MATHEMATICAL MODELS FOR LOCATING SALES OFFICES IN TURKEY FOR AN APPAREL TEXTILE AND FASHION INDUSTRY

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MATHEMATICAL MODELS FOR LOCATING SALES OFFICES IN TURKEY FOR AN APPAREL TEXTILE AND FASHION INDUSTRY

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

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ABSTRACT

MATHEMATICAL MODELS FOR LOCATING SALES OFFICES IN TURKEY FOR AN APPAREL TEXTILES AND FASHIONS INDUSTRY

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Growth of the trade volume in the world and in Turkey, continuous participation of new actors and the challenging competitive terms have caused rapid development in retail sector. Companies are developing tighter policies and strategies to achieve more sales and higher turnover rates in their processes to increase their competitiveness. Therefore, they have to take realistic decisions based on scientific methods. Retailing consists of five main processes namely supply, inventory management, retail chain management, sales and after-sales services. Although, there are decision models currently available in the literature that can be utilized in optimizing processes internally, all processes have to be considered together to maximize utility since decisions taken in each process have an impact on the decision mechanisms of other processes. Accordingly, the aim of this thesis is to develop a decision support system that tackles all processes as a whole by constructing a Linear Mathematical Programming Model that maximizes corporate profits. It is aimed to take all critical decisions including opening new stores and/or closing down and/or restoring existing stores by considering the entire system. Within this context, sales forecasting is one of the most important inputs to the model. This, however, constitutes a problem for the locations at which to open up new stores since they do not have past sales data and the literature involves very few studies on this issue. Therefore, potential quantity of sales is forecast via Regression model by implementing Huff Gravity Method used in forecasting the amount of potential customer in literature. This, by itself, contributes to the literature. The developed model is validated by the use of a retail company's data and found applicable.

Keywords: Retail Chain Profit Maximization, Retail Chain Decision Support, Mathematics of Retailing, Huff's Gravity Method, Regional Potential Sales Forecast

ÖZ

TÜRKİYE KONFEKSİYON VE MODA ENDÜSTRİSİNDE SATIŞ OFİSLERİNİN LOKASYONU İÇİN MATEMATİKSEL MODELLER

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Dünyada ve Türkiye'de ticaret hacminin büyümesi, sektöre sürekli yeni aktörlerin katılımı ve zorlu rekabet koşulları perakende sektörünün hızla gelişmesine sebep olmuştur. Şirketler, rekabet güçlerini artırmak, daha fazla satış ve daha yüksek ciro oranları elde etmek için süreçlerinde daha sıkı politikalar ve stratejiler geliştirmektedir. Bu nedenle, şirketler bilimsel yöntemlere dayanan gerçekçi kararlar almak zorundalar. Perakendecilik, tedarik, stok yönetimi, perakende zinciri yönetimi, satış ve satış sonrası hizmetler olarak beş ana süreçten oluşmaktadır. Hali hazırda literatürde süreçleri kendi içinde optimize eden modeller bulunmakla birlikte süreçlerde alınan kararlar diğer süreçlerin karar mekanizmasını etkilediğinden, toplam faydayı maksimize etmek için süreçler bir bütün olarak ele alınmalıdır. Bu bağlamda, bu tezin amacı perakende süreçlerinde firma karını maksimize eden Lineer Matematiksel Programlama Modeli kurularak süreçleri bütünleşik şekilde ele alan karar destek sistemi geliştirmektir. Bu sayede, yeni mağaza açılması ve/veya var olan mağazaların kapatılması ve/veya yenilenmesi de dâhil olmak üzere kritik kararların tüm sistem göz önünde bulundurularak alınması hedeflenmiştir. Bu bağlamda modelin en önemli girdilerinden birisi satış tahminidir. Bu ise geçmiş verisi bulunmayan yeni açılacak mağaza lokasyonları için problem teşkil etmekte ve literatürde bu konuda pek fazla

çalışmaya rastlanmamaktadır. Bu amaçla literatürde potansiyel müşteri tahmini için kullanılan Huff Ağırlık Metodu uyarlanarak potansiyel satış miktarları Regresyon modeli ile tahmin edilmiştir. Bu da kendi başına literatüre bir katkı sağlamaktadır. Kurulan model örnek firma verileri ile sınanarak uygun olduğu görülmüştür.

Anahtar Kelimeler: Perakende Zinciri Kar Maksimizasyonu, Perakende Zinciri Karar Desteği, Perakendecilik Matematiği, Huff'un Ağırlık Metodu, Bölgesel Satış Potansiyeli Tahmini

To my wife and son…

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INTRODUCTION

For centuries, products and services have been offered by marketplaces or by mobile merchants throughout the world. It is known that the first structures similar to retail chains were established in 16th-17th centuries in Europe. In 1670, Hudson's Bay Company was founded in Canada. The birth of the first modern retail chain was in 1859 with the establishment of the Great Atlantic & Pacific Tea Company. After 17th century, stores with departments started to be seen in Europe and Asia. Shopping malls were designed in order to meet all the needs of visitors by the end of the 20th century. During the Ottoman period, retail trade was dominated by groceries and similar businesses of tradesmen. In this period, the covered bazaars attracted attention with their similarity to today's shopping malls as they met all requirements of their visitors under a single roof. In Turkey, although influenced by the layout of the retail trade order of developed countries in 1950s, retailing was in fact boosted with the increase of shopping malls and the entry of foreign products into the country after 1980s.

Growth of the trade volume in the world and in Turkey, continuous participation of new actors in retail sectors and the challenging competitive terms have caused rapid development in retail sector such as Enterprise Resource Planning (ERP) systems, production automation systems, e-commerce and Business to Consumer (B2C) systems. As a result of introduction of new and innovative products into the market as an inevitable result of the consumption age, the increase of competition in retail sector is also indispensable. Considering this increase in competition, it does not appear to be possible for companies to survive and continue with their life cycles solely by manufacturing products and selling those to their customers at stores, keeping up their businesses by some ERP software and to selling products through e-commerce as many companies already do the same. Also, companies are developing tighter policies and strategies in their business processes in order to increase their competitiveness on a continuous basis. Retailing consists of five main indirect processes that can be described as supply, stock management, store management, sales and after-sales services. As these processes are managed, be it a retailer with a single store or a global retailing company that serves operates internationally, all companies have to make use of scientific methods that increase efficiency in these processes in order to sustain their life cycles. Regarding companies that do not fulfill this requirement, the 2008 economic crisis turned into a major event of awareness. In fact, in 2009, the number of companies and cooperatives established in Turkey decreased to 44,000 from 55,000. Inversely correlated, the number of companies that were closed in the same period increased compared to previous years. All of the annual economic data have been behind the pessimistic forecasts, leading to a sharp recession in the markets, as also included in the detailed study of Öcal (2011). Despite this recession, companies that were able to survive accomplished this with a number of scientific methods and management strategies, not by chance or coincidence, which reduced their losses and increased competitiveness. With the impact of this awareness, retailers are now convinced that scientific methods should be used in the management of their processes. The distribution of allocation specialists, disposition specialists, product planning specialists, and the increase of the search by retail companies for specialists in these fields also support this thesis.

With a trend in growth, retailers develop strategies to achieve more sales and higher turnover rates. This attitude by companies leads them to offer more products to their customers, to produce more products or to generate more outlets with aggressive growth policy without considering factors such as production capacity, cost of carry and financial balances. As a result, problems in the form of increased production and storage costs, increased personnel costs, uncontrolled growth and losses in the system, deterioration of financial balances arise one by one. When such losses are at an unstoppable point, the company completes its life cycle early, and justifies the well-known discourse that "a large majority of companies go bankrupt while growing". All operations and decisions in the retail chain should be realized with a process approach. Decisions in all processes such as purchasing, production, warehousing, shipment, sale and after-sales must be carried out by taking all of them into consideration. Majority of companies in most sectors did not use scientific methods, studies or models to manage their processes in order to reach their current status. They grew up with intuitive behaviors required in any specific instance of operation. Companies in disbelief or unaware of the necessity of professionalism, in fact, do not focus all efforts to develop their systems as they grow. The locomotives of growth in retail industry are stores and outlets. These types of companies tend to choose their stores or outlets only in accordance with the amounts of demand that they evaluate solely by costs or assumptions. With this approach, they cannot sustain a policy that can clearly measure the logistic requirements of the products they will sell in a specific region, efficiency of production capacity, storage capacities, financial balances, and more importantly the risks. Another critically important decision-making process covers the amount of production capacity for the next period. The most common method used at this point is to analyze sales from the past periods and determine quantities obtained by using basic mathematics or advanced estimation methods while setting the production target. In addition, some changes are made in production quantities determined by analyzing storage capacities, financial situations and market trends which could be considered as improvement. This approach leads to deviations and losses because it consists of intuitive and experiential methods. In some cases, selling a product by manufacturing the same amount of its sales capacity may cause inefficient use of resources and prevent sales of more profitable products yielding financial losses. Distribution of the manufactured or procured products to outlets is carried out by reconciling with stocks and determining the approximate requirements in a similar way. In cases where the allocation process is not conducted based on a specific method or without a full-scale requirement analysis as well as the lack of a specific strategy through the main supply plan, there might be losses in sales at certain outlets and at some stores, causing cost of carry and even loss of sales for other products due to occupation of valuable shelf space. In addition, products distributed to outlets that do not generate any sales may as well cause extra costs, and the sales attraction generated by no-sales due to not being distributed in some regions. However, total efficiency and profitability can be increased if decisions in all processes can be dealt with through an integrated model.

The business processes of retail companies (supply, inventory management, sales, etc.) are similar to those of other companies in the business world. Numerous techniques, methods and studies related to the management of these business processes have been developed and contributed to the literature. There are dozens of models developed for any situation that sets the optimum balance between the cost of carry and the sell-out costs, such as the Economic Order Quantity (EOQ) and the Economic Production Quantity (EPQ) which can be used in procurement management. There are also models that determine the costs of logistics by which the location, allocation, location & allocation models will be studied for the regions where sales forecasts are made and demand is met. In addition, efficiency can be improved in store layout and design using shelf space allocation and store layout models. The most important differences that distinguish retailer firms from others are the direct contacts with retailing authorities as well as the end consumers. Except for the use of e-commerce applications, companies need to bring their products and services directly to their customers at the location where their customers can be present. Therefore, each business process can be considered rings of chain between procurement and sales. Basic changes in these rings will have an impact on the entire chain. Naturally, the evaluation of each business process or several business processes solely within themselves will cause total inefficiency and misconception. Methods and models that provide improvement in business processes or optimization for specific purposes within the literature will only provide improvement in one or more business processes in the same field. On the other hand, a decision involving a business process can lead to inefficiencies in other processes, namely rings of the chain. Decisions on regions where a store will be opened and the capacities of such stores affect the amount of supply, while the amount of supply will affect production capacities and storage requirements. It can be considered that when shelf area allocation or store layout models are operated, there may be results that increase the sales efficiency of stores. However, if these results are not in line with the production capacity and decisions within the supply chain process, it will lead to inefficiency for the original model as well as for all other processes. Therefore, decisions in all processes as the rings of chain must be evaluated with an integrated perspective.

In this thesis, business processes in the retail chain are evaluated to develop a mathematical model that provides decision support through an integrated approach to critical decision points such as production and supply volumes, warehouse levels, region selection for store alternatives, alternative store capacity selection, and product distribution quantities. In order to construct this model, a company model was needed to provide a set of parameters as inputs and to enable the parametric structure to be rendered as close to real life case as possible. This company offers ready-to-wear garments to its customers in fifty stores. It grows by adding five more stores annually. There are eleven main product groups, some of which have seasonal sales figures. The company produces 300 different product designs per season. The main reason behind choosing ready-to-wear garment industry as a sample model is that the retail sales in this sector are very widespread and popular. The fact that the ready-to-wear industry has slight differences compared to other retailing industries does not prevent the developed model from being applied in all retail sectors. The parameters provided as model inputs (product shelf usage, new/old season sales prices, production capacities, store rental expenses, etc.) are obtained by analyzing considered company processes. At this point, another basic need in the industry attracts attention. Sales and demand forecasts are generally made by using the accepted demand forecasting techniques such as "n-moving average" and "exponential smoothing technique", by using time series data from the past. However, these methods cannot be used in cases where the region to open up a new store is to be decided upon lack of data. In the thesis, this problem is overcome by developing a new approach through "Huff's Gravity Method".

In the developed model, all processes and variables affecting the profitability of the retail chain are addressed as much as possible. Impact of production and contract manufacturing processes in supply management on decision making processes of dynamics of retail chain such as capacity variability and financial effect, warehouse capacities, cost of carry, effect of seasonality on buying and selling prices, alternative store locations in store management, capacities and sales potentials, shelf capacity and shelf usage are all taken into consideration. By dealing with all the dynamics of retailing, an end-to-end decision support system is developed. Thus, optimum solutions are offered by blending the impact of all processes on each other, not only those in certain fields. In this way, the most profitable scenario according to the conditions, in which the company is in, can be determined. This model also provides the whole output of the scenario because it deals with all the processes together with providing clear decision support at critical points. When these outputs are reproduced for different conditions, results coming under different conditions and scenarios can be obtained. Thus, significant data can be obtained for taking precautions and strategic decisions for different scenarios such as economic crises in retailing, changes in production capacities, and policy changes in product groups.

In the second chapter of the thesis, the processes and internal dynamics of the retail chains are discussed and a description of the problem is given. Problems in detailing and critical decision moments are examined. In the third chapter, literature focusing on the problems identified is examined and their overlaps with the problem identified within the scope of thesis are argued. The similarities and differences between this thesis and the studies in the literature are considered. In the fourth chapter, the developed model is explained. In this context, the parameters and variables of the model are explained, the objective function and constraints are given and detailed explanations are provided. In the following chapter, the analysis for estimating the model parameters is explained. Firstly, it is explained how regional sales forecasts are obtained with "Huff's Gravity Model" approach. Afterwards, the methods of obtaining the other inputs used in the model are explained. The results of the model are presented and assessed under different scenarios in chapter six. Finally, the general evaluation of thesis is made and the findings are summarized in chapter seven.

CHAPTER 2

PROBLEM DEFINITION

Retail chain companies' processes of procurement management, production, warehousing and shipment are similar to the companies in other sectors. On the other hand, merchandising management processes do not have any similarities with any other sectors or processes. Merchandising management processes that divide retailing from other sectors make the entire management style and decision-making mechanism of retailing differ from each other, especially considering the fact that all rings of this structure are connected to each other and all processes have to be evaluated together in order to manage this chain. The main processes of retail chain companies are supply chain and production management, inventory management, retail chain management, sales and customer relationship management as shown in **Figure 1**.

Figure 1 Main Processes of a Retail Chain

Each main process has its own critical decision points. Therefore, each process should be examined under its own heading.

2.1. SUPPLY CHAIN MANAGEMENT OF FINAL PRODUCT

Retail companies are making supplies by purchasing the final products they sell or by manufacturing themselves. Purchasing processes are relatively simple when compared with production processes. The procurement process is completed when the product of which the purchasing price, supply amount and deadline is obvious is taken into inventory with offer, order and transfer processes. In ready-to-wear sector, companies generally design and sell their own products. Products are manufactured in large quantities and then shipped to outlets. This volume of production requires a lot of people, machines, plants and materials. The structure grows in a system that is difficult to manage and dispersed, leading to inefficiency, poor performance, high retention and investment cost. Because of that, not only the retailer companies that manufacture those but also the companies in other sectors have overcome such results with subcontractors.

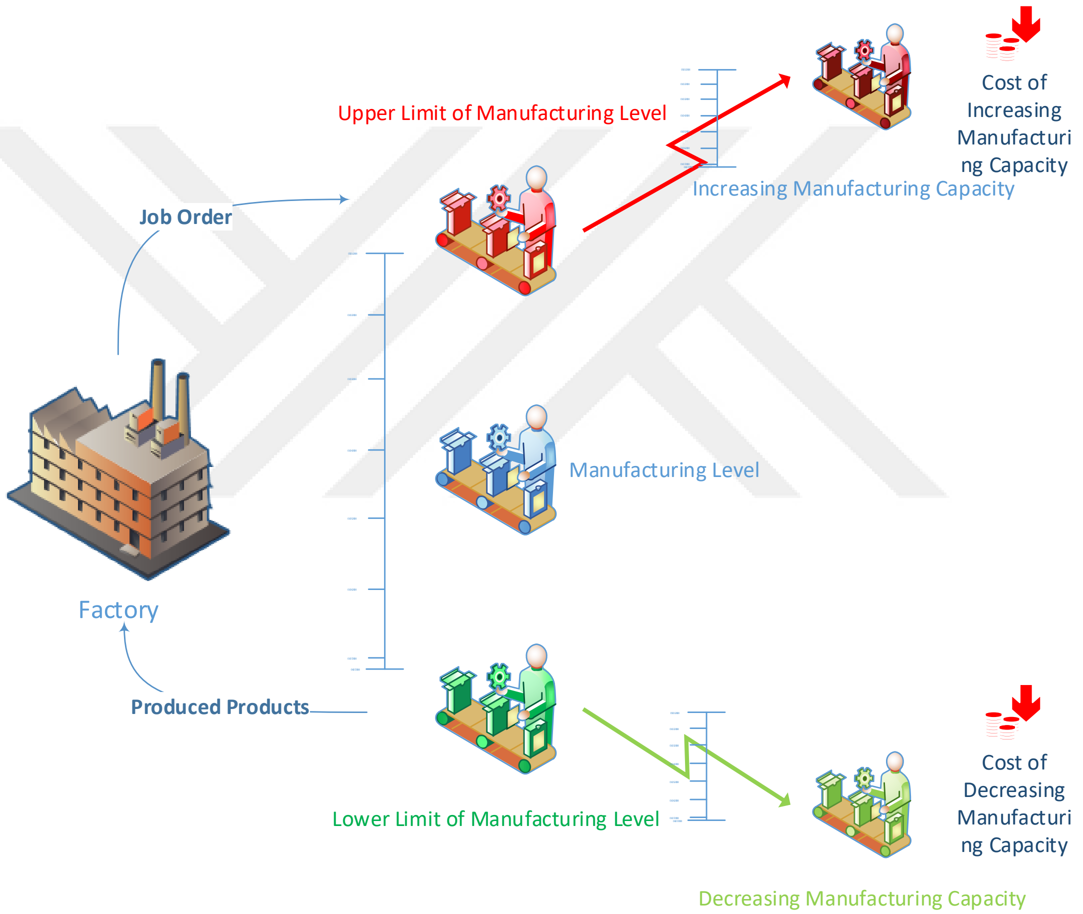

Figure 2 Company & Subcontractor Relationship

As indicated in **Figure 2**, the products are manufactured by subcontractors regarding the company which is analyzed. Agreements are made for product groups with subcontractors regarding a certain business volume and price on a seasonal basis. The company designs the products by itself. Each subcontractor adjusts the production path according to the product it has agreed on and therefore productivity is ensured in workforce. As a result, the diversity of the product group in production lines with serial production becomes as small as possible and this increases the productivity. In line with this strategy that reduces product cost, agreement is made with each subcontractor for a single product. Flexibility is possible at certain rates based on the amount of production negotiated. Production requests can be made above or below the contracted amount according to changing conditions and sales factors. This change incurs extra costs when a certain ratio is exceeded, as indicated in **Figure 2**. When the production demand for a certain product group exceeds the capacity of the subcontractor, it causes quality problems, additional overtime costs and extension of deadlines. Sometimes subcontractors not included to the system are needed for demand that exceeds the capacity. Agreements made with these contractors are disadvantageous in terms of cost and desired results in quality standards may not be achieved. In cases where demand and production are below expectations, the cost per product increases by lowering the amount of product obtained while the fixed costs such as design costs, personnel costs and building costs of the products do not change. Besides, when the amount of work given to the subcontractors is far below the agreement, they might suffer losses. In such cases, typically subcontractors can devote to other business resources and cause poor quality in products, extended deadlines, and therefore loss of sales. In fact, the company can also suffer losses by completely losing its subcontractor which had been in compliance with its work style, quality policy, and business style. As a result, no extra cost is incurred if the production of the company's product groups is within certain proportions of the targeted production capacity. However, when they go beyond these rates according to their capacity, they need to bear extra costs.

2.2. INVENTORY MANAGEMENT

The generally accepted definition of inventory management for products is a "process involving taking finished products into inventory and managing before supplying it to the customer". In retailing, the customer supply process is carried out at other outlets or at owned stores of the company. If the process of supplying products to customers is carried out within the company's own stores, the company must also manage the inventory of its own. In addition, shelves or hangers in the stores are also considered as inventory areas. In this case, the inventory management process of the products includes stocking and management of finished products, and also supplying and placing on sale at stores (see **Figure 3**).

Figure 3 Inventory Management Processes

In this thesis, as in the company modeled as a sample, products that are supplied or manufactured in the company are stocked in one or several main storages. Having a few main warehouses causes high holding cost, extra expenses (rent, labor, etc.) and difficulties in inventory management. Despite this, it enables the reduction of costs such as transportation and customs and the rapid product/service delivery. In the company taken as example, a main distribution warehouse is present in order to make room for storage after the production phase. Here, the ironed products are kept on the shelves until their delivery. Each store also has a warehouse within itself. The products to be distributed from the main warehouse are placed in the cardboard boxes and are distributed through a cargo company. Packaged products are stored in their box until they are placed on store shelves. This provides a significant advantage in saving space. With the help of the highly developed ERP systems today, the main distribution warehouse, the warehouses and store shelf areas within stores can be monitored instantaneously through the system.

2.3. RETAIL CHAIN MANAGEMENT

Unlike other sectors, retailing includes processes such as merchandising, store opening processes, discount and campaign management, and product allocation processes. In cases where these processes are not properly managed, the company may suffer great losses, but if it is managed well, it can gain a great advantage in competition. A store opened in the wrong place with a wrong size and at the wrong time might cause inefficient use of resources such as time and money. A competitive advantage can be achieved through an accurately managed discount and campaign policy. Sometimes, by selling the right product in the right place at the right quantity, a gain can be obtained in each process like production, procurement, inventory management and sales, and total productivity can be maximized. Therefore, profit can be maximized by a model based on total productivity rather than optimizing each process individually.

By increasing the product diversity and competitive advantage, retail companies can grow steadily in terms of turnover and sales volume. In addition, they can achieve rapid growth by increasing the number of stores and sales. Opening a store is always the riskier method. Because it is easier to control and foresight in the first method is relatively easy. When a store is opened, the ability of that store to reach the expected sales potential is related to uncontrolled and unexpected situations. Priority of companies whose products and outlets have not reached saturation and potential both in national or international levels is to open up new stores and outlets in order to extend customer reach. This process is critical for growing companies. Selection of store might cause monetary gain but it may also cause losses. The most critical question focused at this point is "How much does this store sell if its alternative is in place?" This question becomes very challenging if there is no sales data available in that region. Some companies try to estimate this by looking at the target population or only the total population in the region. The basic error here is the assumption that the sales potential of a region is proportional to the region's own population. For the customer, if the attractiveness of the region is high, it can attract customers from other regions, and the residents of that region can also choose other regions for shopping. Another method used is the company's exchange of sales data in a region with the sales data of another company operating in the region company wants to open a new store. This is a very effective method and indicates how significant a company's privacy and data security are. The limited availability of data in this subject, the toughness of administration and reduction of privacy reduces productivity in management. There are also companies that use scientific methods and statistics more often. But this question does not have a single answer. Each forecasting method has some faults. The factor that ensures success here is how big the error is and how much of this miscalculation can be tolerated.

Since the model developed in this thesis includes all the dynamics of retailing, it is necessary to provide the sales potential of the product groups in the regions as input. Calculation of sales potentials in the regions can be the subject of another study.

However, since providing this sales potential as input to the model with certain fault tolerances will affect the success and results of the model, all districts in Turkey (whether central or not) are accepted as regions with sales potential in this thesis and an approach based on Huff's Gravity Method is used to estimate the sales potential.

It is not an accurate model to open an alternative store with the highest potential only by looking at the sales potential. The parameters such as the total area, rent, fixed costs, personnel costs of the store to be opened has great importance for selection of the store. Even if these aspects are taken into consideration, selection of store should not be independent from other processes. This process should consider other processes which are the rings of chain such as supply management, production capacities, inventory management, budget and finance management. Similarly, the process of renewing the stores that need to be renewed at periodic time intervals and their closure will affect all processes. If the opening or closing decision of a store is carried out independently of the other processes, it will cause deviations in the production targets, finance and budget systems.

2.4. SALES PROCESS

Companies use the discount policy a lot especially in ready-to-wear retail industry. These discounting practices have become a competitive policy for most companies. The discount policy, which is particularly efficient for products with seasonal sales figures, varies according to changing conditions and the company. Some companies place a relatively high price tag on their labels for products that are still on the shelves and usually name them as products of the new season, and they offer a discount on a certain rate. This price without the discount is named as the list price. Many companies use list price in their products they initially introduce to the market and strengthen the perception of economic product among their customers, thereby increasing their sales. For seasonal products, another discount is made in accordance with the course of sales and the policy of the company at the end of season and all of the seasonal products which are now called old season product are aimed to be sold.

