12.22	4	9.52
Y	10668	74.61	33	78.57
Z	1883	13.17	5	11.90
Total	14299	100%	100	100%

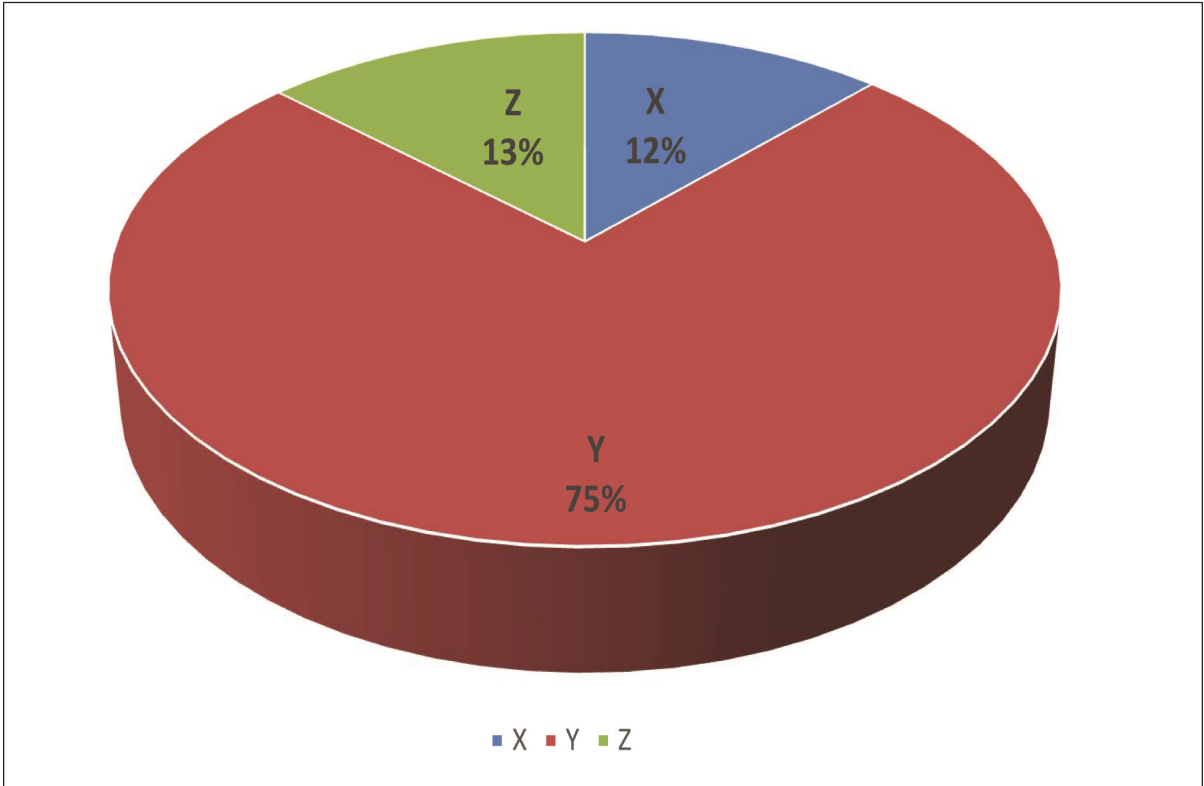Table 