# CROSS SELLING DECISION SUPPORT SYSTEM IN PRIVATE PENSION AND LIFE INSURANCE SYSTEMS

(BİREYSEL EMEKLİLİK VE HAYAT SİGORTALARI SİSTEMLERİNDE ÇAPRAZ SATIŞ KARAR DESTEK SİSTEMİ)

by

**Burçin YAKAN, B. S.**

**Thesis**

Submitted in Partial Fulfillment

of the Requirements

for the Degree of

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Supervisor : Assoc. Prof. S.Emre ALPTEKİN

Committee Members : Prof. Dr. Gülçin BÜYÜKÖZKAN FEYZİOĞLU

Asst. Prof. Dr. Ruhi TUNCER

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**ABSTRACT**

Private pension and life insurance sector, which is one of the most promising potential sectors, has increased its active size by 60% over past three years. It has an increasing importance in financial sector. Private pension system serves as an investment options for Turkish people, and also a supplementary component of the social security system. The main purpose of the private pension system is providing investment and regular income during retirement for contributor, long term funding for Turkish economy, and revenue generation for private pension companies. The main purpose of the life insurance system is protecting insured person and their loved ones from financial difficulties in case of illnesses, accidents and death of the insured. Turkey with its high and young population is a promising potential sector for life insurance companies.

Private pension and life insurance sector through its high growth, Turkey attracts both foreign and Turkish investors. The competition between private pension and life insurance companies is increasing day after day due to advertising and marketing activities. Thus, increasing the sales and profitability is crucial for companies and they must apply right marketing strategies to achieve those aims.

In this thesis, increasing sales and profitability is the main motivation for us. In order to achieve our aims, cross selling strategy is applied to make use of different sales opportunities and to sell new products to current customers instead of searching for new customers. There are two main issues in application of this approach. First, is finding each customer considering different demographic properties of each product, and second is developing cross selling strategy to these customers. As a consequence of lack of literature that is using both of the techniques; this study can be considered as a novel approach.

In order to demonstrate applicability of proposed approach, we have chosen one of the biggest companies in this sector. As a consequence of limited resource of this company to reach all current customers, they have to focus on the most profitable customers. The most profitable customer profiles are examined by Design of Experiments in order to determine customer profiles. Duration of stay in pension system and saving amount values are selected to be maximized to find target customer profile in pension system. Also in life insurance system, a total premium amount value is selected to be maximized to find target customer profile in life insurance system. As a result, target customer profiles are determined after those values are optimized. Customer profiles are divided into 3 groups in terms of profitability, good customer group, moderate customer group and bad customer group based on scores that are calculated using properties of customer and his/her product. After we divided customers into groups; company can choose a target customer group to apply cross selling, if its selling staff is not enough to reach all customers.

Fuzzy logic is applied in order to measure success of sales in cross selling area. It provides to translate the current score of customer to the score in target system. Therefore, if the score of customer is known in the current system, the achievement score in cross-selling system can be calculated. We utilized Fuzzy tool box of Matlab, in order to establish Cross selling decision support system which calculates the achievement score of customer in cross selling system. Cross selling decision support system can be used by selling staff of company and the selling decision can be made depending on the score obtained from the system. With this proposed approach, by determining target customer profile, company is both increasing its sales and profitability by selling new products to its current customers and profitability is to be estimated be long lasting as the products are sold to the right customer.

**RESUME**

La retraite privée et le secteur de l'assurance de vie qui est l'un des secteurs les plus prometteuses, ont augmenté la taille de 60% dans les trois dernières années. Ils ont eu une importance croissante dans le secteur financier, de même. Le système privé de pension sert à une des options de placement pour les turques, mais aussi une composante supplémentaire du système de sécurité sociale. L'objectif principal du système de retraite privée est d'apporter des investissements et des revenues régulières pendant la retraite de contributeur un financement à long terme pour l'économie turque, et la génération de revenues pour les entreprises de pensions privées.

L'objectif principal du système de l'assurance devie est de protéger l'assurance des parents en cas des difficultés financières et en cas de maladies, d'accidents et de décès. La majorité de la population jeune de la Turquie promis le potentiel pour les entreprises d'assurance de vie. La retraite privée et le secteur de l'assurance de vie, à travers sa forte croissance, la Turquie attire les investisseurs étrangers et le turc. La concurrence entre les régimes de retraites privées et les sociétés d'assurance devie augmente de jour en jour, en raison des activités de publicité et de marketing. Ainsi, l'augmentation des ventes et la rentabilité est cruciale pour les entreprises et elles doivent appliquer des stratégies de marketing appropriées pour atteindre ces objectifs.

Dans cette thèse, l'augmentation des ventes et de la rentabilité a été la principale motivation pour nous. Pour atteindre nos objectifs, la stratégie de vente croisée est appliquée à obtenir des opportunités de vente différentes. Puis, ça sert à vendre de nouveaux produits aux clients actuels au lieu de chercher nouveaux clients. Il y a deux problèmes principaux dans l'application de cette approche. Tout d'abord, chaque client a été trouvé en tenant compte des propriétés démographiques de chaque produit. Puis, la stratégie de vente croisée s'est développée. En raison de l'absence de recherche qui

utilise ce type de méthodologies, ce travail peut être considéré comme une nouvelle approche.

Afin de démontrer l'applicabilité de l'approche proposée, nous avons choisi une des plus grandes entreprises de ce secteur. En raison de ressources limitées de cette société pour atteindre tous les clients actuels, nous avons assumé qu'ils doivent se concentrer sur les clients les plus rentables. Les profils des clients les plus rentables sont examinés par la méthode Design of Experiments. Durée du séjour en régime de pension et les valeurs de montant d'épargne sont sélectionnées pour être maximisée pour trouver le profil du client cible dans le système de retraite. Parallèle au système de l'assurance devie, une valeur totale des primes des montants sont sélectionnés pour être maximisée pour trouver le profil du client cible dans le système de l'assurance devie. En conséquence, les profils de clients cibles sont déterminés en optimisant ces valeurs. Les profils de clients sont classifiés en 3 groupes en termes de rentabilité : le groupe de bon clients, le groupe de clients modérées et le groupe de clients mauvais basée sur les scores qui sont calculées en utilisant les propriétés de la clientèle et sa / son produit. L'entreprise peut choisir un groupe de clients cible pour appliquer la vente croisée, si son personnel de vente ne suffit pas à atteindre tous les clients. La logique floue est appliquée pour mesurer le succès des ventes dans le secteur des ventes croisées. Il fournit à traduire le score actuel du client au score dans le système cible. Par conséquent, si le score de client est connu dans le système actuel, le score de réalisation de vente croisée peut être calculé.

Nous avons utilisé les outils floues de MATLAB. La vente croisée aide à la décision et peut être utilisés par le personnel de vente dans l'entreprise et la décision de vente peut être faite en fonction du score obtenu par la méthodologie proposée. Avec cette approche proposée, en déterminant le profil du client cible, l'entreprise à la fois augmente ses ventes et la rentabilité par la vente de nouveaux produits à ses clients actuels et la rentabilité.