Allocation has other meanings such as distribution and sharing. In retailing, this process is carried out by various analyzes so that the products can be sold with the highest profit as soon as possible. Each product has different shelf usage, price, profit rate and sales potential. Therefore, the specific product group you display on the shelves of the point of sale is very important in terms of profitability. There may also be cases, where sales potential of product groups differs in each season and in each region. This case makes the allocation processes more difficult. However, the accurate management of allocation process directly affects the amount of specific products sold and the turnover. Therefore, they are the factors that determine the profitability and competitiveness. The allocation process depends on the sales potential, shelf usage, profitability, stock quantity, supply quantity and production capacity. Therefore, other decision processes determine the decisions in the allocation process.

2.5. CUSTOMER RELATIONS MANAGEMENT

The quality, distribution, innovation and performance of products and services are important arguments for having sales and competitive superiority. The competitive conditions of the new era, customer supply and requirements, after-sales services and customer relationship management gained great importance for selling products and services. In some cases, the warranty of products/services and after-sales customer relationships are the most important criteria for customers. Companies' products and services may have less quality than their competitors' products and services. However, as long as the performance / price ratio satisfies the customer, the most important criteria for the customer are the confidence and the perception of the brand and company and the quality of the after-sales service. This process involves managing the relationship between the customer and the company after the product is sold and affects the product sales performance by improving customer perception. However, the impact of this process can be seen in the long-term. The effects of all processes on this process and the effects of this process on profitability and competitiveness are very slow. Therefore, the impacts of this process have been neglected in the analysis made in the following parts of this thesis.

Decisions affecting other processes are being taken at every stage of these processes. In fact, the decision taken in one process may constitute the input of another decision to be made. Therefore, the decision mechanism is examined as a whole in the next section.

2.6. FUNCTIONING OF RETAIL CHAIN DECISION MECHANISM

The main purpose of companies is to make money. Making money necessitates profitability. In addition, profitability enables competitiveness and this capability enables the company to maintain its life cycle. Therefore, decisions made in all interconnected retailing processes must be made with the most profitable scenarios possible by taking into account the interrelationships and interactions among each other. It is possible to make decisions that will achieve the goal of profit maximization by modeling all interrelated processes by conducting very detailed analyzes and adding all the processes to the system.

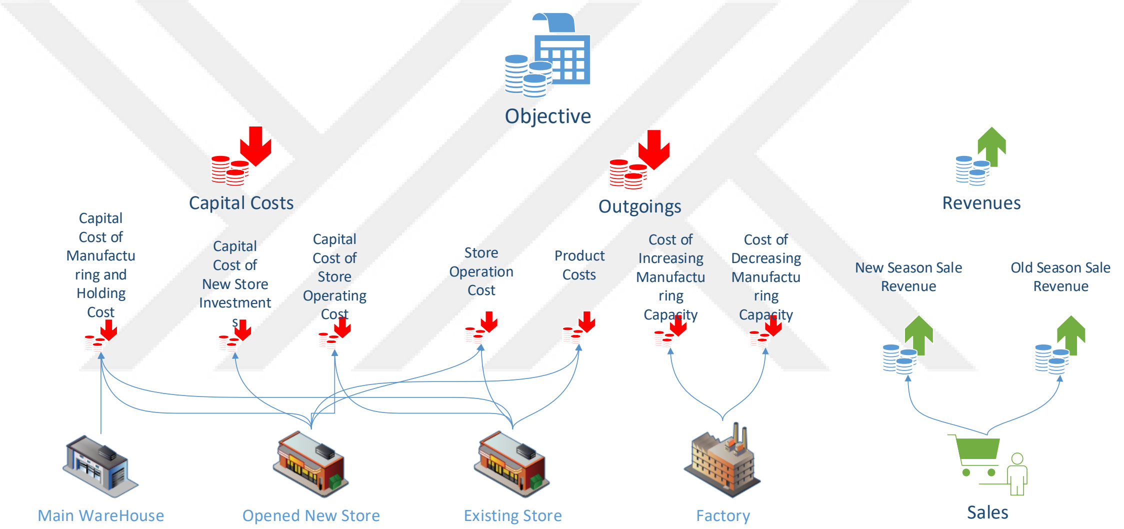

Figure 4 Costs and Incomes in a Retail Chain

For profit maximization, every income and expenditure in retailing should be considered as indicated in **Figure 4**. Income is gained only through sales. Expenditures are provided under two main groups as direct costs and investment costs.

- Direct Cost Items
    - Product Cost
    - Store and Personnel Costs
    - Production Capacity Increase/ Reduction Cost
- Investment Costs
    - Store Opening and Renewal Capital Cost
    - Product Retention Cost

The decisions that make up these costs are taken in different processes of the management chain and affect the entire system. As stated in Section 2.1, there may be differences between the agreements made with the contracted companies over the production target of the considered company and the actual production quantity. This difference creates undesirable costs when the tolerable limits are exceeded. Production increases and decreases at certain rates over the production target will not incur any costs. However, with the exception of such decrease and increase rates, it is possible to increase and decrease the production quantities more. However, the increase and decrease rates causing this cost should have a limit.

Inputs regarding the decisions to be made in this process are;

- Seasonal production targets determined by a contracted company for a product group,
- Production level limits, where production can be done on a production group basis without any cost,
- Extra production increase / decrease rate limits cost,

and decision points are,

- Production level on the basis of seasonal production target for product group,
- The rate of increase / decrease of seasonal extra production based on the cost of some products in the product group.

The decisions made during the production process are the factors that directly affect the quantity of goods to be sent to the store and therefore the sales amounts. From another point of view, they are also directly affected by the stores opened and closed. The fact that the production levels in this process and the cost of production made by bearing extra costs are dependent on the other processes which can negatively affect the profitability.

The products manufactured are stocked in the main warehouse, store warehouses and store shopping areas. The products are stocked in hangers / shelves within the main warehouse and shopping areas, and in cardboard boxes in the store warehouse to save space. Products should be exhibited above a certain rate in shopping areas at a given time. When a new store is opened, it will not decrease below this rate and the product is sent to the new store in order to be exhibited in the shopping areas of the new store. This amount should be considered as the cost of capital, not the cost of the product. When a store is closed, the products of the closed store are sent to the main warehouse. These products are not considered as expense or income because they remain in the system. Stores need to be renewed in a certain period. Renewal process of renovated stores is completed between 3 and 7 days. In this study, the loss of sales revenues during renovation and the cost saving of personnel on leave are neglected.

As in the case of other retail chain companies, there is list price application in the company as stated in Section 2.4. That is, even if a product takes its place on the shelf for the first time, a price named as list price is determined and placed on the shelf by applying a specified discount on this product. When the product becomes old season product, another discount is applied by considering the list price. Besides, the products exhibited after dispatched to the stores have a certain sales rate. This rate may vary for old and new season products. In some cases, this ratio may even vary depending on the product group. The sales ratios of the displayed quantities of more basic products are higher than those of the more qualified and fashionable products. This is generally witnessed in ready-to-wear products.

The inputs for decision processes in merchandise management are;

- The total storage and shopping area of existing or new alternative stores, the cost per square meter (rent, personnel, withholding, electricity etc.), opening and renewal costs, store age, renewal period,
- Product group cost, crossed sales price, box and shelf / hanger usage,
- Store minimum occupancy rate, old / new season product sales rate,
- Capacity of main warehouse,
- Periodical sales potential of product groups in the districts,
- Budget allocated for store investments,

and the decision points are,

- Determination of store alternatives to be opened,
- The decision to renew or to close the stores whose renovation time has come,

- Closing stores that are inefficient or less efficient than new alternatives,
- The amount of old / new season products according to product groups that will be shipped from main warehouse to the store warehouses,
- The amount of old / new season products according to product groups that will be shipped from warehouse areas within the store to the store shopping areas,
- Use of the budget for store investments,
- Product quantities to be shipped to the newly opened stores,

and other indicators are,

- Periodic sales quantities of product groups in the stores,
- The amount of new / old season products in stores, store warehouses and main warehouse at the beginning and end of the term,
- The amount of product that will be shipped to the main warehouse from the closed stores,
- Sales income to be obtained from sales,
- Merchandising operating expenses (rent, personnel and other),
- Product costs (material and extra production costs),
- Investment costs (investment cost of the budget used for store investments, the stocks carried, the cost of goods and operating expenses for newly opened stores).

Decisions on opening new stores by evaluating store alternatives in store management can affect production quantities as well as decisions to close down these stores. Considering limited production capacity, more efficient store alternatives can be found in terms of performance indicators (sales/cost) relative to existing stores. In such a case, limited production or supply may not be sufficient to saturate existing stores and more efficient store alternatives. It may not be the right decision to open stores with higher performance indicators and close the ones with lower indicators. In this case, opening of new stores should be at a level where the difference of performance according to the stores to be closed can also amortize the investment costs. Another point of decision is the quantity of products to be shipped, and it is directly affected by the production quantities. Sales are also affected by the distribution and quantities of the product groups being shipped. On the other hand, the stores have to be saturated at a certain rate. Therefore, the whole system is interlocked and the response for all of these decisions should be sought through an integrated model. All of the merchandising indicators are in full interaction with these decisions.

The inputs provided for the functioning of all these decision-making mechanisms, the decision points and the indicators that are decided upon are the actual factors of the operation of the retail chain. All processes are carried out by transforming these inputs into decisions and indicators. What is important, therefore, is how and in what ways the inputs are transformed into decisions and indicators. These inputs can be transformed into decisions and indicators through the experience gained by firms or by scientific studies in these fields of processes. Experience-based decisions can sometimes be very effective and rapid, but they may also cause too many misconceptions. Taking decisions in a process without taking into account all of the scientific processes and other processes in their field may not be fruitful for total profitability. The purpose of this thesis is to establish an integrated decision-support model that will provide decision support for all decision points by also taking into account all these decisions, their interrelationship with each other, and their impact on each other.

CHAPTER 3

LITERATURE REVIEW

This study necessitates the integration of subject matters investigated under various titles within the literature. Accordingly, the review of literature is presented separately in sub-titles for the mentioned subjects to accommodate an investigation on their similarities, differences, and shortcomings compared to this study.

3.1. INVENTORY MANAGEMENT

Subjects focused in inventory management are the reduction of holding costs, ordering costs, and shortage costs stemming from the incapability to meet demand. There are many EOQ and EPQ models developed as a solution. In classical EOQ model, the optimum order amount is calculated as

$$Q_0 = \sqrt{\frac{2RC_p}{C_H}} \tag{3.1}$$

where,

Q_0 = *optimum lot size*

R = *annual demand in units per year*

C_H = *holding cost in dollars per unit-year*

C_p = *order cost in dollars per order.*

It is possible to revise this model as in equation (3.2) so as to include cases of shortage.

$$Q_0 = \sqrt{\frac{2RC_p}{C_H} \times \frac{C_h C_s}{C_s}} \tag{3.2}$$

C_s = *shortage cost in dollars per unit short-year*

In addition to classical EOQ model and EOQ with shortage, models such as EPQ, “Fixed Demand, Variable Delivery Period Model” and “Variable Demand and Variable Delivery Period Model” can be found developed in the literature. See Zandin (2001) for further information on the issue.

There is a specified amount of demand or sales target underlying EOQ models. The model does not modify the amount of demand deciding on the sources that constitute the demand (store, sales point, dealer, etc.). In reality, the numbers of stores to be opened and closed as well as related amount of supply may vary. In such a case, an EOQ model independent of retailing decisions cannot be utilized. However, the preferred model is supposed to include holding and shortage costs, as well.

3.2. LOCATION ALLOCATION MODEL

A multitude of location - allocation models in designating stores or sales points can be found in the literature. Some of the studies are listed below. Studies on optimum facility location are first seen in early 20th century. Weber (1909) allocates a facility that can operate in three centers of demand with minimum logistics costs for one.

Facility location models aspire to select a specified amount of service points to operate in a specified area so as to ideally support an intended function under certain restrictions. These models meet certain criteria while choosing a spot with the minimum costs possible. (Kulluk & Türkbey, 2004)

Among them, the most common is the “maximum demand capture” model. This problem was first investigated by Church and ReVelle (1974). One of the fundamental principles of Maximum Capture models in choice of location is whether customer locations are fully covered or not. However, these models designate neither the necessary size of store/sales point to be opened at the related spot nor product/production requirements. In effect, this leads to insufficient results in the choice of store/sales point locations.

A deterministic linear programming model where all prices can be calculated is the subject of a study conducted by Canel and Khumawala (2001). The researchers address a number of factors to be considered in the choice of warehouse locations, while maximization of profit constitutes the purpose of the model. Additionally, the formula of the problem also involves customers from different countries and stock keeping possibilities. This model can determine optimum countries for warehouses, production quantities, and quantities to be transferred from the warehouses to customers. However, the authors do not take investment decisions and costs into consideration.

Bassou et al. (2016) developed a linear programming model with an objective function that minimizes total, opening, and service costs of a company. In this model, stores can serve the entire demand point meanwhile warehouses can serve every store. Moreover, the model designates stores so as to not overwhelm their capacity with demand amount. Though in this model; criteria, variables, and decision processes such as production capacity, investment costs, demand based on product groups or distribution quantities are not taken into consideration.

Such models that can be used for choice of store recognize production or supply capacities as a constant. They do not provide increase or decrease in production capacity as per variable costs. Therefore, they cannot be used as standalone for the problem in hand.

3.3. SALES FORECASTS

Primary target of businesses is to make money through sales. All models in the above-mentioned studies including the model developed in this study aim to increase profit by decreasing costs based on sales. Sales potential, sales target, sales forecasts, whatever the name might be, predicted sales should be fed into the system as inputs. However, it is not always easy to obtain such estimates. As mentioned in the introduction, there are certain forecasting models that can predict future sales data based upon sales from the past such as “n-moving average” and “exponential smoothing technique”. When the subject matter in question is designation of new store/sales points, past sales data for these new areas either cannot be found or is not easy to obtain. Companies at times exchange their own sales data with peers that operate in a similar industry in areas where the store is projected to open, or purchase data from such companies. Along with the fact that this is not always feasible, it also constitutes a problem in terms of principles of privacy.

Huff (1963) formulizes the likelihood of a customer to prefer a shopping mall as

$$P\left(C_{i,j}\right) = \frac{\frac{S_j}{T_{i,j}^{\lambda}}}{\sum_{j=1}^{n}\left(\frac{S_j}{T_{i,j}^{\lambda}}\right)} \tag{3.3}$$

where

$P\left(C_{i,j}\right)$= the probability of a consumer at a given point of origin i traveling to a given shopping center j;

S_j = the square footage of selling space devoted to the sale of a particular class of goods by shopping center j;

$T_{i,j}$ = the travel time involved in getting from a consumer's travel base i to shopping center j; and,

λ = a parameter which is to be estimated empirically to reflect the effect of travel time on various kinds of shopping.

The method is based on the likelihood of a customer at the demand point to prefer an area for shopping. It is sought in the method to obtain a parameter that predicts sales potential obtained from the distribution of customers among shopping areas based on such probabilities. Huff's original model given in equation (3.3) is utilized in various versions in many studies. On grounds of not being able to utilize from known forecasting methods, this study investigates studies conducted on "Huff's Gravity Model".

Huff's method is profoundly convenient in estimating sales potential in a region. As Goodchild (1984) also states, it can only be determined where stores will be designated, but allocation of demand is pertinent to behavioral tendencies of customers. The reason being is that customers are free in their choice of places for shopping. However, shopping behavior of majority of the consumers is generally to choose the nearest shopping area, which is also the fundamental idea behind the simple nearest-center model. Yet, consumers tend to make multi-purpose shopping trips. This is why they prefer shopping areas qualified with higher shopping attraction. Then, customer behavior can be modelled by using the information as follows:

Let $x_{i,m}, i = 1,..,n,\ m = 1,..,q$ denote consumer trip counts between the n demand points and q existing sites. A suitable class of models has the general form of equation (3.4) where E_i is interpreted as a function of the demand in origin zone i, A_m as the attraction of the destination store m, and f as a decreasing function of the distance between them.

$$x_{i,m} = E_i A_m f(d_{im}) \tag{3.4}$$

However, the demand at a shopping zone does not only stem from the origin zone. For this reason, Goodchild (1984) changes the formulation as

$$x_{i,m} = P_i \frac{A_m f(d_{im})}{\sum_k A_k f(d_{ik})} \tag{3.5}$$

where P_i is the potential demand in zone i and using it to forecast demand in zone m from zone i. Further, Drezner (2014) revised this model to estimate market share and named it the gravity-based approach.

Suppose there are k existing facilities and n demand points. The attractiveness of facility *j* is A_j for $j = 1, \ldots, k$, and the distance between demand point i and facility *j* is d_{ij}. The purchase power at demand point *i* is b_i. In effect, the proportion of the purchase power (market share) M_j attracted by facility j is:

$$M_j = \sum_{i=1}^{n} b_i \frac{A_j / d_{i,j}^{\lambda}}{\sum_{m-1}^{k} (A_m / d_{i,m}^{\lambda})} \tag{3.6}$$

where λ is the power to which distances are raised. The gravity approach can be classified as a special case of the random utility approach.

Huff's gravity method was also utilized by Mendes and Themido (2003). In fact, there are many versions of Huff's gravity method found in the literature. This approach seems to be effective in estimating sales potential.

CHAPTER 4

MATHEMATICAL MODEL

The model developed in this study, provides an integrated answer to questions raised from a decision support system in retail chain management. Possible decision alternatives in retail chain management are locating, operating, renewing and closing stores. However, in addition to this, decisions related to capacity, production and shipment planning are also important. The goal of the model is to find satisfactory answers to all of these questions. A company can lose or make money by making decisions appropriately for optimizing the profitability of the business.

4.1. MODEL INDICES, PARAMETERS, AND VARIABLES

There are various parameters which provide information on internal dynamics of retail chain management.

4.1.1. MODEL INDICES

There are various product groups, districts, alternative store locations in the districts and seasons in a planning horizon as indices.

i	product group index	$i = 1, \dots, I$
j	district index	$j = 1, \dots, J$
k	store location index	$k = 1, \dots, K$
t	period (season) index	$t = 1, \dots, T$

4.1.2. MODEL PARAMETERS

All of the parameters may differ from company to company, and also it may change according to the organizational structures and marketing procedures.

p_i	average unit list price for product group *i*
$OSPDFactor$	old season price discount factor
$NSPDFactor$	new season price discount factor
$OpenSCost_{j,k}$	total cost for opening a store in alternative location *k*, in district *j*
$RenewSCost_{j,k}$	total cost for renewing the store in alternative location *k*, in district *j*
$UnitCOExpenses_{j,k,t}$	the unit cost representing the sum of expenses in period t, per unit area for operating the store in alternative store location *k*, in region *j* (rent, wages, cost of energy and other services etc.)
$MaxBudget$	budget limit for opening and renewing stores in a retail chain
$CFactorIncMC_{i,t}$	cost factor for increasing manufacturing capacity for producing product group *i*, in period *t*
$CFactorDecMC_{i,t}$	cost factor for decreasing manufacturing capacity for producing product group *i*, in period *t*
$MaxPercentIncMC$	maximum percentage for increasing of manufacturing capacity
$MaxPercentDecMC$	maximum percentage for decreasing of manufacturing capacity
$UpperUtilLMC$	upper utilization limit for manufacturing capacity
$LowerUtilLMC$	lower utilization limit for manufacturing capacity
$UnitAvgCost_i$	unit average cost of producing product group *i*
$MCapacity_{i,t}$	manufacturing capacity for producing product group *i*, in period *t*
$TotArea_{j,k}$	total area available in alternative store *k*, in district *j*
$CapacitySW_{j,k}$	box storage capacity for store *k*, in district *j*
$HangingCapacityMW$	hanging capacity for the main warehouse
$HangingCapacityS_{j,k}$	hanging capacity available in alternative store *k*, in district *j*
$HangingWidth_i$	hanging width (cm) of a unit for product *i*
$UnitBoxUsage_i$	unit box usage for product group *i*
$MinHangingUtil$	minimum hanging utilization for a store
$MaxNSSalesPercent$	maximum new season sales percentage for a store
$MaxOSSalesPercent$	maximum old season sales percentage for a store
$SalesPotential_{i,j,t}$	sales potential of product group *i*, in district *j*, in period *t*
$AgeStore_{j,k}$	the age of store *k*, in district *j*
$MinAgeClose$	minimum age for an existing store to be closed
$Renew_{j,k}$	binary *(0/1)* parameter showing *1* if alternative store *k*, in district *j* should be renewed, *0* otherwise in this planning horizon
$IAmountOSStockMW_i$	initial stock amount of old season product group *i* in the main warehouse
$IAmountOSStockSW_{i,j,k}$	initial stock amount of old season product group *i*, in alternative store *k*, in district *j*
i_q	interest rate per quarter

M	a sufficiently large number

4.1.3. MODEL VARIABLES

All of the important variables for retail chain management are defined below. These variables include decisions related to capacity, production and shipment planning together with decisions for locating, operating, renewing and closing stores in retail chain management.

Variables related to "Capacity and Production Planning" decisions are given below:

$MCLevel_{i,t}$	Manufacturing capacity level of product group *i*, in period *t*
$MCLevelIncPercent_{i,t}$	Increment percentage of manufacturing capacity for product group *i*, in period *t*
$MCLevelDecPercent_{i,t}$	Decrement percentage of manufacturing capacity for product group *i*, in period *t*

Variables related to "Shipment and Inventory Planning" decisions are given below:

$AmountOSSent_{i,j,k,t}$	amount of old season product group *i*, sent to store location *k*, in district *j*, during period *t*
$AmountNSSent_{i,j,k,t}$	amount of new season product group *i*, sent to store location *k*, in district *j*, during period *t*
$AmountOSStockMW_{i,t}$	amount of old season product group *i*, in main warehouse at the beginning of period *t*
$AmountOSStockSW_{i,j,k,t}$	amount of old season product group *i*, in warehouse of store location *k*, in district *j*, at the beginning of period *t*
$AmountOSHanged_{i,j,k,t}$	amount of hanged old season product group *i*, in store location *k*, in district *j*, during period *t*
$AmountNSHanged_{i,j,k,t}$	amount of hanged new season product group *i*, in store location *k*, in district *j*, during period *t*
$AmountOSLeftHangedS_{i,j,k,t}$	amount of old season product group *i*, left hanged in store location *k*, in district *j*, at the end of period *t*
$AvgAmountStockW_{i,t}$	average amount of product group *i*, handled in main and store warehouses during period *t*
$AvgAmountStockHanged_{i,t}$	Average amount of product group *i*, handled in shopping areas of all stores during period *t*
$AmountOSStockReturnedMW_{i,j,k}$	amount of product group *i*, returned from closed store location *k*, in district *j*
$InitalOSStockSentOpenS_{i,j,k}$	initial amount of old season product group *i*, sent to opened store location *k*, in district *j*
$AmountOSSales_{i,j,k,t}$	amount of old season sales for product group *i*, in store location *k*, in district *j*, during period *t*

$AmountNSSales_{i,j,k,t}$	amount of new season sales of product group *i*, in store location *k*, in district *j*, during period *t*

Variables related to "Retail Store Management" decisions are given below;

In retail chain management, opening new store(s) to alternative locations, for existing stores renewing, closing, or keeping in order to continue operating are very significant decisions.

$$OpStore_{j,k} = \begin{cases} 1 \text{ if alternative store k is opened in district j,} \\ 0 \text{ otherwise} \end{cases}$$

$$RenStore_{j,k} = \begin{cases} 1 \text{ if alternative store k is renewed in district j,} \\ 0 \text{ otherwise} \end{cases}$$

$$KeepStore_{j,k} = \begin{cases} 1 \text{ if alternative store k is kept in district j,} \\ 0 \text{ otherwise} \end{cases}$$

$$CloseStore_{j,k} = \begin{cases} 1 \; if \; alternative \; store \; k \; is \; closed \; in \; district \; j, \\ 0 \; otherwise \end{cases}$$

4.2. MODEL FORMULATION

The model should reflect all dynamics of retail chain management in order to obtain the best performance. Generally, the stores are considered to be the marketing tools of the retail chain management system (see **Figure 5**). The stores are composed of shopping areas with a pre-defined hanging capacity for products and warehouse areas for storage of products in boxes.

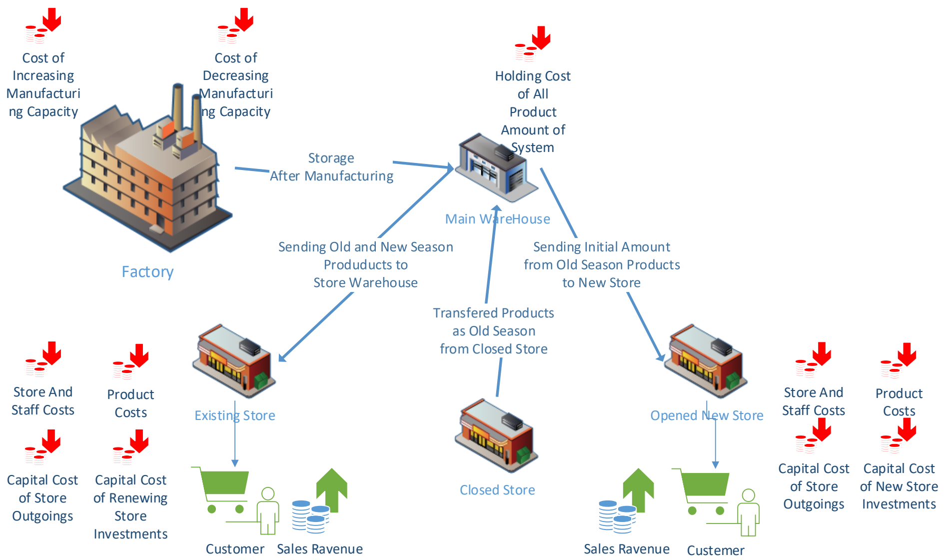

Figure 5 Retail Chain Management System

Continuously new products are designed and produced as new season products. Such products produced as new season products and products remaining from previous seasons called old season products are being hanged in shopping area of the stores.