8. Inventory Items Classification for UBS Company
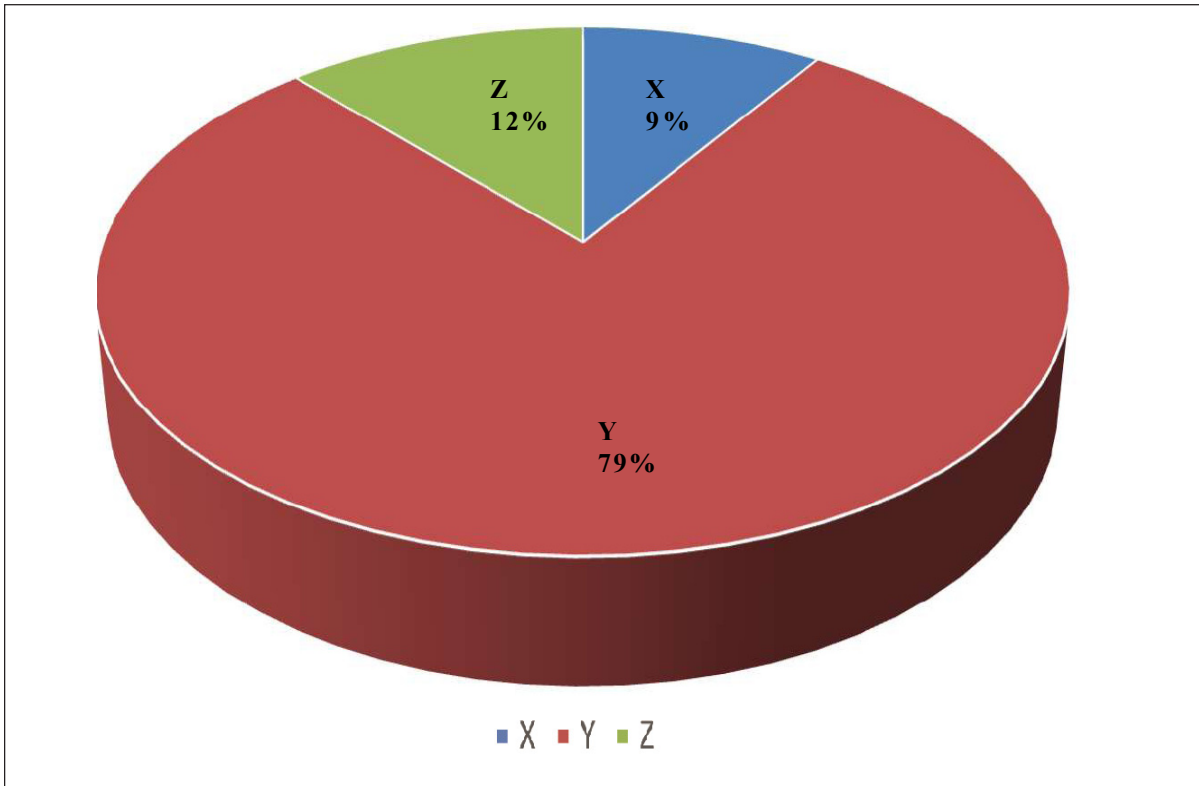
Figure 8. Demand Percentage

