



Hacettepe University Graduate School of Social Sciences

Business Administration Department

Production/Operation Management and Quantitative Method

**A METHODOLOGY FOR COMBINING STAKEHOLDER PERSPECTIVES IN  
MULTICRITERIA INVENTORY CLASSIFICATION : AN APPLICATION IN  
TURKISH RETAILING SECTOR**

Z. Gizem AKKAYA

Master's Thesis

Ankara, 2019



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## ACCEPTANCE AND APPROVAL

The jury finds that Z. Gizem Akkaya has on the date of 29.05.2019 successfully passed the defense examination and approves her Master's Thesis titled "A Methodology For Combining Stakeholder Perspectives In Multicriteria Inventory Classification : An Application In Turkish Retailing Sector"

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***Z. Gizem AKKAYA***

## ÖZET

AKKAYA, Z. Gizem. *Çok Kriterli Envanter Sınıflandırmasında Paydaşların Perspektiflerinin Birleştirilmesi Methodolojisi : Türk Perakende Sektöründe Uygulama*, Yüksek Lisans Tezi, Ankara, 2019.

Türkiye ve dünyadaki değişen dinamiklerle, perakende sektörünün büyüme hızı, her geçen gün daha da artmaktadır. Büyüyen ve değişen bu sektörde, stok yönetimi kavramı da firmalar için daha önemli bir noktaya gelmiştir. Perakende sektörünün en önemli başarı kriterleri arasında, satış tutarı, kar marjı, doğru satınalma yönetimi olsa da, aslında firmaların atladığı en önemli kriterlerden biri doğru stok yönetimidir.

Stok yönetimi, perakende gibi sezonu olan, trendlere göre hareket eden ve müşteri taleplerinin hızlı bir şekilde değişebildiği sektörlerde zor ama kesinlikle gözardı edilmemesi gereken bir konudur. Çünkü stoklar, firmalar için en önemli maliyet kalemlerinden biridir. Firmalar, gelir ve gider bütçelerine paralel bir şekilde stoklarını yönetemediği durumda, eksik yada fazla oluşan stoklar finansal tablolarını doğrudan etkilemektedir. Şirket finansallarının etkilendiği gibi, şirket içerisinde de stokların etkilendiği bir takım paydaşlar bulunmaktadır. Bunlar şirket sahipleri, ürün yöneticileri ve mağaza yöneticileridir. Tüm paydaşları memnun edecek ideal stoğa ulaşmak için de farklı stok yönetim yöntemleri bulunmaktadır. Çok kriterli envanter sınıflandırma modelleri de bu yöntemler arasında en yaygın olarak kullanılan stok yönetim modellerinden biridir.

Stok yönetimi kararlarında, birden fazla amacın, paydaşın ve kriterin etkin olması, Çok Kriterli Karar Analizi tekniklerinin bu alanda uygulanmasını mümkün kılmaktadır. Bu amaca yönelik olarak çalışmada, ABC sınıflandırması ve UTADIS Çok Kriterli Sınıflandırma tekniği detaylı olarak ele alınmakta ve Türkiye perakende sektöründe uygulaması yapılarak sonuçlar yorumlanmaktadır.

**Anahtar Sözcükler** *Stok Yönetimi, Çok Kriterli Envanter Sınıflandırması, Perakende*

## ABSTRACT

AKKAYA, Z. Gizem. *A METHODOLOGY FOR COMBINING STAKEHOLDER PERSPECTIVES IN MULTICRITERIA INVENTORY CLASSIFICATION : AN APPLICATION IN TURKISH RETAILING SECTOR*, MASTER THESIS, Ankara, 2019.

The growth rate of the retail industry is increasing with each passing day because of the changing dynamics in Turkey and the world. In this growing and changing industry, the concept of inventory management has become a more significant point for companies. One of the most important success criteria of the retail industry is sales, profit margin, and right purchasing management, though one of the most important criteria that companies actually fail to notice is the proper inventory management.

In the industry such as retail is one of the industries in which the season is moving according to trends and customer demands can change rapidly. For this reason, inventory management is a difficult but definitely not to be overlooked issue. Because, inventory is one of the most important cost items for companies. If the inventories are not managed in parallel with the revenue and expense budgets, it causes the stocks that are missing or over. In this case, the financial statements of the companies directly affect. There are a number of stakeholders affected by inventories within the company, as the company's financials are affected. These are company top management, product managers and store managers. There are different inventory management methods to reach the ideal stock which will satisfy all stakeholders. Multi-criteria inventory classification models is one of the most widely used inventory management models among these methods.

In inventory management decisions, the effectiveness of more than one objectives, stakeholder and criteria, makes it possible to apply Multi Criteria Decision Analysis techniques in this field. For this purpose, the study in the ABC classification and Multiple Criteria Classification UTADIS method is discussed in detail and an application of the method in Turkish retail industry is performed in order to interpret the results.

**Keywords** *Inventory Management, Multicriteria Inventory Classification, Retail*



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## ABBREVIATIONS

ADU	Annual Dollar Usage
CM	Category Manager
DEA	Data Envelopment Analysis
HV Model	Hadi Vencheh Model
MC UTADIS	Multiple Criteria Utilities Additives Discriminantes
MCDA	Multiple Criteria Decision Analysis
MCIC	Multicriteria Inventory Classification
R. CUSHION	Rectangular Cushion
R Model	Ramanathan Model
S. CUSHION	Square Cushion
SKU	Stok Keeping Unit
SM	Store Manager
TM	Top Management
UTADIS	Utilities Additives Discriminantes
ZF Model	Zhou and Fan Model

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## INTRODUCTION

Each passing day, retail industry's growth rate, location, and mode of operations vary accompanied by the changing dynamics in Turkey and the world. The most important factors of this change are economic growth, population, and information technologies. It is inevitable for retailers to adopt new technologies, new processes and new organizational formats and develop an appropriate business strategy in order to keep up with these changes.

Increasing competitive pressure in the retail industry leads companies to seek alternative ways to reduce costs. While maintaining customer loyalty for a long-term and successful strategy, it is necessary to control costs. In industry such as retail, which is seasoned, moving according to trends and where customer demands can change rapidly, inventory management is difficult but definitely regarded. Since, inventories are one of the most important cost items for companies. The concept of inventory management has become a more important point for companies. When the inventories are not managed in parallel with the budget of the company, it leads to overstocking or stock out situation. This undesirable situations directly affects the cash flow and the customer satisfaction. Inventories not only have a direct impact on company financials, but also it causes conflict between stakeholders. These are the company's top management, product managers and store managers. While the top manager deals with profitability, the store manager concerns with the supply of hot products. The category manager is under stress of timing, product selection and logistics. It is difficult to perform the inventory management that will satisfy each of stakeholders, in order to prevent problems caused by differences in perspectives. Since, each stakeholder has different perspectives, competencies, and priorities, different inventory management methods are available to reach the ideal inventory.

The main purpose of this study is to propose a novel way of classifying products with respect to multiple criteria. Most of the companies do not apply classification techniques based on a method to their products. They give importance to products according to their perspectives, experiences, and product histories, and they may be ranked within themselves, but this is unscientific approach. The organizations managed without relying

on a method are vulnerable to make mistakes, waste time in the wrong product, have financial difficulties, make wrong decisions.

In the recommended methodology for preventing these problems is applying classifications by taking into consideration the criteria of stakeholders. Predefined multi-criteria ABC classifications are reclassified by the MC UTADIS methodology and error rates are deduced between them. Thus, it is aimed to reach the most robust classification.

Within the scope of this study, a large literature research on inventory management and inventory classification has been made and various mathematical models are emphasized. The proposed method is developed based on a real world case in Turkish retail industry. The company's inventory problem and point of view have been examined by considering the company's inventory information. Based on this data, studies and inventory management practices have been made. The document is organized as follows:

In the first part of the study, inventory classification, models and applications are discussed. In this section, firstly, general information about the classification types in the literature and the most used models are given. Then, the studies and applications in the literature with these models are discussed.

In the second part, the application of the company and its problem were discussed. The general structure of the company, its perspective on inventory management, and current problems are given. In addition, the points and conflicts of stakeholders within the company are emphasized. In this section, the aim of the study, the design of the model and the description of the criteria is given to a large extent.

In the third part, the findings of the models and analyzes carried out within the scope of the study are included. In this section where mathematical data is included, comparisons have been made between models and stakeholders.

In the last part of the study, the evaluation of the appropriate model obtained as a result of the application of models to 3 stakeholders with multi-criteria decision analysis techniques. The purpose and benefits of the model are given in this part.



The paper is arranged as indicated. Chapter 1 determines the relevant literature review. In Chapter 2 determines that the definition and position of company, which is one of the biggest retailer company in Turkey. The findings of models are given in Chapter 3, and conclusion of paper is investigated in Chapter 4.

# **CHAPTER 1**

## **LITERATURE REVIEW**

### **1.1 INVENTORY CLASSIFICATION**

Inventory is defined as raw material, semi-finished product, product or assets that a company has in order to produce. They are one of the most active elements which play a vital role of business activity and represent stocks of goods held for a short period of time before being converted into sales. (Duru, 1989). Inventory management is a decisive and crucial function that affects the supply chain and company's future of finance. Since, the holding cost is an aggravating factor for every industry, even if inventory holding pattern change. That is, inventory, influence company's financial situation directly because of the fact that inventory is one of the most crucial cost items of companies; therefore, inventory should be managed properly, kept under control and appropriate level should be determined.

All organizations or industry related to the production or sale of products have to manage their inventory in some way. That is to say that inventory management, which is important component for various industries such as computer and electronics, telecommunication, aeronautical and defense, medicine, chemistry, food and beverage or retail, is looking for solutions in different application areas.

Inventory management models vary according to the industry, and type of the work due to the fact that inventory assessment of each industry is different. That's why, there are differences in inventory type and inventory classification in each business' inventory management.

When looking at the types of inventory, there are some stockpile types based on the functionality of inventories. They are as follows:

- I. Lot-size Inventories
- II. Fluctuation Inventories
- III. Transportation Inventories
- IV. Anticipation Inventories

Source : Shivam, 2016

Lot-size inventories is a type of stockpile method that company buys the products in a large quantities, this is used because the way of purchasing provides a discount in terms of quantity price, shipping costs, set up costs and so on.

Fluctuation inventories is a type of stockpile method that it is the purchasing way of the company depending on the seasonality of the products. The aim of the stockpile is that company protects themselves against to forecast mistaking. For this reason, company purchases in a large quantities to meet the high demand. In another way, fluctuation inventories can also be called as safety stocks.

Transportation inventories is also stockpile type. It is explained as inventories' in transit situation. That is to say, products are transported from supplier to buyer, and in this transit process, inventory is recorded to company.

Anticipation inventories is another type of stockpile method. Company has a prediction that their suppliers will increase their prices. For this reason, they purchase in a large quantities. Companies generally make this prediction before high season periods or agreement renewal time.

In inventory management, there are several types of inventory types as well as a variety of inventory classifications due to the fact that companies often need to manage their inventories, which are stock keeping units (SKUs). When the numbers and varieties increase, this management becomes more difficult; therefore, inventory is required to be

classified. For this reason, technology based systems and process improvement solutions have been introduced. Inventory classification is one of the introduced solution methods in literature.

In order to effectively control a large number of inventory items, the traditional approach is to separate the inventory into different groups. The method of classifying is the most understandable and available method at this point.

There is no doubt to say, inventory management type is depending on the nature of business, and it is a beneficial for the company to classify their inventory according to inventory type. First and foremost, company's capital makes it more efficient to use. So it would be positive cash flow. Also, classification provides the creation of an appropriate storage location. It helps to shorten the supply time, and it allows for better-cost management. It also supports accurate management of non-stationary inventory items and so on.

Considering all these benefits, inventory items can be categorizing into to their importance to control inventory process, and it can be said that their importance comes from contribution to the company. In an organization, Many of stocks holding units provide an effective control of them, items should be dividing into groups, which means classifying in terms of their specifications, which are quantitative and qualitative.

Several classification methods are in the literature to ensure effective control of inventories. They are as follows:

***ABC Classification*** is an inventory classification method that items are classified into three categories in order to control. Categories are A, B and C. Class A items is the minimum class that includes highest value items. Medium value items are in group B, and low cost value items are in group C.

***FSN Classification*** is an inventory classification method that items are classified into again three categories, which are F, S, and N. This classification is depending on inventories' quantity, percentage of consumption etc. In fact, the description of the letters explains the way of classification. The letter F represents frequently used items. That is fast moving items. The letter S represents less used items. That is slow moving items. The letter N represents long time non-used items. That is non-moving items.

**VED Classification** is an inventory classification method that items are classified into again three categories, which are V, E, and D. This classification method is based on the inventory manager's experience. Explained in letters, the letter V that is Vital represents items that must be kept in continuous stock. The letter E that is Essential represents items that need to be kept in sufficient stock. The letter D that is Desirable represents items that are not obliged to be kept in stock, and that do not affect the process of absence.

**HML Classification** is an inventory classification method that items are classified into again three categories, which are H, M, and L. This classification method is depending on product unit cost. High cost items are in group H. Medium cost items are in group M, and low cost items are in group L.

**SDE Classification** is another inventory classification method that items are classified into three categories, which are S, D, and E. This classification method is based on the length of the delivery time of the product or availability of product. S group that is Scarce includes imported products and longer delivery time products. D group that is Difficult includes products supplied in less than 6 months. E group that is Easily includes easily supplied products.

**SOS Classification** is an inventory classification method that items are classified into two categories, which are S, and OS. This classification method is depending on seasonality of products. S represents items that are seasonal, and OS represents items that are off seasonal.

**XYZ Classification** is an inventory classification method that items are classified into three categories, which are X, Y, and Z. This classification method is depending on demands of variability of products. X represents items that include reliable predictable products. Y represents items that include more difficult to predict demand of products. Z represents items that include where reliable demand estimation is impossible.

**GOLF Classification** is an inventory classification method that items are classified into four categories, which are G, O, L, and F. This classification method is depending on the nature of suppliers. G represents Government, O represents open market, L represents local and F represents foreign market items.

In all organizations, even if it is medium-sized, there can be a lot of inventory stock holding units. To effectively control this large volume of inventory items, the conventional approach is to divide the inventory into different groups. (Ng, 2007). The classification is applied by different models, and to manage in an effective way, inventory items are classified with these models in terms of their feasibility that is the structure of problem and process characteristics. Among these classifications, the most common use of classification in the literature is ABC inventory.

## **1.2 ABC INVENTORY CLASSIFICATION**

The inventory classification made using Always Better Control analysis, which is called as ABC, is one of the most used techniques in companies. This classification is based upon the Pareto principle. (Ramanathan, 2004).

ABC classification separates a large number of items into three groups in order to identify and control. It is very difficult for companies to apply separate inventory policy for various items. Therefore, grouping of items is a kind of solution. This sort of classification helps to manage the high volume inventory and prioritize proper category. For this reason, it is an effective method to distinguish items requiring close control from items not requiring close control. This method has a structure that is sufficiently flexible to determine the amount, value and percentages of each enterprise according to their inventories.

ABC inventory classification provides to efficient control of a lot of inventories from a traditional point of view, traditional means that evaluation on one criterion, usually “annual dollar usage”, for classification of inventory. (Torabi et al, 2012). That’s to say that ABC analysis primarily uses dollar usage, product of demand volume and unit price among the criteria. (Collier and Evans, 2010). However, many other criteria can be important and should be include in the classification process.

ABC Classification allows companies to distinguish stock keeping units. (Partovi and Anandarajan, 2001). Class A items are small, but large amounts constitute annual use value, and Class C items are in great numbers, but they create annual value for use in small quantities. The items between Class A and Class C also form Class B. (Ramanathan,

2004). In other words, a small number of high valued products are grouped as A class. Moderate products in terms of number and value are grouped as B class. A large number of low valued products are grouped as C class. From this point of view; Class A is the lowest class that includes highest scoring materials, followed by class B and then class C. Following Pareto analysis, class A comprises 15 to 20% material, consisted of 30 to 35% B class and C class includes 45 to 55% items. (Iqbal and Malzahn, 2016)

ABC classification indicates that while an inventory is being reviewed, according to the following rules, determined grades such as A, B and C. As seen in Table 1.

Class A inventory items which are goods with top annual consumption value. That's to say that 70 to 80% of the annual consumption value of the company's business but only taking up 10 to 20% of inventory.

Class B inventory items which are interclass items have moderate annual consumption value. 15 to 25% of annual consumption value of the company's business but only taking up 30% of inventory.

Class C inventory items, which are goods with lowest annual consumption value. 5% of annual consumption value of the company's business but only taking up 50% of total inventory.

