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Research Article

ABC/XYZ Inventory Management Model in a Construction Material Warehouse

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ABSTRACT

Accounting monitoring stocks of raw materials and supplies plays an important role in the business of every major company. Since inventories are one of the most expensive types of company assets, accounting for more than 50% of total invested capital, optimal inventory management should be an integral part of every company's business. In order to get complete results, this paper applies the ABC method, XYZ method, as well as the cross ABC XYZ method. The goal is to reduce costs of keeping the inventory as much as possible, while maintaining a level of service customers requires. The process of assortment planning, ordering and inventory management in the construction material warehouse is analyzed. The importance of monitoring inventory movements in order to achieve optimal amount of inventory, as well as the obtained results and guidelines for future operations is presented.

Keywords: Inventory Management, ABC Analysis, XYZ Analysis, Warehouse

1. Introduction

Business process defining and structuring influences the evolution of organizations' business activities [1]. At the same time, the optimization of storage space is very important for both trade and manufacturing companies due to large flow-thru warehousing, and the construction costs, as well as the storage of goods. Therefore, more and more attention is paid to the improvement of this activity. Shorter storage time results in smaller quantities of goods in the warehouse and lower company costs. The cost of shipping goods from the warehouse mostly depends on the type of goods that are stored, as well as the demand for it. Warehousing is a very important function of the logistics system, because improper storage can lead to damaging goods, which again leads to higher expenditures.

Every process within a company cannot be successfully completed without a proper storage of goods. Warehouse operations are focused on continuous production supply, i.e., selling the required quantity of goods, of appropriate quality and with the lowest storage costs. Due to the constant increase in the number of competitors in the market, a great deal of attention is paid to improving all supply logistics subsystems, including storage. One way to achieve a better position in the market is to constantly monitor costs caused by storage, as well as other subsystems.

A big problem with storage is the stocks which are held in the warehouse. The goal is to reduce inventory costs as much as possible, while maintaining a level of service customers require. Inventory management is one of the most important logistics processes. Many companies nowadays face the impossibility of determining the optimal amount of stock held in a warehouse. This is caused by unforeseen developments in the market, inability to predict demand for certain goods, long delivery times, etc. If a company does not have enough inventory in the warehouse, it affects sales and loss of customers, causing large deficit. On the other hand, having too much items in stock increases costs and leads to possible damage and obsolete inventory. The point of having control over stock materials, and therefore, over the amount of funds invested in current assets, is that the supplies are kept in an appropriate amount. In fact, they should be as low as possible in order to ensure a normal business process, and this primarily requires knowledge of the factors on which the amount of inventory depends.

2. Literature Review

The ABC analysis is one of the most commonly used inventory management techniques where the classification of items is done in predefined categories: A (very important items), B (moderately important items), C (relatively unimportant items) [2]. Such analysis provides a mechanism for identifying items that will have a significant impact on total inventory costs by providing a method for identifying different categories of inventories that will require different management and control policies [3]. In practice, not all stocks can be controlled the same way, so the goal is to make appropriate decisions [4]. The literature is rich in modifications and upgrades of the usual ABC method. According to Ching et al. [4] one of the most important improvements of ABC is the ability to use different classification criteria. The purpose of using ABC analysis helps categorize products by using different

criteria that may have different significance. This allows multiple results of different criteria to be combined into one assessment for each product and further stock classification [5].

An article published by Flores et al. [6] discusses the importance of many criteria in classifying each item. The theory is applied to inventory maintenance in a service organization and an industrial firm. Samples were used to illustrate multicriteria classification. Special procedures have been developed to manage all items in all categories. The results indicate that the theory of ABC analysis can be extended to include multiple criteria, and that specific rules can be developed for inventory management. In addition, the rules can be used to classify products. From the very beginning, managers of both organizations were able to evaluate all items and reclassify those that did not fit. In the process of reviewing initial classifications, management introduced a fourth category for some items. The use of specific product classification policies for inventory management purposes has proved useful. The results showed that it is possible to reduce stocks to an optimal amount.