## ÖZET

Geçtiğimiz üç yılda aktif büyüklüğünü %60 oranında artıran bireysel emeklilik ve sigortacılık sektörü, Türkiye'de gelişmekte olan önemli potansiyel sektörlerden biri haline gelmiştir. Bireysel emeklilik sistemi ve hayat sigortacılığı her geçen gün finans sektöründe ağırlığını hissettirmeyi başarmaktadır. Bireysel Emeklilik sistemi Türk halkı için mevcut yatırım seçeneklerinden biri, aynı zamanda sosyal güvenlik sisteminin tamamlayıcı bir unsuru olmayı başarmıştır. Bireysel Emeklilik sisteminin temel amacı, katılımcı için yatırım yapmak ve emeklilik aşamasında düzenli bir gelir elde etmek, devlet için Türk ekonomisine uzun vadeli kaynak aktarımı yapmak ve bireysel emeklilik şirketi için ise sağlam temellere oturtulmuş ticari yapılar olarak gelir elde etmektir. Hayat sigortacılığında amaç, insanların yaşamları boyunca karşılaşabilecekleri hastalık, kaza ve ölüm gibi nedenlerden dolayı doğacak maddi zorluklara karşı sigortalıyı ve sevdiklerini korumaktır. Türkiye, yüksek ve genç nüfuslu olma özelliklerinden dolayı sigorta şirketleri için verimli, potansiyel bir pazar olarak nitelendirilmektedir.

Bireysel Emeklilik ve Hayat Sigortacılığı sektörü gelişen yapısıyla, Türkiye, hem yabancı hem Türk yatırımcıların ilgisini yoğun olarak çekmektedir. Bireysel emeklilik ve hayat şirketlerinin tanıtım, pazarlama ve yeni satış kadroları kurmalarıyla beraber gösterdikleri başarı, sektördeki rekabeti günden güne artırmaktadır. Bu nedenle, şirketlerin satışlarını ve şirket karlılıklarını artırmaları büyük önem taşımaktadır. Karlılığın ve satışların artırılması için doğru pazarlama stratejilerini uygulamak gerekmektedir.

Bu çalışmada satışların ve karlılığın artırılması temel motivasyonumuzdur. Satışların ve karlılığın artırılması için yeni müşteri bulmak yerine hem farklı satış fırsatlarından yararlanmak hem de yeni satış yapılmasını sağlamak amacıyla çapraz satış tekniğini uygulamaya karar verdik. Bu tekniğin uygulamasında 2 temel konu bulunmaktadır.

Öncelikle, satışların başarılı ve uzun ömürlü olabilmesi için şirketin mevcut müşterilerinin demografik özellikleri ve satın almış oldukları ürünlerin özellikleri üzerinden müşteri profillerinin belirlenmesi ve ikinci olarak, müşteri profillleri belirlendikten sonra, hedef müşteri profiline çapraz satış uygulanmasıdır. Yapılan literatür araştırmaları sonucu, bu iki yöntemi bir arada kullanan çalışma olmadığından, bu çalışmada yeni bir yaklaşım önerilmektedir.

Geliştirilen yöntemin uygulaması, sektörün en büyük şirketlerinden birinde yapılan örnek çalışma ile incelenmektedir. Müşteri profillerinin belirlenmesi amacıyla Design of Experiments(DOE) yöntemi ile şirket için en karlı müşteri profilleri değerlendirilmiştir. Bireysel Emeklilik sisteminde, hedef müşteri profilini belirlemek için, bireysel emeklilik sisteminde kalış süresi ve katılımcının birikim tutarı, şirket karını arttırdığı için en büyükleyecek değerler olarak belirlenmiştir. Hayat Sigortacılığı sisteminde ise, sigortalının poliçe yenileme süresi boyunca ödediği toplam yıllık prim tutarı şirket karını artırdığından, en büyükleyecek değer olarak belirlenmiştir. Bu değerlerin optimize edilmesi sonucunda ideal müşteri profilleri belirlenmiştir. Her müşteri profiline ait skorlar, müşteri ve ürün özelliklerine göre hesaplanarak, şirket karlılığı açısından müşteriler iyi, orta ve kötü olarak gruplara ayrılmıştır. Müşterilerin gruplara ayrılması sonucu, şirket yetersiz satış kaynağına sahip olması durumunda, çapraz satış uygulamak istediği müşteri grubunu kendisi belirleyebilmektedir.

Müşterilerin gruplara ayrılması ile çapraz satış yaklaşımının başarısını ölçmek adına bulanık mantık metodu uygulanmıştır. Müşterinin mevcut sistemdeki skoru, bulanık mantık ile hedeflenen sistemdeki skora dönüştürülmüştür. Bu sayede, müşterinin mevcut sistemdeki başarı puanı bilindiği takdirde, çapraz satış yapılacak sistemdeki başarı puanı hesaplanabilmektedir. Çapraz satış yapılacak sistemdeki başarı puanı, hedeflenen müşteri grubunu işaret ediyorsa, şirket kararları dahilinde çapraz satış gerçekleştirilebilir. Bulanık mantık ile çapraz satış yapılacak sistemdeki puanın hesaplanması, Matlab'ta Fuzzy tool box kullanımı sonucu gerçekleştirilmiş, ve bu sayede çapraz satış karar destek sistemi oluşturulmuştur. Çapraz satış karar destek sistemi, çapraz satış yapacak satıcı tarafından aktif olarak kullanılarak, müşterinin mevcut sistemindeki puanı sisteme girildiği takdirde, müşterinin karşı sistemindeki

puanına göre, şirket kararları çerçevesinde satış yapıp yapmama kararı verilebilmektedir. Bu çalışma sayesinde, hedef müşteri grupları belirlenerek, şirketin mevcut müşterilerine hem yeni ürün satışı yapılarak şirketin karlılığı ve satışları artırılmakta hem de doğru müşteriye satış yapıldığından, karlılık uzun süreli olmaktadır.

# 1. INTRODUCTION

Private Pension system and life insurance system are two main financial instruments that are founded because of pursuit of security in people lives. These two systems involve risk and investment issues. Insurance and private pension system gained higher importance in this period that was characterized by negative concerns for the future due to global economic crisis environment which started in 2008.

Private Pension System is a profitable investment system that converts savings into income by planning the future from today. It is a supplementary to the social security system, with government tax advantages, and it allows people to start building savings from today for a happy retirement. The pension system is based on making investment to pension funds and if a participant has paid contributions at least for 10 years, at the age of 56, he has a right to retire and receive his accumulated savings. The participant has many privileges in pension system, which allows him/her to determine the amount of the contribution, payment rate, currency of contribution, duration of participation in the system. The most outstanding property of private pension system is offering tax advantages that are not offered by any other investment instrument. Therefore, participant may receive a tax deduction up to 35 percent of his paid contributions. Tax advantages continue while participant paying his contributions, the saving increasing its value and participant retiring from the system.

Life Insurance system is based on a contract, when various risks happens during the policy term such as, death and disability of person that protects policyholder and his family members from financial problems. When this risk happens, the benefit which is the amount determined in the contract, is given to beneficiaries. Policyholder is the responsible of paying premiums that is calculated by the coverage amount. Insurance premiums may vary, depending on the coverage selected, the age of policyholder and

the coverage amount. There are various types of life insurance products, such as life insurance for banking products which pays the credit risk, education insurance which pays the cost of education of policyholder's children.

As it is mentioned, private pension and life insurance sector is promising that attracts many investors. Therefore, there is high rise in the number of domestic and flammable companies which have recently entered the sector and there has been great competition between companies. Under these conditions, companies should consider to increase the sales and profitability in order to survive.

Companies that sell private pension and life insurance products, give importance for their marketing activities, as Soopramanien et al. (2010) surveyed companies make investments on their marketing activities to manage customers and determine new prospective customers. In this phase, it is an undisputable fact that, Cross- selling technique has an important place among these marketing activities. Under these conditions, we use cross selling strategy to boost the sales of company with the principle of using different sales opportunities. Liu (2011) reveals that, the cost of winning a new customer is five times as much as retaining an old customer, and the profit earned by winning over 10 customers can not offset the expense caused by losing a valuable customer, so it is important to grab the potential customers.