Figure 9. Items Used Percentage

All calculations of XYZ analysis for Suppliers Company are shown in Table 9. The important outputs of this stage are categorized in order to obtain the indication of movement for each item.

NO.	Items		Demand	Average	S.D	C.V	Category
1	BAT 3634U	TOSHIBA	220	36.67	14.33	0.391	Y
2	BAT 3465	TOSHIBA	250	41.67	24.32	0.584	Z
3	BAT 840,1015	DELL	137	22.83	7.31	0.32	Y
4	SCREEN 17	DELL	133	22.17	8.23	0.371	Y
5	BAT 3680	ACER	111	18.50	3.67	0.199	X
6	KEY G62	HP	268	44.67	2.42	0.054	X
7	KEY D255	ACER	463	77.17	44.92	0.582	Z
8	KEYPAD	DELL	306	51.00	3.46	0.068	X
9	KEYPAD	TOSHIBA	267	44.50	14.32	0.322	Y
10	(CPU)	TOSHIBA	224	37.33	6.77	0.181a	X
11	(USB)	TOSHIBA	91	15.17	4.31	0.284	X
12	Fuser units	TOSHIBA	173	28.83	10.11	0.351	Y
13	Memory	TOSHIBA	143	23.83	3.31	0.139	X
14	Internal Hard	TOSHIBA	121	20.17	3.19	0.158	X
15	chargers	TOSHIBA	482	80.33	41.93	0.522	Z
16	Mouse	TOSHIBA	174	29.00	3.41	0.117	X
17	LCD screens	TOSHIBA	111	18.50	3.78	0.204	X
18	External hard	TOSHIBA	366	61.00	7.48	0.123	X
19	(CPU)	ACER	440	73.33	9.83	0.134	X
20	(USB)	ACER	398	66.33	3.39	0.051	X
21	Fuser units	ACER	109	18.17	3.76	0.207	X
22	Memory	ACER	109	18.17	3.82	0.21	X
23	Internal Hard	ACER	199	33.17	1.94	0.059	X
24	chargers	ACER	251	41.83	1.94	0.046	X
25	Mouse	ACER	342	57.00	26.29	0.461	Y
26	External hard	ACER	420	70.00	23.80	0.34	Y
27	(CPU)	HP	191	31.83	24.66	0.775	Y
28	(USB)	HP	257	42.83	23.25	0.543	Z
29	Fuser units	HP	304	50.67	14.05	0.277	X
30	Memory	HP	393	65.50	29.76	0.454	Y
31	Internal Hard	HP	343	57.17	16.77	0.293	X
32	chargers	HP	325	54.17	32.23	0.595	Z
33	Mouse	HP	283	47.17	25.42	0.539	Z
34	External hard	HP	293	48.83	22.73	0.465	Y

35	(CPU)	DELL	239	39.83	22.42	0.563	Z
36	(USB)	DELL	288	48.00	26.32	0.548	Z
37	Fuser units	DELL	291	48.50	20.33	0.419	Y
38	Memory	DELL	272	45.33	20.90	0.461	Y
39	Internal Hard	DELL	249	41.50	21.94	0.529	Y
40	chargers	DELL	255	42.50	27.98	0.658	Y
41	Mouse	DELL	328	54.67	29.34	0.537	Z
42	External hard	DELL	220	36.67	24.16	0.659	Y

Table 9. XYZ Analysis for Suppliers Company

The flow of items according to XYZ analysis is shown in Figure 10. This curve demonstrates the relationship between Coefficient variation (C.V) and accumulative percentage of items, where (C.V) is plotted along X-axis to show the distribution of items movement, while the Y-axis represents the accumulative percentage of items depending on the demand.
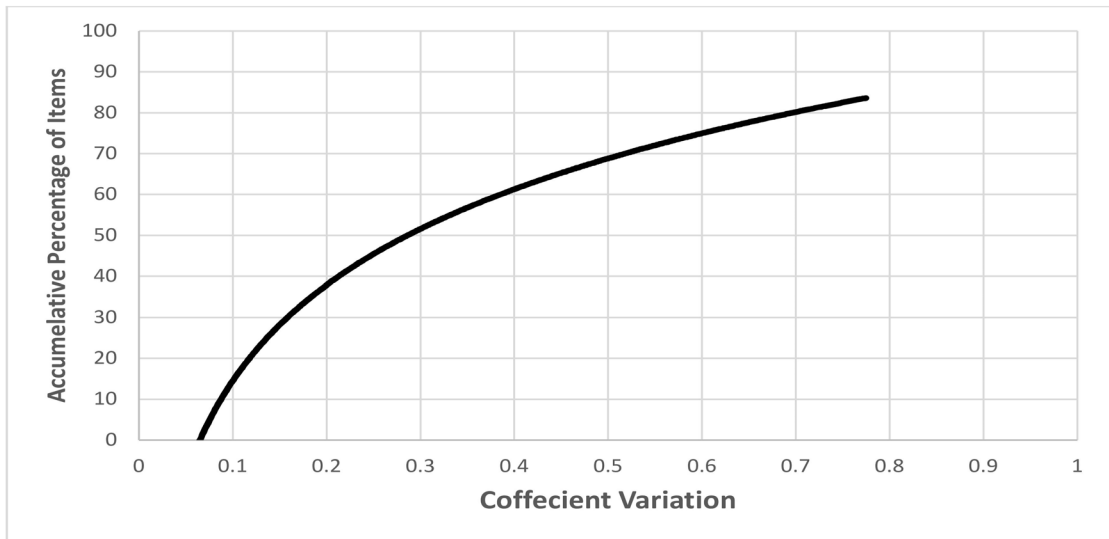