3. METHODS

3.1. ABC METHOD

According to [4], each optimal production program implies that among a large quantity of products, the range that will provide the best economic effects from a limited amount of production resources is selected. The selection is made on the basis of a given quantitative or qualitative criteria and serves to classify and control the entire volume of production. The first step in managing each company's inventory is to use a method known as ABC analysis. ABC analysis is an analytical method widely used in commodity and material business. ABC analysis is closely related to Pareto's law which states that there is often an inverse relationship between the percentage of subjects in each group and the meaning of the groups. The ABC method appears as a special system of inventory management, which starts from the fact that, in terms of monitoring and control, only a few materials deserve attention, which, however, have a significant share in total values, i.e., inventory costs. These are materials that are classified in group A, while groups B and C contain materials whose share increases by type and decreases by value. In other words, the most attention is paid to group A, less to group B, and the least to group C [7].

Group A requires the utmost attention and management control. The situation with the movement of this group is important in the past, but future trends are also important, and they are determined by the demand and production forecast. In order to achieve the above, it is necessary to commit to inventory management at every company level.

In **Group B**, an attempt is made to automate all routine decisions and thus, save time. It is mostly possible to manage group B by using a computer, creating the preconditions for the management to pay maximum attention to Group A products.

With **Group C**, it is important to point out its large representation of total number of products in low value (80: 20% or 65: 5%). In this group, the goal is to increase security stocks and minimize the number of orders. A great advantage is that today's modern

systems allow Group C to be approached to in the same manner as with Group B, i.e., in a rational way that allows rational time management.

The share of costs in total value of the procurement should satisfy the constraint represented by the following equation.

A=40-80%, B=15-40%, C=5-20% (1)

The share in the total number of different product types should satisfy the constraints represented by the following equation.

A=5-25%, B=20-40%, C=40-75% (2)

The third constraint implies that C has the most product, then B and A the least.

A<B<C (3)

3.2. XYZ Method

The previous chapter explains ABC analysis and its use. It is based on the criteria of classifying inventories according to their value, in groups A, B and C. Sometimes such inventory classification does not always give a satisfactory result; sometimes, companies are forced to use other methods while optimizing inventories, based on different criteria. One of those methods is the XYZ analysis, which uses the criteria of continuity in material consumption / sales, based on historical data, and the criteria of security spending forecast.

XYZ analysis is, therefore, a method that encompasses another dimension of stocks and items it consists of, and that is the variability of demand for individual items. The purpose of applying this classification as in the ABC analysis is to establish an effective (optimal) system of purchasing, sales and warehousing operations in order to reduce inventory, procurement and warehousing costs, which is one of the fundamental goals of logistics, especially in this current recession era [8].

XYZ analysis also classifies materials into three groups: [9]

- Group X includes materials that are continuously consumed or have minor fluctuations in their consumption (up to 10%) - so high accuracy of demand forecast is achieved. Their sales do not change significantly over time (they can vary only slightly) so future demand forecast can be determined with great accuracy. A recommendation for X items is to always have them in enough quantity until the next delivery arrives (it is not necessary to provide a large safety stock).
- Group Y includes materials that are consumed discontinuously; their consumption is neither constant nor occasional. Consumption fluctuations in certain time periods (e.g., in certain months during the year) are up to 60%. Trends can be followed for Y items (e.g., that usage increases or decreases over time or that demand seasonality is characteristic). That is why it is only possible to achieve medium forecast accuracy.
- Group Z items include materials that are occasionally consumed with large deviations in the amount of consumption (over 60%, demand varies greatly and is sporadic, while in some time periods it does not exist at all), so it is almost impossible to recognize the trend of consumption. For such materials, a very demanding low forecasting accuracy

is achieved, and it is recommended to invest more time in manual forecast computing without automation.