**Table 1.** ABC Classification Inventory Items

CLASS	% OF TOTAL ITEMS PURCHASED	% OF TOTAL ITEMS PURCHASE (amount)
<b>A ITEMS</b>	10	70
<b>B ITEMS</b>	20	20
<b>C ITEMS</b>	70	10

Source : Flores, 1992

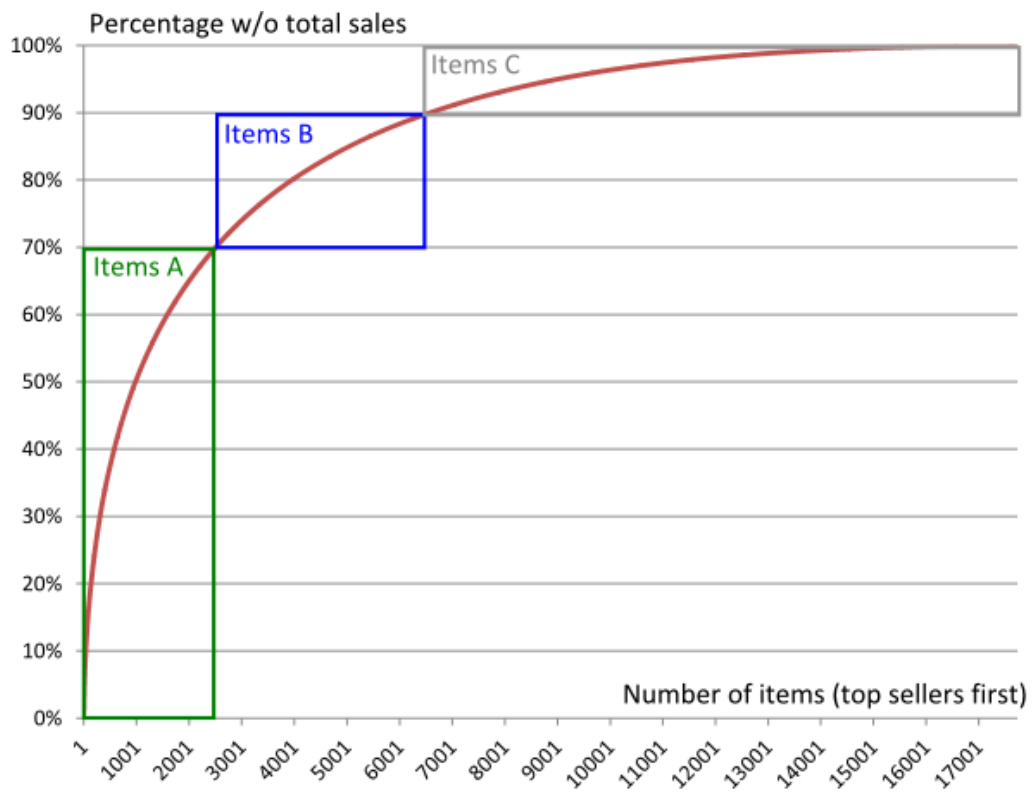
**Table 2.** ABC Classification Ratings in e-commerce Example

Item Category	Level Of Management	Percent of Total in Category	
		Line Items	Annual Dollar Demand
A	High	10 - 20	70 - 80
B	Medium	25 - 30	15 - 25
C	Low	50 - 60	5 - 10

Source: Collignon and Vermorel, 2012

The annual consumption value formula is as follows:

$$(\text{Annual demand}) \times (\text{item cost per unit})$$



**Figure 1.** Sales distribution of a US e-commerce in 2011

Source: Collignon and Vermorel, 2012

Figure 1 presents the annual sales breakdown for all products sold at least once by US e-commerce in 2011. Products are sorted starting with the highest sales volume. The graph has 17000 references. Through references:



- The highest 2500 products representing 70% of the sales and they constitute %15 of the total references.
- Later 4000 products representing 20% of the sales and they constitute %25 of the total references.
- The lower 10500 products representing 10% of the sales and they constitute 60% of the total references. A summary of rates is given in Table 2.

ABC Classification is beneficial for companies to optimize the inventory management function. Each class of the inventory attracts attention to management based on their value. Accordingly, expenditures can be planned. While close attention of the most important items is provided, it is ensured that they are not spend on less important items. That is, ABC Classification prohibits the equal treatment of every item in the inventory. Moreover, focusing on the most important items will prevent to loss of business opportunities and so on.

Considering these advantages, in most of the organizations, the inventory is classified according to ABC classification method. The companies that have a variety of items have applied this classification in order to enable their enterprises to have a more efficient inventory management. Most of the literature on ABC classification emphasizes its use in the manufacturing environment. However, it is crucial to consider that ABC Classification principles apply to most of the industry such as health, textile, automotive, retail etc. can be shown as examples. In fact, even if service industry is used the ABC Classification in the literature. Service companies need to pay attention to cost management like other industries in order to be competitive. In a service industry, determining and reducing the service cost is a crucial component for success.

ABC Classification is applied by considering single or multi criteria. They are called single criteria (traditional) inventory classification and multi criteria inventory classification. According to criteria of ABC Classification, many models are used. In the next part, we discuss common methods of multicriteria ABC inventory classification methodologies.

### 1.3 MULTICRITERIA ABC INVENTORY CLASSIFICATION

Organizations generally use the ABC Classification analysis to have effective control over the inventory item. This classification is examined two main groups in terms of criteria condition, which are single, or multi. Single inventory classification is called also traditional inventory classification. Traditional inventory classification takes into account only one criteria, the annual use of dollars to classify inventory items. In ABC Classification, various methods have been developed to take into account other important criteria for the results to be more acceptable. These models are called multicriteria inventory classification (Torabi et al, 2012). Many criteria can significantly affect the classification. They can be qualitative or quantitative such as holding cost, component criticality, length and variability replenishment time, partnership, and substitutability, scarcity, endurance and storage unit penalty. Therefore, traditional classification cannot give reliable results since it contains only one criterion (Guvenc and Erel, 1998).

The first method to consider many criteria for ABC inventory classification is presented in the work of Flores and Whybark (1986). There have been several methods developed from this method. These are multi various cluster analysis, metaheuristics cluster analysis, analytic hierarchy process based multi criteria inventory classification, and data envelopment analysis models. (Park and Bae, 2014).

Data Envelopment Analysis models are also widely accepted methodologies among multicriteria inventory classification methods. The models can be given as, Ramanathan Model (R) , Zhou and Fan Model (ZF) , NG Model (NG), and Hadi -Vencheh Model (HV).

For the multicriteria inventory classification, Ramanathan recommended a weighted linear optimization model. Ramanathan model, which is called R model creates a range of weights for each item and appoint standardized score to this item. The aim is to aggregate more than one performance score of an item according to different criteria to a single score for the next score (Zhou and Fan 2007).

In other words, R model allows each item to choose their own weight to forecast the performance score. That is, if an item has a value that is predominant for specific criteria, it is always classified as a class A by the R model, without considering of its values in terms of other criteria.

**R model**, developed by Ramanathan (2006) enables a number weight criterion for the aggregation of each item. From the models in the multicriteria inventory classification, the R model is coherent and flexible to include as an extra information from inventory managers (Chen, 2011).

R model can conveniently compound subsequent information from decision makers into inventory classification. The model allows the user to select own weight to forecast the performance scores of the each item. In addition to the ease of use and understanding of this model, we are seeing flexibility. Another advantage of this model is that no input request from the inventory manager is expected in terms of experience; therefore, this situation can be beneficial for new items. Because, the weights of items are independent of experience (Lolli, 2014). However, The R model does not provide a good distinction between inventory items. (Iqbal, 2016).

**ZF model**, developed by Zhou and Fan (2007) has similar characteristics to the R model. Many sources state that the improved version of the R model is the ZF model. ZF model is also a weighted linear optimization model, which is reasonable and comprehensive. It allows each item to choose a weight group that is least preferred for performance combining. That is, an item with a relatively high value for a minor criterion can lead to a situation in which a substance with relatively low values in terms of other important criteria is inappropriately classified as class A. (Chen, 2011)

To overcome these problems, Zhou and Fan have presented an expanded version of the R-model named ZF-model to improve the R model's shortcomings.

According to the ZF model, the most convenient and optimal weights are determined first. These two excess weights are then collected by a control parameter and determined. However, this flexibility can cause some difficulties when deciding. (Torabi, 2012)

**NG model**, developed by Wan Lung Ng (2007) is another multi criteria inventory classification method. The model transforms all benchmark measurements of an inventory level into a scalar score. The classification build the scores calculated using the ABC analysis was applied. (Vencheh, 2010)

NG model is like to R model in terms of simplicity, easiness and flexibility. That is to say that NG model is ease to use, understand and flexible. Flexibility means that additional information for the decision-makers can easily integrate inventory classification. Although, it has advantages such as, convenience, simplicity and flexibility, NG model, that gives rise to a situation where the point is independent of the weight of each item derived from the model. This can cause to a circumstance that an item is classified improperly. (Vencheh, 2010)

NG Model provides inventory managers to classify inventory items without a linear optimizer. In addition to this, the NG model calculates scores on an individual basis of the weights of the item. This situation can give rise to an improper classification of an item. For this reason, Hadi-Vencheh offers a non-linear programming model developed from the NG model. (Torabi, 2012)

**HV model** developed by Hadi – Vencheh (2010) allocates unequal weights to the measures using the reduced ordering criterion constraint. (Iqbal, 2016). Since the HV model is an improved version of NG model, it has similar features. Actually, while NG and HV models state the optimal weight value of each item, they follow an independent consideration attitude rather than a relative consideration attitude. That is to say that, HV model does not consider the relative consideration of the inventory items. (Park, 2014)

Multicriteria ABC inventory classification is one of the most commonly used methods of inventory control, which proposed to classify inventory items taking into account multiple criteria. Multicriteria inventory classification that determined to classify inventory items considering more than one criterion and it is one of the most commonly used techniques for inventory control.

Each of above mentioned multicriteria ABC inventory classification methods has its own characteristics, criteria, constraints and aspects of development. Mostly every model has emerged in terms of developing the previous model. The applications and results of these

models will also vary in this direction. Details of the mathematical forms of Multicriteria models are given below.

### 1.3.1 R Model

A model, referred to as the R model for the MCIC, was proposed by Ramanathan in 2006. A weighted additive function is accustomed to determine the most appropriate score for each item  $i$ ,  $\forall i = 1, \dots, n$ , according to different criteria  $j$ ,  $\forall j = 1, \dots, J$ . The weights  $v_{ij}$  of  $y_{ij}$  values (evaluation of item  $i$  on criterion  $j$ ) are identified by solving, for all items, a linear optimization model. This model is shown below:

Given that :

$v_{mj}$ =Weight of  $m$ th inventory items under criteria  $j$

$y_{mj}$ =Score of  $m$ th inventory items under criteria  $j$  (1)

$$\max \sum_{j=1}^J v_{mj} y_{mj}$$

$$\sum_{j=1}^J v_{mj} y_{nj} \leq 1 \quad n = 1, 2, \dots, N$$

$$v_{mj} \geq 0, \quad j = 1, 2, \dots, J$$

In order to obtain the most appropriate point for each item, The R model must be solved by continuously interchange each time. The points obtained are used to divide the products into three categories which are A, B and C.

### 1.3.2 ZF Model

A model, referred to as the ZF model for the multicriteria inventory classification, was proposed by Zhou and Fan in 2007. There is another approach to the point. ZF model uses the best and the worst of the two sets of weights for each item. Thus, Good Index ( $G_i$ ), and Bad Index ( $B_i$ ) definitions are emerging.  $G_i$  is produced using the most appropriate elements for which they are derived from a maximization function. In contrast to the Good Index,  $B_i$  is gained by a linear optimization model with an objective function to minimize the weight. Final score, the corresponding  $G_i$  and  $B_i$  scores combined.

The form of the ZF model is as follows:

$i$ =inventory items

$n$ =criteria

$y_{in}$ =score of  $i$ th inventory item under criteria  $n$

$w_{in}^b$ =weight of  $i$ th inventory item under criteria  $n$

$bl_i$ =least favorable aggregate score of  $i$ th inventory item

$gl_i$ =most favorable aggregate score of  $i$ th inventory item

$gl^*$ =maximum value of good index

$gl^-$ =minimum value of good index

$bl^*$ =minimum value of bad index

$bl^-$ =maximum value of bad index

$\lambda$ =control parameter that is specified by user

$nl_i$ =composite index for an item

$0 \leq \lambda \leq 1$  is a control parameter that reflects the decision maker's preference for  $G_i$  and  $B_i$ .

$$bI_i = \min \sum_{n=1}^N w_{in}^b y_{in}$$

$$\sum_{n=1}^N w_{in}^b y_{mn} \geq 1$$

$$w_{in}^b \geq 0$$

$$m = 1, 2, \dots, M$$

(2)

$$gI_i = \max \sum_{n=1}^N w_{in}^g y_{in}$$

$$\sum_{n=1}^N w_{in}^g y_{mn} \leq 1$$

$$w_{in}^g \geq 0$$

$$m = 1, 2, \dots, M$$

$$nI_i(\lambda) = (\lambda * (gI_i - gI^-)/(gI^* - gI^-)) + ((1 - \lambda) * (bI_i - bI^-)/(bI^* - bI^-))$$

The scores obtained are used to divide the products into three categories which are A, B and C.

### 1.3.3 NG Model

Ng released a latest model for the multicriteria inventory classification in 2007. Ng maintains the objective function of the R model because of the similarities, but another restrictions arise. According to NG model assumption, the criteria are sorted by importance the weights of these criteria are reflected in relation to:  $w_1 \geq w_2 \geq \dots \geq w_j$  and for any item  $i$ . A linear optimization model was created for each item  $i$ .

Given that:

$w_{ij}$ =Weight of the  $i$ th inventory item under criteria  $j$

$y_{ij}$ =Score of  $i$ th inventory item under criteria  $j$

$$\begin{aligned} \max S_i &= \sum_{j=1}^J w_{ij} y_{ij} \\ \sum_{j=1}^J w_{ij} &= 1 \\ w_{ij} - w_{i(j+1)} &\geq 0 \quad j = 1, 2, \dots, (j-1) \\ w_{ij} &\geq 0 \quad j = 1, 2, \dots, J \end{aligned} \quad (3)$$

### 1.3.4 HV Model

Hadi Vencheh presented the new version of the NG model in 2010, taking into account the weight of the factors in the quadratic form. For this reason, HV model, there is the same logical NG model except for the restriction on the sum of the weight factors.

$\sum_{j=1}^J w_{ij} = 1$  Changed by a squared sum of weight factors of

$\sum_{j=1}^J w_{ij}^2 = 1$  The HV model, which is a non-linear optimization model,

Given that:

$w_j$ =relative importance weight attached to  $j$ th criteria

$y_{ij}$ =score of  $i$ th inventory item under criteria  $j$



$$\begin{aligned} \max S_i &= \sum_{j=1}^J y_{ij} w_{ij} \\ \sum_{j=1}^J w_{ij}^2 &= 1 \\ w_{ij} &\geq w_{ij+1} \geq 0 & j = 1, 2, \dots, (j-1) \\ w_{ij} &\geq 0 & j = 1, 2, \dots, J \end{aligned} \tag{4}$$

### 1.3.5 Multicriteria ABC Inventory Classification Applications

Multi-criteria inventory classification models can be used in a large number of industries. Because of the fact that holding cost is an undesirable situation for every industry. Inventory management in industry started to be managed with a more professional aspect with the developing technology and changing inventory understanding. Looking at these industries; computer and electronics, telecommunication, aerospace and defense, pharmaceutical, chemical, food and beverage, health, and many other industries.

In terms of the models and industries applied in the literature, the issue of hospital inventory management problems implemented by Reid in 1987 is most remarkable and used application. Many models have been applied on the data of this problem.

Data is based on data from Reid's article on hospital inventory management. In this example, Reid classified 47 single-use products used in a hospital-based respiratory therapy unit, using annual dollar use as the only criterion.

A large number of models were applied with data belonging to hospital inventory management. These; Zhou Fan applied this data to the R model while working on the advanced model of R. This data also was used in a study where R and ZF models were used together. Hadi Venceh used this data in the comparison of Ng and ZF model. That

is to say that in the literature, there are many examples of the hospital inventory management problem's data.

However, there is an application of a factory in the literature. This factory consists of two separate parts. In the first part is the production line of the beverage and the second part is in the production of biscuits. The model is applied for the warehouse with raw materials of beverages in the production line. 35 items are in this warehouse. And these items are classified by multicriteria inventory classification. Another application is that items held in the inventory room of the purchasing department of university. In other words, it is applied for the items, which are in inventory and cause cost. Therefore, these models were also used in the education industry.

When the inventory classification applications are considered, the models are used alone or with more than one model. The use of the models was implemented either to indicate the inadequacy of a model or to compare the results between models. This purpose is based on the decision maker and is relevant to the industry.

#### **1.4 UTADIS AND MC UTADIS METHOD FOR CLASSIFICATION**

As indicated in the introduction, we aim to combine the classifications obtained from different approaches using UTADIS method. In this part, we introduce the basic UTADIS methodology and its derivation to handle more than one prior classification, namely as Multiple Criteria UTADIS (MC UTADIS).

UTADIS (Utilities Additives Discriminantes) method is a Multiple Criteria Decision Analysis method for classification which has an application area on financial aspects such as selection of research and development projects, bankruptcy risk estimation, portfolio management, investment decisions. (Diakoulaki, 1999).

The UTADIS technique was first introduced by Devaud (1980). It was later developed by Jacquet - Lagreze and Siskos (1982). Initially, this technique was used in research and development projects and later used to classify financial decision problems. The purpose of the model is to classify alternatives in predetermined groups and to determine the thresholds of groups to minimize errors. (Zopounidis and Doumpos, 1999).

Most of the present classification methods are based on unconditional comparisons between some reference profiles that differentiate between alternatives and classes. UTADIS aims a new approach that includes comparisons based on the Multiple Criteria Decision Analysis. The basis of the methodology is the preferred relationship used to make comparisons between alternatives. The criteria weights used to constitute the preferred relationship are determined using linear programming techniques. (Zopounidis and Doumpos, 1999). That is to say that The UTADIS model is a linear programming model based on calculating the global benefit score for each alternative, minimizing the classification error.

The model of the UTADIS methodology is formed as shown below.

$$\min \sum_{k=1}^o \frac{1}{h_k} [\sum_{x_i \in c_k} (\sigma^+(x_i) + \sigma^-(x_i))]; \quad (5)$$

s.t

$$U(x_i) - u_1 + \sigma^+(x_i) \geq 0 \quad x_i \in c_1; \quad (6)$$

$$U(x_i) - u_k + \sigma^+(x_i) \geq 0 \quad x_i \in c_k, 2 \leq k \leq o - 1; \quad (7)$$

$$U(x_i) - u_{k-1} - \sigma^-(x_i) \leq \delta \quad x_i \in c_k, 2 \leq k \leq o - 1; \quad (8)$$

$$U(x_i) - u_{o-1} - \sigma^-(x_i) \leq \delta \quad x_i \in c_o; \quad (9)$$

$$\sum_{j=1}^n \sum_{l=1}^{p-1} w_{jl} = 1 \quad (10)$$

$$u_k - u_{k+1} \geq \gamma \quad k = 1, \dots, o - 2; \quad (11)$$

$$\sigma^+(x_i), \sigma^-(x_i), w_{jl} \geq 0 \quad (12)$$

Using the mathematical model given above, the purpose of the UTADIS technique is to calculate the global benefit scores of the alternatives in predetermined groups, to move the alternatives to a new scale ranging from 0 to 1, and to determine the thresholds of groups to minimize errors.