Since there are many various case features in real life scenarios, companies have difficulties in adapting their cross selling strategies, such as applying cross- selling to right customer profile. Thus, it is very important to determine the target customer type for companies. Wood et al. (2009) indicated many companies state that to stay profitable, it is essential for them to be able to identify customers where they could optimize profit. Also, they take into account a range of demographic and financial characteristics of customers, such as age of customers, geography of customers.

This paper introduces cross selling decision support system based on Design of Experiments (DOE), and Fuzzy Expert systems. Initially, we have determined target customer profiles over factors related to customer and product with Design of Experiments. While determining most profitable customer types, we considered

duration of stay and saving amount for pension system; and total premium amount for life insurance system to maximize. Since, we found most profitable customer types; we decided to divide them into 3 parts in terms of profitability: good customer group, moderate customer group and bad customer group. After we divided customers into 3 groups, we applied Mamdani-style inference in fuzzy logic not only to evaluate customers according to their membership degrees but also to make a model that includes two distinct parts, evaluating the rule antecedent and applying the result to the consequent which is called fuzzy rules. Therefore, it reveals the status of the customer in cross-selling system by evaluating the status of the customer in current system. The last phase of the proposed methodology involves the establishment of cross selling decision support system, by fuzzy tool box of Matlab. By cross selling decision support system, the score of customer in cross selling area is revealed and this proposed decision support system (DSS) can be used by the call center employee to offer cross selling if customer has enough score in the cross selling system. To the best of our knowledge we could not find any study in the literature that integrates Design of Experiments Method and Fuzzy Inference method.

The remaining part of the study is organized as follows: In section 2, we give related literature, which is about private pension, life insurance systems and cross selling; Section 3 briefly describes the problem definition of the study; Section 4 describes the methodologies, Design of Experiments, Fuzzy Logic techniques which constitute the proposed framework. The steps and details of proposed cross selling decision support system and its implementation in private pension and life insurance system are given in Section 5. Finally, Section 6 concludes the study.

# 2. LITERATURE REVIEW

We reviewed the literature review into three groups, private pension system and life insurance system and cross selling. To the best of our knowledge we could not find any study in the literature that integrates Design of Experiments Method and Fuzzy Inference method.

First we compiled literatures of private pension system and life insurance system, and then we mentioned literature of cross selling, which is our aim to achieve.

## 2.1. PRIVATE PENSION SYSTEM

There are many studies which focused on private pension system. For instance, Cohen (1983) dealt with increasing the benefits of private pension system for women by making changes in age rules, part-time exclusions, vesting rules, industry coverages and integration rules with social security services. To test the changes of these effects, two simulation models are applied and significant differences are found in some effect. Seidman (1980) focused on relation between social security system and private pension plans and they made observations about early retirement, benefit formula and the growth of private pensions. They mentioned that social security program is fundamental thing for providing income for retirees. However private pension has unstoppable improvement and has major effect for retirees. Flagg (1993) focused on selecting best tax environment for retirement planning which returns greatest tax amount in retirement. They performed a scenario analysis about selecting a plan among four retirement plans.

Kapinos (2012) states on a relationship between gender type and age of workforce with offered private pension plan of firm. By using firms' private pension and employer house hold data, research is conducted. A hazard model is set and fixed effects, main

effects are determined, such as fraction of female employees in the firm. Instrumental variables are estimated to investigate the correlation of the firm's pension policy. Hidalgo et al. (2008) suggests that in private pension system, matching the industry's price leader reasons to reduce Customer Lifetime Value. Therefore it reduces marketing effort for this customer. Gupta and Lehmann method is applied to measure and analyze the CLV.

There is a research about private pension system in Russia. Pension fund strategies and trends of private pension funds are examined. The role and evaluation of private pension system is evaluated through many countries. Also, private pension funds are categorized according to their own assets. Some strategies are mentioned to increase the efficiency of funds from seven risk levels that are about risk portfolio and investment rating (Aranzherreev & Novikov, 2011).

Sepulveda (2012) used Panzar and Rosse H–statistic by using Arellano and Bond GMM dynamic panel estimation to measure the degree of competition in Chilean private pension system. Data is taken from pension funds from 1996 -2006. The results show that private pension is a monopoly industry during this period. Also, during this time competition has decreased whereas concentration of the industry has increased which is proven by ordinary least square regression with H–statistic. Vliet et al. (2012) made a study that is conducted between 15 countries for the period 1995-2007. As it's known that private pension is less common than public social security, thus it results on unequal income among older people. This study analyses distributional effects of shifts from public to private pension. They ran a number of pooled time series cross-section regressions to determine the relationship between pension reform and income inequality. It is found that there is no evidence that shifts from public to private pension provision are related with high levels of income inequality.

## 2.2. LIFE INSURANCE SYSTEM

Dündar (2011) indicates that insurance is a contract between policy holder and insurer. According to this contact, the policy holder has to pay an amount of money to insurer,

which is called premium, and insurer has to compensate future losses of policy holder if it happens. The purpose of this contract is to protect policy holder against the possible risks in his life, by an amount of money which is called compensation amount. The insurance companies are important factors in financial market to take risks. They have two main parts; life insurance companies and non-life insurance companies. According to utility theory, insurance premium and risk expectations are connected. The insurance companies earn from the difference between the people willing to pay for being insured and expected claims, which means insurance companies takes premium that is larger than the expected claim size. Economic agents who aware the huge impact of risk, can look for other alternatives to transfer this risk to the other companies in the insurance market.

Abrahams et al. (2009) demonstrate the use of decision tree for achieving new marketing strategy for insurance company. They used both decision tree approach and profit optimal decision algorithm, to determine the characteristics of profitable demographics and this method is called SBP. In the conclusion part, they evaluated the results and give recommendations to managers according to the US census data and their own data source. Results show that entropy based decision tree approach, which focus on node purity, reach lower profits compared to SBP method which is built in this study.

Verhoef et al. (2001) made a study based on relationship between potential value and realized value of customers in insurance industry. They reveal a model that predicts the potential value of current customer, so managers can apply specific strategies. Customer data is examined based on age, education, household size, income and home ownership of customer and the bases for stratification are relation duration, purchase level of insurances and claiming behavior. In discussion part, it is mentioned that among all types of insurance policies ranging from fire, theft insurances to life insurance, legal aid and travel insurance are typically related to the customer's socio-demographic characteristics.

In study Ainslie et al. (1992) shows a typical application of DBM (database marketing) in insurance companies' database. Short-term insurance, presents low barriers for customers to exit from the system. There the aim of the study is despite of gaining more new customer customers, losing fewer existing ones. In the article, the correlation between different variables in the customer database and the frequency of lapse by customers is examined. The following hypothesizes are chosen for testing:

- H1= There is no correlation between the frequency of lapse by customers and different variables in the customer database.
- H2= There is correlation between the frequency of lapse by customers and different variables in the customer database

Customer database has almost 30. 000 rows of data and that includes demographic properties of customer and properties of policy. Data analysis, divided into two sections, in the first part, H1 was tested and in the second part, techniques were used to create a predictive model, in line with H2. In the conclusion part, although, a degree of dependence was shown between the lapse rate and customer variables, the relationship was not strong to create a predictive model, so the hypothesis H2 was not supported.