Practice research has shown that group X includes about 50% of material types, group Y about 20%, and group Z about 30% of the total number of material types. For group X materials, a supply from one's own stocks is recommended, while for group Z materials, individual supply is more economical [10].

3.3. Cross ABC XYZ Method

For better inventory management, it is advisable to perform a cross ABC XYZ analysis. This analysis is a combination of the results of ABC and XYZ analysis to obtain a matrix of nine different groups in which products are classified.

The groups obtained by the combination of ABC and XYZ analysis are: group AX, AY and BX, group AZ, BY and CX and group BZ, CY and CZ.

- Items AX, AY and BX in the group have a medium or large share in total value, and predictable or more difficult to predict consumption or demand.
- The middle groups AZ, BY and CX have different specifics, which include items with large and small share of consumption, as well as those with great and little possibility forecasting consumption.
- Groups BZ, CY and CZ represent items with a small to medium share in total value, occasional or discontinuous consumption, and low to medium accuracy of forecasting needs [11].

After such detailed analysis, it is much easier to determine the optimal stock level, i.e., to determine if there is too much or too little inventory in regards to demand. The purpose of applying these analyses is to establish an optimal warehousing system to reduce inventory costs, which is a fundamental goal of logistics. Inventory policy is directly related to the level of service towards consumers. Thus, the larger the stocks, the more likely it is that consumers' needs will be satisfied, but also, the higher the cost of keeping them for the manufacturer. Table 1 shows the matrix of ABC / XYZ analysis results.

The degree of predictability / security forecasts	**A**	**B**	**C**
X	AX High consumption value and high predictability	BX Medium consumption value and high predictability	CX Low consumption value and high predictability
Y	AY High consumption value and medium predictability	BY Medium consumption value and medium predictability	CY Low consumption value and medium predictability
Z	AZ High consumption value and low predictability	BZ Medium consumption value and low predictability	CZ Low consumption value and low predictability

Table 1. Cross ABC/XYZ analysis

4. Application Procedure for A Combined Model In The Construction Material Warehouse

4.1. Application of ABC Analysis

Data used in the application of the ABC analysis was collected at Škrebo company. The collected procurement data covered one calendar year, i.e., the period from January 1, 2019 to December 31, 2019. The obtained data was systematized according to: product code, product name, quantity of products purchased, purchase value per product unit, and total purchase value. The product range for a period of one year contains 78 products. ABC analysis is necessary to determine which products have the most financial impact on procurement. The application of ABC analysis is shown in Table 2.

Or. n.	Product	Annual values of procurement	Percentage of usage	Cumulative	Group
1	P1	97739.2	9.76%	9.76%	A
2	P2	84780	8.46%	18.22%	A
3	P3	80936.55	8.08%	26.30%	A
4	P4	74333.04	7.42%	33.72%	A
5	P5	66410.5	6.63%	40.35%	A
6	P6	29618	2.96%	43.31%	A
....	.....				
21	P21	16166.4	1.61%	75.86%	B
22	P22	15278.95	1.53%	77.39%	B
23	P23	14486.61	1.45%	78.83%	B
24	P24	14202.13	1.42%	80.25%	B
25	P25	13949.84	1.39%	81.64%	B
26	P26	13815	1.38%	83.02%	B
...	.....				
50	P50	1934.2	0.19%	97.38%	C
51	P51	1908.72	0.19%	97.58%	C
52	P52	1852.8	0.18%	97.76%	C
53	P53	1807.3	0.18%	97.94%	C
54	P54	1676.6	0.17%	98.11%	C
55	P55	1622	0.16%	98.27%	C
56	P56	1572.65	0.16%	98.43%	C
...	...				

Table 2. Application of ABC analysis

The process of applying ABC analysis was performed through several stages. First and foremost, data was collected on the type of goods sold in the company, as well as the annual procurement value, and the procurement quantity in one year. After that, the value of goods was calculated by multiplying the quantity of individual materials with their purchase prices. The next step is to sort the materials in descending order according to the value of the annual procurement and the cumulation of percentages. The final step is to sort the material into groups A, B and C.