In marketing systems, there is list price, a discounted price for a new season products and an extra discounted price for old season products. The retail chain works with subcontractors which have seasonal production capacities within lower and upper limits, based on annual contracts made at the beginning of planning horizons. If the company tries to produce below or above such limits, extra costs should be incurred. In a period, all products produced can be either sent to store warehouses in boxes or they are stored in the main warehouse(s) of the company. If a store is to be opened, a certain amount of old season products is sent to the stores from the company main warehouse(s). And, if a store is to be closed, all products remaining in the closed store should be sent back to the main warehouse(s).

Maximize

$$\boldsymbol{R - C - H - M - I - O}$$

where

$$\boldsymbol{R} = \sum_{i}^{N}\sum_{j}^{J}\sum_{k}^{K}\sum_{t}^{T} \begin{matrix} \left(1 + i_q * (T - t)\right) * p_i \\ * \begin{pmatrix} AmountNSSales_{i,j,k,t} * NSPDFactor \\ +AmountOSSales_{i,j,k,t} * OSPDFactor \end{pmatrix} \end{matrix}$$

$$\boldsymbol{C} = \sum_{t}^{T}\sum_{j}^{J}\sum_{k}^{K} \left(1 + i_q * \left(T - (t - 1)\right)\right) * \begin{bmatrix} \left(OpStore_{j,k} + RenStore_{j,k} + KeepStore_{j,k}\right) \\ * UnitCOExpenses_{j,k,t} * TotArea_{j,k} \end{bmatrix}$$

$$\boldsymbol{H} = \sum_{i}^{N}\sum_{t}^{T} \begin{bmatrix} \left(AvgAmountStockW_{i,t} + AvgAmountStockHanged_{i,t}\right) \\ * UnitAvgCost_i * i_q * \left(T - (t - 1)\right) \end{bmatrix}$$

$$\boldsymbol{M} = \sum_{i}^{N}\sum_{t}^{T} \begin{bmatrix} MCapacity_{i,t} \\ * \left[MCLevel_{i,t} + MCLevelIncPercent_{i,t} - MCLevelDecPercent_{i,t}\right] \\ * UnitAvgCost_i * \left(1 + i_q * (T - t)\right) \end{bmatrix}$$

$$\boldsymbol{I} = (i_q * T) * \sum_{j}^{J}\sum_{k}^{K}\left[\left(OpStore_{j,k} * OpenSCost_{j,k} + RenStore_{j,k} * RenewSCost_{j,k}\right)\right]$$

$$\boldsymbol{O} = \sum_{i}^{N}\sum_{t}^{T}\left[\begin{bmatrix} MCLevelIncPercent_{i,t} * CFactorIncMC_{i,t} \\ +MCLevelDecPercent_{i,t} * CFactorDecMC_{i,t} \end{bmatrix} * \left(1 + i_q * (T - t)\right)\right]$$

Subject to

$$\sum_{j}^{J}\sum_{k}^{K} AmountOSSent_{i,j,k,t} \leq AmountOSStockMW_{i,t} \qquad \forall\, i,t \quad (1)$$

$$\sum_{j}^{J}\sum_{k}^{K} AmountNSSent_{i,j,k,t} \leq$$

$$MCapacity_{i,t} * \left[MCLevel_{i,t} + MCLevelIncPercent_{i,t} - MCLevelDecPercent_{i,t}\right] \quad \forall\, i,t \quad (2)$$

$$AmountOSStockMW_{i,t} = AmountOSStockMW_{i,t-1}$$
$$+MCapacity_{i,t-1} * \left(MCLevel_{i,t-1} + MCLevelIncPercent_{i,t-1} - MCLevelDecPercent_{i,t-1}\right)$$
$$-\sum_{j}^{J}\sum_{k}^{K} AmountOSSent_{i,j,k,t-1} - \sum_{j}^{J}\sum_{k}^{K} AmountNSSent_{i,j,k,t-1} \qquad \forall\, i,t > 1 \quad (3)$$

$$AmountOSStockMW_{i,t} = IAmountOSStockMW_{i} + \sum_{j}^{J}\sum_{k}^{K} AmountOSStockReturnedMW_{i,j,k}$$
$$-\sum_{j}^{J}\sum_{k}^{K} InitalOSStockSentOpenS_{i,j,k} \qquad \forall\, i,t = 1 \quad (4)$$

$$\sum_{i}^{N} AmountOSStockMW_{i,t} * HangingWidth_{i} \leq HangingCapacityMW \qquad \forall t \quad (5)$$

$$MCLevel_{i,t} \leq UpperUtilLMC \qquad \forall\, i,t \quad (6)$$

$$MCLevel_{i,t} \geq LowerUtilLMC \qquad \forall\, i,t \quad (7)$$

$$MCLevelIncPercent_{i,t} \leq MaxPercentIncMC \qquad \forall\, i,t \quad (8)$$

$$MCLevelDecPercent_{i,t} \leq MaxPercentDecMC \qquad \forall\, i,t \quad (9)$$

$$CloseStore_{j,k} * IAmountOSStockSW_{i,j,k} = AmountOSStockReturnedMW_{i,j,k} \qquad \forall\, i,j,k \quad (10)$$

$$AmountOSStockSW_{i,j,k,t} = AmountOSStockSW_{i,j,k,t-1} - AmountOSHanged_{i,j,k,t-1}$$
$$-AmountNSHanged_{i,j,k,t-1} + AmountOSSent_{i,j,k,t-1}$$
$$+AmountNSSent_{i,j,k,t-1} \qquad \forall\, i,j,k,t > 1 \quad (11)$$

$$AmountOSStockSW_{i,j,k,t} = IAmountOSStockSW_{i,j,k}$$
$$-AmountOSStockReturnedMW_{i,j,k} \quad \forall\, t = 1 \quad (12)$$

$$\sum_{i}^{N} AmountOSStockSW_{i,j,k,t} * UnitBoxUsage_i \leq CapacitySW_{j,k} \qquad \forall\, j,k \quad (13)$$

$$\sum_{i}^{N}\sum_{t}^{T}\left(AmountOSSent_{i,j,k,t} + AmountNSSent_{i,j,k,t}\right) \leq$$
$$\left(OpStore_{j,k} + RenStore_{j,k} + KeepStore_{j,k}\right) * M \quad \forall\, j,k \quad (14)$$

$$AmountNSHanged_{i,j,k,t} \leq AmountNSSent_{i,j,k,t} \qquad \forall\, i,j,k,t \quad (15)$$

$$AmountOSHanged_{i,j,k,t}$$
$$\leq AmountOSStockSW_{i,j,k,t} + AmountOSSent_{i,j,k,t} \qquad \forall\, i,j,k,t \quad (16)$$

$$AmountOSLeftHangedS_{i,j,k,t} = AmountOSLeftHangedS_{i,j,k,t-1} + AmountOSHanged_{i,j,k,t}$$
$$+AmountNSHanged_{i,j,k,t} - AmountOSSales_{i,j,k,t} - AmountNSSales_{i,j,k,t} \quad \forall\, i,j,k,t > 1 \quad (17)$$

$$AmountOSLeftHangedS_{i,j,k,t} = InitalOSStockSentOpenS_{i,j,k} + AmountOSHanged_{i,j,k,t}$$
$$+AmountNSHanged_{i,j,k,t} - AmountOSSales_{i,j,k,t} - AmountNSSales_{i,j,k,t} \quad \forall\, i,j,k,t = 1 \quad (18)$$

$$\sum_{i}^{N}\left(AmountOSLeftHangedS_{i,j,k,t} * HangingWidth_i\right) \leq$$
$$HangingCapacityS_{j,k} * \left(OpStore_{j,k} + RenStore_{j,k} + KeepStore_{j,k}\right) \quad \forall\, j,k,t \quad (19)$$

$$\sum_{i}^{I}\left(AmountOSLeftHangedS_{i,j,k,t} * HangingWidth_i\right) \geq$$

$$HangingCapacityS_{j,k} * MinHangingUtil * \left(OpStore_{j,k} + RenStore_{j,k} + KeepStore_{j,k}\right) \quad \forall\, j,k,t \quad (20)$$

$$AmountNSSales_{i,j,k,t} \leq AmountNSHanged_{i,j,k,t} * MaxNSSalesPercent \quad \forall\, i,j,k,t \quad (21)$$

$$AmountOSSales_{i,j,k,t} \leq \left(AmountOSLeftHangedS_{i,j,k,t-1} + AmountOSHanged_{i,j,k,t}\right) * MaxOSSalesPercent \quad \forall\, i,j,k,t > 1 \quad (22)$$

$$AmountOSSales_{i,j,k,t} \leq \left(AmountOSHanged_{i,j,k,t} + InitalOSStockSentOpenS_{i,j,k}\right) * MaxOSSalesPercent \quad \forall\, i,j,k,t = 1 \quad (23)$$

$$\sum_{i}^{N}\left(InitalOSStockSentOpenS_{i,j,k} * HangingWidth_i\right) = OpStore_{j,k} * HangingCapacity_{j,k} * MinHangingUtil \quad \forall\, j,k \quad (24)$$

$$\sum_{i}^{N}\sum_{t}^{T}\left(AmountOSSales_{i,j,k,t} + AmountNSSales_{i,j,k,t}\right) < \left(OpStore_{j,k} + RenStore_{j,k} + KeepStore_{j,k}\right) * M \quad \forall\, j,k \quad (25)$$

$$\sum_{k}^{K}\left(AmountOSSales_{i,j,k,t} + AmountNSSales_{i,j,k,t}\right) \leq SalesPotential_{i,j,t} \quad \forall\, i,j,t \quad (26)$$

$$AvgAmountStockW_{i,t} = 0.5 * \left(AmountOSStockMW_{i,t} + AmountOSStockMW_{i,t+1}\right) + 0.5 * \sum_{j}^{J}\sum_{k}^{K}(AmountOSStockSW_{i,j,k,t} + AmountOSStockSW_{i,j,k,t+1}) \quad \forall\, i,t < T \quad (27)$$

$$AvgAmountStockW_{i,t} = AmountOSStockMW_{i,t} + \sum_{j}^{J}\sum_{k}^{K} AmountOSStockSW_{i,j,k,t}$$

$$+0.5 * MCapacity_{i,t} * \left(MCLevel_{i,t} + MCLevelIncPercent_{i,t} - MCLevelDecPercent_{i,t}\right)$$

$$-0.5 * \sum_{j}^{J}\sum_{k}^{K}\left(AmountOSHanged_{i,j,k,t} + AmountNSHanged_{i,j,k,t}\right) \qquad \forall\, i, t = T \quad (28)$$

$$AvgAmountStockHanged_{i,t} =$$

$$0.5 * \sum_{j}^{J}\sum_{k}^{K}\left(AmountOSLeftHangedS_{i,j,k,t-1} + AmountOSLeftHangedS_{i,j,k,t}\right)$$

$$\forall\, i, t > 1 \quad (29)$$

$$AvgAmountStockHanged_{i,t} =$$

$$0.5 * \left[\sum_{j}^{J}\sum_{k}^{K}\left(InitalOSStockSentOpenS_{i,j,k} + AmountOSLeftHangedS_{i,j,k,t}\right)\right]$$

$$\forall\, i, t = 1 \quad (30)$$

$$OpStore_{j,k} + RenStore_{j,k} + CloseStore_{j,k} + KeepStore_{j,k} \leq 1 \qquad \forall\, j, k \quad (31)$$

$$\left(1 - OpStore_{j,k}\right) * M \geq AgeStore_{j,k} \qquad \forall\, j, k \quad (32)$$

$$CloseStore_{j,k} * MinAgeClose \leq AgeStore_{j,k} \qquad \forall\, j, k \quad (33)$$

$$\left(RenStore_{j,k} + CloseStore_{j,k}\right) * M \geq Renew_{j,k} \qquad \forall\, j, k \quad (34)$$

$$KeepStore_{j,k} \leq AgeStore_{j,k} \qquad \forall\, j, k \quad (35)$$

$$\left(RenStore_{j,k} + CloseStore_{j,k} + KeepStore_{j,k}\right) * M \geq AgeStore_{j,k} \qquad \forall\, j, k \quad (36)$$

$$RenStore_{j,k} \leq Renew_{j,k} \qquad \forall\, j, k \quad (37)$$

$$\sum_{j}^{J}\sum_{k}^{K}\left(OpStore_{j,k} * OpenSCost_{j,k} + RenStore_{j,k} * RenewSCost_{j,k}\right) \leq MaxBudget \qquad \forall\, j,k \quad (38)$$

4.2.1. OBJECTIVE FUNCTION

In retail chain management, incomes are provided with products sales. The product sales are divided into two as new season and old season product sales (**R**). All costs can be examined in four main groups. These are store management costs (renting, staff costs etc.) (**C**), inventory management costs (**H**), production costs (**M**), store investment costs (**I**), over production capacity cost (**O**), Interest value of the costs also should be considered. If this money is not spent for retail chain investment, the company could earn money with other investment. However, retail chain revenues cannot earn money with investment or restricted bank deposit. Because the income is unusable for investment, it is not considered for interest value of the money. Simple interest rate is applied in the objective function. But objective function with compound interest for all costs and revenues and objective function with no time value of money respectively in **Appendix 1 & 2**.

4.2.2. CONSTRAINTS

(1) *Old season products or remaining products produced as new season products but to be distributed to the store warehouses in the next periods (seasons) are stored in the category of old season products in the main warehouse. A total amount of products distributed to the store warehouses should be less than the amount of products stored in the main warehouse (**See Figure 6**).*

(2) *All products produced in any time period considered as new season products for that period. All new season products produced in any period can be distributed the store warehouses in that period. Also remaining products produced in any period can be stored in the main warehouse to be sent as old season products to the store warehouses in the next periods. There are upper and lower manufacturing limits. The company can manufacture within these limits without any extra cost. However, in some periods the company may require an increase*

or decrease in manufacturing capacity beyond these limits with the associated cost.

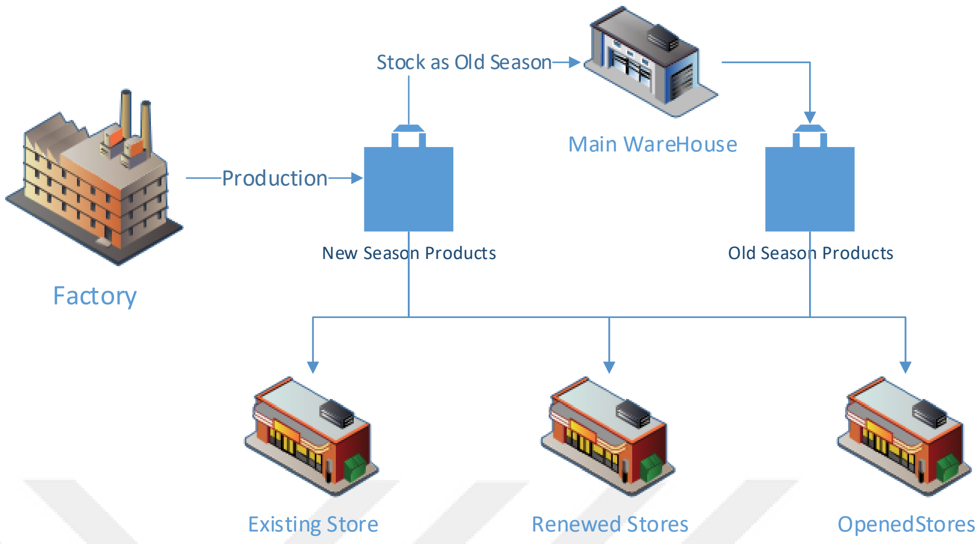

Figure 6 Product Transfer Scheme

(3) *At beginning of any period, the amount of product in the main warehouse is equal to the amount of product at beginning of previous period, plus the amount of product produced during that period, minus the amount of old season and new season products sent to store warehouses in the previous period.*

(4) *At beginning of the first period, all products from the previously closed stores are transferred back to the main warehouse. Also, the products in order to fill up the newly opened stores will be shipped. As a result, the initial amounts of products are set for the main and store warehouses.*

(5) *The amount of ironed end products is limited to hanging capacity in the main warehouse at any period.*

(6) *The upper capacity utilization limit for manufacturing any product for any period.*

(7) *The lower capacity utilization limit for manufacturing any product for any period.*

(8) *The company can manufacture between upper and lower limits of manufacturing capacity without any extra cost. If the company wants to manufacture over the upper capacity limit, there is a maximum limit for the extra manufacturing capacity to be increased.*

(9) *If the company wants to manufacture below the lower capacity limit, there is a maximum limit for the manufacturing capacity to be decreased.*

(10) There may be remaining inventory stocks in the warehouses of the closed stores at the beginning of the first period that should be returned back to the main warehouse.

(11) The amount of the product at the beginning of the period at a store warehouse is equal to the amount product at the beginning of previous period plus the amount of new season and old season products sent from the main warehouse minus the amount of hanged new season and old season products in the shopping area of a store in the previous period. For a new season product received by a store, it should be hanged in the shopping area of the store in order to be sold as new season product in that period. Otherwise, it can be sold later as an old season product.

(12) If the store is not closed, it initializes amount of products at the beginning of the period for the store warehouse, otherwise sets to zero.

(13) All products are packaged in boxes to be transferred from main warehouse to store warehouses. All products received from main warehouse are stored in packaged boxes in store warehouses with a total box capacity limit.

(14) In order to transfer any old or new season product to a warehouse of a store location, the store location has to be either newly opened, or renewed, or continued to be operated as it is.

(15) Amount of new season product hanged in the shopping area of a store location in a period can't exceed the amount of new season product sent from main warehouse in that period.

(16) Amount of old season product hanged in the shopping area of a store location in a period can't exceed the amount of old season product sent from main warehouse in that period, plus the remaining amount of old season product from the previous period.

(17) The amount of old season product left on hanged in a period in the shopping area of a store location, is equal to the amount of old season product left on hanged from the previous period, plus the amount of new season and old season products hanged in that period, minus the amount of new season and old season products sold in that period.

(18) The amount of old season product left on hanged in the first period in the shopping area of a store location, is equal to the initial amount of old season product sent

from main warehouse, plus the amount of new season and old season products hanged in that period, minus the amount of new season and old season products sold in that period.

(19) *The hanging capacity required for the amount of old season products hanged on remained to the next period should not exceed the hanging capacity of the shopping area of a store location.*

(20) *The hanging capacity required for the amount of old season products hanged on remained to the next period should utilize more than the minimum level for utilization of hanging capacity of the shopping area of a store location.*

(21) *The sales amount of a new season product can't exceed a predefined maximum percentage of the amount of new season products hanged in the shopping area of a store at a period.*

(22) *The sales amount of old season product can't exceed a predefined maximum percentage of the amount of old season products hanged on left in the shopping area of the store from the previous period plus the amount of old season products hanged in the shopping area of the store in that period.*

(23) *The sales amount of old season product in the first period can't exceed a predefined maximum percentage of the initial amount of old season products hanged on left in the shopping area of the store at the beginning of the first period plus the amount of old season products hanged in the shopping area of the store in that period.*

(24) *In a newly opened store, the initial amount of old season products to be sent from the main warehouse at the beginning of the first period is determined by the minimum hanging capacity to be utilized in the store.*

(25) *In order to sell any new season or old season product from a store location, a store should exist (either newly opened, or renewed, or kept on operating as it is) in that alternative location.*

(26) *In a district, total sales amount of both old season and new season products of all alternative store locations cannot exceed estimated sales potential in any period.*

(27) *The average amount of the stocks in the system is equal to the average of beginning and ending stocks in Main Warehouse and Store Warehouses in a period.*

(28) At the last period, the average amount of the stocks in the system is equal to the sum of beginning stocks in the main warehouse and store warehouses plus the half of the difference between the total amount of the products produced and the total amount of products hanged in the shopping areas of the stores.

(29) The average amount of products hanged in the shopping area of stores in a period is equal to the sum of the average of beginning and ending period amount of products hanged in the shopping area of stores.

(30) The average amount of products hanged in the shopping area of stores in the first period is equal to the sum of the average of initial amount of old season products and ending amount of old season products hanged in the shopping area of stores.

(31) In a store location, either an existing store can be closed, renewed or kept on operating as it is or a non-existing store location can be opened newly or continued as non-existing in the planning horizon.

(32) Only at non-existing store locations a new store can be opened.

(33) In order to close an existing store, the age of the store should be greater than or equal to the minimum age for closing a store.

(34) A store should be renewed periodically at some ages. If an existing store is required to be renewed, it is either closed or renewed.

(35) An existing store can only be kept on operating as it is.

(36) An existing store can only be renewed, closed, or kept on operating as it is in the planning horizon.

(37) In order to renew an existing store, the periodic renewing requirement should exist.

(38) The company has a maximum budget limit to be used in the costs of opening and renewing stores in a planning horizon.

CHAPTER 5

DATA ANALYSIS AND PARAMETERIZATION

A mathematical model created by taking retailing system as an integrated process approach into consideration can support all decision points in management. In reality, all processes involve outputs that comply with inputs of the said processes as well as decisions made at decision points. Mathematical models transform inputs of the processes into decisions and outputs by optimizing objective function. However, models that best reflect the system can provide accurate decision support and outputs. The underlying issue here is the accuracy of the inputs as well as the model to be used. Integrated modelling of all processes is performed in Chapter 4. In this chapter, however, data to be used as inputs for the model are obtained.

For the model to be able to produce an output, several parameters need to be obtained such as production capacity and production costs in supply chain management; hanger occupation by products and warehouse capacity in inventory management; and costs related to processes, store area and age in retailing processes. Some of the parameters like product sales price, hanger occupation by products, and warehouse capacity already exist in the company that will use the model. As obtaining certain inputs like product and retailing costs exceeds the scope and extent of this study, the solution is obtained by assuming that such data are already known. On the other hand, even though regional sales potential forecasts are not the subject matter of this thesis, they are forecasted via certain statistical methods under the following headers since they are difficult to obtain and critical for modeling. The sales data of product groups for 2015 are taken from the mentioned company. Minitab 16, MS Access 2016, and Java Development Kit version 1.8.0 are used for analysis and data gathering.

The mathematical programming model presented in this study is solved with calculations for a period of one year. In cases where stores, especially with high investment costs required in the coverage of sales potential, became unable to redeem themselves due to investment costs, it might become more preferable to verge towards other alternatives with lower investment costs during investment decisions taken in a period of one year. However, this occurs when investment costs overwhelm annual turnover and profits. Considering the investment costs of the store where the investment is made, it would begin to fail in a year as it becomes unable to redeem itself. Such cases necessitate solutions further in the long-term. In that case, due to extension of term for solutions in parameters such as sales potential and production capacity, inputs with higher error will be obtained. Besides, since factors that can change in the short run are considered for long-run decisions, the efficiency of the results will decrease. On the other hand, store investment costs have little share in retail processes compared to annual turnover and profits made through the store.

This case is presented in **Table 1** through an approximate calculation of 30% gross profit in 1, 2, 3, 4, and 5 year solutions for the considered company.

Table 1 Net Profit through an Approximate Calculation of 30% Gross Profit in 1, 2, 3, 4, and 5 Year Solutions for Alternative Districts

Alternative District	Revenue	Gross Profit (%30)	Capital Cost of Investment	Net Profit(Gross Profit - Capital Cost)				
				Solution for 1 Year	Solution for 2 Years	Solution for 3 Years	Solution for 4 Years	Solution for 5 Years
1	2,000,000	600,000	97,562	502,438	1,102,438	1,702,438	2,302,438	2,902,438
2	1,000,000	300,000	79,245	220,755	520,755	820,755	1,120,755	1,420,755
3	500,000	150,000	64,367	85,633	235,633	385,633	535,633	685,633
4	250,000	75,000	52,282	22,718	97,718	172,718	247,718	322,718

Table 1 reveals the detail that bestselling store alternatives will bring more profits in any way as long as gross profit redeems the investment cost within the first year.

Table 2 shows results through and approximate calculation for the case of financial loss with 1-year gross profit overwhelmed by investment costs.

Table 2 Net Profit through an Approximate Calculation of 2.5% Gross Profit in 1, 2, 3, 4, and 5 Year Solutions for Alternative Districts

Alternative District	Revenue	Gross Profit (%2,5)	Capital Cost of Investment	Net Profit(Gross Profit - Capital Cost)				
				Solution for 1 Year	Solution for 2 Years	Solution for 3 Years	Solution for 4 Years	Solution for 5 Years
1	2.000.000	50.000	97.562	-47.562	2.438	52.438	102.438	152.438
2	1.000.000	25.000	79.245	-54.245	-29.245	-4.245	20.755	45.755
3	500.000	12.500	64.367	-51.867	-39.367	-26.867	-14.367	-1.867
4	250.000	6.250	52.282	-46.032	-39.782	-33.532	-27.282	-21.032

As can be seen from **Table 2**, the 4th alternative made the least total of financial loss compared to all other alternatives in the 1-year solution obtained by 2.5% gross profit so that the model will choose it to open. Yet, looking from the long-term perspective results, it can be observed that all other alternatives are more profitable. However, this can only occur when the gross profit obtained during the solution is overwhelmed by investment costs while the investment becomes irredeemable as in factory, facility, dam, or bridge construction investments. As shown in **Table 1**, the store's annual gross profit is far from the store investment costs in retail chains. As a result, failure will be out of the question in the choice of store for solutions obtained over one year. In this way, all parameters and solutions are obtained over one year.