Liao et al. (2009) examined what functionalities best fit the customer needs and wants for life insurance products, by getting information about rules and patterns of customer, and their demand chain. This article uses a priori algorithm and clustering analysis for data mining. The database of Personal information of customer, level of demand cognition, demands, life insurance products and additional service for policy are examined according to the databases of market segmentation, consumer demand and consumer behavior. In the knowledge extraction part, it is focused on designing new product mix and marketing through database. In the conclusion part, the article reveals that, customers who are just starting to family stage and those with growing family stage have very similar properties in insurance package demands. Also, younger people who are new to the workplace and unmarried workers share some similarities. Insurers can consider to combining these two groups to increase market shares and sales performances.

## 2.3. LITERATURE REVIEW OF CROSS SELLING

Cross selling is an important technique in marketing area. There are some literature studies that carried out cross selling applications. Thuring (2011) examined, a credibility method for profitable cross selling of insurance products. This method is revealed for identifying an expected profitable set of customers, to offer them an additional insurance product. Customer specific latent profile is estimated for the additional product by customer data set for current insurance product. Then, including a specific customer in an expected profitable set of customers is considered. The method is applied in real data set in Danish insurance company and as a result of the method, customer set with 36% less claims than priori expected. Therefore, this method is beneficial for insurance companies when applying cross selling. Ahn et al. (2011) examined facilitating cross selling in a mobile telecom market to develop customer classification model on hybrid data mining technique. As the competition increases, it is important for companies to diversify their business areas, so cross selling is critical for companies to expand their revenues and profits. A customer classification model is proposed, which is facilitating cross selling in mobile telecom market. Existing customer data that includes their demographic data and old products patterns is used for finding new products and services with high sales potential. Classification techniques are applied to the purchase of new product and then GA is applied to make the final decision for target customers. Kamakura et al. (2003) investigated cross selling through database marketing which is about a mixed data factor analyzer for data augmentation and prediction. Database marketing enables firms to leverage on knowledge about current customers, so that maximizes the sales effort, minimizes the risk of annoying customer. In this study, a tool is presented to support cross selling with DBM. It is tailored to a situation where the transaction database is augmented with information on ownership of products from competitors collected through a survey. The tool allows firm to predict its customer's likely buying behavior for the products of the firm. Kamakura et al. (2004) focused on identifying innovators for the cross selling of new products. The wealth of information in databases of companies is useful for identifying customers who are most likely to purchase a new product and in predicting when this adoption happens. Therefore database marketers can determine when

individuals should be targeted for a new product. For this aim, a model is proposed to consider the timing of past purchases across multiple product categories, and estimates customers wanting to purchase in a particular product category and the timing of their purchases. Also, this model provides estimation of aggregate penetration for new brands within database.

Liu (2011) is created a model about customer segmentation and evaluation based on, current value, potential value of customer and customer loyalty. Customer value is analyzed according to current value, potential value and customer loyalty. A model is proposed to classify customers into sixteen categories based on self-organization map. Cross selling possibility represents a measure of the potential value of the customer. As a result, segmentation model is able to classify customers into sixteen categories according to current value, cross selling potential and customer loyalty value and enterprise can take different marketing tactics according to the different value among customers.

There are some cross selling practices as well. Vyas et al. (2006) made a comparative study of cross selling in public and private sector banks in India. It is revealed that cross selling practices in public sector and private sector banks are not the same. These differences are their philosophy, back ground and distinct target customer segments. As a result, public sector banks should focus on introducing specialized training and incentives, whereas private sector banks should introduce enough control mechanism and avoid indiscriminate cross selling. However, it was found that both of the sectors know the importance of cross selling for profitability.

Some of the studies focused on increasing the performance of cross selling. Malms et al. (2011) have investigated the internal preconditions that must be done to realize cross selling potential among existing customers. Incorporating organizational culture (cross-divisional orientation) and testing salespeople's behaviors' and mindsets have key influences on cross selling success. Also, cross selling readiness of salespeople depends on cross selling motivation which means that by establishing motivated employees, the firm ensures their readiness to engage in cross selling. The firm ensures, cross selling

motivation by training salesperson who can adapt to customer needs. Therefore this study provides an advance research into cross selling. Zboja et al. (2010) are focused on using internal relationship marketing activities to enhance cross selling performance in services. This study creates and controls a model that investigates how management initiated activities shape frontline employee responses that, in turn, lead to improve cross selling performance. As a result, managers can improve employees' cross selling performance by implementing internal relationship marketing activities which are training and incentives. Those enhance employee role clarity and self-efficacy and by providing incentives that increase employee motivation to cross sell.

Some of the studies are about cross selling applications in call centers. Örmeci et al. (2010) has investigated revenue management through dynamic cross selling in call centers. The cross selling problem of call center is modeled, as a dynamic service rate control problem. The model in the paper answers to questions of when and whom to cross sell. The existence of preferred calls, always generate a cross-sell attempt. These provide guidelines in segment formation for marketing managers. Increased staffing for the same call volume proves to have a positive and increasing return on revenue via cross selling. The proposed heuristic leads to optimal performance in a wide range of settings. The settings provide to explore the difference between customers whose buying behavior is not affected by how long they wait in the queue of call center. Gurvich et al. (2009) examined cross selling in call center with a heterogeneous customer population. The paper considers, a call center with a cross-selling capability that serves a pool of customers that are differentiated in terms on their revenue potential and delay sensitivity. It studies, the operational decisions of staffing, call routing and cross selling under many forms of customer segmentation and proposes deterministic relaxation for problems in call center, such as cross selling capability, cross selling and customer segmentation.

# 3. PROBLEM DEFINITION

In this thesis we discuss most profitable customer profiles in both private pension system and life insurance system. Furthermore we develop Cross selling decision support system to offer customers convenient cross-selling product. Therefore we examined this issue based on two phases. First, is finding most profitable customer type in private pension and life insurance systems and second is developing a selling strategy to these customers.

The problem that we search about is increasing company profit by making more sales. In private pension system and life insurance life system, sales of company is based on two phases; face to face selling and selling over the phone. During selling, contacting with right customer, convincing ability of seller, and product knowledge of seller are very important. However, even if the seller has enough ability and knowledge to sell the product, the customer may not be likely to buy the product, so the seller cannot be successful. In such a manner, there are many factors that affect the success of selling. For this reason, it is an undisputable fact that sales process is very challenging for sellers. The daily sales target of a seller is to reach 500 TL, which makes 3 private pension products and 3 life insurance products to sell in a day. Sometimes, sellers cannot reach this target, so the company fails to reach its sales target neither.

Although, we mention that sales activity is very challenging. We aim to achieve the company's sales target. It is clear that current customer of the company is always a potential customer for new products of company at the same time. If current customer is satisfied with the product or service that he bought from the company, instead of looking for new customers, the proposal of different products can be presented to the current customers. Therefore, we decided to use company's current customer data, rather than developing different strategies to find new customers. As a result, we

decided to apply cross selling strategy, which is an action or practice of selling an additional product or service to the current customer.

We planned to apply cross selling strategy as follows, the company in our case study has two main sales areas, one of them is private pension system and the other is life insurance system. Both of them are equally important, private pension system is a growing sector and company has a great market share in this system; in terms of life insurance, company is an insurance partnership of one the biggest banks in Turkey. Moreover, profits of these two systems are almost same for the company. Therefore we decided to develop a cross selling strategy for both systems, which means the strategy will be applied for private pension system to life insurance system and for life insurance to private pension system. We decided to apply cross selling strategy in this manner, when call center of the company phone the customer to sell a product for the first time, or phone the current customer who has already a product in the system, the agent of call center should be able to offer cross selling product in the system.