- From the previous table we see that group A consists of 19 products with the highest value (24.36%), which means that these products should be given the most attention in the future.
- 22 products belong to group B, which is 28.20%
- The largest number of products, i.e., the remaining 37 belong to group C, with the lowest value of 47.44%

4.2. Application of XYZ Analysis

XYZ analysis is a method that encompasses another dimension of products that make this analysis, and that is the demand variability for individual products. It is a secondary analysis that speaks of demand stability for a particular product and is performed by classification into three groups, just like ABC analysis, with items in the

XYZ analysis being classified into groups X, Y and Z. Measuring sales variability is performed with the coefficient of variation, which is calculated by converting the deviation from the average (standard deviation) and the average sales (arithmetic mean) into ratio. In order to complete an XYZ analysis, data on sales volume during the period from January 1, 2019 until December 31, 2019 was collected, and it included 78 products.

Since the coefficient of variation was very large, it was impossible to assume that the coefficient of variation for X products was up to 10%. The reason for this is that the warehouse in question is a warehouse of construction materials and that this type of warehouse is characterized by seasonal sales from April to September 2019. Table 3 shown XYZ analysis for one season.

Or. n.	1	2	3	4	5	6	St. dev	KV	Gr.
1.	0	0	0	0	0	0	0	0	X
	1257	1260	1251	1255	1247	1239	8	0.006	X
3.	119	118	120	122	121	123	2	0.016	X
4.	487	491	502	494	482	475	9	0.019	X
5.	439	419	440	427	410	424	12	0.027	X
6.	445	439	432	426	415	410	14	0.032	X
...									
24.	106	89	127	113	109	105	12	0.114	Y
25.	43	56	42	49	42	44	6	0.121	Y
26.	176	170	165	188	194	132	22	0.128	Y
27.	1012	1300	1523	1420	1380	1225	178	0.136	Y
28.	44	42	49	53	39	37	6	0.138	Y
29.	41	45	52	54	37	49	7	0.142	Y
...									
46.	8	9	11	15	10	8	3	0.260	Z
47.	17	15	11	16	12	8	3	0.261	Z
48.	27	31	21	19	15	20	6	0.262	Z
49.	16	27	21	14	14	21	5	0.272	Z
50.	43	36	40	29	64	45	12	0.276	Z
51.	1120	982	1245	828	736	492	273	0.303	Z
52.	17	20	35	29	19	18	7	0.317	Z
...									

Table 3. Application of XYZ analysis during one season

The coefficient of variation was as follows:

- Group X up to 10%;
- Group Y up to 25% and
- Group Z over 25%.
- The previous table shows that Group X consists of 23 products, which is 29.49%, meaning that sales of these items do not change significantly during one year.
- Group Y consists of 22 products or 28.20%. The use of these products is neither permanent nor occasional, but varies in sales and demand.
- Group Z consists of 33 remaining products, which is 42.31%. These products are not used regularly. Basically, their use can vary greatly, and a no-consumption period can often occur.

4.3. Application of The Combined ABC XYZ Method

In order to come to a more complete interpretation of the obtained results of ABC and XYZ analysis, it is necessary to make a cross ABC XYZ analysis. This way, nine groups of articles with the characteristics of ABC and XYZ analysis are acquired. Table 5 is a representation of the cross-ABC XYZ analysis.

1.	**P1**	**A**	**Z**
2.	P2	A	Z
3.	P3	A	Z
4.	P4	A	Z
5.	P5	A	Y
...	...		
20.	P20	B	X
21.	P21	B	X
22.	P22	B	Z
23.	P23	B	Z
24.	P24	B	Y
25.	P25	B	Y
...	...		
42.	P42	C	Y
43.	P43	C	X
44.	P44	C	Y
45.	P45	C	Y
46.	P46	C	X
47.	P47	C	Z
...	...		