Although the UTADIS method is used to solve the problem in many financial areas, most of the time, it is necessary to take into account more than one classification criterion in some decision-making problems. At the point of more than one classification criteria, UTADIS is not sufficient. For this reason, the advanced version of UTADIS, Multiple

Classification Criteria (MC) UTADIS, is activated. MC UTADIS is the method used when there are multiple classification criteria with different predefined classes for alternatives. This method is often used when more than one person's interests conflict or do not fit, and it aims to create interpersonal consensus that conflicts of interests.

There is no doubt to say that MC UTADIS method is not intended to make a group decision which means that it does not try to collect different classifications. Instead of in the case of more than one classification criteria, to find out the general behavior of the model, it tries to find a utility function that minimizes the errors collected over all classifications.

As previously emphasized, the UTADIS model is a linear programming model based on calculating the global benefit score for each alternative that minimizes classification error. The MC UTADIS model is the goal programming model. (Ulucan and Atıcı, 2013). Actually, goal programming is the extension of linear programming. However, while linear programming focuses on a single purpose, target programming considers multiple objectives simultaneously.

That is, like the standard UTADIS model, the MC UTADIS model also analyzes with a minimum total classification error. However, it considers more than one classification at the same time.

The model of the MC UTADIS method is formed as shown below.

$$\min \sum_{r=1}^q z_r \left[ \sum_{k=1}^o \frac{1}{h_{kr}} [\sum_{x_i \in c_{kr}} (\sigma_r^+(x_i) + \sigma_r^-(x_i))] \right]; \quad (13)$$

s.t.

$$U(x_i) - u_{m_1} + \sigma_r^+(x_i) \geq 0 \quad x_i \in c_{1r} \quad r = 1, \dots, q; \quad (14)$$

$$U(x_i) - u_{m_k} + \sigma_r^+(x_i) \geq 0 \quad x_i \in c_{kr} \quad 2 \leq k \leq o - 1, r = 1, \dots, q; \quad (15)$$

$$U(x_i) - u_{m_{k-1}} - \sigma_r^-(x_i) \leq -\delta \quad x_i \in c_{kr} \quad 2 \leq k \leq o - 1, r = 1, \dots, q; \quad (16)$$

$$U(x_i) - u_{m_{o-1}} - \sigma_r^-(x_i) \leq -\delta \quad x_i \in c_{or} \quad r = 1, \dots, q; \quad (17)$$

$$\sum_{j=1}^n \sum_{l=1}^{p-1} w_{lj} = 1; \quad (18)$$

$$u_{m_k} - u_{m_{k+1}} \geq \gamma \quad k = 1, \dots, o - 2; \quad (19)$$

$$\sigma_r^+(x_i), \sigma_r^-(x_i), w_{jl} \geq 0 \quad (20)$$

Following the discussion of the basics of the mathematical models within the scope of this study, in the next section we define our real – world problem, and our model design.

## **CHAPTER 2**

### **PROBLEM DESCRIPTION AND MODEL DESIGN**

#### **2.1 THE COMPANY**

*Mudo* is one of the largest retailer companies in Turkey which was established in 1964 in Beyoğlu/ İstanbul. They began to their retailing experience with gift items, discs, colour fanilias. Their mission was following the global trends and meets these with the customer. The company always open to innovative initiatives, and they showed it with the sale of the first printed t-shirt in Turkey in 1967. The company developed itself in the field merchandising every year. Company's innovation and diversity point of view not only in the product range but also in the way of communication which means that it was the first brand in Turkey to use billboards as an advertising. Besides merchandising innovations, the company supports various social responsibility projects in arts, sports, health and women.

Every passing year, accessories have become even more important with changing trends, and the company increased their product diversity with sub brand which name is *Mudo* Concept. Its principle is offering everything for home and life. With the increasing of product range, the company started to be position in the retail industry, and they opened their first store in Akmerkez which shopping mall was the leading the development of shopping center understanding in Turkey. Today, the company serves 115 stores in Turkey, and their missions are at least one *Mudo* product in each house, always keeping up to date and providing tasteful, accessible, and quality products.

With this principle, they offered thousands of products, which include indoor furniture, outdoor furniture, bath, home textile, kitchen, lighting, decoration and personal accessories categories. The success of the company lies in its ability to manage too many products. The actors in the inventory management (store manager, category manager, etc.) act by thinking of the whole system, not their own benefits, for the success of the company. In this way, it keeps the satisfaction level of the customers high by keeping the costs low. In this thesis, inventory classification problem, which is many important in inventory management, is discussed in order to take the success of the company forward.

### 2.1.1 The Importance of Inventory Management for the Company

Organizations, even if it is small, can hold lots of items in stock. For organizations that protect thousands of inventory items, it is unsubstantial to treat each item equally. (Felice et al, 2014). In addition to the fact that not all inventory items can be treated equally, it is a fact that inventory has an important role to make an effective organization. The inventory is one of the important items of existing assets that make the sales process of the company work smoothly. Management of these products, which are inventory, is also referred to as inventory management.

For many businesses, physical inventory is their biggest expense. As in other companies, *Mudo* aims to manage this expense by maintaining sufficient inventory for sales, and minimizing investment in inventory to increase the company's profitability. For this purpose, the importance of inventory management for the company is given in terms of excessive or insufficient inventory perspectives.

*Excessive investment in inventory* leads to decrease in profitability of the company because of the fact that the capital invested in the product excessively, it give rise to cost increasing activities for the company. The invested capital can be considered in other areas, instead of waiting for sale in the warehouse which means the company can be look for ways to generate revenue in return for sales through other channels. Because the company that is the subject to our study also has a ready-made clothing brand in the retailing sector, along with the home and living company.

In the company's inventory management, the cost increase activities resulting from excess inventory are stated below.

- Inventory can be lost or damaged in the warehouse if it is more than the optimum level. This leads to an unexpected cost for the company.
- Excessive inventory means more space in the warehouse. The efficiency of the space used in the warehouse is another important factor in the company's inventory management and it is another way of creating costs.
- With increasing inventories, all logistics processes of the products will increase, and logistic activities are important for the company's inventory management.

- The staff who perform operational activities is a cost for the company. As the productivity of the company is related to the productivity of the employees, it is the most important factor for the company to spend their time of the employees in more efficient operations instead of dealing with the cost increasing inventory.

*Insufficient investment in inventory* is another factor that plays a role in the company's inventory management. The inadequacy of the inventory is an obstacle for the company to achieve its purpose. Because of the high sales expectation and profitability is difficult to accomplish with missing products.

Reduction in sales due to insufficient inventory in the company's inventory management are as follows..

- Insufficient inventory situation brings to various problems in terms of sales channel. Most importantly, insufficient inventory means loss of sales for the company. Because, in retail industry, product variety and competence are important factors for having a share in market, and the aim of the the company is to ensure product diversity and to be a leader in a strong market by presenting the most up to date and trend products.
- Visuality is another important issue for the company. Lack of product adversely affects visual display. This situation is undesirable for the company and one of the important factors affecting the sale.
- Insufficient inventory situation leads not only to loss of sales revenue, but also to the loss of confidence in brand, reputation, loyalty and so on. *Mudo* is aimed to customer satisfaction by purchasing appropriate products to trend, season, special days or period. While assuring diversity, product sufficiency in stores should be ensured.

Excessive or insufficient inventory situations are not desirable for the company. Because of the fact that inventory situation directly affects all activities of the company even if it doesn't have to be a retail company. Even though the company doesn't produce, it purchased to sell like a many retail company. At this point, how much or which one product to buy questions emerge which means the importance of inventory management



emerge. In this way, understanding of customer demand of your products and acting in this direction becomes more crucial.

All in all, proper inventory management provides the company to the productivity, sustainability and financial gain. It brings a competitive advantage and strong business character. This perspective of the company emphasizes the importance of inventory management. For all these reasons, inventory management is important and needed for the company.

### **2.1.2 Current Problems in Managing Inventory of the Company**

It is the goal of each business to manage its inventory effectively. It is not easy for companies to achieve this goal. Because companies confront a number of problems in their current operations and, like many companies, there are a number of inventory problems in the current functioning of *Mudo*.

The company is already implementing the classic inventory management system which counts and controls the inventory is based on their experience and sales of previous periods. In this classical understanding, the company aims to reach the most appropriate inventory level to ensure the economic balance between inventory holding costs and sales. Many imperfections arise due to the company's point of view of inventory management. When comparing the problems of the company in terms of stock-out or overstocking, the overstocking problem is generally more dominant than stock out problems because of the fact that products which are cushions, throws or kitchen textile have seasonal characteristics and, if they do not return to sales own season, it is a burden for the next season. And there is no doubt to say that textile products go out of fashion quite soon because of the changing trends. All the processes that cause an inventory problems in the company are given below.

***In product selection process***, failure to meet customer expectations and demands lead to inventory problems for the company. Trends matching with the customer, or the selection of products suitable for the season are important factors to avoid inventory problems. The company strives to meet trends with their customers at the right time with the right product. However, most of the time, this timing is not correct for customers. That is, a

fashion, a color or a style, which is trend in the world, is also not a trend in our country at the same time and may not be demanded by the customer. In retail industry has some significant periods. These are two main seasons, summer and winter, and special occasions such as Christmas, Valentine's Day, Mother's Day and Father's Day etc. These periods are very important for the company due to the fact that it affects decisions in product selection.

In addition to adapting to the season and the trend, working in harmony with other categories is important parameter for product selection, and managing in inventory of the company. Products should be in compliance with other categories, which are kitchen, indoor, outdoor furniture category etc. The exhibition of the products directly affects the selections and purchases. Because, the purchases made for these special days are also much important. If the sale in the season is not enough, the products will be transferred to the next year. This is important for the company due to not only in terms of cost, but also for the customer demand. Since, customers want to see new products every year. The company is experiencing inventory management problems after these processes.

***Order quantity process*** that causes problems in the company's inventory management. When this process is examined in itself, product sales performance, minimum order quantity concepts stand out. Sales performance information of the product provides order quantity forecasting. Past sales and sales forecasts are the most important parameters affecting purchasing habits and stocking patterns. There is no doubt to say that past sales figures of the product are the most helpful to us to see the place of the product in tree of life. The sales history of the product helps to determine how much product should be stored in the warehouse. Since the number of orders based on sales performance does not depend on a methode; therefore, it causes inventory problems for the company. The minimum order quantity is one of the most important constraints in determining the number of orders. This parameter indicates how dependent on the supplier, and most of the time, due to this restriction, the company has to make more purchases.

***Number of stores*** of the company directly affects the number of orders. The purpose of having sufficient products in each store can often cause inventory problems for the company due to the sales performance of each store is different.

*The size of the square meter area* for home textile category in the store greatly affects the purchase quantity of the company. Due to the fact that products' store quantity and placement design are related to store square meters.

*Visual arrangement* is one of the most important processes due to the nature of the company. The impact of visibility on sales is one of the reasons. Product quantities are directly effective with visual layout. Deficiency, redundancy or adaptation problems are undesirable for the company and they cause an inventory problems.

*Type of supplier* who is domestic or foreign is another crucial parameter for the company. Domestic and foreign suppliers have different dynamics for themselves in terms of production and delivery processes. The processes are different in domestic and foreign suppliers. For the company, the production and delivery processes can be more easily controlled by the domestic supplier than the foreign suppliers. When the delivery method and duration are not properly managed, problems for the company arise. If the process is not properly organized, it returns to the company as an inventory load, and cost.

*Product lead-time* is another factor that leads to inventory management problems, when not properly managed. Lead times vary from company to company according to suppliers' production power, capacity and where they are. In addition to the qualitative features of lead time, long or short lead-times have some meaning in the inventory management of the company. Long lead times are undesirable and negative for the customer and the company, while short lead times are much sought for company profitability and customer satisfaction.

*Economic reasons* are the most influential factor for the company's inventory management. It is most effective factor but least control factor compared to other parameters. Since the controllability of economic reasons is low, it is difficult for the company to manage the inventory problem. The company makes all sales organizations by purchasing method, and the purchase of imported products is more than domestic products. For this reason, the company is a fragile against economic parameters such as changing exchange, custom tax procedures etc. The dependency on the foreign supplier greatly affects the company in terms of managing inventory.

In summary the problems of inventory management of *Mudo* can be listed as :

- In product selection process
- Order quantity
- The size of the square meter are
- Number of store
- Visuality
- Type of supplier
- Lead time
- Economic reasons.

That is to say, the company has inventory problems in the home textile category. It can be said clearly, different perspectives of the stakeholders, the differentiation of the costs of the products in the category, the seasonality, purchasing habits and other reasons are the factors that lead to inventory management problems.

### **2.1.3 Stakeholders**

Stakeholders are a person or group of people who involved with an organization. They all have a responsibility for the success of the company, and they can affect or be affected by the organizations activities in terms of directly or indirectly. Not all stakeholders have the same rights. For this reason, the areas and rates they affect or be affected are different.

The impact of 3 key stakeholders within *Mudo* is quite dominant. They are internal stakeholders who are top management, category managers and store managers. There is no doubt that all stakeholders have different perspectives and priorities. Even if all stakeholders are together for the same purposes, which are company's profitability, sustainability and success. Different priorities and criteria can cause conflicts among stakeholders. Each stakeholder's perspective is necessary to achieve the most effective result from their point of view.

**Top Management** who have the highest authority in the company, margin, net sales TL, inventory cost and, purchasing cost are among the effective criteria in the inventory management for them. One of the foremost criteria for the company is the profitability of the company. For this reason, margin and net sales TL come first when considering

profitability, followed by the cost of product and how much product is waiting in stock. Since, the company ties its capital to the product, the cost of purchasing a product and the sales price of the product, ie. The margin is in the company's priority. Then comes the cost of inventory. According to the company, if there is a product waiting to the warehouse, it means money waiting in warehouse. And the top managers do not accept the waiting their money in stock because of the fact that the company always prefer to use its capital in other areas, instead of waiting in storage. In other words, the effect of inventory cost on inventory management is as important as margin for the company. Since the priority of the top management is different from other stakeholders, it is inevitable that there will be conflicts.

**Category Management** represents the product managers, who are responsible predominantly for selecting, buying, pricing a product then distributes products to the stores, decides which product to send to which store in what number. Actually, category manager is taking place at every organization related to the product. For category manager; margin, net sales volume, net sales TL, total inventory quantity, and inventory cost are among the effective criteria in the inventory management. Category manager attaches importance to profitability with a viewpoint like the top management, which means that margin and net sales TL are priority criteria. Category manager is also responsible for sales; therefore, there is an anxiety about having enough inventories for category manager. The total number of stocks and net sales volume are also among the criteria of the category manager because of the fact that when there are enough store and warehouse inventories, there will be provide maximum sales. Inventory cost is also the criteria of category manager's inventory management. Because product manager is responsible for the purchase, and every wrong purchase made causes inventory cost. The category manager is also responsible for the cost of the product waiting in the warehouse. This situation leads to slow down new purchases, and even stop buying. That is to say that existing inventory is expected to be sold. In this case is undesirable for the category manager. This is a sign that inventory management is directly affected inventory cost for category manager. Conflicts are expected for this perspective because this is a more important criteria for category manager.

*Store Management* represents the store authority. The store manager expects the customer to buy any product he/she wants in any quantity. Store manager who closely observes the customer – product relations. Therefore, expectations and priorities of store manager differ from other stakeholders. For instance, the store manager always wants to have maximum numbers and variety of products in their store. As well, store managers want to keep both most expensive and affordable products in their store to reach all kinds of customer profiles so that they expect to get more sales due to the keeping wide customer profile range. For this reason, store stock, average unit cost, net sales volume and net sales TL are effective criteria in the inventory management for store manager.

In an organizational structure, since stakeholders' role is different, their perspectives are different. For this reason, there are conflicts. As a priority of top management, the store manager is not interested at all, while the store manager's priority criteria is the last for the category manager. That is to say that, priorities determined the stakeholder's level of conflicts.

For illustration, the importance given by category manager or top management of cost of inventory is not the same as the importance given by store manager. Even though there are common criteria, the rankings among the stakeholders are different. Top management and store managers always want to see seasonal and trendy products at the store. The inventory cost of this purchase takes precedence over for category manager. For top management, this is less important than category manager, while the store manager is not interested in it.

At this point, in spite of all conflicts, to achieve the common mission of all stakeholders which is “always up-to-date capture; focus on what our customers will want in the future, not just their current needs; to be a companion that gives value to the material by offering tasteful, accessible and quality products.” It is important and necessary to meet at a common point in all stakeholders' perspectives with the aim of benefiting from different perspectives.

### 2.1.4 The Products of the Company

*Mudo* is one of the largest company in Turkey. Providing services in 26 cities, the company offer its customers a wide range of products, from indoor and outdoor furniture to lighting, bathroom, kitchen products, decorative and personal accessories and home textile products.

Home Textile category is one of the categories with the highest number and variety products of the company. This category has its own subgroups, which are decorative cushion, carpet&rug, throw and bed spread. Active purchases continue in all subgroups. But, the company has not made any purchases for bed spread subgroup in a long time. However, instead of keeping the products in the warehouse, it is among the plans to continue in the appropriate stores and try to finish the stocks. For this reason, bed spread is not included in the data of this study.

Besides, subgroups are also divided into product classes themselves, and each product class has a detail and name description. Product classes are important for subgroups. All of them are evaluated and planned within themselves. They are given in Table 3.

**Table 3.** Subgroup and Class Definitions of Products in the Home Textile Category

Subgroup	Product Class	# of Products
Decorative Cushion	Cushion	139
	Doorstopper	8
	Mat	7
Rug & Carpet	Rug	102
	Small Carpet	19
Throw	Throw	24
	Tablecloth & Runner	20
<b>Total</b>		<b>319</b>

There are many and varied products in each class. The management of these products is crucial and difficult for the company. Because, each subgroup's characteristics, purchasing habits and stocking shapes are separated from each other. With the effect of number of products, the number of subgroups and classes also play an important role in management. That is, inventory management is required for a category, which includes 3

subgroups and 7 classes. The characteristics of each subgroup in terms of inventory management are given below.

***Decorative Cushion*** has 3 classes in itself and most of the category's products are in this subgroup. They are the most exposed to the seasonality and up on all the trend problems. At the same time, on special days, such as Christmas, Valentine's Day, Mother's Day and Father's Day, most investments are made in this subgroup. The investment allocated to this subgroup has a large share in the category. Because the majority of the products in this subgroup are imported and their unit costs are high.