One of the common cross selling strategies is to reach all current customers and offer cross selling. However, company has limited resources to call all customers to offer cross selling. A call center agent can call 50 customers per day and 150 employees work in the call center of company. There would be approximately 3 million customer data to be called by call center, if they wanted to phone every customer in the system. Increasing the number of call center employees to call all customers will be more disadvantageous because of its cost to the company. Therefore we eliminate customer data to call and offer cross selling. We eliminate current customer data according to the special selection criteria to obtain the customer group to be called.

In the first phase, it is very crucial to set selection criteria that utilize the choice of the customers that are the most likely to buy the products from the other system. Therefore, we carefully considered this while setting the selection criteria for each step in application of cross selling strategy for private pension system and life insurance system separately.

We decided that the best private pension customer is the one that makes more profit than the others to the company. We assume that if we determine this customer type, the company will have higher sales in cross selling activity.

We assume the properties of best private pension customer are as follows;

- The customer, who stays in the private pension system as long as possible, could be the best customer. Because, the company earns from administration and fund management fees. These fees are paid by customer in every contribution payment, as a specific proportion of the contribution. This means, the customer, who has a long duration in the system, pays more fees to the company.
- The customer, who has more pension savings than the others, could be the best customer. Contribution amount is an amount that customer pays regularly to the private pension company. A customer who invests more contribution to the system, he will earn more investment amount in his retirement. The company cut specific percentage of contribution as administrative and fund management fees. These fees are the most important source of income for the company. Therefore a customer, who pays more contribution, gets more pension savings. This means, high pension savings ensure company to get more fees.

At the Figure 3. 1 below, there is a simulation example about a customer who joins the system at his 23 and pays 105 TL regularly as contribution payment. The assumption of his investment is increasing day by day and accumulated savings will be about 200. 000 TL when he retires[1].

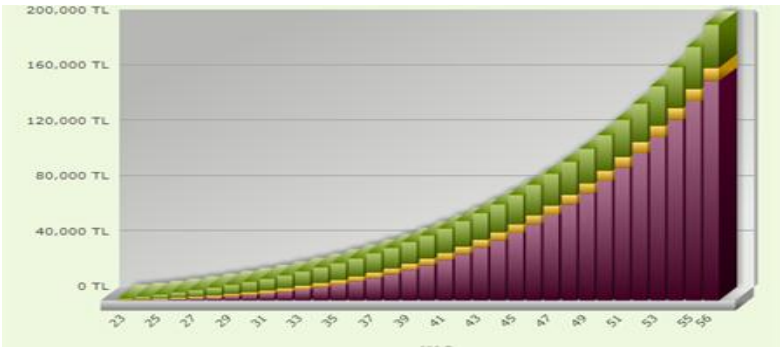



Figure 3. 1 Simulation of customer savings

[1] http://www. garantipension. com/pages/what_is_private_pension. aspx

The best life insurance customer is the one that makes more profit to the company than the others. We assume that it is more profitable, if we determine and call this type of customer.

We assume that the properties of best life insurance customer are as follows;

- The customer who stays in the life insurance system as long as possible, he could be the best customer. Because, he pays life insurance premiums for a specific duration that customer accepted. In this duration, insurance product covers the death and other risks as long as customer pays the insurance premiums.
- The customer who pays more premiums than the others, he could be best customer. Because, the amount of premiums is an important income of company. Life insurances include primarily "death benefit", which is the main benefit and the death coverage increases according to the premiums that customer pays for death benefit.

After we determined, how the best private pension and life insurance customer should be, the properties of customer are researched. In this phase we applied our first proposed method, Design of Experiments method that gives us the properties of best private pension and life insurance customer. (The method will be described detailed in methodology chapter. )

In second phase, we aim to explore cross selling opportunities to the current customers. As a consequence of increasing competition and reducing effectiveness of traditional marketing, cross selling is a significant alternative to the traditional methods. Cross-selling is a profitable activity for both companies and customers. While cross selling provides companies to increase their sales volumes and cost reduction in customer acquisition, it also provides customers one-stop solution.

In application of cross selling method, it is very important to determine the customer type to apply it. The company should find profitable customer type, because even cross selling is better than the traditional marketing methods, applying it to the customers

causes cost for the company. Therefore, cross selling activity should be profitable, and also customer should be satisfied with the cross selling product. For instance, if cross selling method is applied to wrong customer, he could not pay the premiums or he could cancel the life insurance policy which is sold by cross selling method.

The other important issue is to decide when and how cross selling can be applied. As it is mentioned in the first strategy, call center agents of the company can call the selected customer data to offer cross selling. This means call center make a progressive dialing, when company decides to apply cross-selling. Moreover, customer can call the call center for some reason about his current product, like taking information about his product and making some changes on it. At this stage, call center agent, should be able to offer cross selling if he is appropriate customer. For instance, he could be in group of good customer type for the system that is chosen for cross selling.

As a consequence, Cross Selling Decision Support System is required to perform these cross selling activities. Through decision support system, when the call center agent makes a phone call, the success degree of cross selling can be shown by the system, so according to results, he can decide whether to apply cross selling or not. Moreover, by decision support system, call center agents can make a progressive dialing to the list of customers to offer cross selling. Cross selling decision support system is based on fuzzy inference method that will be described detailed in methodology chapter.

# 4. METHODOLOGY

In this section, we mentioned Design of Experiments and Fuzzy Expert Systems methodologies that we have used in this study. Also we compile some literature of those methods.

## 4.1. LITERATURE REVIEW OF DESIGN OF EXPERIMENTS

Design Experiment method has an important role in marketing and there are several studies that used factorial design method. Curhan (1974) examined the effects of merchandising and temporary promotional activities on the sales of fresh fruits and vegetables in supermarkets, Fractional factorial design is used in four large supermarkets and retail price, newspaper advertising, display space, and display location were tested at two levels . The results are analyzed for four classes of fruit items. The experiment suggested certain significant relationships among these variables which are not apparent previously. Also this study reveals the benefits of factorial experimental designs to marketing research, because it provides information on the effects of combinations of variables. Although, fractional factorial designs don't use some detail, it reduces the number of treatments. It is mentioned that fractional factorial design is useful when it is used as the first step of a two-stage research.

There is a study about salability judgments of retail buyers'. Ettenson et al. (1986) examined the judgment strategies of retail buyers, assistant buyers and fashion merchandising majors from the perspective of industrial buying model. Participants asked to evaluate the salability of merchandise, which was described by five qualitative, three quantitative cues. Fractional factorial design is used and 16 cases were replicated, then ANOVA of the fractional factorial design was performed on the salability

judgments of each participant. As a result, while there some differences among the groups, selling history has an important effect in the salability judgment of all three groups.

Jaffe et al. (1992) examined the impact of comprehension of an ad's positioning on advertising response. The impact of two competing positioning on advertising response is assessed. Then the impact of comprehension on positioning effect is examined. Six factors are determined, with two levels, positioning (modern-traditional female), execution, product (money market funds- certificates of deposit), institution, comprehension, sex-role identity (segments in women market). Design is a complete factorial with a designed blocking scheme. By varying the two levels of positioning, product, institution and execution, there are 16 possible combinations to ask respondent to answer questionnaire. In the conclusion part, the most important finding is comprehension of ad's positioning has a real and measurable effect on advertising response.

Wilkinson et al. (1982) examined the importance of temporary price reductions, display alternatives, and newspaper advertising to the unit sales of supermarket products. The research is conducted in supermarket in US by using factorial design. The factorial design consists three factors; price level (regular- cost- reduced), display level (normal-expanded- special), and advertising level (advertising-no advertising) so, there are totally 18 treatments. Four products are chosen as experimental subjects based on sufficient sales volume and stable price; soap, apple juice, rice and pie shells. The data of change in sales is collected for 36 weeks (two observations per treatment for 18 treatments). The main and interaction effects of these variables were tested for statistical significance with Anova. As a result, price level and display level have a strong impact on sales for all four products, so price reduction and changes in production display are more important than advertising for increasing unit sales of selected products.