5.1. FORECASTING SALE POTENTIALS OF PRODUCT GROUPS

In forecasting sales potential, generally accepted methods already exist. Especially in forecasting sales by using past sales data, techniques such as "n-moving average" and "exponential smoothing technique" are utilized. Forecasting sales potential for regions without sales data becomes albeit more difficult. At that point, companies can conduct forecasts based on their own observations and experience. They determine new sales points as well as sales quantities based on sales quantities in existing regions. For a more scientific method, regression models that associate data such as regional population, development index, and distribution income can also be established. Notwithstanding the reality that this problem does not have one single solution, certain statistical methods and approaches are used in this chapter as a solution to the problem.

It is clear there is a direct relationship between sales potential of products and regional population. Additionally, it also depends on population density, regional distribution of income, spending culture, the potential of customers coming from other regions, and many other factors, as well. It can even be associated with Google search volumes in the region. Hence, the correlation between the company's sales data from 2015 and population, population density, clothing expenditures, per capita income from 2015 as well as 2014 development index of provinces collected from TÜİK (Turkish Institute of Statistics) website are first investigated as presented in **Table 3**. Moreover, the correlation between sales data and 2015 search volumes of related keywords from Google AdWords for products of the considered company is also analyzed.

It can be seen from **Table 3** that the highest correlation is around keyword search volumes on Google, followed by population of women, total population, and SEGE 2014 index. The correlation between population of women and total population is so high that the correlation results have the same values. Population density seems to be less related to sales compared to other factors. On the other hand, no meaningful correlation was found between per capita income and sales. With a regression analysis established with three highly correlated variables, it is possible to forecast total sales in the province. However, these three variables are directly associated with each other, having correlation higher than 95%. Minitab results are given in **Appendix 3**.

Table 3 Correlation Coefficients between Factors and 2015 Sales

Factor	**Correlation Coefficient**
Amount of Average Monthly Key Words Searching Value on Google in 2015	**0.87***
Women Populations in 2015	**0.82***
Populations in 2015	**0.82***
SEGE - 2014 Index	**0.80***
Population Density	0.68*
Clothing Expenditure Rate for Province in 2015	0.31**
Average National Income per Capita in 2015	0.06
Sege - 2014 Index Sequencing	-0.26**

*, ** indicates significance at the 0.01, 0.05 level; respectively.

Population data form the basis in the calculation of SEGE data. Pursuant to province-based observations, population of women is half the total population with ratio differences of around one in a thousand. Further, Google keyword search volumes are directly related to regional population. In effect, these three factors altogether cannot be used as explanatory variables in the regression analysis since it will cause multi-collinearity problem. As the other two variables can be used separately in the regression analysis, it seems logical to utilize from Google search volume values in the regression analysis as an explanatory variable. One of the fundamental aspects of sales potential forecasting problems is the necessity to obtain sales estimates within smaller fractions of provinces instead of basing it on the entire province. At this point, central and peripheral districts of provinces can form the basis. Approaching to the problem from this perspective reveals that, Google search volumes can be obtained based on provinces not districts, as well whether Google data or other data such as population are utilized, a forecast based on a regression model that uses any directly obtainable value of the district as explanatory variable will lead to fallacies since potential customers of a district also interact with other districts as can be seen from **Figure 7**.

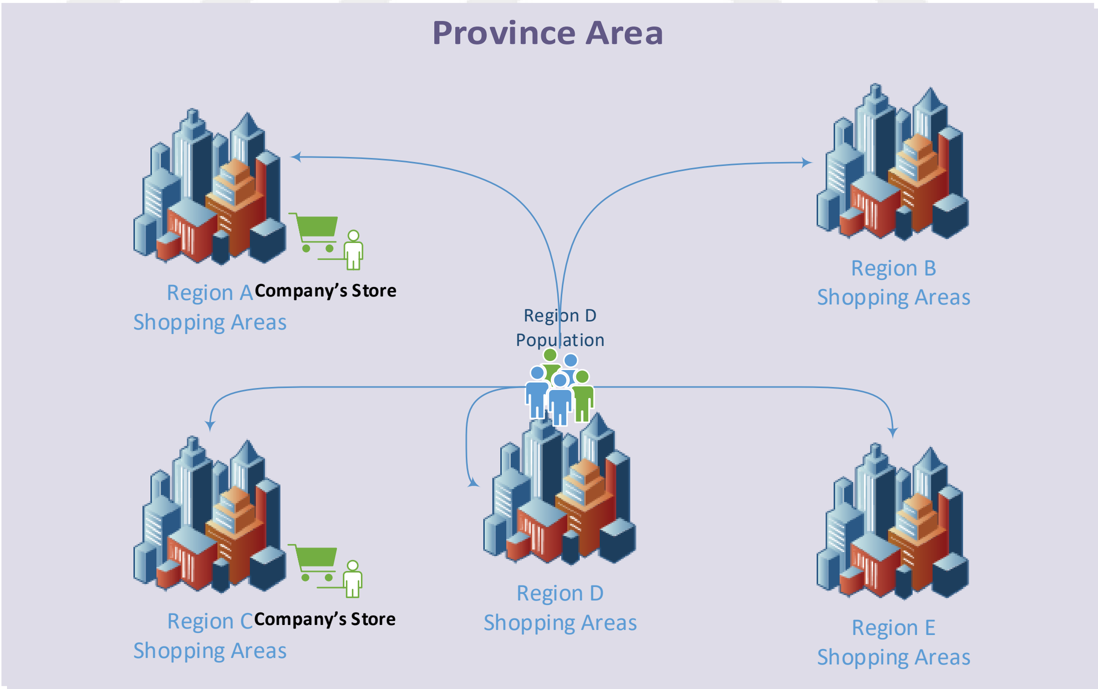

Figure 7 Customer Choices of Shopping within a Province

Even in cases where province-based estimations will suffice, there may not be a store/sales point in districts within provincial borders. Stores/sales points may be found in almost all districts of a province whereas a store/sales point maybe found in only one district of another province. In such cases, revealing the relationship between provincial sales and an explanatory variable while forecasting will bolster erroneous results. As mentioned earlier, a forecast that solely considers a direct variable of districts where a store exists will lead to erroneous results without taking into consideration the potential interaction with other districts or potential sales from other districts.

Consequently, the most direct variable that has an impact on a sale to be forecast is population within this framework. Population of a district cannot be a factor solely by itself. The variable that must be solidified here is how much of the population constitutes potential for the products in question, how much of this potential would prefer other districts, and how much of the potential population in other districts would prefer this district for shopping. Collating these four variables after designation based on districts would enable the use of this variable as an explanatory variable in the forecasting model.

Huff's gravity method explains a customer's likelihood to prefer a region to be inversely proportional to the power function of customer's location's distance to shopping areas, whereas directly proportional to the attraction of the shopping area. The likelihood of customers in each region to prefer their own or other regions can be found via this approach. Goodchild (1984) and Drezner (2014) use the distribution of population by these probabilities to obtain the sales potential of each region.

In total, the first 25 of the 926 districts are given in **Appendix 4** in alphabetical order for provinces together with their population data. Distances of the districts within provincial boundaries are taken from Google Maps Server by running a java code given in **Appendix 5** as an example. Coordinate data to retrieve distances among districts from Google Maps is obtained from the website of General Directorate of Highways of the Republic of Turkey. Obtained top 25 distances are given in **Appendix 6**. As the calculation of shopping attraction of a district can be performed via total shopping area in that district on sectoral basis, considering the fact it would exceed the scope of this thesis and that population is the most meaningful data on level of development, population of the district is assumed to be the parameter of attraction in this study. A customer's shopping outside their province is neglected and it is assumed that they shop only within their provincial boundaries. Moreover, attraction parameter of districts with populations lower than 30 thousand are considered as 0 and λ in equation (3.3) is taken as 2 to calculate preference probabilities of 926 districts and the parameter named as Huff's parameter through the analysis from now on are obtained from equation (3.6).

In the light of the obtained data and the assumptions, steps of calculating Huff's parameter on Çorum are given in **Tables 4-6** as an example. In order to get a clearer picture of the results on Çorum, distances of the regions to each other are calculated manually with the help of Google Maps and given in **Table 4** together with their population information.

Table 4 Distances among districts of Çorum and their population data

		CENTER OF CORUM	**İSKİLİP**	**OSMANCIK**	**SUNGURLU**
Populations		280,631	33,812	43,469	50,214
Attraction		280,631	33,812	43,469	50,214
District	**Population**		**Distance**		
MERKEZ	280,631	12	56	59	72
ALACA	29,669	54	110	115	75
BAYAT	17,728	45	44	74	52
BOĞAZKALE	3,867	87	118	145	60
DODURGA	6,066	42	45	37	117
İSKİLİP	33,812	56	7	61	83
KARGI	15,441	106	51	43	203
LAÇİN	4,829	29	57	44	117
MECİTÖZÜ	15,714	36	91	93	96
OĞUZLAR	5,631	68	38	44	103
ORTAKÖY	8,371	57	137	143	79
OSMANCIK	43,469	59	61	7	173
SUNGURLU	50,214	72	83	173	8
UĞURLUDAĞ	6,738	63	57	103	43

The province of Çorum has four districts that can attract as a sales point in accordance with **Table 4** as districts with populations lower than 30,000 are considered to have an attraction parameter of 0: Çorum centrum, İskilip, Osmancık, and Sungurlu. In light of the data, the likelihoods that a customer in a district would prefer attractive districts calculated from equation (3.3) are given in **Table 5**.

For instance, the likelihood of a customer, who resides in Alaca, of preferring Çorum centrum is calculated as $\frac{\frac{280{,}631}{54^2}}{\frac{280{,}631}{54^2}+\frac{33{,}812}{110^2}+\frac{43{,}469}{115^2}+\frac{50{,}214}{75^2}} = 0.87$. As can be clearly seen from **Table 5**, the likelihood of someone from Çorum centrum to prefer another district for shopping is very low. However, as can be seen from the İskilip example, even if the likelihood of a district to be preferred by its own population is at the highest, the probability for that population to prefer centrum due to high sales attraction is higher than other districts being preferred by customers. The probability of customers in a district with no sales attraction to prefer another district varies based on attraction (or in other words, population) as well as distance to that district.

Table 5 Customer's Probability of Choosing a Shopping Area in Çorum

	CENTER OF ÇORUM	İSKİLİP	OSMANCIK	SUNGURLU
MERKEZ	0.983	0.005	0.006	0.005
ALACA	0.867	0.025	0.029	0.079
BAYAT	0.759	0.096	0.043	0.102
BOĞAZKALE	0.668	0.044	0.037	0.251
DODURGA	0.753	0.079	0.150	0.017
İSKİLİP	0.112	0.864	0.015	0.009
KARGI	0.398	0.207	0.375	0.019
LAÇİN	0.901	0.028	0.061	0.010
MECİTÖZÜ	0.937	0.018	0.022	0.024
OĞUZLAR	0.545	0.210	0.202	0.043
ORTAKÖY	0.878	0.018	0.022	0.082
OSMANCIK	0.082	0.009	0.907	0.002
SUNGURLU	0.064	0.006	0.002	0.928
UĞURLUDAĞ	0.629	0.093	0.036	0.242

Distribution of Huff's parameters obtained by multiplying probabilities given in **Table 5** with population is presented in **Table 6**. As the forecast also suggests, Çorum centrum has the highest value of parameter in total. Sungurlu stands as the second candidate, while İskilip is found to display the lowest attraction. Similarly, by performing the same operation on provincial basis, Huff's parameters are calculated for each district.

Table 6 Huff's Parameters for Districts of Çorum

	Population	CENTER OF ÇORUM	İSKİLİP	OSMANCIK	SUNGURLU
MERKEZ	280,631	275,964	1,527	1,768	1,372
ALACA	29,669	25,712	737	867	2,354
BAYAT	17,728	13,458	1,696	771	1,803
BOĞAZKALE	3,867	2,582	169	144	972
DODURGA	6,066	4,569	480	912	105
İSKİLİP	33,812	3,789	29,219	495	309
KARGI	15,441	6,150	3,201	5,789	300
LAÇİN	4,829	4,353	136	293	48
MECİTÖZÜ	15,714	14,724	278	342	370
OĞUZLAR	5,631	3,071	1,185	1,136	239
ORTAKÖY	8,371	7,352	153	181	685
OSMANCIK	43,469	3,581	404	39,409	75
SUNGURLU	50,214	3,217	292	86	46,619
UĞURLUDAĞ	6,738	4,240	624	246	1,628
TOTAL	522,180	372,762	40,100	52,439	56,879

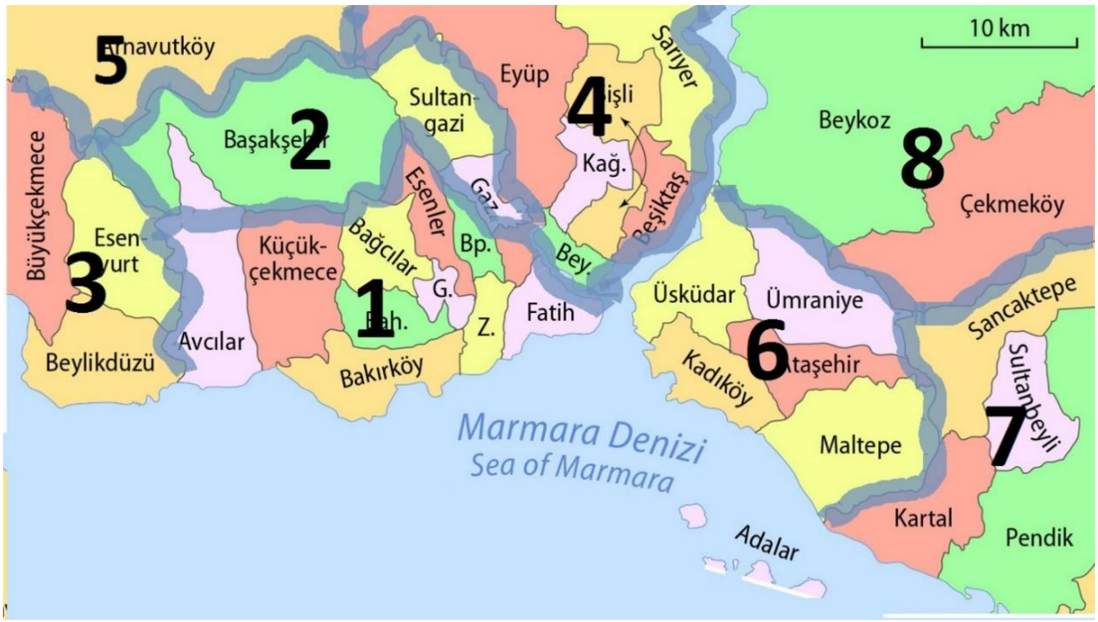

Figure 8 Created Regions of İstanbul

However, considering the fact that the number of districts in İstanbul is quite high with especially mixed up boundaries, they are grouped as shown in **Figure 8** while performing related calculations. The reason being is that a customer can take a 500 meter walk to go to another district for shopping. For instance, a customer may comfortably transit to the district of Zeytinburnu by walk after shopping in the district of Fatih. Such a customer is able to complete her shopping in multiple districts in one single trip. In this case, utilizing from Huff's parameter on districts will result in faulty calculation. Hence the districts are grouped and separated into regions. The considered company does not operate a store in every region of İstanbul. When referring to districts from now on, we mean the above-mentioned regions in İstanbul covering such districts in order to avoid ambiguity.

Table 7 Huff's Parameters and Total Sales in Districts Where Company has Stores

NO	CITY	DISTRICTS	HUFF'S PARAMETERS	SALES
1	AFYON	AFYON	357,448	12,567
2	ANKARA	ÇANKAYA	996,366	27,594
3	ANKARA	KEÇİÖREN	930,882	29,848
4	ANKARA	MAMAK	585,539	14,907
5	ANKARA	YENİMAHALLE	791,546	30,985
6	ANTALYA	MURATPAŞA	476,697	14,553
7	BURSA	OSMANGAZİ	1,953,000	68,769
8	ÇORUM	ÇORUM	341,032	18,731
9	DENİZLİ	MERKEZEFENDİ	737,815	27,553
10	ESKİŞEHİR	ODUNPAZARI	477,162	17,069
11	KAHRAMANMARAŞ	ONİKİŞUBAT	633,142	12,699
12	KAYSERİ	MELİKGAZİ	634,303	23,712
13	KÜTAHYA	KÜTAHYA	299,713	11,426
14	MALATYA	BATTALGAZİ	530,378	16,496
15	SAMSUN	İLKADIM	563,000	16,978
16	SİVAS	SİVAS	520,805	26,076
17	BİLECİK	BOZÜYÜK	102,118	5,613
18	İSTANBUL	İST1	4,829,836	95,040
19	İSTANBUL	İST2	1,198,621	21,639
20	İSTANBUL	İST3	1,280,998	12,839
21	İSTANBUL	İST6	2,479,218	52,237
22	İSTANBUL	İST7	1,959,455	34,293

Districts where stores of the considered company are located, total sales quantities by piece in these districts, and the calculated Huff's parameters are presented in **Table 7**. İstanbul Region 1 has the highest Huff's parameter value, where districts such as Fatih, Zeytinburnu, and Bağcılar are located. The highest quantity of sales is also made in this region. Once again, with its lower parameter value, Bozüyük has the lowest sales quantity. In addition, obtaining the Huff's parameter from Google Maps servers for Çorum centrum in **Table 7** by using Java code reveals incidental differences compared to the Huff's parameter calculated with manually-obtained data given in **Table 6**.

By utilizing from the data in **Table 7**, total sales are modelled via basic linear regression method with Huff's parameter as an explanatory variable. It is seen that the regression model explains 83% of the variance in sales ($R^2(adj) = .83,\ F = 103.6\ p < .001$). Further, as the model is to be used in the sales forecast of new sales points where the company does not operate any, it will be required to well-determine how successful it forecasts sales in a new region. For this purpose, the predicted R^2 value is calculated by taking out a datum from the data set and predicting this data from the model for each data points. It is observed that the predicted R^2 value of the model is high (81%). Therefore, it is found that Huff's parameter can remarkably forecast sales ($\beta = .0184,\ p < .001$). The equation that explains sales via Huff's parameter is

$$Total\ Sales = 7961 + 0.0184 \times Huff'sParameter. \tag{5.3}$$

Afterwards, whether the regression has a constant variance and the residuals are distributed normally are investigated. Since the data set is cross-sectional, no autocorrelation is expected. When the residuals are examined, it is observed that residuals obtained from Bursa and İstanbul 3 are unusual. This can also be observed from the normal probability plot given in **Figure 9**.

Then, the regression analyzes are re-calculated without these unusual observations. Minitab results of regression analysis for both cases are presented in **Appendix 7 and 8**, respectively.

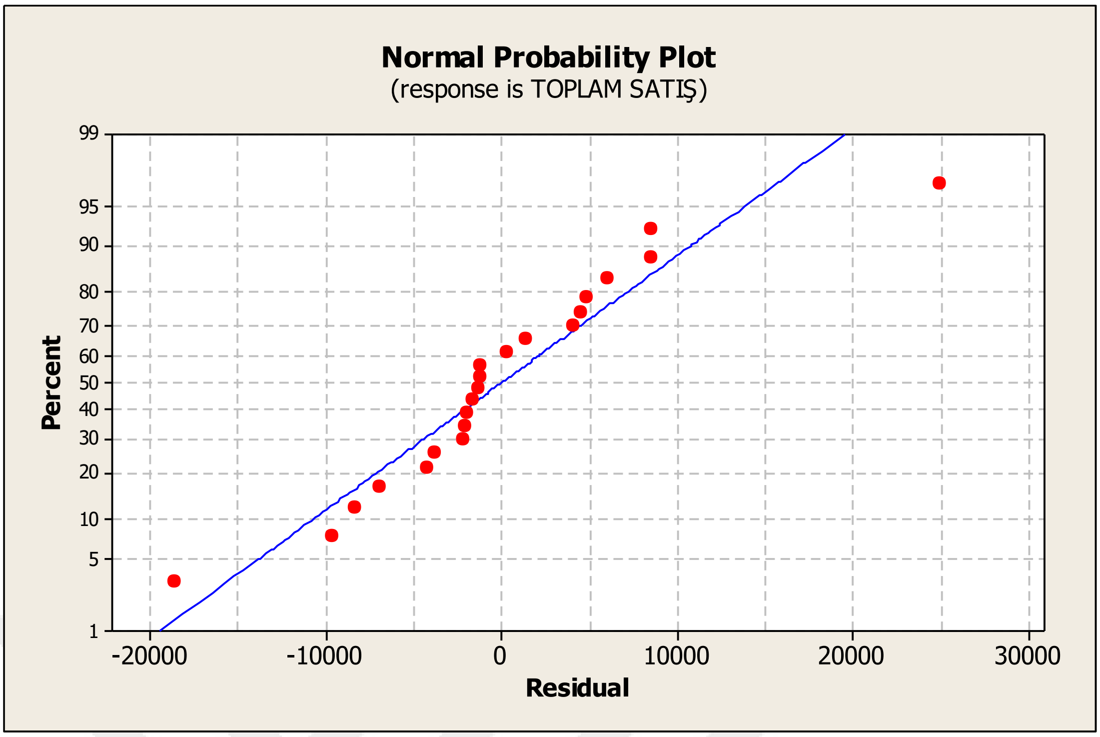

Figure 9 Normal Probability Plot of Residuals

The Simple Linear Regression analysis conducted by removing unusual observations reveals that the model explains 93% of the variance in sales ($R^2(adj) = .93, F = 245.0\ p < .001$). It is also observed that the predicted R^2 value is increased to 91%. Once again in this analysis, Huff's parameter succeeds to forecast sales remarkably ($\beta = .0175,\ p < .001$). The fitted equation is

$$Total\ Sales = 8485 + 0.0175 \times Huff'sParameter. \qquad (5.4)$$

As can be seen from the normality plot given in **Figure 10**, no more unusual values exist while normality assumption seems appropriate. Next, standardized residuals versus fitted values are plotted to examine the appropriateness of constant variance assumption. The plot is given in **Figure 11**.