***Rug & Carpet*** has 2 classes in itself, and has the 2<sup>nd</sup> highest number of products within the category. They are influenced by seasonality and trend changes but this is not as much as the impact of the Decorative Cushion subgroup. Especially in the summer season, more slim and trendy colors are taken care to purchase products. However, in general, there are products without seasoning in this group. The investment allocated to this subgroup has the largest share in the category. Most of the products in this sub-group are imported, and the unit costs are the highest within the category.

***Throw*** has 2 classes in itself, and the least of the category's products are in this subgroup. This subgroup is not affected by the seasonality. Because of the fact that nature of the subgroup mainly includes winter season products. The investment allocated to this subgroup has the lowest share in the category. The number of domestic and imported products is close to each other in this subgroup, and the balance exists in unit costs.

## **2.2 AIM OF STUDY**

In this study, it is aimed to bring together different stakeholders, different perspectives and different models, in order to achieve optimum results by considering all factors of inventory management.

The large number and variety of products make the inventory management difficult for the company because of the fact that where too many products are managed, it is inappropriate to make the same decisions about inventory management decisions for each product.



Three different stakeholders affect the stock decisions in the company. These stakeholders have different criteria of importance. Criteria that determine the importance of the products are different according to stakeholders. Their level of importance is different, even if they are the same criteria. The combination of different stakeholders leads to different perspectives. It is difficult to make the same decisions with different perspectives. For this reason, different models have been implemented for each stakeholder.

In this study, multi-criteria classification techniques in the literature are discussed in detail and it is aimed to help the company's problem. Inventory problems generally involve stakeholders with different perspectives, capital intensive investment, and interest groups of many stakeholders from different perspectives. Because of these characteristics, the decisions to be taken in this regard are in a structure where more than one purpose, criterion or quality come together. As a result of these structures, inventory problems are the types of problems that Multi Criteria Decision Analysis methods have applied. Looking at the starting point of inventory problems, one of the biggest shortcomings of the company is planning. The aim of the study is to analyze the inventory management problem, which is one of the main problems of the company, with the help of MC UTADIS methodology from Multi Criteria Decision Analysis techniques.

### **2.3 CRITERIA DESCRIPTION**

*Mudo* has 3 key stakeholders, which are top management, category managers and store managers. The top management of the company are very interested in the decisions taken and most of the time in product selection and purchasing decisions are included. Category managers are responsible for product management in the company. The category manager is the person who has been in all stages of the product from procurement stage, including pricing, sample inspection in the warehouse, distribution to stores, sales control and if necessary campaign organizations. The store manager is responsible for all the store's organizations. The store manager has duties such as tracking the sales of the products in the store, entering the manual order except for the products that go out automatically after sale warehouse, being responsible also for store tidiness which means that which product is displayed with which product, directing the customer demands, complaints to the

category responsible and so on. Since each stakeholder's responsibilities and roles are different, their perspectives are differentiated at this point.

We have considered some criteria in this study according to stakeholders' perspectives. These include; purchase quantity, purchase cost, inventory quantity, store quantity, inventory cost, net sales units, net sales amount, margin, and average unit amount.

Many criteria that each stakeholder considers to be important according to the point of view. By interviewing different stakeholder representatives, we identify three criteria sets reflecting each stakeholder's perspective as seen in Table 4.

**Table 4.** Stakeholder's Perspective for Evaluation Criteria

Evaluation Criteria	Stakeholders			
	Characteristic	TM	CM	SM
G1. Net Sales Quantity	Max		√	
G2.Net Sales Amount	Max	√	√	
G3.Margin	Max	√	√	
G4.Purchase Quantity	Max			√
G5.Purchase Cost	Min	√		√
G6.Store Quantity	Max			√
G7.Total Inventory Quantity	Min		√	
G8.Inventory Cost	Min	√	√	
G9.Average Unit Amount	Min			√

Since top management are most closely involved with the company's objectives, the criteria they care about are related to company objectives; therefore, Purchase cost, Net Sales Amount, Margin and Inventory Cost are effective criteria for top management due to the fact that one of the most important things for the top manager is its profitability and return. Top management links their capital to stock. For this reason, the purchase cost of a product and how much this product will be sold and will save money are utmost importance for the company. After that, the cost of inventory is the highest priority of the top managers because of the fact that the product that is waiting in the stock means still money waiting in stock for the top managers. They want to use their capital elsewhere

instead of keeping the product in inventory; therefore, this criteria, which is inventory cost, is very important in inventory management for Top Management.

Category manager have a similar perspective to the top management. As they give importance to the profitability like top managers, margin and net sales amount are priority criteria for them. At the same time the category manager is responsible for the sale. Therefore, there is also a concern of the having sufficient number of stocks. Since it will have maximum sales when there is sufficient store and warehouse stock, which means that total inventory, is one of another important criteria for category manager. The responsibility of the inventory cost is primarily the category manager. For this reason, inventory cost is another most important criteria for category manager.

Store manager' criteria is different from top managers and category managers in terms of point of view. Generally, they want to keep most product types and varieties in their store. Having a large number products in their stores does not bother them; therefore, their one of the most important criteria is store inventory quantity. Moreover, according to product group, store manager want to keep both the most expensive and affordable products in their stores because of the fact that they reach all kinds of customer profiles in this way. This situation enables them to get the most sales. That is to say that Store Manager has priorities such as the sales quantities, amount of its sales, the unit price of that product and sufficient stocks, rather than the profitability of a product.

Each stakeholder's perspectives are different, and their criteria importance are shaped according to their point of view as described above. Indeed, all criteria have a numerical value. In evaluating the criteria, a criterion as a numerical value, more or less it varies in itself. The more or less of the values of the criteria are effective in decision making of stakeholders.

The criterion, which is desirable to have a high numerical value, is called "most good criteria". The criterion, which is desirable to have a low numerical value, is called "few good criteria".

We have considered 9 criteria in this study according to stakeholders' point of views given in Table 4. Considering these criteria as "most good criteria" or "few good criteria"; Net sales quantity is most good criteria because of the fact that as the sales volume

increases, the sales revenue will increase, so it is desirable to be “too high”. A net sales amount is most good criteria. There is no doubt to say that high value of sales amount is desirable for each stakeholder. Margin is also most good criteria due to the fact that profit expectation is also too high. Purchase quantity is generally most good criteria because of the fact that high sales expectation is met with sufficient purchase quantity. Purchase cost is few good criteria. Since, it is expected to make most affordable purchase and use the budget effectively. Store quantity is most good criteria because of the fact that net sales are made through stores; it is desirable to have enough pieces here. Inventory quantity is somewhere in between in this evaluation. This value is expected to be high, but it is desirable to be less, which means that when the product is sold, it is expected to go to the stores from warehouse without waiting. It can be also called as having safety stock. Beside this, the product waiting in the warehouse is undesirable situation. It can be also called as passive stock. In general, they prefer the lack of product in warehouse. It’ given, inventory quantity is generally desirable to be less which means that it is a few good criteria. Inventory cost is also few good criteria. Since, companies view inventory cost as the capital waiting to be wasted in the warehouse; therefore, they want to use that capital instead of the inventory cost. Average unit amount is also few good criteria due to the fact that few are desirable.

## **2.4 MODEL DESIGN**

In this study, firstly, 4 classification models were implemented to bring together 3 stakeholders’ perspectives. In this way, 4 models, which are R, Ng, HV, and ZF, are applied for each stakeholder and 12 models emerge. It is done in multicriteria inventory classification feature. Top Management’s 4 model application results are given in Table A1. Category Manager’s 4 model application results are given in Table A2, and Store Manager’s 4 model application results are given in Table A3.

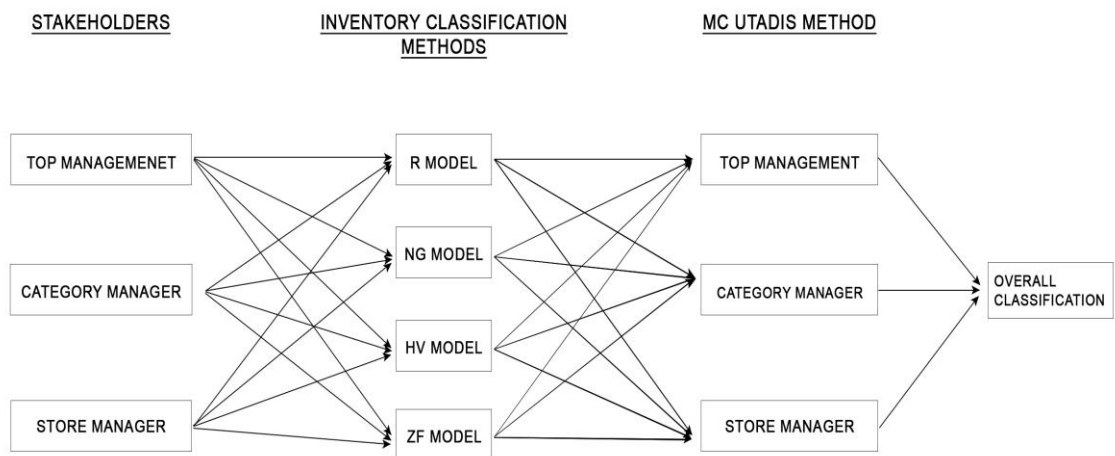
After these classifications, the classification was repeated with the MC UTADIS method. MC UTADIS technique is a model consisting of alternative set and criteria as in other Multi Criteria Decision Analysis techniques. In MC UTADIS application, the alternatives are primarily divided into classes by the decision maker, taking into account a particular set of characteristics. The best and worst alternatives are grouping. Then, group thresholds

between 0 and 1 are determined so that the alternatives in the best group receive the highest score. The aim is to calculate the marginal benefits of alternatives. In addition, two types of classification are mentioned in this method. They are over estimation error and under estimation error. These errors occur when there is a difference between the first classification and the MC UTADIS classification according to the global utility function. The purpose of the MC UTADIS method is to calculate the global benefit scores of the alternatives in predetermined groups, to move the alternatives to a new scale ranging from 0 to 1, and to determine the thresholds of groups to minimize errors.

In the second part of the study, MC UTADIS was implemented for each stakeholder. Since there are 4 classifications applied for each stakeholder, MC UTADIS has been implemented with the consideration of these 4 classification which are R, Ng, ZF and HV. As Ng and HV models gave the same results according to the first classification results, they were treated as a single classification in the MC UTADIS method.

After the first classification errors' which are over estimation and under estimation are determined, a new classification is formed according to the MC UTADIS method. While MC UTADIS was applied, each stakeholder's own criteria were taken into consideration and evaluated over 319 products. Overall classification of models for stakeholders summary is given in Table 5.

**Table 5.** Overall Classification of Models for Stakeholders



## CHAPTER 3

### FINDINGS

In this study, home textile data of Retail Company were used. The data includes 3 stakeholders, 5 classification models. 4 of them ABC Classification, 1 is MC UTADIS method, 9 criteria and 319 kinds of products. Stakeholders are Top management, Category Manager and Store Manager. Classification models are R model, NG Model, Z model and HV model and MC UTADIS Method. Considering criteria are purchase quantity, purchase cost, inventory quantity, store quantity, inventory cost, net sales units, net sales amount, margin, and average unit amount.

According to each stakeholder, 4 ABC Classification models are applied and 319 kinds of products were evaluated. In this way, 12 models emerge in total and these models are evaluated within themselves. 4 different models have been applied considering the criteria of the stakeholders. The results of the classes according to each model are in given Table 6.

**Table 6.** Number of Items in Each Class with Respect to Methods and Stakeholders

<b>TM</b>	<b>R</b>	<b>NG</b>	<b>HV</b>	<b>ZF</b>
A	40	9	9	32
B	246	30	30	196
C	33	280	280	91
Total Data	319	319	319	319

<b>CM</b>	<b>R</b>	<b>NG</b>	<b>HV</b>	<b>ZF</b>
A	31	9	9	29
B	195	30	30	149
C	93	280	280	141
Total Data	319	319	319	319

<b>SM</b>	<b>R</b>	<b>NG</b>	<b>HV</b>	<b>ZF</b>
A	25	4	4	3
B	73	22	22	74
C	221	293	293	242
Total Data	319	319	319	319

According to the findings, the results of NG and HV models are very similar. After these ABC Classification models, the MC UTADIS methodology is applied for all 4 models for each stakeholder and it is aimed to reach 1 model for each stakeholder. Firstly, 12 models are reduced to 3 models with MC UTADIS with considering each stakeholder's criteria. Afterwards, MC UTADIS methodology is implemented by taking into account all stakeholders and all criteria.

The first part of the findings section contains the results of the ABC classification models. The second part of the findings section contains the results of the MC UTADIS Method.

### 3.1 R MODEL RESULTS

**Table 7.** R Model Results for Each Stakeholder

<b>TM</b>	<b># of items</b>	<b>%</b>
A	40	13%
B	246	77%
C	33	10%
<b>CM</b>	<b># of items</b>	<b>%</b>
A	31	10%
B	195	61%
C	93	29%
<b>SM</b>	<b># of items</b>	<b>%</b>
A	25	8%
B	73	23%
C	221	69%

The results of the R model according to each stakeholder are as seen in Table 7.

When the results are analyzed on the basis of stakeholders;

According to Top Management, 13% of the products were classified in category A, 77% of the products were classified in category B, and 10% in category C.

According to Category Manager, 10% of the products were classified in category A, 61% of the products were classified in category B, and 29% in category C.

According to Store Manager, 8% of the products were classified in category A, 23% of the products were classified in category B, and 69% in category C.

The distribution rate of A, B and C classes of each stakeholder vary. For class A, an average of 10% is observed for all stakeholders. For B class, an average of %54 is observed and an average of %36 is observed in class C.

On a product class basis,

- The cushions are concentrated in the B class for the top management and category manager, and in the C class for the store manager.
- Considering stoppers, the stoppers are concentrated in the B class for TM and SM, and in the A class for CM.
- Considering mats, the mats are concentrated in the A class for TM and SM, and in the B class for CM.
- When look at the table of rugs, the rugs are concentrated in the A class for the TM, in the B class for the CM, and in the C class for SM.
- Considering small carpets, the carpets are concentrated in the B class for TM and CM, and in the C class for SM.
- Considering throws, the throws are concentrated in the B class for TM and CM, and in the C class for SM.
- Considering tablecloth and runner, they are concentrated in the B class for TM and CM, and in the C class for SM.

The results are given in Table 8.



**Table 8.** R Model Results for Product Classes and Stakeholders

<b>CUSHION</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	6%	6%	13%
B	74%	53%	39%
C	20%	40%	48%
<b>STOPPER</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	63%	0%
B	88%	38%	100%
C	13%	0%	0%
<b>MAT</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	57%	43%	57%
B	43%	57%	14%
C	0%	0%	29%
<b>RUG</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	24%	12%	1%
B	74%	68%	1%
C	3%	21%	98%
<b>SMALL CARPET</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	16%	0%	0%
B	84%	89%	0%
C	0%	11%	100%
<b>THROW</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	4%	8%	4%
B	96%	58%	21%
C	0%	33%	75%
<b>TABLECLOTH &amp; RUNNER</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	0%	5%
B	95%	70%	20%
C	5%	30%	75%

On a product basis,

- Products are in category A class for all stakeholders as seen in Table 9. Because this products have an affordable sales price, high margin and available for volume etc. That's to say that, it is compatible with the interests of all stakeholders.

**Table 9.** Class A Products for All Stakeholders

ITEM	TM R	CM R	SM R
MINI CUSHION 13	1	1	1
MAT 1	1	1	1
MAT 2	1	1	1
MAT 3	1	1	1
THROW 7	1	1	1

- Products are in category C class for all stakeholders as seen in Table 10. That's to say that, these products are more distant from the criteria of all stakeholders.

**Table 10.** Class C Products for All Stakeholders.

ITEM	TM R	CM R	SM R
R.CUSHION 1	3	3	3
S.CUSHION 10	3	3	3
S.CUSHION 12	3	3	3
S.CUSHION 14	3	3	3
S.CUSHION 85	3	3	3
LARGE RUG 1	3	3	3
SMALL RUG 1	3	3	3
SMALL RUG 3	3	3	3

- Most of the rugs are in A category for Top Management and Category Manager, while these products are in category C for Store Managers. Products are determined in Table 11.

**Table 11.** Classes of products in Rug & Carpet Subgroup.

ITEM	TM R	CM R	SM R
LARGE RUG 6	1	1	3
LARGE RUG 9	1	1	3
LARGE RUG 56	1	1	3
LARGE RUG 57	1	1	3
LARGE RUG 58	1	1	3
LARGE RUG 59	1	1	3
LARGE RUG 60	1	1	3
LARGE RUG 61	1	1	3
LARGE RUG 62	1	1	3
LARGE RUG 63	1	1	3
SMALL RUG 34	1	1	3
SMALL RUG 35	1	1	3

- Most of the cushions are in A class for CM and SM, while these products are in B or C class for TM as seen in Table 12.

**Table 12.** Class Conflict of Decorative Cushion Subgroup

ITEM	TM R	CM R	SM R
S.CUSHION 82	2	1	1
S.CUSHION 83	2	1	1
MINI CUSHION 2	3	1	1
MINI CUSHION 5	3	1	1
MINI CUSHION 7	3	1	1
MINI CUSHION 12	3	1	1
MINI CUSHION 6	3	1	1

- Mini cushions are also differentiated in the classification due to the stakeholders' priorities. These products are always stocked in stores in high volumes, and their sales quantity is always high because of the advantages of being small and affordable. This product group is more suited to the interests and priorities of store manager. For this reason, they are in A group for SM. Results are given in Table 13.

**Table 13.** Classes of products in Mini Cushions.

ITEM	TM R	CM R	SM R
MINI CUSHION 13	1	1	1
MINI CUSHION 1	3	3	1
MINI CUSHION 2	3	1	1
MINI CUSHION 3	3	2	1
MINI CUSHION 4	3	2	1
MINI CUSHION 5	3	1	1
MINI CUSHION 7	3	1	1
MINI CUSHION 8	3	2	1
MINI CUSHION 9	3	3	1
MINI CUSHION 10	3	3	1
MINI CUSHION 11	3	2	1
MINI CUSHION 12	3	1	1
MINI CUSHION 6	3	1	1

All in all taking into consideration, R model was examined for 3 different stakeholders who are top management, category managers and store managers. Classes vary according to stakeholders, groups, and products. Due to the criteria and priorities of stakeholders, these differences and common decisions are observed at some points.