Barclay (1969) revealed an application of factorial design and analysis to a pricing experiment in retail store level. The article is a general approach for marketing

experimentation with multiple factors with interactions. Three products are examined A, B, C which are competing with one another. Factorial design in randomized blocks answered the questions that are asked in the article, the effect of increasing the price of A, corresponding effect of increasing the price of B, the interaction between two factors. Factor effects were estimated with the analysis of factorial in randomized blocks and questions are answered in the results part. In the conclusion, it is mentioned that factorial approach as a worth consideration whenever a marketing experiment evaluates two or more factors.

Bruggen et al. (1996) examined the impact of quality of a marketing decision support system. The experimental variables in study were the quality of MDSS with three levels, no MDSS, medium quality and high quality and time pressure with two levels, low time pressure and high time pressure. In the 3*2 factorial designs, six experimental groups were created. The variables are; market share (the performance of the subjects was measured by the level of market share) a number of simulations (the intensity of MDSS is measured by the number of what-if simulations. ), decision-confidence and perceived usefulness of the MDSS. In the conclusion part, it is found that, decision makers, using high quality MDSS which show a predictive precisions as high as possible, even for operating under time-pressure and high quality MDSS is used more intensively than the medium-quality MDSS.

Bell et al. (2006) examined the experimental design on the front lines of marketing: testing new ideas to increase direct mail sales. Marketers have recently begun to use experimental designs for marketing and advertising testing. Full factorial, fractional factorial, and Plackett-Burman are very beneficial for marketers to increase the speed, power and profitability of their testing programs. This article reveals how experimental designs provide benefits over common change one variable at a time testing techniques. In the case study, the 19 factors are shown to influence customer's decision to sign up for the advertised credit –card product. Plackett-Burman is carried out with 19 factors and 20 runs. Also a follow up experiment is carried out with full-factorial design with four factors to test changes in chosen factors. The findings are four main effects (no

account opening fee, interest rate, annual fee, initial interest rate) and two interactions are significant.

In study Jaffe et al. (1992) considers the use of experimental design in direct mail applications to see the impact of various factors on response rate. The superiority of factorial designs over traditional one-factor-at a time is established. Fractional factorial design is introduced which reduces the cost of testing and retain the advantages of full factorial design. Than Taguchi method is described on the case study, to simplify the fractional factorial design.

## 4.2. METHODOLOGY OF DESIGN OF EXPERIMENTS

The goal of this chapter is to introduce Design of Experiments Method. Ronald A. Fisher was introduced design of experiments method in 1926, which is about making an factorial experiment in which each of possible combinations of the levels of several factors are located to one or more experiments (Adelman, 1972). His studies are about increasing agriculture yields in Agriculture Experimental Station outside London. Experimental design methodologies have been used for many years in various areas, such as manufacturing, psychology, and pharmaceutical clinical trials where engineers could change the factors such as time, pressure, and flow rate (Almquist & Wyner, 2001). Fisher, first introduced the idea of interaction effects with block effects. However it was left in mid 1930's for Yates to give a detailed explanation of the principles of confounded factorial experiments. Fractional factorial experiments were introduced by Finney in 1945. In the latter part of 1940's, many studies have been done about factorial and fractional factorial experiments. In 1950's and 1960's Herzberg and Cox have published detailed bibliography of contributions in design of experiments (Adelman, 1972). Box and Wilson has introduced response surface method. Since 1965, almost all of the factorial experiments involve fractional factorial experiments (Adelman, 1972). In late 1970 and until 1990, this method was used in quality improvement initiatives in many companies. Especially, when Japanese had got great success about electronics and automobiles, DOE method was used for robust parameter

design. After 1990, the modern era has begun and the advent of persona computer has increased the use of this method (Anderson & Whitcomb, 1953).

In general, experiments are used to study the performance of processes and systems. Figure 4. 1 shows an example of inputs and outputs (Montgomery, 2005). Jiju (2003) indicate that a process is the transformation of inputs into outputs. Inputs can be people, machines, methods, etc. and outputs can be performance or quality of product. Output may have one or more observable response variables. Some of process variables are controllable variables, where as some of them are uncontrollable. The aim of an experiment can be, determining most influential variables, determining where to set influential variables for desired response, determining where to set influential variables to reduce variability in response, determining where to set influential variables to minimize the effects of uncontrollable variables (Montgomery, 2005).

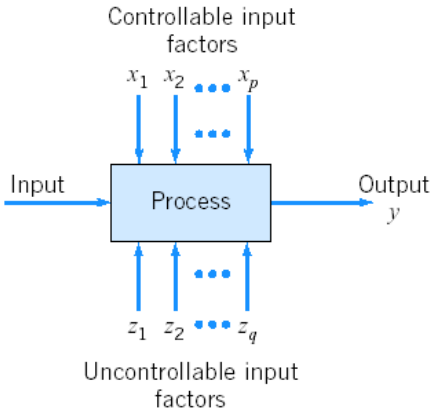



Figure 4. 1. Inputs and outputs of process

The strategy of experimentation is planning and carrying out an experiment. There are some ways to achieve the strategy of experimentation. Best guess approach is used mostly by engineers and scientists which is about deciding the best combination of factors by guessing. However, best guess may not produce desired results and there is no guarantee that the best guess can be the best solution for experiment. One-factor-at-a-time approach is about selecting a starting point then, varying each factor level with other factors held constant to see the results in response variable. The major

disadvantage of this method is, it fails give correct results when there is an interaction between factors.

Jiju (2003) indicate that Design of Experiments refers to process of planning, designing and analyzing the experiment by using simple and statistical methods to get outputs effectively and efficiently. A Factorial experiment is an experimental strategy in which factors are varied together, instead of varying each constant in its range while holding other factors constant. Factorial design allows experimenters to test many factors simultaneously.

Anderson (2000) indicate that the simplest factorial designs involves two factors where all factors have two levels, coded factor levels low for (-) and high for (+). We can assume the levels of factors$A^-$, $A^+$, $B^-$and $B^+$.

If we compare one factor at a time method with factorial design, factorial design is more advantageous. Factorial design provides contrasts of averages, so it provides statistical power to affect estimates, while in OFAT method; the runs must be replicate to get same power. For example, OFAT needs 6 runs versus 4 for the factorial design for two factors. Factorial design has two more advantages over OFAT; first, Factorial design covers larger area, and second it explains interactions between factors. Therefore, the correct approach to dealing with several factors is to conduct a factorial experiment (Anderson & Whitcomb, 1953).

I will illustrate factorial design with a simple example. There are many factors to be successful in play of golf. Here are some factors that affect the results.
-the type of driver used (oversized or regular sized)
-the type of ball used (balata or three-piece)
-the type weather (windy or calm)
-the type of beverage for player
-etc.

The Figure 4. 2 shows, two factorial experiment involving the type of ball and driver. These two factors have both two levels. Geometrically, the four runs form a square. This type of factorial experiment is called a $2^2$ factorial design (Montgomery, 2005).

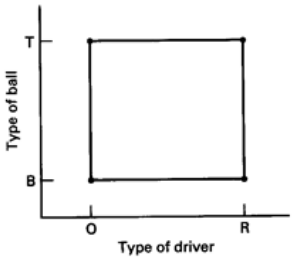



Figure 4. 2. Two factorial experiment with ball and driver

In this example, the effect of driver can be found, by finding the average difference between right and left hand sides of square as it shown in first square in Figure 4. 3. The effect of ball can be found, by finding the average difference between at the top of results and at the bottom of the results as it shown in second square in Figure 4. 3. The effect of interaction between driver and ball can be found, by subtracting average difference on the left to right diagonal in the third square in Figure 4. 3 (Montgomery, 2005).