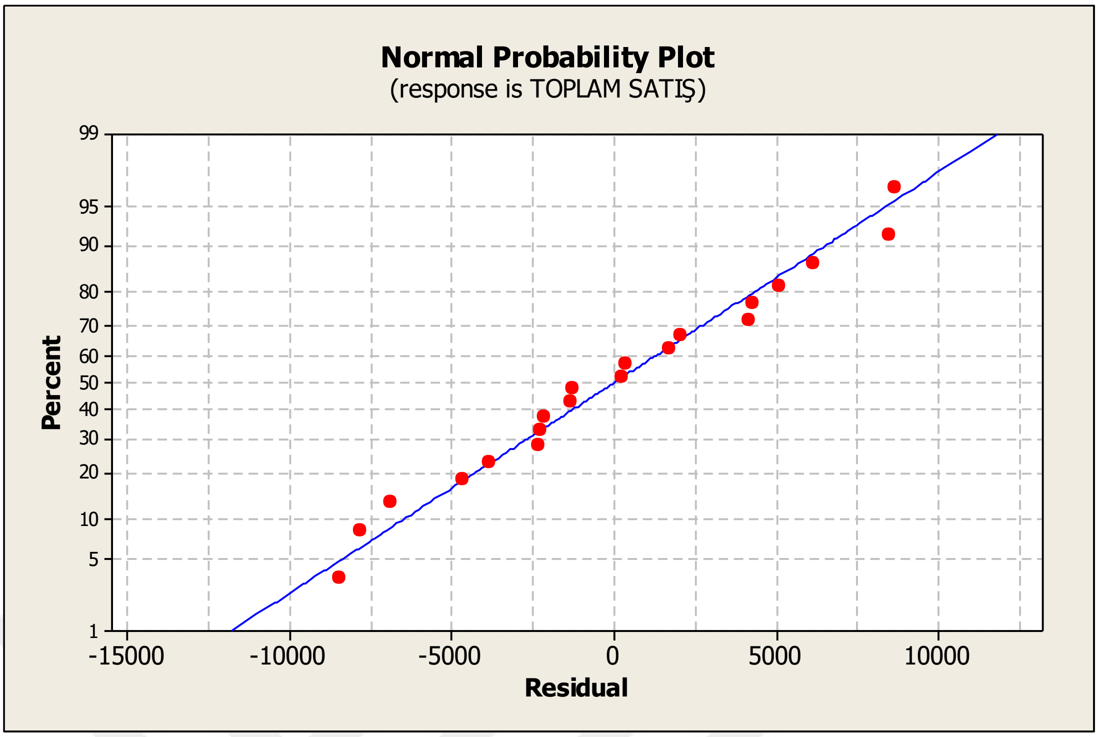

Figure 10 Normal Probability Plot of Residuals without Unusual Observations

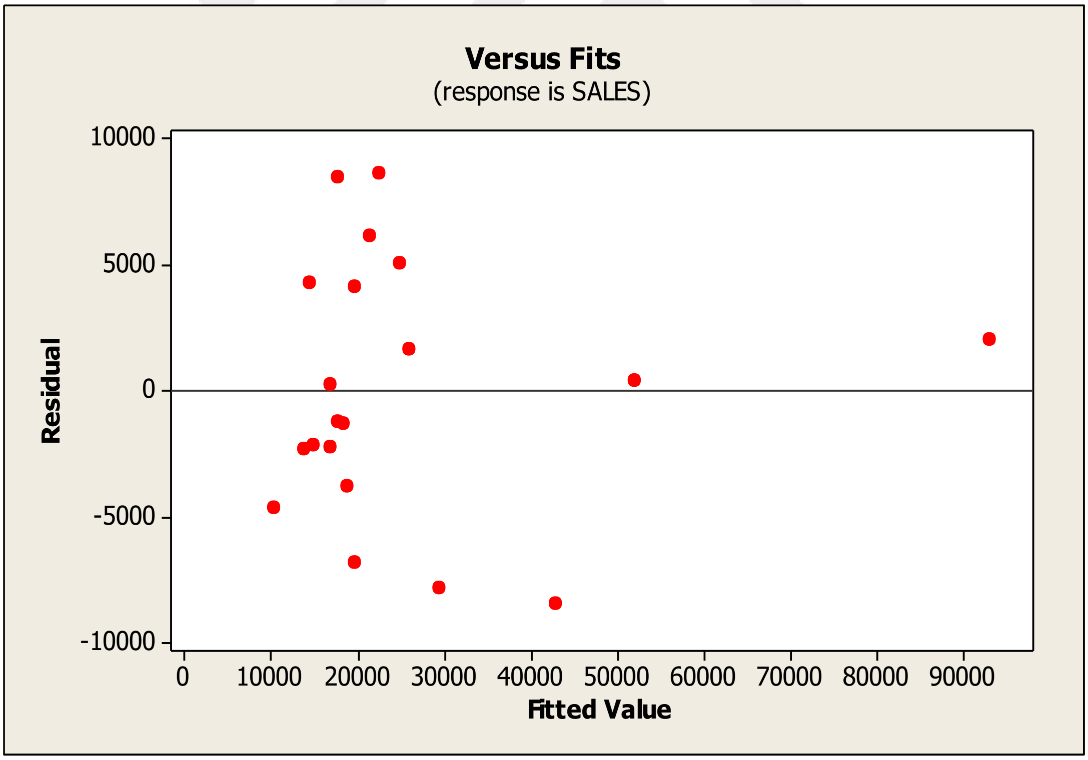

Figure 11 Residuals vs Fits for Sales

It can be seen from **Figure 11** that there is no pattern indicating no violation of constant variance.

It is understood via all these analyzes that Huff's parameter can be utilized in forecasting sales. Naturally, by analyzing in detail each shopping area with sales attraction based on industry, the total shopping area at these points as well as their distances to potential customer regions, the model can further be enhanced. Advanced geographical data systems at present make it possible to collect such data. The method can be considered successful at this stage while it seems to be useful to further enhance the model in the mentioned way in future studies.

Table 8 Product Groups

Group Num.	Product Groups
1	Trousers-Skirt Group
2	Shirt Group
3	Tunic Group
4	Summer Topcoat Group
5	Winter Topcoat Group
6	Scarf Group
7	Waist Group
8	Fast Wear Group
9	Surcoat Group
10	Topcoat
11	Various Products

The model requires sales potentials of product groups given in **Table 8** as inputs. In that case, Huff's parameters should be used in forecasting sales for product groups. Results of the regression analysis that uses Huff's parameter as an explanatory variable in modeling sales for product groups are given in **Table 9**.

As seen in **Table 9**, similar results to regression analyzes performed on total sales are obtained as expected. Minitab outputs of these analyzes are presented in **Appendix 9**. Again, the model assumptions are checked and found that they are unviolated. All results indicate that Huff's parameter has a high significance in explaining sales of product groups. First 25 predicted values calculated via the obtained regression model are presented in **Appendix 10**.

Table 9 Regression Results by Product Groups

Sales of	Constant	Huff's Parameter	Adjusted R^2	Prediction R^2	F-value
Group 1	1,791.3* (503.2)	0.0032* (0.0003)	0.803	0.750	86.35*
Group 2	692* (177.6)	0.0011* (0.0001)	0.804	0.774	87.12*
Group 3	966.6* (273.6)	0.0017* (0.0001)	0.797	0.765	83.22*
Group 4	731.4** (323.7)	0.0024* (0.0002)	0.848	0.834	118.02*
Group 5	410.9** (181.7)	0.0011* (0.0001)	0.800	0.782	84.75*
Group 6	456.4** (230.3)	0.0024* (0.0001)	0.919	0.847	238.33*
Group 7	196.44* (59.34)	0.0002* (0.00004)	0.677	0.626	44.97*
Group 8	286.6** (107.1)	0.0006* (0.00007)	0.761	0.724	67.73*
Group 9	143.79* (42.38)	0.0002* (0.00003)	0.722	0.691	55.57*
Group 10	54.13** (20.92)	0.0001* (0.0001)	0.756	0.730	66.04*
Group 11	2,494** (1039)	0.0048* (0.0007)	0.703	0.668	48.25*

*, ** indicates significance at the 0.01, 0.05 level; respectively.

As the company data are on annual basis, sales can be forecast annually via these models. Yet the model requires seasonal sales quantities. Examining product groups reveals that some of them can be used in every season whereas others involve seasonality. Within this context, annual sales potential forecasts for product groups numbered 6, 7, 8, 10, and 11 that show no seasonality can be converted to quarterly forecasts by simply dividing into 4, whereas seasonal fluctuations in other products have to be included in the calculation. Therefore, conversion of the annual sales potential predictions for such product groups into seasonal sales is described in the following section.

5.1.1. Seasonal Decomposition of Sales

The data analyzed for seasonality belong to certain stores operated by the company since establishment. These stores are chosen on grounds of their achieved recognition, satisfaction, and potential. Additionally, the reason to choose these stores is also influenced by the availability of their sales data for a few years back. These data belong to several stores in Ankara, Bursa, Denizli, and İstanbul. Sales seasonally vary for certain product groups as can also be seen from the **Figure 12**.

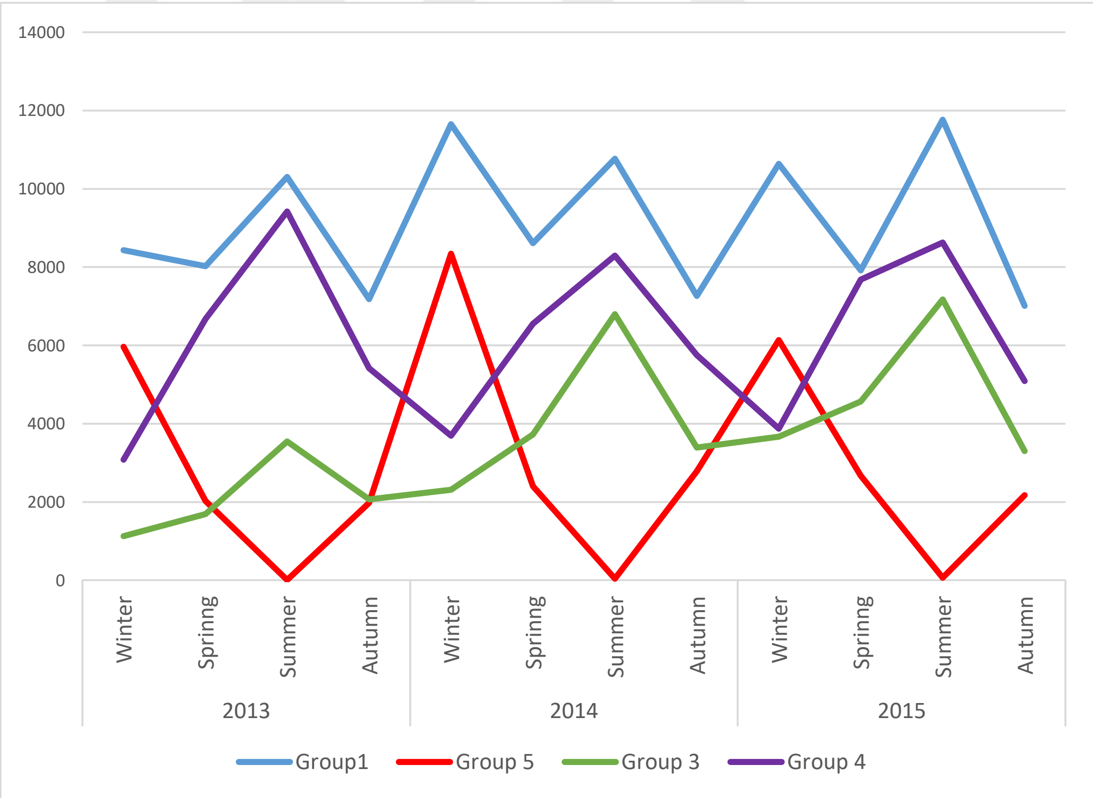

Figure 12 Time Series Plot of Quarterly Sales for Product Groups 1, 3, 4 and 5

Seasonal indices are calculated for each product group to decompose annual data into quarterly data. To calculate these indices, sales data are decomposed into their components. A time series can be represented as a function of its components as

$$Y_t = f(S_t, T_t, I_t, C_t) \tag{5.5}$$

where

$Y_t = the\ time\ series\ value\ at\ time\ period\ t$

$S_t = the\ seasonal\ component\ at\ time\ period\ t$

$T_t = the\ trend\ cycle\ component\ at\ time\ period\ t$

$I_t = the\ irregular\ component\ at\ time\ period\ t$

$C_t = the\ cyclical\ component\ at\ time\ period\ t.$

The exact functional form depends on the decomposition model actually used. There are two common approaches:

(i) Additive Model:
is appropriate if the magnitude of the seasonal fluctuation does not vary with the level of the series. Formulation of additive model approach is

$$Y_t = S_t + T_t + I_t. \tag{5.6}$$

(ii) Multiplicative Model:
is more prevalent with the time series which have seasonal variation that increases with the level of the series. Formulation of multiplicative model approach is

$$Y_t = TC_t \times S_t \times I_t. \tag{5.7}$$

The seasonal indexes for additive models can be obtained as follows:

Step 1: Compute the trend-cycle component (T_t).

If n is an even number, the trend-cycle component is computed by using a 2m moving average to obtain $\hat{T}_t$. If n is an odd number it is computed by using an m moving average to obtain $\hat{T}_t$.

Step 2: Calculate the de-trended series as

$$S_t + I_t = Y_t - T_t$$

Step 3: Estimate the seasonal component by simply averaging the de-trended values for that season $\hat{S}_n$.

The seasonal indexes for multiplicative models can be obtained as follows:

Step 1: Compute the moving average (MA) as

$$MA_t = \frac{Y_{t-n/2} + .. + Y_t + .. + Y_{t+\frac{n}{2}-1}}{n}$$

Step 2: Compute centered moving average (CMA) as

$$CMA_t = \frac{MA_t + MA_{t+1}}{2}$$

Step 3: Calculate the de-trended series as

$$S_t \times I_t = Y_t \div CMA_t$$

Step 4: Find seasonal estimate (i.e. seasonal indices)

(i) Sum the seasonal variation according to the respective season, Then find average seasonal estimates($\hat{S}_n$).

$$\hat{S}_n = \sum_t^T S_t \times I_t \qquad \forall\, t \equiv n(mod\ N)$$

(ii) Compute the normalization factor

$$Normalization\ Factor = {}^{N}\!/_{\sum_n^N \hat{S}_n}$$

(iii) Make final seasonal indices

$$S_t = \hat{S}_n \times Normalization\ Factor$$

Implementing both methods, it was investigated which yields the better result and observed that they produce values quite similar to each other. See **Figures 13 and 14** as examples. Therefore, both models can be used to produce seasonality indices. In this study, multiplicative model is preferred since it gives slightly better results in terms of MSE in most of the cases.

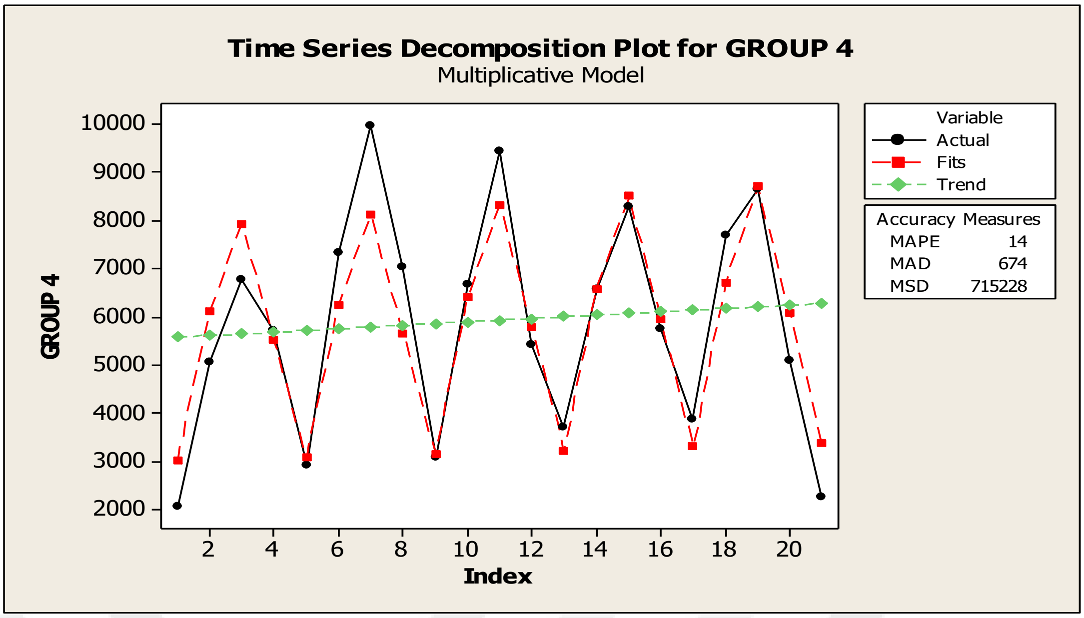

Figure 13 Multiplicative Decomposition of Product Group 4

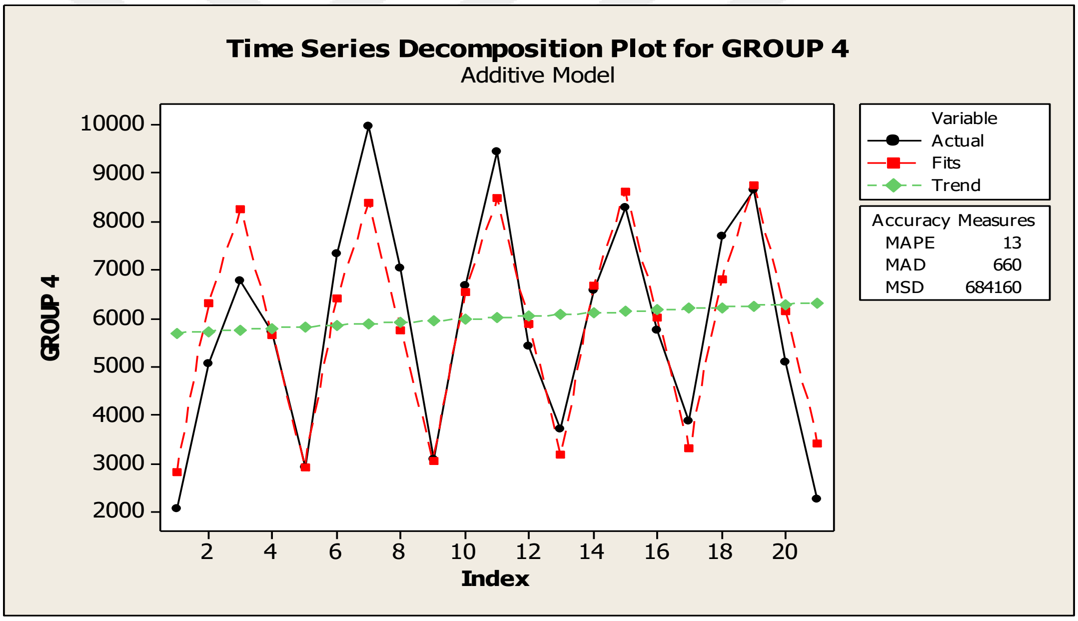

Figure 14 Additive Decomposition of Product Group 4

Seasonal indices obtained for each product group are presented in **Table 10**.

As can be seen from **Table 10**, seasonal index values for product groups numbered 6, 7, 8, 10, and 11 are 1. In other words, they do not display any seasonality. Annual sales values predictions via Huff's parameters are converted into quarterly sales data by using related indices. For instance, as given in **Appendix 10**, yearly sales potential of product group 4 is predicted to be 12,470 for Region 1 of İstanbul by using regression model. By the use of seasonal indices given in **Table 10**, this annual value is disaggregated into quarters as given in **Table 11**. Top 25 quarterly sale predictions of product groups are given in **Appendix 11**.

Table 10 Seasonal Indices of Product Groups

	Periods			
	1	**2**	**3**	**4**
Group 1	0.96	0.92	1.25	0.88
Group 2	0.75	0.98	1.45	0.83
Group 3	0.78	0.96	1.56	0.71
Group 4	0.60	1.10	1.38	0.92
Group 5	2.50	0.86	0.01	0.63
Group 6	1.00	1.00	1.00	1.00
Group 7	1.00	1.00	1.00	1.00
Group 8	1.00	1.00	1.00	1.00
Group 9	0.50	1.16	1.62	0.71
Group 10	1.00	1.00	1.00	1.00
Group 11	1.00	1.00	1.00	1.00

Table 11 Seasonal Sale Predictions of Group 4 for Region 1 in İstanbul

Group 4					
Yearly Sale Potential of Region 1 in İstanbul:					**12,470**
	Q1	**Q2**	**Q3**	**Q4**	**Total**
Seasonality Index	0.60	1.10	1.38	0.92	4.00
Index Ratio	0.15	0.28	0.35	0.23	1.00
Seasonal Sale Estimation	1,871	3,429	4,302	2,868	12,470

5.2. STORE PARAMETERS

The parameters related to stores as required by the model are as follows:

- Total cost for opening a store in an alternative store location
- Total cost for renewing an existing store
- The unit cost representing the sum of expenses per unit area for operating the store (rent, wages, cost of energy and other services etc.)
- Total area available in a store

- Hanging capacity available in a store
- Minimum hanger utilization for a store
- Maximum old/new season sales percentage for a store
- Age of stores
- Existing stores which are in renewal period
- Budget size for retail chain
- Effective interest rate per quarter.

It must be noted here that all stores (existing and new potential stores) are considered as an alternative store throughout this thesis. For existing stores, the parameter values are known for certain. The considered company prefers to open up new stores at busy and popular main streets as well as shopping malls due to branding strategy and policy. Store alternatives in compliance with the policy of the company are selected from real estate advertisement websites such as “sahibinden.com”. Ratio of available hanger capacity to total area of new stores, minimum hanging utilization, and maximum sales percentage are assumed to be equal to the ones used in existing stores. Operating costs of a new alternative store are rent and staff cost per m2. Number of staff and staff salaries are determined according to the known company’s staff policy. Number of staff should be one person for 50 m2. Opening and renewal costs per m2 are known according to company policy. Also, the company has a certain budget for growth by opening and renewing stores. Effective interest rate is assumed to be 20%. This ratio varies depending on return on the company’s investments or the cost of capital supplied by external sources. The above-mentioned parameters used in the solution of the mathematical model are presented in **Appendix 12**.

5.3. MANUFACTURING PARAMETERS

The product groups and manufacturing-related parameters needed by the model are:

- Manufacturing capacity for producing a product group in a season
- Cost factor for increasing/decreasing manufacturing capacity for producing a product group
- Maximum percentage for increasing/decreasing manufacturing capacity
- Upper/lower utilization limit for manufacturing capacity

- Average unit cost of product group i
- Average unit list price for product group
- Old/new season price discount factor
- Hanging width (cm) of a unit for products
- Unit box usage for product groups
- Initial stock amount of old season product groups in stores and warehouse

Companies tend to create production and supply plans for future periods. As with the considered company, liaison contracts are made with suppliers or subcontractors in line with these plans. In effect, manufacturing capacity set by the company for product groups, upper/lower utilization limits to extend the capacity, costs incurring when production/supply requirements are way above or below the capacity, and their limits are stereotypically known by companies. For certain retailing companies, however, there are no such policies and they are able to supply in whatever amount they require independent from any supplier. Such companies are generally businesses that do not own unique product designs or never incorporate any production stage. In these cases, solution can be provided by giving sufficiently flexible values to related parameters thanks to the flexible nature of the model. Parameters related to production are obtained from the company. These values are presented in **Appendix 12**.

Costs of product groups, list prices, new and old season discount rates over list prices, usage of box and shelves are approximately known by companies. Values of these parameters and calculation methods may vary from one company to another as well as sectors. While analyzing their processes and financial positions, companies regularly report most of the data. Certain parameters such as shelf and box usage can be obtained on the basis of product group in a measurable and exact manner. In real life cases, such data are supposed to be provided by the company. Considering the forecast of these parameters are not attempted and remain outside the scope of this thesis, solutions are obtained assuming that the data obtained from the company are realistic. All utilized data are presented in **Appendix 12**.

CHAPTER 6

MATHEMATICAL MODEL SOLUTIONS

In this chapter, the mixed-integer linear programing formulation of the model developed in Chapter 4 will be solved using the obtained parameter set in Chapter 5. We tried three different scenarios with various time value approaches for the overall profit objective using Gams optimization software. Solutions are derived for the first 50 districts in which the selected retail chain company has stores with the highest sales potentials. These districts are given in **Appendix 13**. Together with the currently operated stores in each of these districts, it is assumed that there are a total of 4 alternative store locations in each district.

In the first scenario, the current status of the model of the selected retail chain company is examined with two alternative objective functions. In the first alternative, the time value of money is considered as the future value of the overall profit (total revenue – total cost) to be computed with simple interest. In the second alternative, no time value of the money is considered. And, the obtained results are discussed for the verification with respect to current real status of the selected retail chain company. Although it is not realistic to compute the time value of the money using compounding, the derivation of the objective function is straight forward and given in the **Appendix 1**. Also, the decision support that the model supplies in the processes is discussed over the results.

In the second scenario, it is assumed that the company is not willing to grow with opening new stores. That is, the company's goal is to continue with operating the current stores. Based on this scenario, while keeping the status of the company unchanged, the values of overall expected profit, revenue and costs of the company is discussed using the solution obtained. The investment expenditures for stores is analyzed whether increased or decreased with respect to the first scenario.

The last scenario is designed in order to predict the effects of some possible threats in the near future, especially a significant decrease in the market demand, very similar to the global economic crisis realized in 2008.

With the help of this model, such risks that will appear in the future and their possible results will be analyzed before.

6.1. RESULTS UNDER SCENARIO I

The results obtained from solving the current status of the company with taking (both with simple and compound interest) and without taking the time value of money in the calculation of the profit is summarized in **Table 12**. For all three cases, the Gams solution outputs obtained are given in **Appendix 14, 15 and 16**, respectively. If the cost and revenue figures for solutions obtained using simple and compound interest are compared to each other, it is clear that there is no significant difference in between. The slight decrease in profitability with compounding is because of the timing of major cost components. These cost components located at the beginning of the planning horizon result in more cost at the end of this period as a future worth using compound interest. That leads to less profit with respect to simple interest.

Table 12 Gams Results for Current Status: Scenario I

	With Time Value Of Money (simple interest)	With Time Value Of Money (compound interest)	With No Time Value Of Money (no interest)
(+) Revenue From Store Sales	139,385,900	140,094,000	130,964,900
(-) Store Outgoings	42,477,600	42,843,400	37,426,867
(-) Capital Cost of Inventories	9,652,500	10,077,200	10,857,700
(-) Capital Cost of Investment	352,500	392,760	356,500
(-) Direct Product Cost	45,310,100	45,566,000	43,192,500
(-) Increased Manufacturing Capacity Cost	17,767	17,767	304,850
(-) Decreased Manufacturing Capacity Cost	34,511	34,727	54,043
TOTAL PROFIT	41,540,830	41,162,120	49,986,640
Corrected TOTAL PROFIT	**41,540,830**	**41,162,120**	**38,772,440**
Budget Usage	1,762,500	1,762,500	1,782,500
Total Manufacturing Amount	397,096	398,542	403,813
New Season Sale Amount	146,536	147,330	141,188
Old Season Sale Amount	285,322	285,566	298,226
Sale - Manufacturing Ration	108.8%	108.6%	108.8%

In the solution obtained with taking the time value of money in the objective, the overall profit is found to be approximately 8,5 million TL less than without taking the time value of the money in the objective, and it is realized as 41,540,830 TL. This is because, when we do not consider the time value of money in the objective, the capital cost for investing, operating, manufacturing and holding inventory is not included.