### 3.2 NG MODEL RESULTS

**Table 14.** NG Model Results for Each Stakeholder

TM	# of items	%
A	9	3%
B	30	9%
C	280	88%
CM	# of items	%
A	9	3%
B	30	9%
C	280	88%
SM	# of items	%
A	4	1%
B	22	7%
C	293	92%

The results of the NG model according to each stakeholder are as seen in Table 14.

When the results are analyzed on the basis of stakeholders;

According to Top Management, 3% of the products were classified in category A, 9% of the products were classified in category B, and 88 % in category C.

According to Category Manager, 3 % of the products were classified in category A, 9 % of the products were classified in category B, and 88% in category C.

According to Store Manager, 1% of the products were classified in category A, 7 % of the products were classified in category B, and 92% in category C.

The distribution rate of A, B and C classes of each stakeholder are similar. Moreover, the high number of products in category C class is similar for 3 stakeholders.

On a product class basis,

- When look at the table of cushions, the cushions are concentrated in the C class for all stakeholders. Only the store manager's B class ratio is more than the others.
- Considering stoppers, the stoppers are concentrated in the C class for TM and CM, and in the B class for SM.
- Considering mats, the mats are concentrated in the C class for all stakeholders.
- When look at the table of rugs, the rugs are concentrated in the C class for the all stakeholders. Indeed, for SM, they did not classify any item in A and B class.
- Considering small carpets, the carpets are concentrated in the C class for TM, CM, and SM, and they did not classify any item in A and B class for SM.
- Considering throws, the throws are concentrated in the C class for TM, CM, and SM.
- Considering tablecloth and runner, they are concentrated in the C class for TM and CM, and SM.

The Results are given in Table 15.

**Table 15.** NG Model Results for Product Classes and Stakeholders

<b>CUSHION</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	0%	1%
B	1%	1%	9%
C	99%	99%	90%
<b>STOPPER</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	0%	0%
B	0%	0%	100%
C	100%	100%	0%
<b>MAT</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	0%	0%
B	14%	14%	14%
C	86%	86%	86%
<b>RUG</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	3%	3%	0%
B	21%	21%	0%
C	76%	76%	100%
<b>SMALL CARPET</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	5%	5%	0%
B	5%	5%	0%
C	89%	89%	100%
<b>THROW</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	21%	21%	8%
B	13%	13%	4%
C	67%	67%	88%
<b>TABLECLOTH &amp; RUNNER</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	0%	0%
B	10%	10%	0%
C	90%	90%	100%

On a product basis,

- Products are in category A class for all stakeholders as seen in Table 16. That's to say that, it is compatible with the interests of all stakeholders.

**Table 16.** Class A Products for All Stakeholders

<b>ITEM</b>	<b>TM NG</b>	<b>CM NG</b>	<b>SM NG</b>
THROW 6	1	1	1
THROW 7	1	1	1

- Only one product is in category B class for all stakeholders given in Table 17.

**Table 17.** Class B Products for All Stakeholders

ITEM	TM NG	CM NG	SM NG
MAT 5	2	2	2

- C class products for all stakeholders are high in NG model.
- Rugs are in category class A for TM and CM given in Table 18. They are in category class C for SM.

**Table 18.** Class A Rugs for Top Management and Category Manager.

ITEM	TM NG	CM NG	SM NG
LARGE RUG 3	1	1	3
LARGE RUG 6	1	1	3
SMALL RUG 6	1	1	3

- Most of the rugs, which are 78 pieces, are in category class C for all stakeholders. Some of these are given in Table 19.

**Table 19.** Class C Rugs for All Stakeholders.

ITEM	TM NG	CM NG	SM NG
LARGE RUG 1	3	3	3
LARGE RUG 2	3	3	3
LARGE RUG 47	3	3	3
LARGE RUG 48	3	3	3
LARGE RUG 64	3	3	3
LARGE RUG 65	3	3	3
SMALL RUG 1	3	3	3
SMALL RUG 2	3	3	3
SMALL RUG 3	3	3	3
SMALL RUG 4	3	3	3
SMALL RUG 5	3	3	3
SMALL RUG 7	3	3	3

- Some kinds of cushions are in category A class for SM, they are in category B class for TM and CM given in Table 20.

**Table 20.** Class A Cushions for Store Manager.

ITEM	TM NG	CM NG	SM NG
S.CUSHION 82	2	2	1
S.CUSHION 83	2	2	1

On the whole, the NG model was examined for 3 different stakeholders who are top management, category managers and store managers. It can be clearly seen that TM and CM results are more similar each other. SM results differentiate them.

### 3.3 HV MODEL RESULTS

**Table 21.** HV Model Results for Each Stakeholder

TM	# of items	%
A	9	3%
B	30	9%
C	280	88%
CM	# of items	%
A	9	3%
B	30	9%
C	280	88%
SM	# of items	%
A	4	1%
B	22	7%
C	293	92%

The results of the HV model according to each stakeholder are given in Table 21.

When the results are analyzed on the basis of stakeholders;

According to Top Management, 3% of the products were classified in category A, 9% of the products were classified in category B, and 88 % in category C.

According to Category Manager, 3 % of the products were classified in category A, 9 % of the products were classified in category B, and 88% in category C.



According to Store Manager, 1% of the products were classified in category A, 7% of the products were classified in category B, and 92% in category C.

The distribution rate of A, B and C classes of each stakeholder are similar to NG model results.

On a product classes and product basis,

- Cushions are concentrated in the C class for all stakeholders. Only the store manager's B class ratio is more than the others.
- Considering stoppers, the stoppers are concentrated in the C class for TM and CM, and in the B class for SM.
- Considering mats, the mats are concentrated in the C class for all stakeholders.
- The rugs are concentrated in the C class for the all stakeholders. Indeed, for SM, they did not classify any item in A and B class.
- Small carpets, the carpets are concentrated in the C class for TM, CM, and SM, and they did not classify any item in A and B class for SM.
- The throws are concentrated in the C class for TM, CM, and SM.
- Tablecloth and runner, they are concentrated in the C class for TM and CM, and SM.

That's to say that all results are the same like NG model which are given in Table 14.

In general, the HV model has been examined for 3 different stakeholders: top management, category managers and store managers. It is clear that TM and CM results are closer to each other. SM results differentiate them.

### 3.4 ZF MODEL RESULTS

**Table 22.** ZF Model Results for Each Stakeholder

<b>TM</b>	<b># of items</b>	<b>%</b>
A	32	10%
B	196	61%
C	91	29%
<b>CM</b>	<b># of items</b>	<b>%</b>
A	29	9%
B	149	47%
C	141	44%
<b>SM</b>	<b># of items</b>	<b>%</b>
A	3	1%
B	74	23%
C	242	76%

The results of the ZF model according to each stakeholder are given in Table 22.

When the results are analyzed on the basis of stakeholders;

According to Top Management, 10% of the products were classified in category A, 61% of the products were classified in category B, and 29 % in category C.

According to Category Manager, 9% of the products were classified in category A, 47% of the products were classified in category B, and 44% in category C.

According to Store Manager, 1% of the products were classified in category A, 23 % of the products were classified in category B, and 76% in category C.

On a product class basis,

- When look at the table of cushions, the cushions are concentrated in the B class for TM and CM. They are concentrated in C class for SM.
- Considering stoppers, the stoppers are concentrated in the C class for TM and SM, and in the B class for CM.
- Considering mats, the mats are concentrated in the A class for TM and CM. They are in category C class for SM.
- When look at the table of rugs, the rugs are concentrated in the C class for CM and SM, in the B class for TM.

- Considering small carpets, the carpets are concentrated in the B class for TM, CM. They are in C class for SM.
- Considering the throws, it is observed that the distribution rates are different from the others. Because, according to the top management, 50% of the products are in class B and 50% in class C. Moreover, they are concentrated in class C for CM and SM.
- Considering tablecloth and runner, they are concentrated in the B class for TM and CM. For SM, they are in C class.

The results are given in Table 23.

**Table 23.** ZF Model Results for Product Classes and Stakeholders

<b>CUSHION</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	7%	8%	0%
B	65%	59%	47%
C	28%	33%	53%
<b>STOPPER</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	0%	0%
B	0%	88%	0%
C	100%	13%	100%
<b>MAT</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	71%	86%	29%
B	29%	14%	29%
C	0%	0%	43%
<b>RUG</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	15%	7%	0%
B	66%	28%	1%
C	20%	65%	99%
<b>SMALL CARPET</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	5%	16%	0%
B	63%	47%	0%
C	32%	37%	100%
<b>THROW</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	0%	8%	0%
B	50%	33%	0%
C	50%	58%	100%
<b>TABLE CLOTH &amp; RUNNER</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
A	5%	0%	5%
B	65%	65%	25%
C	30%	35%	70%

On a product basis,

- Products are in category A class for all stakeholders given in Table 24. That's to say that, it is compatible with the interests of all stakeholders.

**Table 24.** Class A Products for All Stakeholders.

ITEM	TM ZF	CM ZF	SM ZF
MAT 1	1	1	1
MAT 4	1	1	1

- Products are in category C class for all stakeholders given in Table 25. That's to say that, these products are more distant from the criteria of all stakeholders.

**Table 25.** Class C Products for All Stakeholders.

ITEM	TM ZF	CM ZF	SM ZF
STOPPER 8	3	3	3
R.CUSHION 3	3	3	3
R.CUSHION 35	3	3	3
S.CUSHION 11	3	3	3
S.CUSHION 32	3	3	3
S.CUSHION 85	3	3	3
MINI CUSHION 1	3	3	3
MINI CUSHION 9	3	3	3
MINI CUSHION 10	3	3	3
LARGE RUG 1	3	3	3
LARGE RUG 10	3	3	3
LARGE RUG 11	3	3	3
SMALL RUG 3	3	3	3
SMALL RUG 7	3	3	3
SMALL CARPET 7	3	3	3
SMALL CARPET 8	3	3	3
THROW 2	3	3	3
THROW 3	3	3	3
TABLECLOTH 6	3	3	3
TABLECLOTH 7	3	3	3

- The following product group is included in different classes for 3 stakeholders. That is to say that product in A class for TM is in B class for CM, and in C class for SM. This indicates the point where conflicts of stakeholders as seen in Table 26.

**Table 26.** Conflicts of Stakeholders for Product Classes in ZF Model

ITEM	TM ZF	CM ZF	SM ZF
R.CUSHION 17	1	2	3
S.CUSHION 2	1	2	3
S.CUSHION 3	1	2	3
LARGE RUG 9	1	2	3
SMALL RUG 28	1	2	3
SMALL RUG 29	1	2	3
SMALL RUG 30	1	2	3
SMALL RUG 31	1	2	3
SMALL RUG 32	1	2	3
SMALL RUG 34	1	2	3
SMALL RUG 35	1	2	3
SMALL RUG 36	1	2	3
RUNNER 3	1	2	3

From the general point of view of all products, it is observed that the most common product in class A is “THROW 7” among 12 models for 3 stakeholders.

The products that each stakeholder cares most are given in Table 49, Table 50, and 51.

According to the Top Management, products are the most common in class A among 12 models given in Table 27.

**Table 27.** Class A products for Top Management Overall Results

ITEM	Rate of Class A in TM	Rate of Class B in TM	Rate of Class C in TM
THROW 7	75%	25%	0%
LARGE RUG 6	75%	25%	0%
SMALL RUG 6	75%	25%	0%
SMALL CARPET 19	75%	25%	0%

According to the Category Manager, products are the most common in class A among 12 models given in Table 28.

**Table 28.** Class A products for Category Manager Overall Results

ITEM	Rate of Class A in CM	Rate of Class B in CM	Rate of Class C in CM
THROW 7	100%	0%	0%
THROW 6	100%	0%	0%
LARGE RUG 6	75%	25%	0%

According to the Store Manager, products are the most common in class A among 12 models given in Table 29.

**Table 29.** Class A products for Store Manager Overall Results

ITEM	Rate of Class A in SM	Rate of Class B in SM	Rate of Class C in SM
THROW 7	75%	0%	25%
S.CUSHION 82	75%	25%	0%
S.CUSHION 83	75%	25%	0%

The product classes that each stakeholder cares most are listed below.

- According to the Top Management, it can be clearly seen that rug and cushion group have priority for the top management. It is given in Table 30.

**Table 30.** Number of Products in Class A According to Top Management

TM	
Product Class	Number of products in Class A
RUG	45
CUSHION	18
THROW	11
MAT	9
SMALL CARPET	6
TABLE CLOTH&RUNNER	1
STOPPER	0
Grand Total	90

- According to the Category Manager, it can be clearly seen that rug and cushion group have priority for category manager. It is given in Table 31.

**Table 31.** Number of Products in Class A According to Category Manager

<b>CM</b>	
Product Class	Number of products in Class A
RUG	25
CUSHION	20
THROW	14
MAT	9
SMALL CARPET	5
STOPPER	5
TABLE CLOTH&RUNNER	0
Grand Total	78

- According to the Store Manager, it can be clearly seen that cushion group has priority for store manager. All results are given in Table 32.

**Table 32.** Number of Products in Class A According to Store Manager

<b>SM</b>	
Subgroup	Number of products in Class A
CUSHION	22
MAT	6
THROW	5
TABLE CLOTH&RUNNER	2
RUG	1
SMALL CARPET	0
STOPPER	0
Grand Total	36

### 3.5 MC UTADIS RESULTS

MC UTADIS methodology explained in Section 1.4 is used to combine different classification obtained throughout the analysis. As a beginning, we have 4 different classifications for each of 3 stakeholders obtained by different models in the ABC literature. Note that Ng and HV model classifications are exactly same for all alternatives. Therefore, we can mention 3 different classifications. For each stakeholder, we use these classifications as prior classes in MC UTADIS and obtain a single classification of 319 alternatives for each stakeholder by taking the criteria set of each stakeholder into account. 3 different analysis is required at this stage summarized in Table 33.

**Table 33.** MC UTADIS Analysis Design for Combining Classifications from Different Methods

	<b>Criteria</b>	<b>Prior Class</b>
Analysis 1	TM Criteria (3)	R&Ng&HV&ZF
Analysis 2	CM Criteria (4)	R&Ng&HV&ZF
Analysis 3	SM Criteria (3)	R&Ng&HV&ZF

\*Ng&HV models classified the alternatives exactly the same, therefore we have 3 prior classes in each analysis.

The results of MC UTADIS regarding above analyses are summarized below.

#### 3.5.1 Classifications for Stakeholders

MC UTADIS classifies 319 alternatives as given in Table 34. by taking all classifications obtained from each method into account as given in Table 33.

**Table 34.** MC UTADIS Classifications for Each Stakeholder

<b>Class</b>	<b>TM (Analysis 1)</b>	<b>CM (Analysis 2)</b>	<b>SM (Analysis 3)</b>
A	33	24	7
B	211	146	71
C	75	149	241
<b>Total</b>	<b>319</b>	<b>319</b>	<b>319</b>



According to Top Management’s MC UTADIS results, the number of products in class B is higher than in other classes.

According to Category Manager’s MC UTASIS results, it is observed that the products are mainly in the B and C classes.

According to Store Manager’s MC UTADIS results, the number of products in class C is higher than in other classes.

**Table 35.** Utility Thresholds for Stakeholders

Utility Thresholds	TM	CM	SM
Threshold 1	0.4487	0.4983	0.4878
Threshold 2	0.3425	0.4193	0.4307

Utility thresholds for stakeholders are given in Table 35. Threshold 1 classifies between Class A and B, threshold 2 classifies between Class B and C.

The Top Management threshold values separating the groups are 0.4487 and 0.3425. Accordingly, in the first group of alternatives with a global utility value greater than 0.4437, in the second group of alternatives with a global utility value between 0.3425 and 0.4437, alternatives less than 0.3425 should be included in the third group.

The Category Manager threshold values separating the groups are 0.4983 and 0.4193. Accordingly, in the first group of alternatives with a global utility value greater than 0.4982, in the second group of alternatives with a global utility value between 0.4192 and 0.4982, alternatives less than 0.4192 should be included in the third group.

The Store Manager threshold values separating the groups are 0.4878 and 0.4307. Accordingly, in the first group of alternatives with a global utility value greater than 0.4877, in the second group of alternatives with a global utility value between 0.4306 and 0.4877, alternatives less than 0.4306 should be included in the third group.

With the MC UTADIS technique, the performance of the models can also be interpreted. The results of the accuracy of modeling approaches are given in Table 36. The accuracy of the model is reached by predictive power. The predictive power of the model is calculated, in the grouping, the alternative numbers which are different from 0 are

considered. Here, two types of errors are mentioned, including an overestimation error  $(a) + \sigma$  and a under estimation error  $(a) - \sigma$ .

On the basis of models, it is observed that the maximum number of errors in terms of over estimation and under estimation is in the NG&HV models. In contrast, the minimum number of errors is in the ZF model.

**Table 36.** Accuracy of Modeling Approaches Regarding Different Stakeholders

	<b>R</b>	<b>Ng &amp; HV</b>	<b>ZF</b>
TM	83.39%	33,54%	85,89%
CM	78.37%	52,35%	79,62%
SM	88.71%	83,39%	89,34%

The MC UTADIS methodology estimates the weight of the evaluation criteria that show their contribution to the classification. Table 37 shows the weights of the evaluation criteria for each stakeholder. The weight of the evaluation criteria varies among the stakeholders. The most important criteria for top management and category manager is the margin and the 3<sup>rd</sup> criteria with a weight of 35.65 % and 49.35 % respectively. The most important criteria for store managers is the purchase cost and the 5th criteria with 42.81 % weight. Looking at the other common criteria, inventory cost criterion weight is higher in Category Manager compared to Top Management. It is not even among the criteria of the Store Manager.