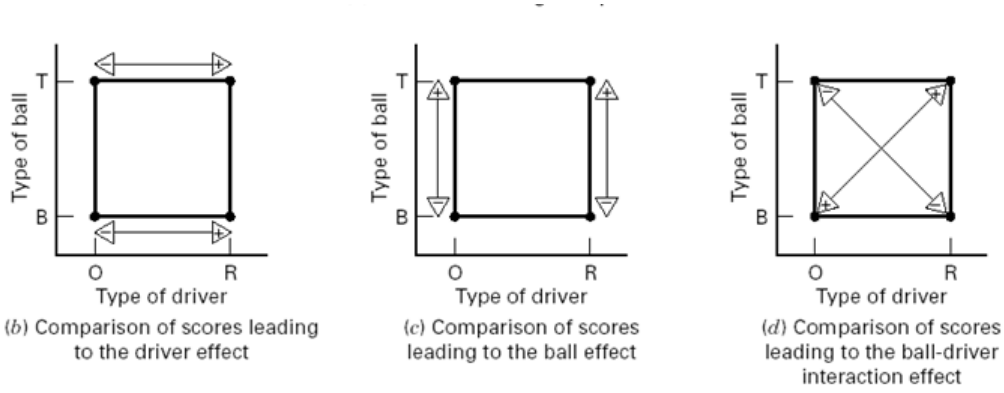



Figure 4. 3. The effect of ball, driver and interaction

In this experiment, factor levels low for (-) and high for (+). Main effect means the primary factors of interest in the experiment. The main effect of driver, the factor $A$, is the difference between average response at the high level of $A$ and the average response at the low level of $A$.

$$A = \overline{y_{A^+}} - \overline{y_{A^-}} \quad (4.1)$$

Similarly, the main effect of $B$:

$$B = \overline{y_{B^+}} - \overline{y_{B^-}} \quad (4.2)$$

When one factor is not same at all level of other factors, we can say there is an interaction between factors the Figure 4. 4 at the below high and low levels of factor lines are parallel, in the next table low and high levels are not parallel, so we can say that there is an interaction between factors A and B (Montgomery, 2005).

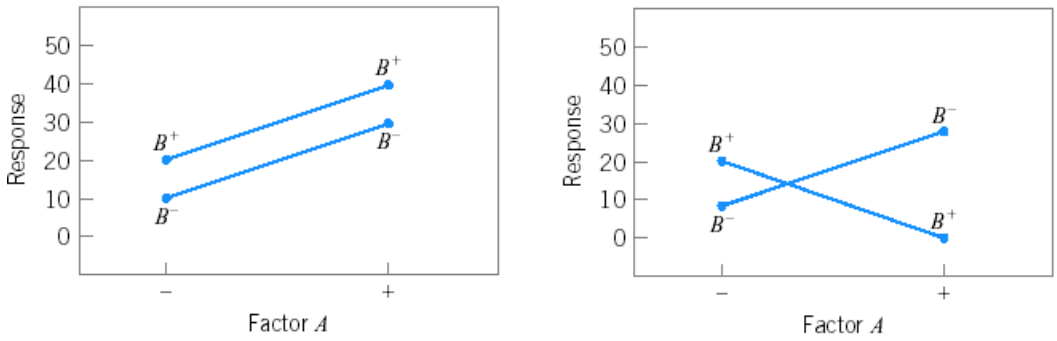



Figure 4. 4. Factor lines

The factorial experiment can be with several factors as well. For example if increase the number of factors 3 assuming all three factors have two levels, design can be set up as shown in figure below. In the Figure 4. 5 shows that there must be eight trials as corners of cube to test all combinations (Montgomery, 2005).

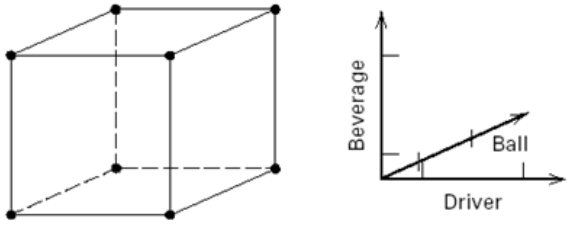



Figure 4. 5. Three factors with two levels

The regression model representation of two-factorial experiment is as follows,

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 + \varepsilon \quad (4.\ 3)$$

Where y is the response, the $\beta$'s are parameters whose values need to be determined, $x_1$ represents factor $A$, and $x_2$ represents factor $B$, and $\varepsilon$ is random error. The values of , $x_1$ and $x_2$ are either -1, or +1, depends on the levels of factor $A$ and $B$. The value of $x_1 x_2$ represents the interaction between factors.

The graphical representation includes, plane of y values generated by factors $x_1$ and $x_2$. This three dimensional graph is called response surface plot as it seen on the left. Figure 4. 6 shows that the contour plot lines parallel, because the response surface is plane (Montgomery, 2005).

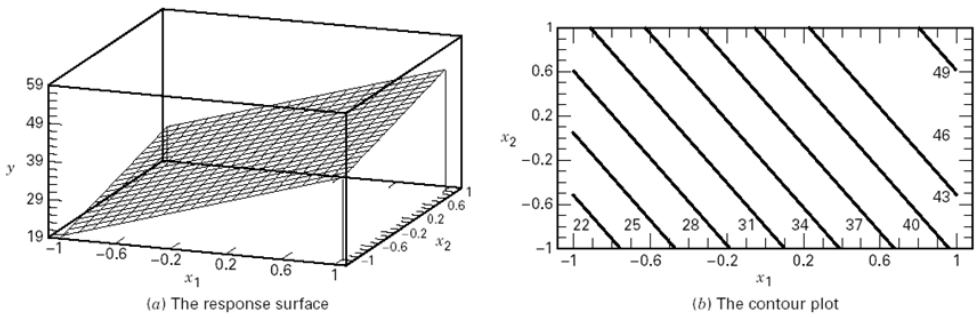



Figure 4. 6. The response surface and the contour plot

Figure 4. 7 shows that, if there is an interaction between factors, the response surface twists because of the interaction. Also, twisting response planes cause curves in contour lines (Montgomery, 2005).

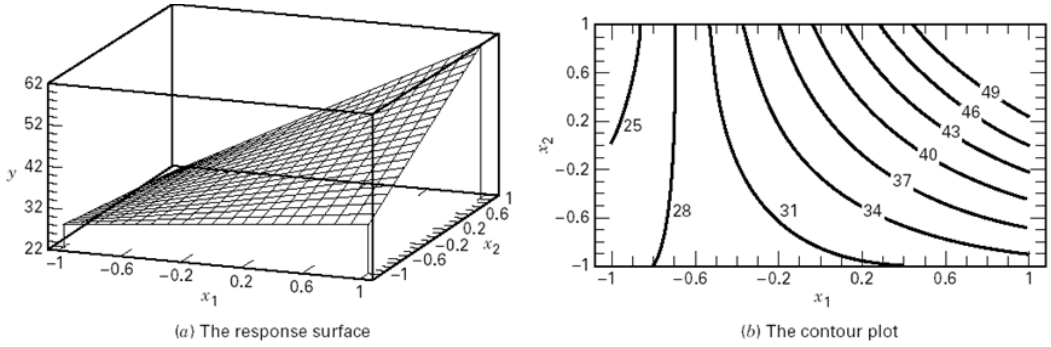



Figure 4. 7. The response surface and the contour plot in interaction

The advantages of factorial design are, they are more efficient than one-factor-at a time method, and when there is an interaction, it avoids misleading conclusions, and also allows to use several levels of factors to experiment all together.