It is seen from **Table 12**, the capital cost of inventories and investments increases the profit significantly when there is no time value of money considered. Taking this into account, the total profit is corrected, and the difference between solutions becomes just the difference between future worth and present worth. When there is no time value of money considered in the objective function, the company makes more investments, in addition produces and keeps on hand more inventory. Under these conditions, the company focuses on increasing the sales.

Table 13 Selected Location Alternatives for Opening a Store by the Model

			Total Store Area And Quarterly Operating Cost Per m2 Of Alternatives							
			1st Quarter		2nd Quarter		3rd Quarter		4th Quarter	
Province	**District**	**Sale Potential**	**Area (m^2)**	**Cost (₺)**	**Area (m^2)**	**Cost (₺)**	**Area (m^2)**	**Cost (₺)**	**Area (m^2)**	**Cost (₺)**
GAZİANTEP	ŞAHİNBEY	24,399	150	786	215	747	250	705	170	783
GAZİANTEP	ŞEHİTKAMİL	22,252	215	732	300	672	205	744	170	768
ANKARA	SİNCAN	21,377	150	771	180	750	314	681	255	711
BURSA	YILDIRIM	20,576	160	774	389	636	264	687	252	699
ELAZIĞ	ELAZIĞ	17,465	220	678	566	588	581	582	275	645
İZMİR	KARABAĞLAR	16,757	120	807	240	657	185	699	300	627
İSTANBUL	İSTANBUL 8	16,272	240	642	200	660	383	594	410	597
ANTALYA	KEPEZ	16,226	120	792	240	642	320	615	186	681

Choice of both objectives

Choice of objective with time value of money

Choice of objective with no time value of money

In three objective cases, there is no closing decision for any already existing store, and all stores requiring renewal are renewed and not closed by the company in the model. Again, in the solution of all objectives, the model tries to open several new stores to alternative locations in 6 districts with the highest sales potentials where there is no existing store before. The store locations selected among the alternatives where new stores are to be opened are given in **Table 13**. There are several minor changes between store location selections among three objectives of the model. Among six alternative location selections in order to open a store, four of the selections are same between two objectives of the model. Only two of the selections are different.

As a result, we can say that, the solutions obtained from the objective with considering time value of money seems to be more realistic and meaningful. In the remaining part of the analysis, we will focus on the results obtained from the objective value in which time value of money is considered. In the solution of the first scenario with considering time value of money, the manufacturing capacity planning decisions by increasing or decreasing manufacturing capacity is given in **Table 14**.

Table 14 Manufacturing Capacity Planning Decisions for Increasing or Decreasing

Product Group	Periods											
	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter		
	Man. Level	Inc. Ratio	Dec. Ratio	Man. Level	Inc. Ratio	Dec. Ratio	Man. Level	Inc. Ratio	Dec. Ratio	Man. Level	Inc. Ratio	Dec. Ratio
1	1.20			1.05			1.20			1.20		
2	1.15			0.89			0.80			1.20		
3	1.01			1.00			1.05			0.80		
4	0.88			1.02			1.01			1.01		
5	0.80			0.80			0.80			1.20		
6	1.00			1.00			1.04			0.80		
7	0.80			0.80			1.20			1.20	0.20	
8	0.86			0.80			1.20			1.20	0.20	
9	0.80			0.99			1.11			0.80		0.20
10	1.09			0.80			0.80			1.19		
11	0.80		0.20	0.80			0.80			1.09		

It is observed that the manufacturing levels and increasing or decreasing manufacturing capacity ratios do not exceed their limits. That is, if the manufacturing capacity increase ratio is set to a non-zero value (0.2), the manufacturing level is set to the upper capacity limit (1.2) and if the manufacturing capacity decrease ratio is set to a non-zero value (0.2), the manufacturing level is set to the lower capacity limit (0.8).

Thus, the model seems to be valid and it gives acceptable solutions for the integrated decision support. In order to see overall results, the model is solved for all districts. But, the decision alternatives related to retail chain management, and capacity, production and shipment planning decisions are not significantly affected. Since, the model is trying to open stores in districts with the highest sales potential and also, there is a limited budget for store investments. This way, the model restricts the decisions related to the store location alternatives with the first 35 districts.

The solutions related to manufacturing capacity planning are summarized in **Table 15**. In order to satisfy the demand, the company produces between the upper and lower capacity limits, more than the upper or less than the lower capacity limits. If you consider product group 11 as an example, the amount of new season and old season sales realized as a total of 6,200 units in the first period together with a high amount of old season products on hand from the same group, the regular manufacturing capacity level of 11,000 units becomes very high for the first period. As it can be seen from **Table 15**, the model tries to balance the amount of production with 6,600 units by utilizing the manufacturing capacity even less than the lower capacity limit with incurring the cost of decreasing manufacturing capacity.

Table 15 Manufacturing Capacity Parameters and Manufacturing Amount

Product Group	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter	
	Manuf. Capacity	Manuf. Capacity	Manuf. Capacity	Manuf. Capacity	Manuf. Capacity	Manuf. Capacity	Manuf. Capacity	Manuf. Capacity
1	13,607	16,329	10,496	11,021	15,360	18,432	17,354	20,825
2	4,599	5,281	7,303	6,498	8,699	6,959	8,978	10,774
3	14,080	14,238	23,273	23,199	16,364	17,218	4,096	3,277
4	13,003	11,449	28,231	28,902	29,003	29,264	7,086	7,135
5	8,192	6,554	0	0	0	0	4,608	5,530
6	40,208	40,205	9,863	9,868	30,608	31,811	9,112	7,289
7	1,242	994	1,242	994	1,863	2,235	1,863	2,608
8	2,353	2,017	2,353	1,883	2,353	2,824	3,530	4,942
9	784	627	3,581	3,531	2,194	2,445	679	407
10	593	645	858	687	1,015	812	1,013	1,207
11	11,000	6,600	11,000	8,800	11,000	8,800	11,000	11,983

From **Table 12**, it can be found that the total cost of increasing or decreasing manufacturing capacity sums up to 52,278 TL in the first period. In periods where the manufacturing capacity should be lowered in order to balance the remaining products to the next period, in which they are considered as old season products and sold with lower prices that decreases the overall productivity of the company.

The company has contracts with the subcontractors on their current manufacturing capacity, so that they arranged their staff, warehouse, designer, model amounts of product groups and others. Decisions for manufacturing capacity planning are difficult, but the solutions of the model yield some predictions about the timing and the need for capacity to manage these subcontractors with lower costs. With the solution of the model, the company can test several scenarios, in order to develop much effective strategies for minimizing management costs of manufacturing capacity.

The correct distribution of product groups to stores where their sales potentials are higher can affect sales and all other decisions. This way, the company can allocate more hanging capacity in the shopping area of the stores to some product groups that have high sales' potential. A product group that has a high sales' potential get more shopping area that may increase the amount of sales and indirectly maximize the overall profit.

Table 16 Amount of Distributed Products vs. Sales for Konya Selçuklu Store

Product Group	1st Quarter		2nd Quarter		3rd Quarter		4th Quarter		Total Amounts for Planning Horizon	
	Amount Sent	Sales Amount	Amount Sent	Sales Amount	Amount Sent	Sales Amount	Amount Sent	Sales Amount	Amount Sent	Sales Amount
1	798	958	928	914	652	812	1,047	874	3,425	3,558
2	241	275	507	361	571	474		304	1,319	1,414
3	1,047	419	335	511	438	726		378	1,820	2,034
4	460	358	1,052	656	881	825	102	547	2,495	2,386
5	348	469		257		3	220	189	568	918
6	1,096	532	250	532	981	532		532	2,327	2,128
7	84	96	144	96	72	96	108	96	408	384
8	206	176	161	176		103	337	176	704	631
9	48	37	152	85	76	95		53	275	270
10	54	34	24	34	39	34	32	34	148	136
11	484	482		193	1,991	77	567	1,452	3,041	2,203

The integrated management of the manufacturing capacity, the retail chain stores, the distribution of product groups to these retail chain stores, the sales prices, and the profitability is very difficult. In this study, distribution amounts of product groups to retail chain stores are determined by solving the developed mathematical model for the company. The amount of product groups sent and the amount of sales to be realized in Konya Selçuklu store is summarized from the solution of the model and given in **Table 16**. The amount of products sent and the amounts of products sold seems to be balanced in that store from period to period. Note that, this type of similar information is available in the solution of the model for all stores in the retail chain.

6.2. RESULTS UNDER SCENARIO II

Under various conditions, if there exist threads and risks, a retail chain company tries to continue operating with keeping the current status unchanged (without opening new stores or closing existing ones) in order to minimize the investment requirements. Even in such cases, the company may decide not to renew a store that is required to be renewed in that period. The objective of such delays is lowering the investment costs to keep current status unchanged. The solution of the model can give directions to answers to such questions, showing which alternative decision seems to be more profitable.

Table 17 Model Results with and without Opening and Closing Store

	With Opening / Closing Store	Without Opening / Closing Store
(+) Revenue From Store Sales	139,385,900	127,068,400
(-) Store Outgoings	42,477,600	39,252,100
(-) Holding Cost Of Products	9,652,500	10,555,600
(-) Investment Capital Cost	352,500	102,500
(-) Direct Product Cost	45,310,100	46,128,400
(-) Increased Manufacturing Capacity Cost	17,767	6,781
(-) Decreased Manufacturing Capacity Cost	34,511	50,792
TOTAL PROFIT	41,540,830	30,972,350
Budget Usage	1,762,500	512,500
Total Manufacturing Amount	397,096	349,760
New Season Sale Amount	146,536	131,128
Old Season Sale Amount	285,322	261,756
Sale - Manufacturing Ration	108.8%	112.3%

The Gams solutions of the models with and without opening and closing stores are summarized in **Table 17**. The Gams output for the case without opening and closing stores is given in **Appendix 17**. As it is expected, the total profit, revenue, store outgoings, investment capital cost and budget usage are decreased in the solution without opening and closing stores. Since no new store is to be opened, the investment budget is only used for renewing stores at a minimal level. Additionally, no new store means no extra profit from new stores could be possible if they are not opened.

Because of this, the total amount of sales will be relatively less than the case in which opening and closing stores are allowed. So, the model will try to decrease actual manufacturing level with paying the cost of decreasing manufacturing capacity below the lower capacity limit.

As a result, without opening and closing stores the company will lose a profit of approximately 11 million TL. This loss of profit seems to be the cost of status co. It will be interesting to analyze whether it is possible to get more profit from the unused investment budget in the other alternative projects for the company in order to recover some portion of the 11 million TL lost profit.

In order to modify the original mathematical model in order to restrict opening and closing decisions, the addition of the following constraint 6.1 will be sufficient.

$$\sum_{j}^{J}\sum_{k}^{K}\left(OpStore_{j,k} + CloseStore_{j,k}\right) \leq 0 \tag{6.1}$$

6.3. RESULTS UNDER SCENARIO III

The model can be used to answer "what if" type questions related to the company under various conditions. For example, the company might want to see the results when the manufacturing capacity of a product group suddenly decreases in a period or the results under different investment budget limits.

In this scenario, based on the expert evaluations, it is suggested that there will be an economic crisis and it is predicted that sales will decrease by 10 percent all over the country. By solving the mathematical model under these conditions, the status of the company's retail chain stores in the future can be analyzed. The results of the model solution related to retail chain management decision and the financial summary of the company under the mentioned scenario are given respectively in **Table 18 and 17**. The Gams solution output is given in **Appendix 18**.

According to the results obtained from the solution of the model under economic crisis scenario that is given in **Table 18**, it is observed that the company is closing the store with 700 m^2 area among the four currently open stores with a total area of 2410 m^2 in İstanbul 1 region with the highest sales potential, the store with 500 m^2 area among the three currently open stores with a total area of 1150 m2 in İstanbul 7 region with the second highest sales potential, the only open store in Antalya Muratpaşa with an area of 275 m^2 requiring renewal. The total store area seems to be more than enough with respect to sales potential in these regions.

Table 18 Store Choice under Scenarios I and III

				Total Store Area And Periodic Operating Cost Per m^2 Of Location Alternatives							
				1		2		3		4	
No	Province	District	Sale Potential	Area (m^2)	Cost (₺)	Area (m^2)	Cost (₺)	Area (m^2)	Cost (₺)	Area (m^2)	Cost (₺)
1	İSTANBUL	İSTANBUL 1	96.344	900	861	700	870	600	876	210	993
2	İSTANBUL	İSTANBUL 7	43.988	500	750	300	792	350	777	250	810
20	ANTALYA	MURATPAŞA	16.941	275	645	243	654	217	684	290	633
25	İSTANBUL	İSTANBUL 4	46.246	300	792	250	810	200	840	170	888
26	GAZİANTEP	ŞAHİNBEY	24.399	150	786	215	747	250	705	170	783
27	GAZİANTEP	ŞEHİTKAMİL	22.252	215	732	300	672	205	744	170	768
28	ANKARA	SİNCAN	21.377	150	771	180	750	314	681	255	711
29	BURSA	YILDIRIM	20.576	160	774	389	636	264	687	252	699
32	İZMİR	KARABAĞLAR	16.757	120	807	240	657	185	699	300	627
33	ADANA	YÜREĞİR	16.549	180	690	250	630	398	588	540	570
34	İSTANBUL	İSTANBUL 8	16.272	240	642	200	660	383	594	410	597

Choice under both scenario
Choice under **Scenario *I***
Choice under **Scenario *III***
Closed stores under **Scenario *III***

Based on the results in **Table 19**, the overall total profit of the company under Scenario III is found to be approximately 2 million TL less than the Scenario I. The total revenue of the company from sales decreases as sales potential decreases. Since, the two stores in İstanbul with high area and cost per meter square is closed, the operating expenses become lower. Again, as the sales potential is decreased, no need for increasing manufacturing capacity so there is no cost associated. But, on the other hand, the cost of decreasing manufacturing capacity is increased, as it is seen from **Table 19**. That is, under Scenario III, the overall manufacturing capacity of all product groups seems to be more than the related overall sales potential.

Table 19 Model Results under Scenario III

	Scenario *I*	**Scenario *III***
(+) Revenue From Store Sales	139,385,900	127,166,200
(-) Store Outgoings	42,477,600	37,972,300
(-) Holding Cost Of Products	9,652,500	9,016,900
(-) Investment Capital Cost	352,500	371,000
(-) Direct Product Cost	45,310,100	40,061,200
(-) Increased Manufacturing Capacity Cost	17,767	0
(-) Decreased Manufacturing Capacity Cost	34,511	144,462
TOTAL PROFIT	41,540,830	39,600,290
Budget Usage	1,762,500	1,855,000
Total Manufacturing Amount	397,096	347,889
New Season Sale Amount	146,536	127,968
Old Season Sale Amount	285,322	264,964
Sale - Manufacturing Ration	108.8%	112.9%

According to the current status of the company, given in **Table 14**, only in two product groups and for two periods decreasing manufacturing capacity is required. But, according to the results under Scenario III, it is observed that, in 5 product groups and for all periods decreasing manufacturing capacity is required (see **Table 20**). With the reduced overall production amount, less direct production cost incurred, and less money tied up in inventories. Both the amount of new season and old season sales reduced. While in the Scenario I, the ratio of new season sales to total sales is 34 %, under Scenario III, this ratio is decreased to 32.5%. This shows that, there is excess amount of production, and this excess amount is sold as old season product. Under Scenario III, people prefer buying the products in the off season when significant amount of discount in the prices exist.

Table 20 Manufacturing Capacity Planning Decisions for Reduction

Product Group	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
3	0.126			
4	0.083			
8	0.200	0.200		
9	0.200			0.200
11	0.200	0.200	0.200	0.104

Even in Scenario III, a loss of 2 million TL profit is not so significant with respect to the total profit. In this case, if the effect of closing stores on the profitability is not significant, it is not necessary to close any store. The prestige of the company should also be considered in store closing decisions.

As an alternative scenario, the model is re-evaluated without closing stores under the Scenario III, and the solution is given in **Table 21**. As it is seen, the overall profit is found to be 39,462,530 TL that is approximately 2 million TL less than the current situation. The Gams solution output is given in **Appendix 19**. Under Scenario III, the effect of keeping the closed stores operational on profitability is approximately making just 140 thousand TL less profit. This is really a small amount that can be hold. In this example, there is no need to close stores under this scenario.

Table 21 Results of the Model under Scenario III without Closing Stores

	Scenario *I*	**Scenario *III* without Closing Stores**
(+) Revenue From Store Sales	139,385,900	136,000,000
(-) Store Outgoings	42,477,600	43,123,600
(-) Holding Cost Of Products	9,652,500	9,486,140
(-) Investment Capital Cost	352,500	397,500
(-) Direct Product Cost	45,310,100	43,564,100
(-) Increased Manufacturing Capacity Cost	17,767	30,501
(-) Decreased Manufacturing Capacity Cost	34,511	45,156
TOTAL PROFIT	41,540,830	39,462,530
Budget Usage	1,762,500	1,987,500
Total Manufacturing Amount	397,096	394,538
New Season Sale Amount	146,536	149,575
Old Season Sale Amount	285,322	282,323
Sale - Manufacturing Ration	108.8%	109.5%

The model selects the alternative locations with the highest sales potentials in order to open new stores. In the current situation, the company with opening a new store can increase the total revenue by approximately 9 million TL relative to the model under economic crises without closing any existing store.

Instead of closing some stores and decreasing manufacturing capacity under the Scenario III, in case, if profitability exists, opening new stores in order to increase the amount of sales while keeping the manufacturing level as it is, seems to be more advantageous. This way, in addition to keeping currently existing stores, with the opening of new stores, the possible growth of retail chain can be reached. This shows that, in case if profitability exists, instead of holding the excess amount of production on hand, it could be turned into an opportunity and the economic crisis does not mean always down-sizing.

As it is seen from **Table 21**, relative to the case with no crisis the financial indicators of the company are not so significant.

But, even in case of crisis, with increasing the number of stores by opening new ones, by looking at the cost of increasing manufacturing capacity, it is obvious that extra manufacturing capacity is needed and utilized. Together with this, the amounts of new and old season sales in economic crises, are not lower than the current situation, which is again observed in **Table 21**.

As a conclusion, the scenario solutions of the model not only supply a decision support in the management of the company, in addition to this, it simulates the results of various types of situations awaiting the company in the future periods. Naturally, the solutions are obtained from the deterministic model that maximizes the total profit with taking into account the time value of money, but the realized performance of the company may be lower than these good results.

The model with analyzing risks, threads, and opportunities and showing what is awaiting the company in the future, gives the company the ability to react with alternative moves. With the results of various scenarios and analysis of situations, alternative contingency plans could be developed for the future. This way, the company may improve itself by taking the required actions, and develops new solutions from the model according to its final status. This is really a good contribution for the system development of the company. It is clear that, the model gives decision support for the design and development of the system, besides the operational decision support supplied. In addition to these, the financial indicators supplied by the solutions of the models are very important as the periodic cash flows expectations. The income and expenditure budgets to be obtained from the solutions of the model, can be used as good indicators for making financial plans in order to meet the resource requirements and investment plans for excess resources.

Focusing alternatively to the development of price policies for the company, it is a serious and complex problem, for which there is no unique answer. If the company can expect how the demand of a product changes with respect to changes in the price of the product, that is called price elasticity, the company can analyze the level of profitability and how the system will be affected from various price policies with respect to changing price and demand parameters in the model.

Furthermore, although it is developed as a static model, if required, it could be revised to be a dynamic model also. By incorporating time variable capacities for supply and production processes, supply and transportation costs, investment budgets with various warehouse locations, the flexible structure of the model can be adapted for a dynamic environment as a future extension.

CHAPTER 7

CONCLUSION

With a holistic approach on critical decision points in retail chain management such as Supply Chain Management, Inventory Management, Retail Chain Management and Sales, an integrated decision support system was developed for these decision points. Possible decision alternatives in retail chain management are locating, operating, renewing and closing stores. However, in addition to this, decisions related to capacity, production and shipment planning are also important. The goal of the model is to find satisfactory answers to all of these questions. For this purpose, a Linear Mathematical Programming Model that maximizes corporate profit was developed. Through this model, decisions of critical importance in retail chain management can be taken such as product group output, product quantities to be distributed to store warehouses, decisions on store opening, closing, and retaining, sales quantities in regions, and use of budget for investments.

Many manufacturing and store related parameters and quarterly sales forecasts are needed as inputs to the model. Certain parameters such as investment budget, product hanger thickness, outsourcing costs, sale price, and discount rates are known for certain by companies. In addition, parameters such as product cost and fixed expenditures and cost per product were assumed to be known as they fall outside the context of this thesis. However, in addition to constituting a subject for whole another thesis, sales forecasts were included within the context of this thesis due to their importance in order for this model to yield healthier results. For locations with existing sales data, it is possible to forecast sales via generally-accepted methods found in the literature. Though, a method that can forecast sales is needed for locations without existing sales data as the method is also to be utilized in decisions of opening new stores. Together with the fact that the literature does not provide a myriad of studies in this context, adaptation of Huff’s Gravity Method over the concept of attraction center used in market share studies was found to be applicable. In this sense, the likelihood of a customer to prefer a region for shopping was calculated through Huff's Gravity Method for provinces with data based on districts, and the number of potential customers was obtained by multiplying the likelihood with district population. A regression model between the variable referred to as Huff's parameter and annual sales quantities was established, later finding that the model performed well at both explanation and prediction levels. Sales forecasts were obtained via this model for locations without existing sales data. As quarterly data were required, it was albeit necessary to convert total sales forecasts into seasonal forecasts. For this, quarterly data from the past on the company's several stores were decomposed to obtain seasonal indexes. By virtue of these indexes, the annual sales forecasts were converted into quarterly sales forecasts.

The mathematical model was run under various scenarios with the data obtained, and healthy results were obtained for decisions in processes. However, due to the variety and surplus of data fed as inputs to the model, analyzes of parameters need to be performed meticulously. Besides, sales potential forecasts can be influenced by economic and political conditions. In that case, the model can be resolved by creating scenarios for various conditions that can occur in the future. By means of analyzing risks, threats, and opportunities in detail, all scenarios can be turned into opportunities. As a basic example, by well-managing its production capacity, contracts, and financial resources followed by a status analysis on two different scenarios obtained based both on shrinkage of market and ordinary conditions, a company that adjusts its production capacity with subcontractors, human resources, and financial resources can turn the case into an opportunity and secure advantage against competitors. Even so, there may be erroneous results as especially possibilities dictate sales potential calculations despite everything. In fact, as can be seen from the "Mathematical Model Solution" chapter, total profit slide is around 4% even under market conditions with 10% decrease in sales. On the other hand, it does not give rise to dramatic changes in decisions of opening, closing, or renovating stores. Consequently, results obtained by putting in accurate parameters will provide insights on the future as well as critical gains in decision points for a retailing company.

The mathematical model developed in this thesis was conducted by adapting sample corporate scenarios. Certain companies may not be producing or may not have any production limits. They may also be avoiding exceed production capacity due to such strategic reasons as quality policies. In another scenario, expanding by opening up new stores or realizing investment expenditures may not be among the future plans. As the model developed in this study is fictionalized by taking into account and adapting all processes of the business life, this provides great flexibility for the model. By removing certain restrictions and parameters from the model if necessary, or by adding in new restrictions applicable to scenario, further results for every scenario can be obtained.

The Linear Programming model was fictionalized based on retail chain companies selling ready wear and footwear. As a continuation of this thesis, the model developed in this thesis can also be used with ease for companies in other industries outside ready wear retailing such as supermarkets, as well. In addition to all of these, certain statistical analyzes in this paper were put forward for forecasting sales potentials. It was observed that the regression model implemented via parameters obtained from Huff Gravity Method could exponentially explain considered company’s sales. Having obtained the parameters based on districts, the same parameters can be further elaborated and utilized in calculations for retail parks, shopping streets, malls, and downtown markets. Indeed, predicating on industries of businesses and business areas in regions obtained from “Google Places” serves, “Google Maps Enterprise” can be utilized. In this way, more precise sales forecast analyzes can be performed by obtaining parameters in greater details.