**Table 37.** Criteria Weights for Stakeholders

<b>TM</b>	<b>Criteria</b>	<b>Weights</b>
G2	Net Sales Amount	26.23%
G3	Margin	35.65%
G5	Purchase Cost	33.77%
G8	Inventory Cost	4.36%
<b>CM</b>	<b>Criteria</b>	<b>Weights</b>
G1	Net Sales Quantity	14.19%
G2	Net Sales Amount	15.94%
G3	Margin	49.35%
G7	Total Inventory Quantity	10.77%
G8	Inventory Cost	9.74%

<b>SM</b>	<b>Criteria</b>	<b>Weights</b>
G4	Purchase Quantity	19.64%
G5	Purchase Cost	42.81%
G9	Average Unit Amount	17.03%
G6	Store Quantity	20.53%

### 3.5.2 Overall Classification

At this stage, we have prior classes for each stakeholder obtained in three different analysis given above. The final objective is to combine different stakeholder perspectives. To achieve this, mainly two approaches can be considered:

- Combine the stakeholder classes by using each stakeholder's criteria
- Combine the stakeholder classes by using all criteria

We apply both approaches resulting in 4 additional analysis (labeled prospective to the analyses in the previous section). MC UTADIS is utilized by taking the criteria and prior classes as given in Table 38.

**Table 38.** MC UTADIS Analysis design for combining classifications for different stakeholders

	<b>Criteria</b>	<b>Prior Class</b>
Analysis 4	TM Criteria (4)	3 (TM&CM&SM)
Analysis 5	CM Criteria (5)	3 (TM&CM&SM)
Analysis 6	SM Criteria (4)	3 (TM&CM&SM)
Analysis 7	All Criteria (9)	3 (TM&CM&SM)

Firstly, all alternatives are classified according to each stakeholders' own criteria. While doing this, each stakeholder's classifications are taken as prior classes. (This refers to analyses 4,5 and 6 in the above table). Threshold values determined for these analyses are given in Table 39.

**Table 39.** Utility Thresholds for Analyses

<b>Utility Thresholds</b>	<b>Analysis 4</b>	<b>Analysis 5</b>	<b>Analysis 6</b>	<b>Analysis 7</b>
Threshold 1	0.5500	0.5047	0.4808	0.4890
Threshold 2	0.4689	0.4202	0.4048	0.3932

**Analysis 4 Results:** All alternatives are evaluated according to the criteria of the Top Management which are given in Table 40. The accuracy results are given in Table 41. It is observed that the more robust classification is Category Managers with respect to 80.88 %. The result is unexpected due to the fact that the classification of the Category Manager accuracy is high instead of the Top Management even if in the classification made using Top Management Criteria.

**Table 40.** Top Management Criteria Weights

<b>ID</b>	<b>Criteria</b>	<b>Weights</b>
G2	Net Sales Amount	22.54%
G3	Margin	46.86%
G5	Purchase Cost	24.51%
G8	Inventory Cost	6.08%

**Table 41.** Accuracy Results of 3 Prior Classification with Respect to TM Criteria

<b>Stakeholders</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
Overall Accuracy	77.12%	80.88%	39.18%

**Analysis 5 Results:** All alternatives are evaluated according to the criteria of the Category Manager given in Table 42. The accuracy results are given in Table 43. It is observed that the more robust classification is Category Manager with respect to 93.10 %. It is expected that the Category Manager will give the highest accuracy with own criteria.

**Table 42.** Category Manager Criteria Weights

ID	Criteria	Weights
G1	Net Sales Quantity	5.72%
G2	Net Sales Amount	13.03%
G3	Margin	50.01%
G7	Total Inventory Quantity	11.36%
G8	Inventory Cost	19.88%

**Table 43.** Accuracy Results of 3 Prior Classification with Respect to CM Criteria

Stakeholders	TM	CM	SM
Overall Accuracy	64.89%	93.10%	47.65%

**Analysis 6 Results:** Finally, all alternatives are evaluated according to the criteria of the Store Manager given in Table 44. The accuracy results are given in Table 45. It is observed that the more robust classification is Store Manager with respect to 84.33 %. The result is also expected that the Store Manager will give the highest accuracy with own criteria

**Table 44.** Store Manager Criteria Weights

ID	Criteria	Weights
G4	Purchase Quantity	32.35%
G5	Purchase Cost	39.79%
G6	Store Quantity	0.38%
G9	Average Unit Amount	28.49%

**Table 45.** Accuracy Results of 3 Prior Classification with Respect to SM Criteria

Stakeholders	TM	CM	SM
Overall Accuracy	35.42%	58.31%	84.33%

**Analysis 7 Results:** The accuracy results of the MC UTADIS method according to all stakeholder's prior classification with 9 criteria are given in Table 46. It is observed that the more robust classification is Category Manager with respect to 91.22 %. In obtaining this result, error rates in classifications are used. In other words, MC UTADIS' accuracy assessment is utilized. With this scope of evaluation; There are a total of 296 misclassified

products in the classification of 3 stakeholders which means that products have been evaluated over or under estimation. We can also explain the over estimation error and under estimation error as type 1 and type 2 error. Type 1 error is that if a product identified as 1<sup>st</sup> grade is actually in 2<sup>nd</sup> grade. or if a product in 2<sup>nd</sup> grade is actually 3<sup>rd</sup> grade. Type 2 error is that if a product identified as 2<sup>nd</sup> grade is actually in 1<sup>st</sup> grade. or if a product in 3<sup>rd</sup> grade is actually 2<sup>nd</sup> grade.

Accordingly, for TM's classification, There are 109 misclassified products, 97 products are type 1 errors, and 12 products are type 2 errors. For CM's classification, there are 28 misclassified products. 17 products are type 1 errors, and 11 products are type 2 errors. For SM's classification, there are 159 misclassified products. 34 products are type 1 errors, and 125 products are type 2 errors.

**Table 46.** Accuracy Results of 3 Prior Classification with Respect to All Criteria

<b>Stakeholders</b>	<b>TM</b>	<b>CM</b>	<b>SM</b>
Overall Accuracy	65.83%	91.22%	50.16%

According to overall accuracy of 3 prior classifications of stakeholders, it is observed that the minimum number of errors are in the Category Manager's classification.

**Table 47.** Criteria Weights for All Stakeholders

<b>ID</b>	<b>Criteria</b>	<b>Weights</b>
G1	Net Sales Quantity	1.91%
G2	Net Sales Amount	18.75%
G3	Margin	46.46%
G4	Purchase Quantity	2.14%
G5	Purchase Cost	2.77%
G6	Store Quantity	1.65%
G7	Total Inventory Quantity	5.91%
G8	Inventory Cost	11.94%
G9	Average Unit Amount	8.47%

The weights of the evaluation criteria for all stakeholders indicating their contribution to the classification are given in Table 47. The weight of the evaluation criteria varies among themselves. The most important criteria for all stakeholders is the margin and the criterion with a weight of 46.46 %.

The summary table of the proposed method is given below in Table 48. This method is has provided the opportunity to combine different perspectives as well as to evaluate accuracy from each perspective.

**Table 48.** Summary of MC UTADIS Results

<b>Summary of Results</b>						
<b>Analysis</b>	<b>Most important criteria</b>		<b>Most accurate stakeholder</b>		<b>Utility Thresholds</b>	
	<b>Criteria</b>	<b>%</b>	<b>Stakeholder</b>	<b>%</b>	<b>Threshold 1</b>	<b>Threshold 2</b>
Analysis 4 (TM Criteria)	Margin	46.86	CM	80.18	0.5500	0.4689
Analysis 5 (CM Criteria)	Margin	50.01	CM	93.10	0.5047	0.4202
Analysis 6 (SM Criteria)	Purchase Cost	39.79	SM	84.33	0.4808	0.4048
Analysis 7 (All Criteria)	Margin	46.46	CM	91.22	0.4890	0.3932

## CONCLUSION

Turkey and the world changing dynamics, population growth, urbanization and similar factors keep the industry alive. Factors such as increase in population and urbanization as well as increasing household expenditures in parallel with purchasing power, and the increase in young population with high disposition tend to create significant opportunities for the development of the retail industry. This situation has created awareness that the needs of the customer are not limited. At the same time, it has created awareness about the impacts of the implementations to meet customer demands. Thus, the concept of the inventory management has become more important for organizations. As in all industry, inventory management is one of the issues of high importance in the retail industry. Effective management of inventories, efficient use of managed inventories, and sustainable success of organization are based on the provision of an appropriate inventory management approach.

With the impact of developing technology and management approaches, inventory management has undergone a great transformation in recent years. Inventory management, which has become an important factor in the competition, has been included in the retail industry's evaluation reports published in 2018 by consulting companies such as KPMG and PWC. In the report, while the process of change of the industry and how the companies are affected in this process, it is stated that the cost of holding goods in stock is getting worse for every industry. Importance of inventory management issues increased all over the world and the lack of awareness of inventory management in Turkey's retail industry has been the main starting point of this study.

In this study, it examines a company, which is one of the biggest retailer company in Turkey, assessment of inventory management and the application of the multi-criteria inventory management methods and classification practices. Within the scope of the study, the following classification models are explained. ABC Classification. Multicriteria Classification, R Model Classification, NG Model Classification, ZF Model Classification, and HV Model Classification.

In this study, firstly, the importance of inventory management, inventory management methods in the literature are mentioned and these methods' examples are given. Then the



most widely used. ABC classification was examined. The basic assumptions of ABC classification, which industry is used, what they classify. the concepts that are important in classifying and the most widely used models are included.

In the multi-criteria classification section, it is explained why the classification is different from the classical ABC classification, why it is important, which are the most widely used models and which are used in the study. The models used in this study are R, Ng, HV, and ZF, and the mathematical formula of each model, its assumptions, its place in the literature, its good and bad areas are given in this section. At the same time. there is a section in the application areas of these models. It is mentioned which industry are applied and what types of inventories are classified.

In the second part of the study, it was started by informing the company about the general structure, vision and mission. Then. the importance of inventory management for the company and the current status of the company are given in this section. Although the company provides data to the study. it is a company that needs to manage the inventory from a professional point of view. Within the scope of the study, 3 different stakeholders' perspectives are given and their views are examined in detail. In this section, the definition of the sample company problem, the purpose of the study, the evaluation of the criteria according to the stakeholder point of view are included. After all these studies, model was established.

Under the scope of the model, 4 ABC Classification methods were applied to combine 3 stakeholder perspectives. R, Ng, HV and ZF classification methods were applied to each stakeholder and 12 models developed. and the rankings are obtained by the Multi-criteria inventory classification feature. After ABC classification application, the models were re-evaluated according to MC UTADIS method. In order to obtain the most effective classification for 3 stakeholders. And then, final objective is to combine different stakeholder perspective with two perspectives. Initially, combining the stakeholder classes by using each stakeholder's criteria. 3 analyzes are obtained. Then, combining the stakeholder classes by using all criteria. 1 analyzes is obtained.

The results of each classification are examined on the basis of stakeholder, product group and product. The common and opposite views of stakeholders in product and product

groups are extensively mentioned in findings section. The obtained values are listed and interpreted as percentage ratios.

All in all, thanks to this application, the robustness ratios of the classifications were obtained with the help of error rates. According to this analyzes, the Category Manager's classification perspective appears to be the most robust among them. If a policy is developed considering these results, it can be clearly seen that products should be examined based on the category manager classification, new products to be entered into the warehouse or to be purchased should be positioned with this perspective, and inventory management should be controlled with this perspective in mind.

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## APPENDIX 1

**Table A1 : TM Results for Each Multicriteria ABC Classification Models**

ITEM	TM R	TM NG	TM HV	TM ZF
STOPPER 1	2	3	3	3
STOPPER 2	2	3	3	3
STOPPER 3	2	3	3	3
STOPPER 4	3	3	3	3
STOPPER 5	2	3	3	3
STOPPER 6	2	3	3	3
STOPPER 7	2	3	3	3
STOPPER 8	2	3	3	3
R.CUSHION 1	3	3	3	2
R.CUSHION 2	2	3	3	2
R.CUSHION 3	3	3	3	3
R.CUSHION 4	2	3	3	2
R.CUSHION 5	2	3	3	2
R.CUSHION 6	2	3	3	2
R.CUSHION 7	2	3	3	2
R.CUSHION 8	2	3	3	2
R.CUSHION 9	2	3	3	2
R.CUSHION 10	2	3	3	2
R.CUSHION 11	2	3	3	2
R.CUSHION 12	2	3	3	2
R.CUSHION 13	2	3	3	2
R.CUSHION 14	2	3	3	2
R.CUSHION 15	2	3	3	2
R.CUSHION 16	2	3	3	1
R.CUSHION 17	2	3	3	1
R.CUSHION 18	2	3	3	2
R.CUSHION 19	2	3	3	2
R.CUSHION 20	1	3	3	1
R.CUSHION 21	1	3	3	1
R.CUSHION 22	1	3	3	1
R.CUSHION 23	1	3	3	1
R.CUSHION 24	2	3	3	2
R.CUSHION 25	2	3	3	2
R.CUSHION 26	3	3	3	3
R.CUSHION 27	2	3	3	2

ITEM	TM R	TM NG	TM HV	TM ZF
R.CUSHION 28	2	3	3	2
R.CUSHION 29	2	3	3	2
R.CUSHION 30	2	3	3	2
R.CUSHION 31	2	3	3	3
R.CUSHION 32	2	3	3	2
R.CUSHION 33	2	3	3	2
R.CUSHION 34	2	3	3	3
R.CUSHION 35	2	3	3	3
S.CUSHION 1	2	3	3	2
S.CUSHION 2	1	3	3	1
S.CUSHION 3	2	3	3	1
S.CUSHION 4	2	3	3	2
S.CUSHION 5	2	3	3	3
S.CUSHION 6	2	3	3	2
S.CUSHION 7	2	3	3	2
S.CUSHION 8	2	3	3	2
S.CUSHION 9	1	3	3	1
S.CUSHION 10	3	3	3	2
S.CUSHION 11	3	3	3	3
S.CUSHION 12	3	3	3	2
S.CUSHION 13	2	3	3	2
S.CUSHION 14	3	3	3	2
S.CUSHION 15	2	3	3	2
S.CUSHION 16	2	3	3	2
S.CUSHION 17	2	3	3	2
S.CUSHION 18	2	3	3	2
S.CUSHION 19	2	3	3	2
S.CUSHION 20	2	3	3	2
S.CUSHION 21	2	3	3	3
S.CUSHION 22	2	3	3	2
S.CUSHION 23	2	3	3	2
S.CUSHION 24	2	3	3	2
S.CUSHION 25	2	3	3	2
S.CUSHION 26	2	3	3	2
S.CUSHION 27	2	3	3	2
S.CUSHION 28	2	3	3	2
S.CUSHION 29	2	3	3	2
S.CUSHION 30	2	3	3	2
S.CUSHION 31	2	3	3	2
S.CUSHION 32	2	3	3	3

<b>ITEM</b>	<b>TM R</b>	<b>TM NG</b>	<b>TM HV</b>	<b>TM ZF</b>
S.CUSHION 33	2	3	3	2
S.CUSHION 34	2	3	3	2
S.CUSHION 35	2	3	3	2
S.CUSHION 36	2	3	3	2
S.CUSHION 37	2	3	3	2
S.CUSHION 38	2	3	3	2
S.CUSHION 39	2	3	3	2
S.CUSHION 40	2	3	3	2
S.CUSHION 41	2	3	3	2
S.CUSHION 42	2	3	3	2
S.CUSHION 43	2	3	3	2
S.CUSHION 44	2	3	3	2
S.CUSHION 45	2	3	3	2
S.CUSHION 46	2	3	3	2
S.CUSHION 47	2	3	3	2
S.CUSHION 48	2	3	3	3
S.CUSHION 49	2	3	3	2
S.CUSHION 50	2	3	3	2
S.CUSHION 51	2	3	3	1
S.CUSHION 52	2	3	3	2
S.CUSHION 53	2	3	3	2
S.CUSHION 54	2	3	3	2
S.CUSHION 55	2	3	3	2
S.CUSHION 56	2	3	3	2
S.CUSHION 57	2	3	3	2
S.CUSHION 58	2	3	3	2
S.CUSHION 59	2	3	3	2
S.CUSHION 60	2	3	3	2
S.CUSHION 61	2	3	3	2
S.CUSHION 62	2	3	3	3
S.CUSHION 63	2	3	3	2
S.CUSHION 64	2	3	3	2
S.CUSHION 65	1	3	3	2
S.CUSHION 66	2	3	3	2
S.CUSHION 67	2	3	3	2
S.CUSHION 68	2	3	3	2
S.CUSHION 69	2	3	3	2
S.CUSHION 70	2	3	3	2
S.CUSHION 71	2	3	3	2
S.CUSHION 72	2	3	3	2



ITEM	TM R	TM NG	TM HV	TM ZF
S.CUSHION 73	3	3	3	3
S.CUSHION 74	3	3	3	3
S.CUSHION 75	3	3	3	3
S.CUSHION 76	3	3	3	3
S.CUSHION 77	3	3	3	3
S.CUSHION 78	3	3	3	3
S.CUSHION 79	2	3	3	3
S.CUSHION 80	3	3	3	3
S.CUSHION 81	3	3	3	3
S.CUSHION 82	2	2	2	3
S.CUSHION 83	2	2	2	3
S.CUSHION 84	2	3	3	2
S.CUSHION 85	3	3	3	3
S.CUSHION 86	2	3	3	2
S.CUSHION 87	2	3	3	2
S.CUSHION 88	2	3	3	3
S.CUSHION 89	2	3	3	3
S.CUSHION 90	2	3	3	3
S.CUSHION 91	2	3	3	3
MINI CUSHION 1	3	3	3	3
MINI CUSHION 2	3	3	3	3
MINI CUSHION 3	3	3	3	3
MINI CUSHION 4	3	3	3	3
MINI CUSHION 5	3	3	3	3
MINI CUSHION 6	3	3	3	3
MINI CUSHION 7	3	3	3	3
MINI CUSHION 8	3	3	3	3
MINI CUSHION 9	3	3	3	3
MINI CUSHION 10	3	3	3	3
MINI CUSHION 11	3	3	3	3
MINI CUSHION 12	3	3	3	3
MINI CUSHION 13	1	3	3	2
MAT 1	1	3	3	1
MAT 2	1	3	3	1
MAT 3	1	3	3	1
MAT 4	1	3	3	1
MAT 5	2	2	2	2
MAT 6	2	3	3	1
MAT 7	2	3	3	2
LARGE RUG 1	3	3	3	3