Figure 10. Relationship between (C.V) and Cumulative of Item Percentage for Suppliers Company

Hence, Table 10 shows the percentage of demand and the items that are represented in Figures 11 and 12. According to the results of Table 10, the percentage of the category (X) is high, the percentage of the category (Y) is acceptable and the percentage of (Z) is very low. This means that the behavior of Suppliers Company is not acceptable in comparison with the standard of XYZ analysis.

Category	Demand	% Demand	Items Used	% Items Used
X	4068	37.53	18	42.85
Y	3856	35.58	15	35.71
Z	2915	26.89	9	21.42
Total	**10839**	**100 %**	**42**	**100 %**

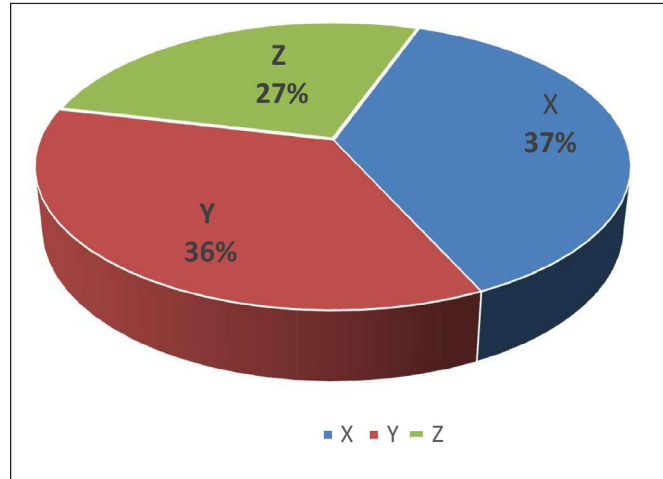Table 10. Inventory Items Classification
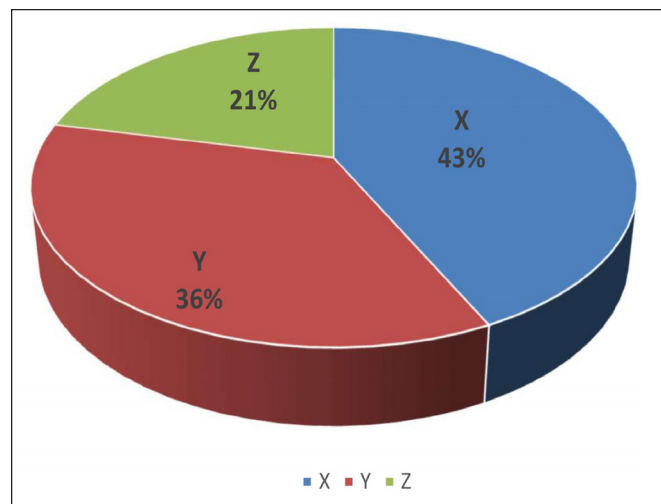
Figure 11. Demand Percentage

Figure 12. Items Used Percentage

7. Conclusion

The results previously calculated and obtained indicate the unacceptable behavior of companies in inventory management as compared to the XYZ category standards. Moreover, the results of Questionnaire that has been prepared throughout this study leads to the same conclusion.

Correct control of the movement of spare parts could be reached by professional understanding of the standards of XYZ analysis in order to classify them correctly in order to reach the optimal point of inventory reduction.