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APPENDICES

Appendix 1 Objective Function with Compound Interest for All Costs and Revenue

Maximize *(objective function with compound interest rate for all terms)*

$$\sum_{i}^{N}\sum_{j}^{J}\sum_{k}^{K}\sum_{t}^{T}(1+i_q)^{(T-t)}*p_i * \left(AmountNSSales_{i,j,k,t} * NSPDFactor + AmountOSSales_{i,j,k,t} * OSPDFactor\right)$$

$$-\sum_{t}^{T}\sum_{j}^{J}\sum_{k}^{K}(1+i_q)^{(T-(t-1))} * \left[\begin{matrix}\left(OpStore_{j,k} + RenStore_{j,k} + KeepStore_{j,k}\right) \\ * UnitCOExpenses_{j,k,t} * TotArea_{j,k}\end{matrix}\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[\left(AvgAmountStockW_{i,t} + AvgAmountStockHanged_{i,t}\right) * UnitAvgCost_i * \left((1+i_q)^{(T-(t-1))} - 1\right)\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[MCapacity_{i,t} * \left[MCLevel_{i,t} + MCLevelIncPercent_{i,t} - MCLevelDecPercent_{i,t}\right] * UnitAvgCost_i * (1+i_q)^{(T-t)}\right]$$

$$-((1+i_q)^{(T)} - 1) * \sum_{j}^{J}\sum_{k}^{K}\left[\left(OpStore_{j,k} * OpenSCost_{j,k} + RenStore_{j,k} * RenewSCost_{j,k}\right)\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[MCLevelIncPercent_{i,t} * CFactorIncMC_{i,t} * (1+i_q)^{(T-t)}\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[MCLevelDecPercent_{i,t} * CFactorDecMC_{i,t} * (1+i_q)^{(T-t)}\right]$$

Appendix 2 Objective Function With No Time Value of Money

Maximize *(objective function with no time value of money)*

$$\sum_{i}^{N}\sum_{j}^{J}\sum_{k}^{K}\sum_{t}^{T} p_i * \left(AmountNSSales_{i,j,k,t} * NSPDFactor + AmountOSSales_{i,j,k,t} * OSPDFactor\right)$$

$$-\sum_{t}^{T}\sum_{j}^{J}\sum_{k}^{K}\left[\left(OpStore_{j,k} + RenStore_{j,k} + KeepStore_{j,k}\right) * UnitCOExpenses_{j,k,t} * TotArea_{j,k}\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[\left(AvgAmountStockW_{i,t} + AvgAmountStockHanged_{i,t}\right) * UnitAvgCost_i\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[MCapacity_{i,t} * \left[MCLevel_{i,t} + MCLevelIncPercent_{i,t} - MCLevelDecPercent_{i,t}\right] * UnitAvgCost_i\right]$$

$$-\sum_{j}^{J}\sum_{k}^{K}\left[\left(OpStore_{j,k} * OpenSCost_{j,k} + RenStore_{j,k} * RenewSCost_{j,k}\right)\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[MCLevelIncPercent_{i,t} * CFactorIncMC_{i,t}\right]$$

$$-\sum_{i}^{N}\sum_{t}^{T}\left[MCLevelDecPercent_{i,t} * CFactorDecMC_{i,t}\right]$$

Appendix 3 Corelation Results of Factors

Correlations: Population; Women Population; Sege 2014; Google Searches

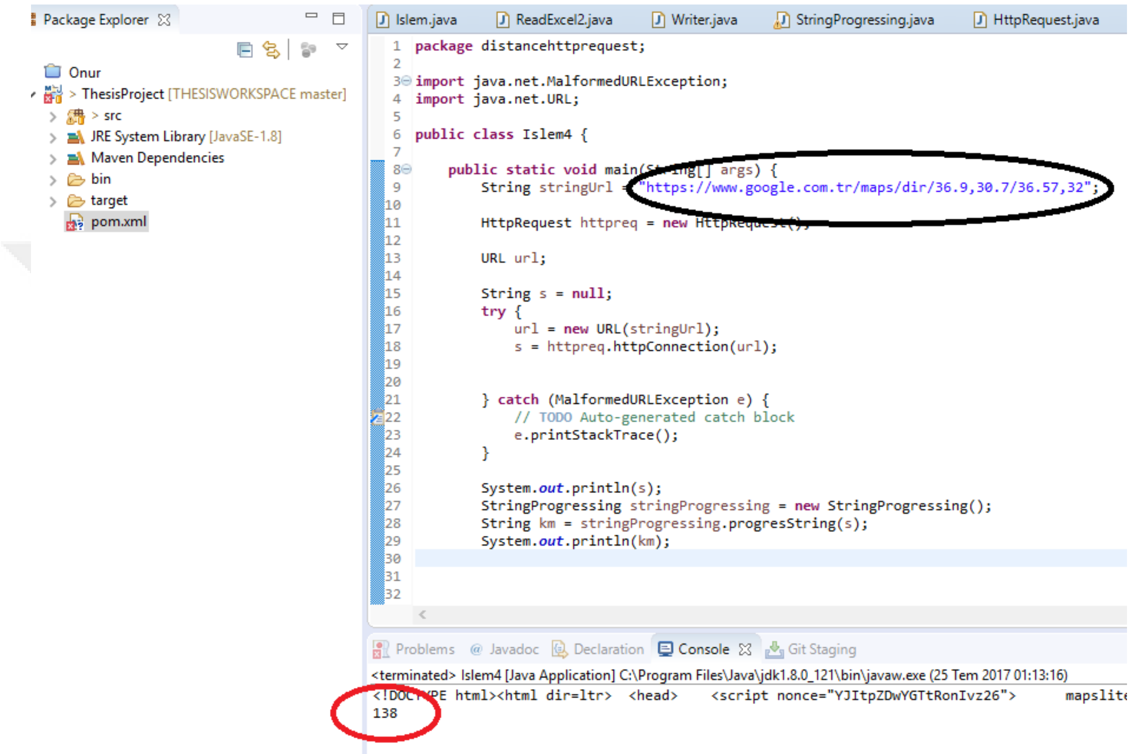
	Population	Women Population	Sege 2014
Women Population	1,000		
	0,000		
Sege 2014	0,972	0,971	
	0,000	0,000	
Google Searches	0,960	0,960	0,955
	0,000	0,000	0,000

Cell Contents: Pearson correlation
P-Value

Appendix 4 Selected Districts List (Top 25)

Province	District	Population
ADANA	ÇUKUROVA	362,351
	CEYHAN	160,171
	KOZAN	129,985
	İMAMOĞLU	28,657
	KARATAŞ	21,867
	KARAİSALI	21,250
	POZANTI	19,362
	YUMURTALIK	17,651
	TUFANBEYLİ	17,558
	FEKE	17,033
	ALADAĞ	16,333
	SAİMBEYLİ	15,239
	ADANA	2,201,670
ADIYAMAN	ADIYAMAN	296,316
	KAHTA	120,378
	BESNİ	75,255
	ÇELİKHAN	15,178
	SİNCİK	17,476
	SAMSAT	7,992
	TUT	10,027
	GERGER	18,785
	GÖLBAŞI	49,077
AFYON	AFYON	714,523
	SANDIKLI	55,770
	BOLVADİN	44,539

Appendix 5 Java Web Site Request Codes Used to Obtain Distances with Google Maps Link



Appendix 6 Some Distance of District Boundaries and Between Districts from Google Servers(Top 25)

Province	District1	District2	link	Dist. (Google Server)
ARTVİN	ARTVİN	HOPA	https://www.google.com.tr/maps/dir/41.2,41.83/41.37,41.43	71.4
	YUSUFELİ	HOPA	https://www.google.com.tr/maps/dir/40.83,41.53/41.37,41.43	141
	HOPA	ARTVİN	https://www.google.com.tr/maps/dir/41.37,41.43/41.2,41.83	70.1
	ARHAVİ	ARTVİN	https://www.google.com.tr/maps/dir/41.33,41.32/41.2,41.83	85
	BORÇKA	ARTVİN	https://www.google.com.tr/maps/dir/41.35,41.68/41.2,41.83	33.3
	ŞAVŞAT	ARTVİN	https://www.google.com.tr/maps/dir/41.23,42.4/41.2,41.83	80.2
	ARDANUÇ	ARTVİN	https://www.google.com.tr/maps/dir/41.12,42.08/41.2,41.83	44.1
	SAİMBEYLİ	CEYHAN	https://www.google.com.tr/maps/dir/37.98,36.1/37.02,35.82	138
	YUSUFELİ	ARTVİN	https://www.google.com.tr/maps/dir/40.83,41.53/41.2,41.83	79
AYDIN	SULTANHİSAR	KARPUZLU	https://www.google.com.tr/maps/dir/37.88,28.15/37.55,27.8	73.2
	İNCİRLİOVA	KARPUZLU	https://www.google.com.tr/maps/dir/37.83,27.7/37.55,27.8	76.2
	ÇİNE	KARPUZLU	https://www.google.com.tr/maps/dir/37.62,28.05/37.55,27.8	38.9
	KUŞADASI	KARPUZLU	https://www.google.com.tr/maps/dir/37.87,27.25/37.55,27.8	123
	NAZİLLİ	KARPUZLU	https://www.google.com.tr/maps/dir/37.92,28.33/37.55,27.8	89.8
	BOZDOĞAN	KARPUZLU	https://www.google.com.tr/maps/dir/37.68,28.3/37.55,27.8	96.3
	YENİPAZAR	KARPUZLU	https://www.google.com.tr/maps/dir/37.8,28.18/37.55,27.8	71
	KÖŞK	KARPUZLU	https://www.google.com.tr/maps/dir/37.85,28.05/37.55,27.8	62.8
	KARACASU	KARPUZLU	https://www.google.com.tr/maps/dir/37.73,28.62/37.55,27.8	131
	KUYUCAK	KARPUZLU	https://www.google.com.tr/maps/dir/37.9,28.47/37.55,27.8	103
	SÖKE	KARPUZLU	https://www.google.com.tr/maps/dir/37.75,27.38/37.55,27.8	119
	KOÇARLI	KARPUZLU	https://www.google.com.tr/maps/dir/37.77,27.7/37.55,27.8	68.6
	GERMENCİK	KARPUZLU	https://www.google.com.tr/maps/dir/37.87,27.58/37.55,27.8	93.3
	AYDIN	KARPUZLU	https://www.google.com.tr/maps/dir/37.83,27.83/37.55,27.8	61.7
	KARPUZLU	YENİPAZAR	https://www.google.com.tr/maps/dir/37.55,27.8/37.8,28.18	70.8
	SULTANHİSAR	YENİPAZAR	https://www.google.com.tr/maps/dir/37.88,28.15/37.8,28.18	15.6

Appendix 7 Regression Results of Sales Amount With Huff's Parameters

Regression Analysis: Total Sales versus Huffs Parameters

```
The regression equation is
Total Sales = 7961 + 0,0184 Huffs Parameters
Predictor             Coef    SE Coef      T      P
Constant              7961       2610   3,05  0,006
Huffs Parameters 0,018364  0,001804  10,18  0,000
S = 8590,60   R-Sq = 83,8%   R-Sq(adj) = 83,0%

PRESS = 1718672933   R-Sq(pred) = 81,16%
Analysis of Variance

Source          DF          SS          MS       F      P
Regression       1  7645276534  7645276534  103,60  0,000
Residual Error  20  1475968188    73798409
Total           21  9121244722


         Huffs   Total
Obs Parameters   Sales    Fit  SE Fit  Residual  St Resid
  1     357448   12567  14526    2198     -1959     -0,24
  2     996366   27594  26258    1833      1336      0,16
  3     930882   29848  25056    1840      4792      0,57
  4     585539   14907  18714    2000     -3807     -0,46
  5     791546   30985  22497    1882      8488      1,01
  6     476697   14553  16715    2087     -2162     -0,26
  7    1953000   68769  43826    2474     24943      3,03R
  8     341032   18731  14224    2214      4507      0,54
  9     737815   27553  21510    1906      6043      0,72
 10     477162   17069  16724    2086       345      0,04
 11     633142   12699  19588    1967     -6889     -0,82
 12     634303   23712  19610    1966      4102      0,49
 13     299713   11426  13465    2257     -2039     -0,25
 14     530378   16496  17701    2042     -1205     -0,14
 15     563000   16978  18300    2017     -1322     -0,16
 16     520805   26076  17525    2050      8551      1,02
 17     102118    5613   9837    2482     -4224     -0,51
 18    4829836   95040  96655    7095     -1615     -0,33 X
 19    1198621   21639  29973    1856     -8334     -0,99
 20    1280998   12839  31485    1886    -18646     -2,22R
 21    2479218   52237  53489    3191     -1252     -0,16
 22    1959455   34293  43944    2482     -9651     -1,17

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Durbin-Watson statistic = 1,72914
```

Appendix 8 Regression Results of Sales Amount With Huff's Parameters without Unusual Observations

Regression Analysis: TOPLAM SATIŞ versus HUFFS PARAMETRE

```
The regression equation is
TOPLAM SATIŞ = 8485 + 0,0175 HUFFS PARAMETRE

Predictor             Coef   SE Coef      T      P
Constant              8485      1593   5,33  0,000
HUFFS PARAMETRE   0,017501  0,001118  15,65  0,000
S = 5206,85   R-Sq = 93,2%   R-Sq(adj) = 92,8%

PRESS = 610116864   R-Sq(pred) = 91,44%


Analysis of Variance

Source          DF          SS          MS       F      P
Regression       1  6643363068  6643363068  245,04  0,000
Residual Error  18   488002967    27111276
Total           19  7131366035

         HUFFS  TOPLAM
Obs  PARAMETRE   SATIŞ    Fit  SE Fit  Residual  St Resid
  1     357448   12567  14741    1352     -2174     -0,43
  2     996366   27594  25923    1165      1671      0,33
  3     930882   29848  24777    1165      5071      1,00
  4     585539   14907  18733    1242     -3826     -0,76
  5     791546   30985  22338    1182      8647      1,71
  6     476697   14553  16828    1289     -2275     -0,45
  7     341032   18731  14454    1361      4277      0,85
  8     737815   27553  21398    1193      6155      1,21
  9     477162   17069  16836    1289       233      0,05
 10     633142   12699  19566    1224     -6867     -1,36
 11     634303   23712  19586    1224      4126      0,82
 12     299713   11426  13730    1386     -2304     -0,46
 13     530378   16496  17767    1265     -1271     -0,25
 14     563000   16978  18338    1251     -1360     -0,27
 15     520805   26076  17600    1269      8476      1,68
 16     102118    5613  10272    1517     -4659     -0,94
 17    4829836   95040  93013    4467      2027      0,76 X
 18    1198621   21639  29463    1191     -7824     -1,54
 19    2479218   52237  51875    2048       362      0,08
 20    1959455   34293  42778    1604     -8485     -1,71

X denotes an observation whose X value gives it large leverage.

Durbin-Watson statistic = 2,52430
```

Appendix 9 Regression Outputs of Minitab by Product Groups

Outputs for Trousers-Skirt Group

Regression Analysis: Trousers-Skirt Group versus Huff's Parameter

```
The regression equation is
Trousers-Skirt Group = 1791 + 0,00323 Huff's Parameter
Predictor              Coef    SE Coef     T      P    VIF
Constant             1791,3      503,2  3,56  0,002
Huff's Parameter  0,0032318  0,0003478  9,29  0,000  1,000

S = 1655,94   R-Sq = 81,2%   R-Sq(adj) = 80,3%

PRESS = 72846562   R-Sq(pred) = 75,02%

Analysis of Variance

Source          DF         SS         MS      F      P
Regression       1  236791304  236791304  86,35  0,000
Residual Error  20   54842618    2742131
Total           21  291633922

Unusual Observations

         HUFFS
Obs  PARAMETER  Trousers-Skirt Group    Fit  SE Fit  Residual  St
Resid
  7    1953000      12609   8103     477      4506      2,84R
 18    4829836      16323  17400    1368     -1077     -1,15 X
 20    1280998       2503   5931     364     -3428     -2,12R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Outputs for Trousers-Skirt Group without Unusual Observations

Regression Analysis: Trousers-Skirt Group versus Huff's Parameter

```
The regression equation is
Trousers-Skirt Group = 1462 + 0,00316 Huff's Parameter



Predictor              Coef    SE Coef      T      P    VIF
Constant             1461,8      248,1   5,89  0,000
Huff's Parameter  0,0031621  0,0001635  19,34  0,000  1,000



S = 755,411   R-Sq = 96,1%   R-Sq(adj) = 95,9%

PRESS = 12417906   R-Sq(pred) = 94,41%



Analysis of Variance

Source          DF         SS         MS       F      P
Regression       1  213518309  213518309  374,17  0,000
Residual Error  15    8559681     570645
Total           16  222077990



Unusual Observations

         HUFFS
Obs  PARAMETER  Trousers-Skirt Group    Fit  SE Fit  Residual  St
Resid
 14    4829836     16323  16734     649      -411     -1,06 X

X denotes an observation whose X value gives it large leverage.
```

Outputs for Shirt Group

Regression Analysis: Shirt Group versus HUFFS PARAMETER

```
The regression equation is
Shirt Group = 692 + 0,00115 HUFFS PARAMETRE



Predictor              Coef    SE Coef     T      P    VIF
Constant              692,0      177,6  3,90  0,001
HUFFS PARAMETRE   0,0011456  0,0001227  9,33  0,000  1,000



S = 584,381   R-Sq = 81,3%   R-Sq(adj) = 80,4%

PRESS = 8243639   R-Sq(pred) = 77,47%



Analysis of Variance

Source          DF        SS        MS      F      P
Regression       1  29752505  29752505  87,12  0,000
Residual Error  20   6830029    341501
Total           21  36582534



Unusual Observations

         HUFFS
Obs  PARAMETRE  GÖMLEK   Fit  SE Fit  Residual  St Resid
  7    1953000    4574  2929     168      1645     2,94R
 18    4829836    6004  6225     483      -221    -0,67 X
 20    1280998     965  2159     128     -1194    -2,10R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large
leverage.
```

Outputs for Shirt Group without Unusual Observations

Regression Analysis: Shirt Group versus Huff's Parameter

```
The regression equation is
Shirt Group = 568 + 0,00112 Huff's Parameter



Predictor                Coef      SE Coef      T      P    VIF
Constant               568,19        77,67   7,32  0,000
Huff's Parameter   0,00112095   0,00005118  21,90  0,000  1,000



S = 236,492   R-Sq = 97,0%   R-Sq(adj) = 96,8%

PRESS = 974724   R-Sq(pred) = 96,48%



Analysis of Variance

Source          DF        SS        MS       F      P
Regression       1  26831535  26831535  479,75  0,000
Residual Error  15    838928     55929
Total           16  27670462



Unusual Observations

         HUFFS
Obs  PARAMETER  Shirt Group     Fit  SE Fit  Residual  St
Resid
 14    4829836  6004,0  5982,2   203,1      21,8      0,18 X

X denotes an observation whose X value gives it large
leverage.
```

Outputs for Tunic Group

Regression Analysis: Tunic Group versus Huff's Parameter

The regression equation is

Tunic Group = 967 + 0,00172 Huff's Parameter

Predictor	Coef	SE Coef	T	P	VIF
Constant	966,6	273,6	3,53	0,002	
Huff's Parameter	0,0017248	0,0001891	9,12	0,000	1,000

S = 900,270   R-Sq = 80,6%   R-Sq(adj) = 79,7%

PRESS = 19604823   R-Sq(pred) = 76,56%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	67445250	67445250	83,22	0,000
Residual Error	20	16209737	810487		
Total	21	83654987			

Unusual Observations

Obs	HUFFS PARAMETER	Tunic Group	Fit	SE Fit	Residual	St Resid
7	1953000	7134	4335	259	2799	3,25R
18	4829836	8987	9297	743	-310	-0,61 X

R denotes an observation with a large standardized residual.

X denotes an observation whose X value gives it large leverage.

Outputs for Tunic Group without Unusual Observations

Regression Analysis: Tunic Group versus Huff's Parameter

```
The regression equation is
Tunic Group = 935 + 0,00163 Huff's Parameter



Predictor              Coef    SE Coef      T      P    VIF
Constant              935,4      150,8   6,20  0,000
Huff's Parameter  0,0016317  0,0001040  15,69  0,000  1,000



S = 483,882   R-Sq = 93,5%   R-Sq(adj) = 93,2%

PRESS = 4954029   R-Sq(pred) = 91,96%



Analysis of Variance

Source          DF        SS        MS       F      P
Regression       1  57652589  57652589  246,23  0,000
Residual Error  17   3980413    234142
Total           18  61633002



Unusual Observations

         HUFFS
Obs  PARAMETER  Tunic Group   Fit  SE Fit  Residual  St Resid
 16    4829836   8987  8816     415       171      0,69 X

X denotes an observation whose X value gives it large
leverage.
```

Outputs for Summer Topcoat Group

Regression Analysis: Summer Topcoat Group versus Huff's Parameter

```
The regression equation is
Summer Topcoat Group = 731 + 0,00243 Huff's Parameter



Predictor               Coef    SE Coef      T      P    VIF
Constant               731,4      323,7   2,26  0,035
Huff's Parameter   0,0024306  0,0002237  10,86  0,000  1,000



S = 1065,29   R-Sq = 85,5%   R-Sq(adj) = 84,8%

PRESS = 26003860   R-Sq(pred) = 83,40%



Analysis of Variance

Source          DF         SS         MS       F      P
Regression       1  133935574  133935574  118,02  0,000
Residual Error  20   22696702    1134835
Total           21  156632276



Unusual Observations

         HUFFS
Obs  PARAMETER  Summer Topcoat Group    Fit  SE Fit  Residual  St
Resid
  7    1953000      7542   5478     307      2064      2,02R
 18    4829836     12395  12471     880       -76     -0,13 X
 20    1280998      1462   3845     234     -2383     -2,29R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Outputs for Summer Topcoat Group without Unusual Observations

Regression Analysis: Summer Topcoat Group versus Huff's Parameter

```
The regression equation is
Summer Topcoat Group = 805 + 0,00237 Huff's Parameter



Predictor              Coef    SE Coef      T      P    VIF
Constant              805,1      256,7   3,14  0,006
Huff's Parameter  0,0023712  0,0001802  13,16  0,000  1,000



S = 839,240   R-Sq = 90,6%   R-Sq(adj) = 90,1%

PRESS = 14975041   R-Sq(pred) = 88,88%



Analysis of Variance

Source          DF         SS         MS       F      P
Regression       1  121950758  121950758  173,15  0,000
Residual Error  18   12677823     704323
Total           19  134628581



Unusual Observations

         HUFFS
Obs  PARAMETER  Summer Topcoat Group    Fit  SE Fit  Residual  St
Resid
 17    4829836     12395  12258     720       137      0,32 X

X denotes an observation whose X value gives it large leverage.
```

Outputs for Winter Topcoat Group

Regression Analysis: Winter Topcoat Group versus Huff's Parameter

The regression equation is
Winter Topcoat Group = 411 + 0,00116 Huff's Parameter

Predictor	Coef	SE Coef	T	P
Constant	410,9	181,7	2,26	0,035
Huff's Parameter	0,0011559	0,0001256	9,21	0,000

S = 597,847   R-Sq = 80,9%   R-Sq(adj) = 80,0%

PRESS = 8154186   R-Sq(pred) = 78,22%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	30291211	30291211	84,75	0,000
Residual Error	20	7148413	357421		
Total	21	37439623			

Unusual Observations

	HUFFS	KIŞLIK					
Obs	PARAMETER	Summer Topcoat Group	Fit	SE Fit	Residual	St Resid	
18	4829836	6000	5994	494	6	0,02 X	
20	1280998	671	1892	131	-1221	-2,09R	

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.

Outputs for Winter Topcoat Group without Unusual Observations

Regression Analysis: Winter Topcoat Group versus Huff's Parameter

```
The regression equation is
Winter Topcoat Group = 455 + 0,00117 Huff's Parameter


Predictor               Coef    SE Coef      T      P
Constant               454,6      165,8   2,74  0,013
Huff's Parameter   0,0011701  0,0001140  10,26  0,000


S = 542,078   R-Sq = 84,7%   R-Sq(adj) = 83,9%

PRESS = 6540422   R-Sq(pred) = 82,10%


Analysis of Variance

Source          DF        SS        MS       F      P
Regression       1  30947579  30947579  105,32  0,000
Residual Error  19   5583122    293849
Total           20  36530701


Unusual Observations

         HUFFS    KIŞLIK
Obs  PARAMETER  Summer Topcoat Group   Fit  SE Fit  Residual  St Resid
 18    4829836      6000  6106     450      -106     -0,35 X
```

X denotes an observation whose X value gives it large leverage.