ITEM	TM R	TM NG	TM HV	TM ZF
LARGE RUG 2	2	3	3	2
LARGE RUG 3	2	1	1	2
LARGE RUG 4	2	2	2	2
LARGE RUG 5	2	3	3	2
LARGE RUG 6	1	1	1	2
LARGE RUG 7	2	3	3	2
LARGE RUG 8	2	3	3	2
LARGE RUG 9	1	3	3	1
LARGE RUG 10	2	3	3	3
LARGE RUG 11	2	2	2	3
LARGE RUG 12	2	2	2	2
LARGE RUG 13	1	2	2	2
LARGE RUG 14	2	3	3	2
LARGE RUG 15	2	3	3	2
LARGE RUG 16	2	3	3	2
LARGE RUG 17	2	3	3	2
LARGE RUG 18	2	3	3	1
LARGE RUG 19	2	3	3	3
LARGE RUG 20	2	3	3	2
LARGE RUG 21	2	2	2	2
LARGE RUG 22	2	2	2	2
LARGE RUG 23	2	2	2	2
LARGE RUG 24	2	3	3	2
LARGE RUG 25	2	3	3	2
LARGE RUG 26	2	2	2	3
LARGE RUG 27	2	2	2	3
LARGE RUG 28	2	2	2	3
LARGE RUG 29	2	3	3	3
LARGE RUG 30	2	3	3	3
LARGE RUG 31	2	3	3	3
LARGE RUG 32	1	3	3	2
LARGE RUG 33	2	3	3	2
LARGE RUG 34	2	3	3	2
LARGE RUG 35	2	3	3	3
LARGE RUG 36	2	3	3	3
LARGE RUG 37	2	3	3	3
LARGE RUG 38	2	3	3	2
LARGE RUG 39	2	3	3	2
LARGE RUG 40	2	3	3	2
LARGE RUG 41	2	3	3	2

ITEM	TM R	TM NG	TM HV	TM ZF
LARGE RUG 42	2	3	3	2
LARGE RUG 43	2	3	3	2
LARGE RUG 44	2	3	3	2
LARGE RUG 45	2	3	3	2
LARGE RUG 46	2	3	3	2
LARGE RUG 47	2	3	3	2
LARGE RUG 48	2	3	3	2
LARGE RUG 49	1	3	3	2
LARGE RUG 50	1	3	3	2
LARGE RUG 51	2	2	2	2
LARGE RUG 52	2	3	3	2
LARGE RUG 53	2	3	3	2
LARGE RUG 54	2	2	2	2
LARGE RUG 55	2	3	3	2
LARGE RUG 56	1	3	3	1
LARGE RUG 57	1	3	3	2
LARGE RUG 58	1	3	3	2
LARGE RUG 59	1	2	2	1
LARGE RUG 60	1	3	3	1
LARGE RUG 61	1	3	3	1
LARGE RUG 62	1	3	3	1
LARGE RUG 63	1	3	3	2
LARGE RUG 64	2	3	3	2
LARGE RUG 65	1	3	3	3
SMALL RUG 1	3	3	3	3
SMALL RUG 2	2	3	3	2
SMALL RUG 3	3	3	3	3
SMALL RUG 4	2	3	3	2
SMALL RUG 5	2	3	3	2
SMALL RUG 6	1	1	1	2
SMALL RUG 7	2	3	3	3
SMALL RUG 8	2	3	3	2
SMALL RUG 9	2	3	3	3
SMALL RUG 10	2	3	3	2
SMALL RUG 11	2	3	3	2
SMALL RUG 12	2	2	2	3
SMALL RUG 13	2	2	2	2
SMALL RUG 14	2	2	2	3
SMALL RUG 15	2	3	3	2
SMALL RUG 16	2	3	3	2

ITEM	TM R	TM NG	TM HV	TM ZF
SMALL RUG 17	2	2	2	2
SMALL RUG 18	2	3	3	2
SMALL RUG 19	2	2	2	2
SMALL RUG 20	2	2	2	2
SMALL RUG 21	2	2	2	2
SMALL RUG 22	2	3	3	2
SMALL RUG 23	2	3	3	2
SMALL RUG 24	2	2	2	2
SMALL RUG 25	2	3	3	2
SMALL RUG 26	2	3	3	2
SMALL RUG 27	2	3	3	2
SMALL RUG 28	1	3	3	1
SMALL RUG 29	1	3	3	1
SMALL RUG 30	1	3	3	1
SMALL RUG 31	2	3	3	1
SMALL RUG 32	2	3	3	1
SMALL RUG 33	1	3	3	2
SMALL RUG 34	1	3	3	1
SMALL RUG 35	1	3	3	1
SMALL RUG 36	1	3	3	1
SMALL RUG 37	1	3	3	2
SMALL CARPET 1	2	3	3	3
SMALL CARPET 2	2	3	3	3
SMALL CARPET 3	2	3	3	3
SMALL CARPET 4	2	3	3	3
SMALL CARPET 5	2	3	3	2
SMALL CARPET 6	2	3	3	2
SMALL CARPET 7	2	3	3	3
SMALL CARPET 8	2	3	3	3
SMALL CARPET 9	2	3	3	2
SMALL CARPET 10	2	3	3	2
SMALL CARPET 11	2	2	2	2
SMALL CARPET 12	2	3	3	2
SMALL CARPET 13	2	3	3	2
SMALL CARPET 14	2	3	3	2
SMALL CARPET 15	1	3	3	1

ITEM	TM R	TM NG	TM HV	TM ZF
SMALL CARPET 16	1	3	3	2
SMALL CARPET 17	2	3	3	2
SMALL CARPET 18	2	3	3	2
SMALL CARPET 19	1	1	1	2
THROW 1	2	3	3	2
THROW 2	2	2	2	3
THROW 3	2	3	3	3
THROW 4	2	2	2	2
THROW 5	2	1	1	3
THROW 6	2	1	1	3
THROW 7	1	1	1	2
THROW 8	2	3	3	3
THROW 9	2	3	3	3
THROW 10	2	3	3	2
THROW 11	2	1	1	3
THROW 12	2	1	1	3
THROW 13	2	2	2	3
THROW 14	2	3	3	2
THROW 15	2	3	3	2
THROW 16	2	3	3	3
THROW 17	2	3	3	2
THROW 18	2	3	3	2
THROW 19	2	3	3	2
THROW 20	2	3	3	2
THROW 21	2	3	3	2
THROW 22	2	3	3	2
THROW 23	2	3	3	3
THROW 24	2	3	3	3
TABLECLOTH 1	2	3	3	3
TABLECLOTH 2	2	2	2	2
TABLECLOTH 3	2	3	3	2
TABLECLOTH 4	2	2	2	3
TABLECLOTH 5	2	3	3	2
TABLECLOTH 6	2	3	3	3
TABLECLOTH 7	2	3	3	3
TABLECLOTH 8	2	3	3	3
TABLECLOTH 9	2	3	3	2

<b>ITEM</b>	<b>TM R</b>	<b>TM NG</b>	<b>TM HV</b>	<b>TM ZF</b>
RUNNER 1	2	3	3	2
RUNNER 2	2	3	3	2
RUNNER 3	2	3	3	1
RUNNER 4	2	3	3	2
RUNNER 5	3	3	3	3
RUNNER 6	2	3	3	2
RUNNER 7	2	3	3	2
RUNNER 8	2	3	3	2
RUNNER 9	2	3	3	2
RUNNER 10	2	3	3	2
RUNNER 11	2	3	3	2

**Table A2 : CM Results for Each Multicriteria ABC Classification Models**

<b>ITEM</b>	<b>CM R</b>	<b>CM NG</b>	<b>CM HV</b>	<b>CM ZF</b>
STOPPER 1	1	3	3	2
STOPPER 2	1	3	3	2
STOPPER 3	2	3	3	2
STOPPER 4	2	3	3	2
STOPPER 5	1	3	3	2
STOPPER 6	2	3	3	2
STOPPER 7	1	3	3	2
STOPPER 8	1	3	3	3
R.CUSHION 1	3	3	3	3
R.CUSHION 2	2	3	3	2
R.CUSHION 3	3	3	3	3
R.CUSHION 4	3	3	3	3
R.CUSHION 5	2	3	3	2
R.CUSHION 6	3	3	3	2
R.CUSHION 7	3	3	3	3
R.CUSHION 8	2	3	3	2
R.CUSHION 9	2	3	3	2
R.CUSHION 10	2	3	3	2
R.CUSHION 11	2	3	3	2
R.CUSHION 12	2	3	3	2
R.CUSHION 13	3	3	3	2
R.CUSHION 14	3	3	3	3
R.CUSHION 15	2	3	3	2
R.CUSHION 16	2	3	3	1
R.CUSHION 17	2	3	3	2
R.CUSHION 18	2	3	3	2
R.CUSHION 19	2	3	3	2
R.CUSHION 20	2	3	3	1
R.CUSHION 21	2	3	3	1
R.CUSHION 22	2	3	3	1
R.CUSHION 23	2	3	3	1
R.CUSHION 24	2	3	3	2
R.CUSHION 25	2	3	3	2
R.CUSHION 26	3	3	3	3
R.CUSHION 27	2	3	3	2
R.CUSHION 28	3	3	3	2
R.CUSHION 29	2	3	3	2

<b>ITEM</b>	<b>CM R</b>	<b>CM NG</b>	<b>CM HV</b>	<b>CM ZF</b>
R.CUSHION 30	2	3	3	2
R.CUSHION 31	3	3	3	2
R.CUSHION 32	2	3	3	2
R.CUSHION 33	3	3	3	3
R.CUSHION 34	3	3	3	3
R.CUSHION 35	3	3	3	3
S.CUSHION 1	2	3	3	2
S.CUSHION 2	2	3	3	2
S.CUSHION 3	2	3	3	2
S.CUSHION 4	2	3	3	2
S.CUSHION 5	3	3	3	3
S.CUSHION 6	2	3	3	2
S.CUSHION 7	2	3	3	2
S.CUSHION 8	2	3	3	2
S.CUSHION 9	3	3	3	3
S.CUSHION 10	3	3	3	3
S.CUSHION 11	3	3	3	3
S.CUSHION 12	3	3	3	3
S.CUSHION 13	3	3	3	3
S.CUSHION 14	3	3	3	3
S.CUSHION 15	3	3	3	3
S.CUSHION 16	3	3	3	3
S.CUSHION 17	3	3	3	3
S.CUSHION 18	3	3	3	3
S.CUSHION 19	3	3	3	3
S.CUSHION 20	2	3	3	2
S.CUSHION 21	3	3	3	2
S.CUSHION 22	2	3	3	2
S.CUSHION 23	3	3	3	2
S.CUSHION 24	3	3	3	2
S.CUSHION 25	3	3	3	2
S.CUSHION 26	3	3	3	2
S.CUSHION 27	2	3	3	2
S.CUSHION 28	3	3	3	2
S.CUSHION 29	3	3	3	2
S.CUSHION 30	3	3	3	2
S.CUSHION 31	2	3	3	2
S.CUSHION 32	2	3	3	3
S.CUSHION 33	2	3	3	2
S.CUSHION 34	2	3	3	2



<b>ITEM</b>	<b>CM R</b>	<b>CM NG</b>	<b>CM HV</b>	<b>CM ZF</b>
S.CUSHION 35	2	3	3	2
S.CUSHION 36	3	3	3	2
S.CUSHION 37	2	3	3	2
S.CUSHION 38	2	3	3	2
S.CUSHION 39	2	3	3	2
S.CUSHION 40	3	3	3	2
S.CUSHION 41	2	3	3	2
S.CUSHION 42	3	3	3	2
S.CUSHION 43	2	3	3	2
S.CUSHION 44	3	3	3	2
S.CUSHION 45	2	3	3	2
S.CUSHION 46	3	3	3	3
S.CUSHION 47	3	3	3	3
S.CUSHION 48	3	3	3	3
S.CUSHION 49	3	3	3	3
S.CUSHION 50	2	3	3	2
S.CUSHION 51	2	3	3	2
S.CUSHION 52	2	3	3	2
S.CUSHION 53	2	3	3	2
S.CUSHION 54	2	3	3	2
S.CUSHION 55	2	3	3	1
S.CUSHION 56	2	3	3	1
S.CUSHION 57	2	3	3	1
S.CUSHION 58	2	3	3	2
S.CUSHION 59	2	3	3	2
S.CUSHION 60	2	3	3	2
S.CUSHION 61	3	3	3	2
S.CUSHION 62	3	3	3	2
S.CUSHION 63	2	3	3	2
S.CUSHION 64	2	3	3	2
S.CUSHION 65	1	3	3	1
S.CUSHION 66	2	3	3	2
S.CUSHION 67	2	3	3	2
S.CUSHION 68	2	3	3	2
S.CUSHION 69	2	3	3	2
S.CUSHION 70	2	3	3	2
S.CUSHION 71	2	3	3	2
S.CUSHION 72	2	3	3	2
S.CUSHION 73	3	3	3	3
S.CUSHION 74	3	3	3	3

ITEM	CM R	CM NG	CM HV	CM ZF
S.CUSHION 75	3	3	3	3
S.CUSHION 76	3	3	3	3
S.CUSHION 77	3	3	3	3
S.CUSHION 78	3	3	3	3
S.CUSHION 79	3	3	3	3
S.CUSHION 80	3	3	3	3
S.CUSHION 81	3	3	3	3
S.CUSHION 82	1	2	2	1
S.CUSHION 83	1	2	2	1
S.CUSHION 84	2	3	3	2
S.CUSHION 85	3	3	3	3
S.CUSHION 86	2	3	3	3
S.CUSHION 87	2	3	3	2
S.CUSHION 88	2	3	3	2
S.CUSHION 89	2	3	3	2
S.CUSHION 90	2	3	3	2
S.CUSHION 91	2	3	3	3
MINI CUSHION 1	3	3	3	3
MINI CUSHION 2	1	3	3	2
MINI CUSHION 3	2	3	3	3
MINI CUSHION 4	2	3	3	2
MINI CUSHION 5	1	3	3	2
MINI CUSHION 6	1	3	3	3
MINI CUSHION 7	1	3	3	2
MINI CUSHION 8	2	3	3	3
MINI CUSHION 9	3	3	3	3
MINI CUSHION 10	3	3	3	3
MINI CUSHION 11	2	3	3	3
MINI CUSHION 12	1	3	3	3
MINI CUSHION 13	1	3	3	2
MAT 1	1	3	3	1
MAT 2	1	3	3	1
MAT 3	1	3	3	1
MAT 4	2	3	3	1
MAT 5	2	2	2	1
MAT 6	2	3	3	1
MAT 7	2	3	3	2
LARGE RUG 1	3	3	3	3
LARGE RUG 2	2	3	3	3
LARGE RUG 3	2	1	1	3

<b>ITEM</b>	<b>CM R</b>	<b>CM NG</b>	<b>CM HV</b>	<b>CM ZF</b>
LARGE RUG 4	2	2	2	2
LARGE RUG 5	3	3	3	3
LARGE RUG 6	1	1	1	2
LARGE RUG 7	2	3	3	3
LARGE RUG 8	2	3	3	3
LARGE RUG 9	1	3	3	2
LARGE RUG 10	3	3	3	3
LARGE RUG 11	3	2	2	3
LARGE RUG 12	2	2	2	2
LARGE RUG 13	2	2	2	2
LARGE RUG 14	2	3	3	3
LARGE RUG 15	2	3	3	3
LARGE RUG 16	2	3	3	3
LARGE RUG 17	2	3	3	3
LARGE RUG 18	2	3	3	3
LARGE RUG 19	3	3	3	3
LARGE RUG 20	3	3	3	3
LARGE RUG 21	3	2	2	3
LARGE RUG 22	2	2	2	3
LARGE RUG 23	2	2	2	3
LARGE RUG 24	2	3	3	3
LARGE RUG 25	2	3	3	3
LARGE RUG 26	2	2	2	3
LARGE RUG 27	3	2	2	3
LARGE RUG 28	2	2	2	3
LARGE RUG 29	3	3	3	3
LARGE RUG 30	2	3	3	3
LARGE RUG 31	3	3	3	3
LARGE RUG 32	2	3	3	3
LARGE RUG 33	2	3	3	3
LARGE RUG 34	2	3	3	2
LARGE RUG 35	2	3	3	3
LARGE RUG 36	2	3	3	3
LARGE RUG 37	3	3	3	3
LARGE RUG 38	2	3	3	3
LARGE RUG 39	2	3	3	3
LARGE RUG 40	3	3	3	3
LARGE RUG 41	2	3	3	3
LARGE RUG 42	2	3	3	2
LARGE RUG 43	2	3	3	2

<b>ITEM</b>	<b>CM R</b>	<b>CM NG</b>	<b>CM HV</b>	<b>CM ZF</b>
LARGE RUG 44	2	3	3	2
LARGE RUG 45	2	3	3	2
LARGE RUG 46	2	3	3	2
LARGE RUG 47	2	3	3	3
LARGE RUG 48	2	3	3	2
LARGE RUG 49	2	3	3	2
LARGE RUG 50	2	3	3	2
LARGE RUG 51	2	2	2	3
LARGE RUG 52	2	3	3	2
LARGE RUG 53	2	3	3	3
LARGE RUG 54	2	2	2	3
LARGE RUG 55	2	3	3	2
LARGE RUG 56	1	3	3	1
LARGE RUG 57	1	3	3	2
LARGE RUG 58	1	3	3	1
LARGE RUG 59	1	2	2	1
LARGE RUG 60	1	3	3	1
LARGE RUG 61	1	3	3	1
LARGE RUG 62	1	3	3	1
LARGE RUG 63	1	3	3	1
LARGE RUG 64	2	3	3	3
LARGE RUG 65	2	3	3	3
SMALL RUG 1	3	3	3	3
SMALL RUG 2	3	3	3	3
SMALL RUG 3	3	3	3	3
SMALL RUG 4	3	3	3	3
SMALL RUG 5	3	3	3	3
SMALL RUG 6	2	1	1	2
SMALL RUG 7	3	3	3	3
SMALL RUG 8	2	3	3	3
SMALL RUG 9	3	3	3	3
SMALL RUG 10	2	3	3	3
SMALL RUG 11	3	3	3	3
SMALL RUG 12	2	2	2	3
SMALL RUG 13	2	2	2	3
SMALL RUG 14	2	2	2	3
SMALL RUG 15	2	3	3	3
SMALL RUG 16	3	3	3	3
SMALL RUG 17	2	2	2	3
SMALL RUG 18	2	3	3	3