Table 5. Application of cross ABC XYZ analysis

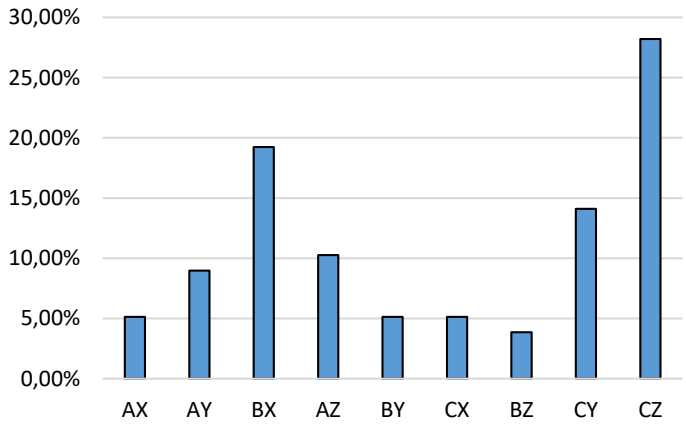

Figure 1. Graphic review of results of cross ABC XYZ analysis

5. Discussion

ABC analysis included the following steps: the first phase included data on annual needs in the past 12 months by type, and the needs value was calculated by multiplying quantities of individual materials with their purchase prices. After that, the products were sorted in descending order according to the value of annual needs, and the percentage of the value of individual materials in the total value of annual needs was calculated, and the percentage shares were accumulated. The final phase included a categorization of products into groups A, B and C. Since the ABC analysis is based on past data, and prices and quantities of consumption of individual materials

may change over time, the classification should be carried out at least once or twice a year. The results of ABC analysis, which included 78 products, showed that group A consists of 19 products with the highest value, group B consists of 22 products, while the remaining 37 products make up group C.

When it comes to XYZ analysis, the results showed that there are certain variations when it comes to certain products. XYZ analysis was completed for the year 2019. When it comes to the whole year, it was noticed that some products were not sold at all during the initial months of 2019, as well as before the end of the year, while the period from April to September was fulfilled. Group X consists of 23 products whose sales do not change significantly over a year. Although, according to their characteristics, the products from group X should have continuous sales, during XYZ analysis we came across a slightly different scenario. It can be seen from Table 2 that some products belong to group X even though they did not have output activities for most of the year. With such items in this company, special attention should be paid when ordering and storing stock, because it is evident that these items have been in stock for most of the year without being sold at all. Ordering these items should be done according to customers' needs in a certain time. As previously mentioned in the thesis, products whose demand varies during the year belong to group Y. Thus, 22 products belong to the Y group, which also had certain variations during the year. Most of the products were sold in the period from April to September, while the remaining 4 months were with minimal or no sales. Group Y products should only be ordered as needed. Group Z consists of 33 products. In this group, a variation in terms of output activities was also observed, and we noticed months with no sales. Group Z products should be ordered as needed, as should Group Y products.

6. Conclusion

Successful inventory management is the goal of every company (manufacturing or trading company) because it enables economic production, supply and sale.

Every company should have an optimal amount of stock at all times, as well as respond to customer requests at a particular time for a particular commodity. When it comes to optimal stocks, there is always the need to determine low (minimum) and high (maximum) quantities and stock values. In order to establish an optimal policy, companies need to pay close attention to many aspects which directly affect business and company's finances. In terms of proper inventory management, one of the key roles is to collect timely and credible information that enables the company to properly assess a situation and act accordingly. If inventory management is not approached appropriately, it can lead to high and unnecessary costs that can be disastrous for the company. In addition to inventories, there are also inventory management methods that aim to reduce storage costs, but enable constant production or sales.

Although the cost management and the efficiency of the company in our area is much lower than in developed countries, this paper presents the possibilities and possible positive results of the application of these models in inventory management. Even if their application in the company requires certain investments and knowledge, it can be concluded that the introduction of these models could significantly improve companies' costs and profitability.

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