Outputs for Scarf Group

Regression Analysis: Scarf Group versus Huff's Parameter

```
The regression equation is
Scarf Group = 456 + 0,00246 Huff's Parameter



Predictor              Coef    SE Coef      T      P
Constant              456,4      230,3   1,98  0,061
Huff's Parameter  0,0024571  0,0001592  15,44  0,000



S = 757,828   R-Sq = 92,3%   R-Sq(adj) = 91,9%

PRESS = 22577631   R-Sq(pred) = 84,78%



Analysis of Variance

Source          DF         SS         MS       F      P
Regression       1  136870714  136870714  238,33  0,000
Residual Error  20   11486051     574303
Total           21  148356765



Unusual Observations

         HUFFS
Obs  PARAMETER  Scarf Group    Fit  SE Fit  Residual   St Resid
 18    4829836  13353  12324    626      1029      2,41RX
 20    1280998   2117   3604    166     -1487     -2,01R



R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large
leverage.
```

Outputs for Scarf Group without Unusual Observations

Regression Analysis: Scarf Group versus Huff's Parameter

```
The regression equation is
Scarf Group = 510 + 0,00247 Huff's Parameter


Predictor             Coef    SE Coef      T      P
Constant             509,7      212,4   2,40  0,027
Huff's Parameter  0,0024743  0,0001461  16,94  0,000


S = 694,452   R-Sq = 93,8%   R-Sq(adj) = 93,5%

PRESS = 18233805   R-Sq(pred) = 87,64%


Analysis of Variance

Source          DF         SS         MS       F      P
Regression       1  138396497  138396497  286,97  0,000
Residual Error  19    9163011     482264
Total           20  147559508


Unusual Observations

         HUFFS
Obs  PARAMETER  Scarf Group    Fit  SE Fit  Residual   St Resid
 18    4829836  13353  12460     577       893      2,31RX

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large
leverage.
```

Outputs for Waist Group

Regression Analysis: Waist Group versus Huff's Parameter

```
The regression equation is
Waist Group = 196 + 0,000275 Huff's Parameter


Predictor                 Coef     SE Coef     T      P
Constant                196,44       59,34  3,31  0,003
Huff's Parameter  0,00027503  0,00004101  6,71  0,000


S = 195,278   R-Sq = 69,2%   R-Sq(adj) = 67,7%

PRESS = 924557   R-Sq(pred) = 62,68%


Analysis of Variance

Source          DF       SS       MS      F      P
Regression       1  1714865  1714865  44,97  0,000
Residual Error  20   762668    38133
Total           21  2477533


Unusual Observations

         HUFFS
Obs  PARAMETER   Waist Group     Fit  SE Fit  Residual  St
Resid
  7    1953000  1349,0   733,6    56,2     615,4      3,29R
 18    4829836  1457,0  1524,8   161,3     -67,8     -0,62 X


R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large
leverage.
```

Outputs for Waist Group without Unusual Observations

Regression Analysis: Waist Group versus Huff's Parameter

```
The regression equation is
Waist Group = 140 + 0,000262 Huff's Parameter



Predictor                Coef     SE Coef      T      P
Constant               140,08       16,99   8,25  0,000
Huff's Parameter   0,00026189  0,00001077  24,31  0,000



S = 49,7790   R-Sq = 97,8%   R-Sq(adj) = 97,7%

PRESS = 77206,2   R-Sq(pred) = 94,84%



Analysis of Variance

Source          DF       SS       MS       F      P
Regression       1  1463866  1463866  590,76  0,000
Residual Error  13    32213     2478
Total           14  1496080



Unusual Observations

         HUFFS
Obs  PARAMETER   Waist Group     Fit   SE Fit   Residual   St
Resid
 12    4829836  1457,0  1405,0    42,9      52,0      2,06RX

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large
leverage.
```

Outputs for Fast Wear Group

Regression Analysis: Fast Wear Group versus Huff's Parameter

```
The regression equation is
Fast Wear Group = 287 + 0,000609 Huff's Parameter



Predictor               Coef     SE Coef      T      P
Constant               286,6       107,1   2,68  0,015
Huff's Parameter  0,00060936  0,00007404   8,23  0,000



S = 352,541   R-Sq = 77,2%   R-Sq(adj) = 76,1%

PRESS = 3000258   R-Sq(pred) = 72,48%



Analysis of Variance

Source          DF        SS       MS      F      P
Regression       1   8418162  8418162  67,73  0,000
Residual Error  20   2485699   124285
Total           21  10903860



Unusual Observations

         HUFFS
Obs  PARAMETER  Fast Wear Group     Fit  SE Fit  Residual  St
Resid
  7    1953000   2602,0  1476,6   101,5    1125,4      3,33R
 18    4829836   3107,0  3229,7   291,1    -122,7     -0,62 X
 20    1280998    376,0  1067,1    77,4    -691,1     -2,01R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Outputs for Fast Wear Group without Unusual Observations

Regression Analysis: Fast Wear Group versus Huff's Parameter

```
The regression equation is
Fast Wear Group = 245 + 0,000597 Huff's Parameter



Predictor               Coef     SE Coef      T      P
Constant              245,14       11,89  20,61  0,000
Huff's Parameter  0,00059696  0,00000677  88,22  0,000



S = 30,1984   R-Sq = 99,9%   R-Sq(adj) = 99,9%

PRESS = 23337,9   R-Sq(pred) = 99,67%



Analysis of Variance

Source          DF       SS       MS        F      P
Regression       1  7097229  7097229  7782,52  0,000
Residual Error   8     7296      912
Total            9  7104524



Unusual Observations

         HUFFS
Obs  PARAMETER  Fast Wear Group      Fit  SE Fit  Residual  St
Resid
  9    4829836  3107,00  3128,35   27,32    -21,35     -1,66 X

X denotes an observation whose X value gives it large leverage.
```

Outputs for Surcoat Group

Regression Analysis: Surcoat Group versus Huff's Parameter

The regression equation is

Surcoat Group = 144 + 0,000218 Huff's Parameter

Predictor	Coef	SE Coef	T	P
Constant	143,79	42,38	3,39	0,003
Huff's Parameter	0,00021838	0,00002929	7,45	0,000

S = 139,482   R-Sq = 73,5%   R-Sq(adj) = 72,2%

PRESS = 453846   R-Sq(pred) = 69,13%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	1081194	1081194	55,57	0,000
Residual Error	20	389103	19455		
Total	21	1470298			

Unusual Observations

Obs	HUFFS PARAMETER	Surcoat Group	Fit	SE Fit	Residual	St Resid
7	1953000	867,0	570,3	40,2	296,7	2,22R
18	4829836	1229,0	1198,5	115,2	30,5	0,39 X
20	1280998	145,0	423,5	30,6	-278,5	-2,05R

R denotes an observation with a large standardized residual.

X denotes an observation whose X value gives it large leverage.

Outputs for Surcoat Group without Unusual Observations

Regression Analysis: Surcoat Group versus Huff's Parameter

```
The regression equation is
Surcoat Group = 132 + 0,000219 Huff's Parameter



Predictor                Coef     SE Coef      T      P
Constant               131,81       23,75   5,55  0,000
Huff's Parameter   0,00021926  0,00001658  13,23  0,000



S = 75,3385   R-Sq = 92,1%   R-Sq(adj) = 91,6%

PRESS = 135930   R-Sq(pred) = 87,39%



Analysis of Variance

Source          DF       SS      MS       F      P
Regression       1   993058  993058  174,96  0,000
Residual Error  15    85138    5676
Total           16  1078196



Unusual Observations

         HUFFS
Obs  PARAMETER  Surcoat Group     Fit  SE Fit  Residual  St
Resid
 15    4829836  1229,0  1190,8    67,4      38,2      1,14 X

X denotes an observation whose X value gives it large leverage.
```

Outputs for Topcoat Group

Regression Analysis: Topcoat versus Huff's Parameter

```
The regression equation is
Seasonal Topcoat = 54,1 + 0,000118 Huff's Parameter



Predictor               Coef     SE Coef     T      P
Constant               54,13       20,92  2,59  0,018
Huff's Parameter  0,00011752  0,00001446  8,13  0,000



S = 68,8551   R-Sq = 76,8%   R-Sq(adj) = 75,6%

PRESS = 109918   R-Sq(pred) = 73,05%



Analysis of Variance

Source          DF      SS      MS      F      P
Regression       1  313086  313086  66,04  0,000
Residual Error  20   94821    4741
Total           21  407906



Unusual Observations

         HUFFS  MEVSİMLİK
Obs  PARAMETER   Summer Topcoat Group    Fit  SE Fit  Residual  St Resid
  7    1953000      466,0  283,6    19,8     182,4      2,77R
 18    4829836      629,0  621,7    56,9       7,3      0,19 X
 20    1280998       62,0  204,7    15,1    -142,7     -2,12R
 22    1959455      147,0  284,4    19,9    -137,4     -2,08R

R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Outputs for Topcoat Group without Unusual Observations

Regression Analysis: Topcoat versus Huff's Parameter

```
The regression equation is
Seasonal Topcoat = 52,7 + 0,000121 Huff's Parameter


Predictor                Coef     SE Coef      T      P
Constant               52,724       7,821   6,74  0,000
Huff's Parameter  0,00012085  0,00000532  22,71  0,000


S = 23,9256   R-Sq = 97,4%   R-Sq(adj) = 97,2%

PRESS = 10714,0   R-Sq(pred) = 96,47%


Analysis of Variance

Source          DF      SS      MS       F      P
Regression       1  295344  295344  515,94  0,000
Residual Error  14    8014     572
Total           15  303358


Unusual Observations

         HUFFS  MEVSİMLİK
Obs  PARAMETER   Summer Topcoat Group    Fit  SE Fit  Residual  St Resid
 15    4829836     629,00  636,41   21,51     -7,41     -0,71 X

X denotes an observation whose X value gives it large leverage.
```

Outputs for Vaious Products

Regression Analysis: Various Prod versus Huff Parameter

```
The regression equation is
Various Prod = 2494 + 0,00488 Huff Parameter

21 cases used, 1 cases contain missing values
Predictor             Coef     SE Coef     T      P
Constant              2494        1039  2,40  0,027
Huff Parameter   0,0048751   0,0007018  6,95  0,000


S = 3274,33   R-Sq = 71,7%   R-Sq(adj) = 70,3%

PRESS = 239008970   R-Sq(pred) = 66,85%


Analysis of Variance

Source           DF         SS         MS      F      P
Regression        1  517332531  517332531  48,25  0,000
Residual Error   19  203703108   10721216
Total            20  721035639


Unusual Observations
```

Obs	Huff Parameter	- Various Prod Products	Fit	SE Fit	Residual	St Resid
7	1953000	22676	12015	943	10661	3,40R
18	4829836	25556	26040	2730	-484	-0,27 X

```
R denotes an observation with a large standardized residual.
X denotes an observation whose X value gives it large leverage.
```

Appendix 10 Predicted Annual Sale Potential of Product Groups (Top 25 Product Sale)

District/ Zone	Province	Prod. Group	Sale Estim	District/ Zone	Province	Prod. Group	Sale Estim
İSTANBUL 1	İSTANBUL	Group 1	17,4	OSMANGAZİ	BURSA	Group 4	2,858
		Group 2	6,225			Group 5	1,423
		Group 3	9,298			Group 6	2,607
		Group 4	12,47			Group 7	437
		Group 5	5,994			Group 8	820
		Group 6	12,32			Group 9	335
		Group 7	1,524			Group 10	157
		Group 8	3,23			Group 11	6,761
		Group 9	1,198	İSTANBUL 6	İSTANBUL	Group 1	9,803
		Group 10	622			Group 2	3,532
		Group 11	26,04			Group 3	5,243
İSTANBUL 7	İSTANBUL	Group 1	8,124			Group 4	6,757
		Group 2	2,937			Group 5	3,277
		Group 3	4,347			Group 6	6,548
		Group 4	5,494			Group 7	878
		Group 5	2,676			Group 8	1,798
		Group 6	5,271			Group 9	685
		Group 7	735			Group 10	345
		Group 8	1,481			Group 11	14,58
		Group 9	572	İSTANBUL 2	İSTANBUL	Group 1	5,665
		Group 10	284			Group 2	2,065
		Group 11	12,05			Group 3	3,034
OSMANGAZİ	BURSA	Group 1	4,62			Group 4	3,644
		Group 2	1,695			Group 5	1,796
		Group 3	2,477			Group 6	3,401

Appendix 11 Predicted Quarterly Sale Potential of Product Groups (Top 25 Product Sale)

District/ Zone	Province	Prod. Group	Per.	Sale Estim.
İSTANBUL 1	İSTANBUL	Group1	Q1	4,18
		Group1	Q2	3,986
		Group1	Q3	5,424
		Group1	Q4	3,811
		Group 2	Q1	1,161
		Group 2	Q2	1,527
		Group 2	Q3	2,253
		Group 2	Q4	1,284
		Group 3	Q1	1,82
		Group 3	Q2	2,221
		Group 3	Q3	3,614
		Group 3	Q4	1,643
		Group 4	Q1	1,87
		Group 4	Q2	3,429
		Group 4	Q3	4,313
		Group 4	Q4	2,859
		Group 5	Q1	3,753
		Group 5	Q2	1,284
		Group 5	Q3	12
		Group 5	Q4	945
		Group 6	Q1	3,081
		Group 6	Q2	3,081
		Group 6	Q3	3,081
		Group 6	Q4	3,081
		Group 7	Q1	381

Appendix 12 Retail Chain and Manufacturing Parameters

Amount of Stores and Age Parameters of Stores for Top 20 Districts

No	Province	District	Huff's Parameters	Amount of Stores	Alternative Store Age			
					1	2	3	4
1	İstanbul	İstanbul 1	4,829,836	4	7	3	1	1
2	İstanbul	İstanbul 7	1,959,455	3	4	1	1	0
3	Bursa	Osmangazi	875,247	3	3	1	1	0
4	İstanbul	İstanbul 6	2,479,218	2	5	1	0	0
5	İstanbul	İstanbul 2	1,198,621	2	4	1	0	0
6	Ankara	Çankaya	996,366	2	8	5	0	0
7	Ankara	Keçiören	930,882	2	6	4	0	0
8	Ankara	Yenimahalle	791,546	2	5	1	0	0
9	Denizli	Denizli	737,815	2	3	1	0	0
10	Afyon	Afyon	357,448	2	5	1	0	0
11	İstanbul	İstanbul 3	1,280,998	1	5	0	0	0
12	Adana	Seyhan	885,608	1	3	0	0	0
13	Konya	Selçuklu	679,556	1	3	0	0	0
14	Kayseri	Melikgazi	634,303	1	3	0	0	0
15	Maraş	Maraş	633,142	1	4	0	0	0
16	Ankara	Mamak	585,539	1	3	0	0	0
17	Malatya	Malatya	530,378	1	4	0	0	0
18	Sivas	Sivas	520,805	1	5	0	0	0
19	Eskişehir	Odunpazarı	477,162	1	3	0	0	0
20	Antalya	Muratpaşa	476,697	1	5	0	0	0

Top 20 District'sAlternative Store Cost Per Square Meters and Store Areas

No	Alternative Store Cost Per m2				Store Area m2			
	1	2	3	4	1	2	3	4
1	861	870	876	993	900	700	600	210
2	750	792	777	810	500	300	350	250
3	717	735	810	645	240	200	140	500
4	795	870	852	795	400	200	240	400
5	717	750	759	780	350	250	241	200
6	702	741	699	708	300	230	332	292
7	702	798	696	735	300	170	365	260
8	690	789	690	666	250	160	275	338
9	723	852	687	792	220	120	280	141
10	645	795	672	723	200	100	182	139
11	780	849	780	765	200	160	200	236
12	672	666	705	762	350	389	250	204
13	615	837	657	657	500	120	325	354
14	630	678	657	813	400	272	299	127
15	630	675	720	687	400	250	212	263
16	615	627	615	696	435	350	400	196
17	597	642	693	684	440	282	189	195
18	627	618	651	639	300	368	244	308
19	657	660	615	741	265	259	344	162
20	645	654	684	633	275	243	217	290

Top 20 District's Alternative Store Hanging Capacity and Store Warehouse Box Capacity

No	Alternative Store Hanging Capacity (cm)				Store Warehouse Box Capacity			
	1	2	3	4	1	2	3	4
1	28,800	22,400	19,200	6,720	2,700	2,100	1,800	630
2	16,000	9,600	11,200	8,000	1,500	900	1,050	750
3	7,680	6,400	4,480	16,000	720	600	420	1,500
4	12,800	6,400	7,680	12,800	1,200	600	720	1,200
5	11,200	8,000	7,712	6,400	1,050	750	723	600
6	9,600	7,360	10,624	9,344	900	690	996	876
7	9,600	5,440	11,680	8,320	900	510	1,095	780
8	8,000	5,120	8,800	10,816	750	480	825	1,014
9	7,040	3,840	8,960	4,512	660	360	840	423
10	6,400	3,200	5,824	4,448	600	300	546	417
11	6,400	5,120	6,400	7,552	600	480	600	708
12	11,200	12,448	8,000	6,528	1,050	1,167	750	612
13	16,000	3,840	10,400	11,328	1,500	360	975	1,062
14	12,800	8,704	9,568	4,064	1,200	816	897	381
15	12,800	8,000	6,784	8,416	1,200	750	636	789
16	13,920	11,200	12,800	6,272	1,305	1,050	1,200	588
17	14,080	9,024	6,048	6,240	1,320	846	567	585
18	9,600	11,776	7,808	9,856	900	1,104	732	924
19	8,480	8,288	11,008	5,184	795	777	1,032	486
20	8,800	7,776	6,944	9,280	825	729	651	870

Top 20 District'sStore Opening Costs

No	Store Opening Costs			
	1	2	3	4
1	-	-	-	-
2	-	-	-	300,000
3	-	-	-	550,000
4	-	-	290,000	450,000
5	-	-	291,000	250,000
6	-	-	382,000	342,000
7	-	-	415,000	310,000
8	-	-	325,000	388,000
9	-	-	330,000	191,000
10	-	-	232,000	189,000
11	-	210,000	250,000	286,000
12	-	439,000	300,000	254,000
13	-	170,000	375,000	404,000
14	-	322,000	349,000	177,000
15	-	300,000	262,000	313,000
16	-	400,000	450,000	246,000
17	-	332,000	239,000	245,000
18	-	418,000	294,000	358,000
19	-	309,000	394,000	212,000
20	-	293,000	267,000	340,000

Top 20 District's Renewing Costs

No	Renewing Costs			
	1	2	3	4
1	450,000	350,000	300,000	105,000
2	250,000	150,000	175,000	-
3	120,000	100,000	70,000	-
4	200,000	100,000	-	-
5	175,000	125,000	-	-
6	150,000	115,000	-	-
7	150,000	85,000	-	-
8	125,000	80,000	-	-
9	110,000	60,000	-	-
10	100,000	50,000	-	-
11	100,000	-	-	-
12	175,000	-	-	-
13	250,000	-	-	-
14	200,000	-	-	-
15	200,000	-	-	-
16	217,500	-	-	-
17	220,000	-	-	-
18	150,000	-	-	-
19	132,500	-	-	-
20	137,500	-	-	-

Purchase and Sale Prices, Hanger and Box Usage, and Manufacturing Capacities

Product Group	Purc. Price	Sale Price	Hang. Usage	Box Usage	Manuf. Capacity			
					Q 1	Q 2	Q 3	Q 4
1	80	256	3	0.1	15,000	20,000	25,000	28,246
2	110	352	4	0.1	6,000	8,000	11,000	9,742
3	140	448	4	0.2	7,000	13,000	20,000	10,000
4	220	704	7	0.2	7,000	18,000	22,000	16,000
5	280	896	9	0.2	20,000	0	0	5,000
6	60	180	0.05	0.1	26,694	22,245	22,245	22,245
7	170	544	6	0.1	3,032	3,032	3,032	3,032
8	120	384	5	0.1	5,745	5,745	5,745	5,745
9	160	512	4	0.2	1,173	2,709	3,782	1,658
10	250	800	8	0.2	1,099	1,099	1,099	1,099
11	50	160	4	0.05	40,000	40,000	40,000	40,000

Upper Lim. Manuf. Cap.	1.2	**Investment Budget**	2.000.000
Low. Lim. Manuf. Cap.	0.8	**Interest Rate**	0.2
Max. Inc. Manuf. Cap.	0.2	**Min. Age for Store Closing**	2
Max. Dec. Man. Cap.	0.2		

Appendix 13 Top 50 Districts for Gams Solution

No	Province	District	No	Province	District
1	İSTANBUL	İSTANBUL 1	26	GAZİANTEP	ŞAHİNBEY
2	İSTANBUL	İSTANBUL 7	27	GAZİANTEP	ŞEHİTKAMİL
3	BURSA	OSMANGAZİ	28	ANKARA	SİNCAN
4	İSTANBUL	İSTANBUL 6	29	BURSA	YILDIRIM
5	İSTANBUL	İSTANBUL 2	30	ELAZIĞ	ELAZIĞ
6	ANKARA	ÇANKAYA	31	BATMAN	BATMAN
7	ANKARA	KEÇİÖREN	32	İZMİR	KARABAĞLAR
8	ANKARA	YENİMAHALLE	33	ADANA	YÜREĞİR
9	DENİZLİ	DENİZLİ	34	İSTANBUL	İSTANBUL 8
10	AFYONKARAHİSAR	AFYON	35	ANTALYA	KEPEZ
11	İSTANBUL	İSTANBUL 3	36	MALATYA	BATTALGAZİ
12	ADANA	SEYHAN	37	İZMİR	BORNOVA
13	KONYA	SELÇUKLU	38	İZMİR	BUCA
14	KAYSERİ	MELİKGAZİ	39	ANKARA	ETİMESGUT
15	KAHRAMANMARAŞ	KAHRAMANMARAŞ	40	TRABZON	TRABZON
16	ANKARA	MAMAK	41	İZMİR	KONAK
17	MALATYA	MALATYA	42	KAYSERİ	KOCASİNAN
18	SİVAS	SİVAS	43	BURSA	NİLÜFER
19	ESKİŞEHİR	ODUNPAZARI	44	DİYARBAKIR	BAĞLAR
20	ANTALYA	MURATPAŞA	45	MANİSA	MANİSA
21	SAMSUN	İLKADIM	46	HATAY	ANTAKYA
22	ÇORUM	ÇORUM	47	BALIKESİR	BALIKESİR
23	KÜTAHYA	KÜTAHYA	48	MALATYA	YEŞİLYURT
24	BİLECİK	BOZÜYÜK	49	ADANA	ÇUKUROVA
25	İSTANBUL	İSTANBUL 4	50	ESKİŞEHİR	TEPEBAŞI

Appendix 14 Gams Output for Scenario I with Simple Interest

```
Fixed MIP status(1): optimal

Solution satisfies tolerances.

MIP Solution:      41540825.806695    (342655 iterations, 0 nodes)
Final Solve:       41540825.806695    (39588 iterations)

Best possible:     43035163.851639
Absolute gap:       1494338.044944
Relative gap:             0.035973

--- Restarting execution
--- Untitled_38.gms(2312) 0 Mb
--- Reading solution for model Proje
--- Untitled_38.gms(2312) 16 Mb
--- Executing after solve: elapsed 0:24:03.876
--- Untitled_38.gms(2314) 17 Mb
*** Status: Normal completion
--- Job Untitled_38.gms Stop 05/05/18 21:12:11 elapsed 0:24:03.908
```

Appendix 15 Gams Output for Scenario I with Compound Interest

```
Removing perturbation.
Fixed MIP status(1): optimal

Solution satisfies tolerances.

MIP Solution:     41162121.287314    (332487 iterations, 0 nodes)
Final Solve:      41162121.287314    (40954 iterations)

Best possible:    42605162.652277
Absolute gap:      1443041.364963
Relative gap:            0.035058

--- Restarting execution
--- Untitled_44.gms(2320) 0 Mb
--- Reading solution for model Proje
--- Untitled_44.gms(2320) 16 Mb
--- Executing after solve: elapsed 0:21:24.304
--- Untitled_44.gms(2322) 17 Mb
*** Status: Normal completion
--- Job Untitled_44.gms Stop 05/29/18 02:13:08 elapsed 0:21:24.330
```

Appendix 16 Gams Output for Scenario I without Interest

```
Solution satisfies tolerances.

MIP Solution:      49986635.588305    (391054 iterations, 0 nodes)
Final Solve:       49986635.588305    (41922 iterations)

Best possible:     51575763.996467
Absolute gap:       1589128.408162
Relative gap:             0.031791

--- Restarting execution
--- Untitled_40.gms(2308) 0 Mb
--- Reading solution for model Proje
--- Untitled_40.gms(2308) 16 Mb
--- Executing after solve: elapsed 0:25:17.998
--- Untitled_40.gms(2310) 17 Mb
*** Status: Normal completion
```

Appendix 17 Gams Output for Scenario II

```
Fixed MIP status(1): optimal

Proven optimal solution.

MIP Solution:      30972351.039700    (45891 iterations, 0 nodes)
Final Solve:       30972351.039700    (33591 iterations)

Best possible:     30972351.039700
Absolute gap:             0.000000
Relative gap:             0.000000

--- Restarting execution
--- Untitled_41.gms(2312) 0 Mb
--- Reading solution for model Proje
--- Untitled_41.gms(2312) 16 Mb
--- Executing after solve: elapsed 0:02:34.648
--- Untitled_41.gms(2345) 17 Mb
```

Appendix 18 Gams Output for Scenario III

```
Fixed MIP status(1): optimal

Solution satisfies tolerances.

MIP Solution:      39600292.251663    (363475 iterations, 0 nodes)
Final Solve:       39600292.251662    (37253 iterations)

Best possible:     41137922.148177
Absolute gap:       1537629.896515
Relative gap:             0.038829

--- Restarting execution
--- Untitled_42.gms(2308) 0 Mb
--- Reading solution for model Proje
--- Untitled_42.gms(2308) 16 Mb
--- Executing after solve: elapsed 0:25:52.576
--- Untitled_42.gms(2310) 17 Mb
*** Status: Normal completion
```

Appendix 19 Gams Output for Scenario III without Closing Store

```
Fixed MIP status(1): optimal

Solution satisfies tolerances.

MIP Solution:      39462527.201419    (330608 iterations, 0 nodes)
Final Solve:       39462527.201419    (42388 iterations)

Best possible:     40061552.395177
Absolute gap:        599025.193758
Relative gap:             0.015180

--- Restarting execution
--- Untitled_43.gms(2309) 0 Mb
--- Reading solution for model Proje
--- Untitled_43.gms(2309) 16 Mb
--- Executing after solve: elapsed 0:17:43.175
--- Untitled_43.gms(2311) 17 Mb
*** Status: Normal completion
```

CURRICULUM VITAE

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Surname, Name: YILMAZ, Onur
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EDUCATION

Degree	Institution	Year of Graduation
M.Sc.	ÇANKAYA University Department of Industrial Engineering	2018
B.Sc.	ÇANKAYA University Department of Industrial Engineering	2013
High School	Polatlı High School	2004

FOREIN LANGUAGES

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HOBBIES

Reading, Trekking, Swimming, Computer Programming, Watching Movie