ITEM	CM R	CM NG	CM HV	CM ZF
SMALL RUG 19	2	2	2	3
SMALL RUG 20	2	2	2	3
SMALL RUG 21	2	2	2	3
SMALL RUG 22	2	3	3	3
SMALL RUG 23	2	3	3	3
SMALL RUG 24	2	2	2	2
SMALL RUG 25	2	3	3	3
SMALL RUG 26	2	3	3	3
SMALL RUG 27	2	3	3	3
SMALL RUG 28	2	3	3	2
SMALL RUG 29	2	3	3	2
SMALL RUG 30	2	3	3	2
SMALL RUG 31	2	3	3	2
SMALL RUG 32	2	3	3	2
SMALL RUG 33	2	3	3	2
SMALL RUG 34	1	3	3	2
SMALL RUG 35	1	3	3	2
SMALL RUG 36	2	3	3	2
SMALL RUG 37	2	3	3	2
SMALL CARPET 1	2	3	3	3
SMALL CARPET 2	3	3	3	3
SMALL CARPET 3	2	3	3	3
SMALL CARPET 4	2	3	3	3
SMALL CARPET 5	2	3	3	2
SMALL CARPET 6	2	3	3	2
SMALL CARPET 7	2	3	3	3
SMALL CARPET 8	3	3	3	3
SMALL CARPET 9	2	3	3	2
SMALL CARPET 10	2	3	3	2
SMALL CARPET 11	2	2	2	2
SMALL CARPET 12	2	3	3	2
SMALL CARPET 13	2	3	3	2
SMALL CARPET 14	2	3	3	2
SMALL CARPET 15	2	3	3	1
SMALL CARPET 16	2	3	3	3

ITEM	CM R	CM NG	CM HV	CM ZF
SMALL CARPET 17	2	3	3	1
SMALL CARPET 18	2	3	3	1
SMALL CARPET 19	2	1	1	2
THROW 1	2	3	3	2
THROW 2	2	2	2	3
THROW 3	2	3	3	3
THROW 4	3	2	2	3
THROW 5	2	1	1	2
THROW 6	1	1	1	1
THROW 7	1	1	1	1
THROW 8	2	3	3	3
THROW 9	2	3	3	3
THROW 10	2	3	3	3
THROW 11	2	1	1	2
THROW 12	2	1	1	2
THROW 13	2	2	2	2
THROW 14	3	3	3	3
THROW 15	3	3	3	3
THROW 16	3	3	3	3
THROW 17	3	3	3	3
THROW 18	3	3	3	2
THROW 19	3	3	3	3
THROW 20	3	3	3	3
THROW 21	2	3	3	2
THROW 22	2	3	3	2
THROW 23	2	3	3	3
THROW 24	2	3	3	3
TABLECLOTH 1	3	3	3	3
TABLECLOTH 2	2	2	2	2
TABLECLOTH 3	2	3	3	3
TABLECLOTH 4	3	2	2	2
TABLECLOTH 5	3	3	3	3
TABLECLOTH 6	2	3	3	3
TABLECLOTH 7	2	3	3	3
TABLECLOTH 8	2	3	3	3
TABLECLOTH 9	2	3	3	2
RUNNER 1	2	3	3	2
RUNNER 2	3	3	3	2

<b>ITEM</b>	<b>CM R</b>	<b>CM NG</b>	<b>CM HV</b>	<b>CM ZF</b>
RUNNER 3	2	3	3	2
RUNNER 4	3	3	3	2
RUNNER 5	3	3	3	3
RUNNER 6	2	3	3	2
RUNNER 7	2	3	3	2
RUNNER 8	2	3	3	2
RUNNER 9	2	3	3	2
RUNNER 10	2	3	3	2
RUNNER 11	2	3	3	2

**Table A3 : SM Results for Each Multicriteria ABC Classification Models**

<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
STOPPER 1	2	2	2	3
STOPPER 2	2	2	2	3
STOPPER 3	2	2	2	3
STOPPER 4	2	2	2	3
STOPPER 5	2	2	2	3
STOPPER 6	2	2	2	3
STOPPER 7	2	2	2	3
STOPPER 8	2	2	2	3
R.CUSHION 1	3	3	3	3
R.CUSHION 2	3	3	3	3
R.CUSHION 3	2	3	3	3
R.CUSHION 4	2	3	3	2
R.CUSHION 5	2	3	3	2
R.CUSHION 6	3	3	3	3
R.CUSHION 7	3	3	3	3
R.CUSHION 8	3	3	3	3
R.CUSHION 9	3	3	3	3
R.CUSHION 10	3	3	3	3
R.CUSHION 11	3	3	3	3
R.CUSHION 12	3	3	3	3
R.CUSHION 13	3	3	3	3
R.CUSHION 14	3	3	3	3
R.CUSHION 15	3	3	3	3
R.CUSHION 16	3	3	3	3
R.CUSHION 17	3	3	3	3
R.CUSHION 18	3	3	3	3
R.CUSHION 19	3	3	3	3
R.CUSHION 20	3	3	3	2
R.CUSHION 21	2	3	3	2
R.CUSHION 22	3	3	3	2
R.CUSHION 23	2	3	3	2
R.CUSHION 24	3	3	3	3
R.CUSHION 25	2	3	3	2
R.CUSHION 26	2	3	3	2
R.CUSHION 27	2	3	3	2
R.CUSHION 28	2	3	3	3
R.CUSHION 29	3	3	3	3



<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
R.CUSHION 30	2	3	3	2
R.CUSHION 31	2	3	3	2
R.CUSHION 32	3	3	3	2
R.CUSHION 33	2	3	3	3
R.CUSHION 34	2	3	3	2
R.CUSHION 35	2	3	3	3
S.CUSHION 1	2	3	3	3
S.CUSHION 2	3	3	3	3
S.CUSHION 3	3	3	3	3
S.CUSHION 4	2	3	3	3
S.CUSHION 5	2	3	3	3
S.CUSHION 6	3	3	3	3
S.CUSHION 7	2	3	3	3
S.CUSHION 8	2	3	3	3
S.CUSHION 9	1	3	3	2
S.CUSHION 10	3	3	3	3
S.CUSHION 11	2	3	3	3
S.CUSHION 12	3	3	3	3
S.CUSHION 13	2	3	3	2
S.CUSHION 14	3	3	3	3
S.CUSHION 15	3	3	3	3
S.CUSHION 16	3	3	3	3
S.CUSHION 17	3	3	3	3
S.CUSHION 18	3	3	3	3
S.CUSHION 19	3	3	3	3
S.CUSHION 20	3	3	3	3
S.CUSHION 21	2	3	3	2
S.CUSHION 22	3	3	3	3
S.CUSHION 23	3	3	3	3
S.CUSHION 24	3	3	3	3
S.CUSHION 25	3	3	3	3
S.CUSHION 26	3	3	3	3
S.CUSHION 27	3	3	3	3
S.CUSHION 28	3	3	3	3
S.CUSHION 29	3	3	3	3
S.CUSHION 30	3	3	3	3
S.CUSHION 31	3	3	3	3
S.CUSHION 32	3	3	3	3
S.CUSHION 33	3	3	3	3
S.CUSHION 34	3	3	3	3

<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
S.CUSHION 35	3	3	3	3
S.CUSHION 36	3	3	3	3
S.CUSHION 37	3	3	3	3
S.CUSHION 38	3	3	3	3
S.CUSHION 39	3	3	3	3
S.CUSHION 40	3	3	3	3
S.CUSHION 41	3	3	3	2
S.CUSHION 42	3	3	3	3
S.CUSHION 43	3	3	3	2
S.CUSHION 44	2	3	3	2
S.CUSHION 45	3	3	3	2
S.CUSHION 46	2	3	3	2
S.CUSHION 47	3	3	3	2
S.CUSHION 48	2	3	3	2
S.CUSHION 49	2	3	3	2
S.CUSHION 50	3	3	3	2
S.CUSHION 51	3	3	3	2
S.CUSHION 52	3	3	3	3
S.CUSHION 53	3	3	3	3
S.CUSHION 54	2	3	3	2
S.CUSHION 55	2	3	3	2
S.CUSHION 56	2	3	3	2
S.CUSHION 57	2	3	3	2
S.CUSHION 58	2	3	3	2
S.CUSHION 59	2	3	3	2
S.CUSHION 60	2	3	3	2
S.CUSHION 61	2	3	3	2
S.CUSHION 62	2	3	3	2
S.CUSHION 63	3	3	3	3
S.CUSHION 64	2	3	3	3
S.CUSHION 65	2	3	3	2
S.CUSHION 66	2	3	3	3
S.CUSHION 67	2	3	3	2
S.CUSHION 68	2	3	3	2
S.CUSHION 69	3	3	3	3
S.CUSHION 70	3	3	3	2
S.CUSHION 71	3	3	3	3
S.CUSHION 72	2	3	3	2
S.CUSHION 73	2	3	3	2
S.CUSHION 74	2	3	3	2

<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
S.CUSHION 75	2	3	3	2
S.CUSHION 76	2	3	3	2
S.CUSHION 77	2	3	3	2
S.CUSHION 78	2	3	3	2
S.CUSHION 79	2	3	3	2
S.CUSHION 80	2	3	3	2
S.CUSHION 81	2	3	3	2
S.CUSHION 82	1	1	1	2
S.CUSHION 83	1	1	1	2
S.CUSHION 84	1	3	3	2
S.CUSHION 85	3	3	3	3
S.CUSHION 86	3	3	3	3
S.CUSHION 87	2	3	3	2
S.CUSHION 88	1	3	3	2
S.CUSHION 89	2	3	3	2
S.CUSHION 90	2	3	3	2
S.CUSHION 91	2	3	3	2
MINI CUSHION 1	1	2	2	3
MINI CUSHION 2	1	2	2	2
MINI CUSHION 3	1	2	2	2
MINI CUSHION 4	1	2	2	2
MINI CUSHION 5	1	2	2	2
MINI CUSHION 6	1	2	2	2
MINI CUSHION 7	1	2	2	2
MINI CUSHION 8	1	2	2	2
MINI CUSHION 9	1	2	2	3
MINI CUSHION 10	1	2	2	3
MINI CUSHION 11	1	2	2	2
MINI CUSHION 12	1	2	2	2
MINI CUSHION 13	1	3	3	3
MAT 1	1	3	3	1
MAT 2	1	3	3	2
MAT 3	1	3	3	2
MAT 4	1	3	3	1
MAT 5	2	2	2	3
MAT 6	3	3	3	3
MAT 7	3	3	3	3
LARGE RUG 1	3	3	3	3
LARGE RUG 2	3	3	3	3
LARGE RUG 3	3	3	3	3

<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
LARGE RUG 4	3	3	3	3
LARGE RUG 5	3	3	3	3
LARGE RUG 6	3	3	3	3
LARGE RUG 7	3	3	3	3
LARGE RUG 8	3	3	3	3
LARGE RUG 9	3	3	3	3
LARGE RUG 10	3	3	3	3
LARGE RUG 11	3	3	3	3
LARGE RUG 12	3	3	3	3
LARGE RUG 13	3	3	3	3
LARGE RUG 14	3	3	3	3
LARGE RUG 15	3	3	3	3
LARGE RUG 16	3	3	3	3
LARGE RUG 17	3	3	3	3
LARGE RUG 18	3	3	3	3
LARGE RUG 19	3	3	3	3
LARGE RUG 20	3	3	3	3
LARGE RUG 21	3	3	3	3
LARGE RUG 22	3	3	3	3
LARGE RUG 23	3	3	3	3
LARGE RUG 24	3	3	3	3
LARGE RUG 25	3	3	3	3
LARGE RUG 26	3	3	3	3
LARGE RUG 27	3	3	3	3
LARGE RUG 28	3	3	3	3
LARGE RUG 29	3	3	3	3
LARGE RUG 30	3	3	3	3
LARGE RUG 31	3	3	3	3
LARGE RUG 32	1	3	3	2
LARGE RUG 33	3	3	3	3
LARGE RUG 34	3	3	3	3
LARGE RUG 35	3	3	3	3
LARGE RUG 36	3	3	3	3
LARGE RUG 37	3	3	3	3
LARGE RUG 38	3	3	3	3
LARGE RUG 39	3	3	3	3
LARGE RUG 40	3	3	3	3
LARGE RUG 41	3	3	3	3
LARGE RUG 42	3	3	3	3
LARGE RUG 43	3	3	3	3

<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
LARGE RUG 44	3	3	3	3
LARGE RUG 45	3	3	3	3
LARGE RUG 46	3	3	3	3
LARGE RUG 47	3	3	3	3
LARGE RUG 48	3	3	3	3
LARGE RUG 49	3	3	3	3
LARGE RUG 50	3	3	3	3
LARGE RUG 51	3	3	3	3
LARGE RUG 52	3	3	3	3
LARGE RUG 53	3	3	3	3
LARGE RUG 54	3	3	3	3
LARGE RUG 55	3	3	3	3
LARGE RUG 56	3	3	3	3
LARGE RUG 57	3	3	3	3
LARGE RUG 58	3	3	3	3
LARGE RUG 59	3	3	3	3
LARGE RUG 60	3	3	3	3
LARGE RUG 61	3	3	3	3
LARGE RUG 62	3	3	3	3
LARGE RUG 63	3	3	3	3
LARGE RUG 64	3	3	3	3
LARGE RUG 65	3	3	3	3
SMALL RUG 1	3	3	3	3
SMALL RUG 2	3	3	3	3
SMALL RUG 3	3	3	3	3
SMALL RUG 4	3	3	3	3
SMALL RUG 5	2	3	3	3
SMALL RUG 6	3	3	3	3
SMALL RUG 7	3	3	3	3
SMALL RUG 8	3	3	3	3
SMALL RUG 9	3	3	3	3
SMALL RUG 10	3	3	3	3
SMALL RUG 11	3	3	3	3
SMALL RUG 12	3	3	3	3
SMALL RUG 13	3	3	3	3
SMALL RUG 14	3	3	3	3
SMALL RUG 15	3	3	3	3
SMALL RUG 16	3	3	3	3
SMALL RUG 17	3	3	3	3
SMALL RUG 18	3	3	3	3

<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
SMALL RUG 19	3	3	3	3
SMALL RUG 20	3	3	3	3
SMALL RUG 21	3	3	3	3
SMALL RUG 22	3	3	3	3
SMALL RUG 23	3	3	3	3
SMALL RUG 24	3	3	3	3
SMALL RUG 25	3	3	3	3
SMALL RUG 26	3	3	3	3
SMALL RUG 27	3	3	3	3
SMALL RUG 28	3	3	3	3
SMALL RUG 29	3	3	3	3
SMALL RUG 30	3	3	3	3
SMALL RUG 31	3	3	3	3
SMALL RUG 32	3	3	3	3
SMALL RUG 33	3	3	3	3
SMALL RUG 34	3	3	3	3
SMALL RUG 35	3	3	3	3
SMALL RUG 36	3	3	3	3
SMALL RUG 37	3	3	3	3
SMALL CARPET 1	3	3	3	3
SMALL CARPET 2	3	3	3	3
SMALL CARPET 3	3	3	3	3
SMALL CARPET 4	3	3	3	3
SMALL CARPET 5	3	3	3	3
SMALL CARPET 6	3	3	3	3
SMALL CARPET 7	3	3	3	3
SMALL CARPET 8	3	3	3	3
SMALL CARPET 9	3	3	3	3
SMALL CARPET 10	3	3	3	3
SMALL CARPET 11	3	3	3	3
SMALL CARPET 12	3	3	3	3
SMALL CARPET 13	3	3	3	3
SMALL CARPET 14	3	3	3	3
SMALL CARPET 15	3	3	3	3
SMALL CARPET 16	3	3	3	3

ITEM	SM R	SM NG	SM HV	SM ZF
SMALL CARPET 17	3	3	3	3
SMALL CARPET 18	3	3	3	3
SMALL CARPET 19	3	3	3	3
THROW 1	3	3	3	3
THROW 2	3	3	3	3
THROW 3	3	3	3	3
THROW 4	3	3	3	3
THROW 5	2	2	2	3
THROW 6	2	1	1	3
THROW 7	1	1	1	3
THROW 8	3	3	3	3
THROW 9	3	3	3	3
THROW 10	3	3	3	3
THROW 11	2	3	3	3
THROW 12	2	3	3	3
THROW 13	2	3	3	3
THROW 14	3	3	3	3
THROW 15	3	3	3	3
THROW 16	3	3	3	3
THROW 17	3	3	3	3
THROW 18	3	3	3	3
THROW 19	3	3	3	3
THROW 20	3	3	3	3
THROW 21	3	3	3	3
THROW 22	3	3	3	3
THROW 23	3	3	3	3
THROW 24	3	3	3	3
TABLECLOTH 1	3	3	3	3
TABLECLOTH 2	3	3	3	3
TABLECLOTH 3	3	3	3	3
TABLECLOTH 4	3	3	3	3
TABLECLOTH 5	3	3	3	3
TABLECLOTH 6	3	3	3	3
TABLECLOTH 7	3	3	3	3
TABLECLOTH 8	3	3	3	3
TABLECLOTH 9	3	3	3	3
RUNNER 1	3	3	3	3
RUNNER 2	3	3	3	3

<b>ITEM</b>	<b>SM R</b>	<b>SM NG</b>	<b>SM HV</b>	<b>SM ZF</b>
RUNNER 3	3	3	3	3
RUNNER 4	3	3	3	3
RUNNER 5	1	3	3	1
RUNNER 6	3	3	3	3
RUNNER 7	2	3	3	2
RUNNER 8	2	3	3	2
RUNNER 9	2	3	3	2
RUNNER 10	2	3	3	2
RUNNER 11	3	3	3	2