Therefore, the researcher reached to a very important recommendation regarding the development of the system of any company aiming to applying an inventory management with correct and professional principles of inventory control. Companies should pay more attention to prepare effective inventory management and scheduling the orders. Only a well-planned and scheduled inventory management can be well executed. According to questionnaire, the most important factors that the companies do not take into consideration are:

1. Reorder point is not systematically selected.

2. Spare parts are classified based on sales movement.

3. Spare parts and order process are managed by an easy-to-use integrated computer system.

Based on the EOQ model represented in this paper, the research work has reached to the optimal point, reorder point and total cost that are very necessary for doing a good cost management. These factors mentioned above are good indications that may help the management staff to make the correct decision concerned with order and inventory management. All necessary factors that obtained from questionnaire should be considered to be used as a core for the development of the system of inventory management.

References

[1] Razi, M. A., Tarn, J. M. (2003). An applied model for improving inventory management in ERP systems. *Logistics Information Management*, 16 (2), 114–124.

[2] Schlesinger, A. M. (2012). Robert Kennedy and his times. Houghton Mifflin Harcourt.

[3] Bailey, G. J., Helms, M. M. (2007). MRO inventory reduction—challenges and management: a case study of the Tennessee Valley Authority. *Production Planning and Control*, 18 (3), 261–270.

[4] Sarmah, S. P., Moharana, U. C. (2015). Multi-criteria classification of spare parts inventories–a web based approach. *Journal of Quality in Maintenance Engineering*, 21 (4), 456–477.

[5] Cavalieri, S., Garetti, M., Macchi, M., Pinto, R. (2008). A decision-making framework for managing maintenance spare parts. *Production Planning & Control*, 19 (4), 379–396.

[6] Rakesh Kumar. (2016). Economic Order Quantity Model (EOQ). *Global Journal of Finance and Economic Management.* 5 (1) 1-5.

[7] Chung, K.-J. (1998). A theorem on the determination of economic order quantity under conditions of permissible delay in payments. *Computers & Operations Paper*, 25 (1), 49–52.

[8] Coetzee, J. (2004). Maintenance. Trafford Publishing, Canada.

[9] Dinesh Kumar Dhoka1, D. Y. L. C. (2013). "XYZ" Inventory Classification & Challenges. *IOSR Journal of Economics and Finance* (IOSR-JEF).

[10] Tersine, R. J., Tersine, M. G. (2010). Inventory reduction: preventive and corrective strategies. *The International Journal of Logistics Management.*

[11] Taha, H. A. (2011). Operations paper: an introduction (Vol. 790). Pearson/Prentice Hall.

[12] Eaves, A. H. C., Kingsman, B. G. (2004). Forecasting for the ordering and stock-holding of spare parts. *Journal of the Operational Paper Society*, 55 (4), 431–437.

[13] Giliyana, S. A., Kalaiarasan, R. (2015). Maintenance Strategy according to the Professional Maintenance methodology as part of World Class Manufacturing. Mälardalen University, Sweden.

[14] Remon, F. A. (2013). Ranking of delay factors in construction projects after Egyptian revolution, *Alexandria Engineering Journal* (2013) 52, 387–406.

[15] McClave, J. T., Benson, P. G., Sincich, T. T. (2014). Statistics for Economics and Business. New York: Pearson.

[16] Kulkarni, V. G. (2016). Modeling and analysis of stochastic systems. Chapman and Hall/CRC.

[17] Minas, J. P., Hearne, J. W., Handmer, J. W. (2012). A review of operations paper methods applicable to wildfire management. *International Journal of Wildland Fire*, 21 (3), 189–196.

[18] Silverman, J. H. (2013). Advanced topics in the arithmetic of elliptic curves (Vol. 151). Springer Science & Business Media.

[19] Cipollini, F., Oneto, L., Coraddu, A., Murphy, A.J., Anguita, D. (2018). Condition-Based Maintenance of Naval Propulsion Systems: *Data Analysis with Minimal Feedback. Reliability Engineering and System Safety. In* Press.

[20] Gu, J., Zhang, G., Li, K.W. (2015). Efficient aircraft spare parts inventory management under demand uncertainty. *Journal of Air Transport Management.* Vol. 42, p 101-109.