In general two-factor factorial experiment, there are $\alpha$ levels of factor $A$ and $b$ levels of factor $B$. observations are taken at random so it is completely randomized design.
The statistical (effect) model is as follows;

$$y = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \epsilon_{ij} \quad \begin{cases} i = 1,2,\dots,a \\ j = 1,2,\dots,b \\ k = 1,2,\dots,c \end{cases} \tag{4. 4}$$

In this equation $\mu$ is the overall mean effect, $\tau_i$is the effect of $i$th level of factor A, $\beta_j$ is the effect of $j$th level of factor, $(\tau\beta)_{ij}$ is the effect of interaction between , $\tau_i$ and $\beta_j$ ,and $\epsilon_{ij}$ is random error. Factors are fixed and deviations from overall mean,
$\sum_{i=1}^{a} \tau_i = 0$ and $\sum_{j=1}^{b} \beta_j = 0$. Also, interaction effects are fixed.
Table 4. 1 shows that there are n replicates of experiment, so there are $abn$ total observations (Montgomery, 2005).

Table 4. 1. Total observations of n replicates of experiment

| Factor A | Factor B: 1 | 2 | . . . | b |
|---|---|---|---|---|
| 1 | $y_{111}, y_{112}, \ldots, y_{11n}$ | $y_{121}, y_{122}, \ldots, y_{12n}$ | | $y_{1b1}, y_{1b2}, \ldots, y_{1bn}$ |
| 2 | $y_{211}, y_{212}, \ldots, y_{21n}$ | $y_{221}, y_{222}, \ldots, y_{22n}$ | | $y_{2b1}, y_{2b2}, \ldots, y_{2bn}$ |
| ⋮ | | | | |
| a | $y_{a11}, y_{a12}, \ldots, y_{a1n}$ | $y_{a21}, y_{a22}, \ldots, y_{a2n}$ | | $y_{ab1}, y_{ab2}, \ldots, y_{abn}$ |

If we examine the statistical analysis of the fixed effects model, $y_{i..}$ is the total of all observations under the $i$th level of factor $A$, $y_{.j.}$ is the total of all observations under the the $j$th level of factor $B$, $y_{ij.}$ is the total of observations' in the $ij$th cell, $y_{...}$ is the grand total of all observations.

The total corrected sum of squares may be written as,

$$\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n}(y_{ijk}-\overline{y_{...}})^2 = bn\sum_{i=1}^{a}(\overline{y_{i..}}-\overline{y_{...}})^2 + an\sum_{j=1}^{b}(\overline{y_{.J.}}-\overline{y_{...}})^2 + n\sum_{i=1}^{a}\sum_{j=1}^{b}\left(\overline{y_{iJ.}}-\overline{y_{i..}}-\overline{y_{.J.}}-\overline{y_{...}}\right)^2 + \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{n}(y_{ijk}-\overline{y_{iJ.}})^2 \quad (4.5)$$

This is fundamental ANOVA equation for the two factorial design. We can write this equation as follows:

$$SS_T = SS_A + SS_B + SS_{AB} + SS_E \quad (4.6)$$

The equation of degrees of freedom break down is:

$$abn = a - 1 + b - 1 + (a-1)(b-1) + ab(n-1) \quad (4.7)$$

Table 4. 2 shows the summary of this analysis of variance (Montgomery, 2005).

Table 4. 2. Summary of this analysis of variance

| Source of Variation | Sum of Squares | Degrees of Freedom | Mean Square | $F_0$ |
|---|---|---|---|---|
| A Treatments | $SS_A$ | $a-1$ | $MS_A = \frac{SS_A}{a-1}$ | $F_0 = \frac{MS_A}{MS_E}$ |
| B Treatments | $SS_B$ | $b-1$ | $MS_A = \frac{SS_B}{b-1}$ | $F_0 = \frac{MS_B}{MS_E}$ |
| Interaction | $SS_{AB}$ | $(a-1)(b-1)$ | $MS_{AB} = \frac{SS_{AB}}{(a-1)(b-1)}$ | $F_0 = \frac{MS_{AB}}{MS_E}$ |
| Error | $SS_E$ | $ab(n-1)$ | $MS_E = \frac{SS_E}{ab(n-1)}$ | |
| Total | $SS_T$ | $abn-1$ | | |

The residual analysis should be applied to check the adequacy of model. Therefore the primary diagnostic tool residual analysis is used. For two-factor factorial model the equation is as follows;

$$e_{ijk} = y_{ijk} - \overline{y}_{ij.} \tag{4. 8}$$

The General Factorial Design is about, extended version of two-factor factorial design. There may be $a$ levels of factor $A$, $b$ levels of factor $B$, $c$ levels of $C$,and so on in factorial experiment. There will be $abc \cdots n$ total observations if there are $n$ replicates. If all factors in the experiment fixed, main effects and interactions can be formulated by ANOVA.

The formula of analysis of variance is as follows when there are 3 factors;

$$y_{ijkl} = \mu + \tau_i + \beta_j + \gamma_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\beta\gamma)_{jk} + (\tau\beta\gamma)_{ijk} + \epsilon_{ijkl} \quad \begin{cases} i = 1,2,\ldots,a \\ j = 1,2,\ldots,b \\ k = 1,2,\ldots,c \\ l = 1,2,\ldots,n \end{cases} \quad (4.9)$$

In this formula, it is assumed that $A, B,$ and $C$ are fixed. Table 4.3 shows the same procedure is applied for analysis of variance table. The $F$ test on main effects and interactions follow from expected mean squares (Montgomery, 2005).

Table 4. 3 The F test on main effects and interactions

| Source of Variation | Sum of Squares | Degrees of Freedom | Mean Square | Expected Mean Square | $F_0$ |
|---|---|---|---|---|---|
| $A$ | $SS_A$ | $a-1$ | $MS_A$ | $\sigma + \frac{bcn\sum \tau_i^2}{a-1}$ | $F_0 = \frac{MS_A}{MS_E}$ |
| $B$ | $SS_B$ | $b-1$ | $MS_B$ | $\sigma^2 + \frac{acn\sum \beta_j^2}{b-1}$ | $F_0 = \frac{MS_B}{MS_E}$ |
| $C$ | $SS_C$ | $c-1$ | $MS_C$ | $\sigma^2 + \frac{abn\sum \gamma_k^2}{c-1}$ | $F_0 = \frac{MS_C}{MS_E}$ |
| $AB$ | $SS_{AB}$ | $(a-1)(b-1)$ | $MS_{AB}$ | $\sigma^2 + \frac{cn\sum\sum (\tau\beta)_{ij}^2}{(a-1)(b-1)}$ | $F_0 = \frac{MS_{AB}}{MS_E}$ |
| $AC$ | $SS_{AC}$ | $(a-1)(c-1)$ | $MS_{AC}$ | $\sigma^2 + \frac{bn\sum\sum (\tau\gamma)_{ik}^2}{(a-1)(c-1)}$ | $F_0 = \frac{MS_{AC}}{MS_E}$ |
| $BC$ | $SS_{BC}$ | $(b-1)(c-1)$ | $MS_{BC}$ | $\sigma^2 + \frac{an\sum\sum (\beta\gamma)_{jk}^2}{(b-1)(c-1)}$ | $F_0 = \frac{MS_{BC}}{MS_E}$ |
| $ABC$ | $SS_{ABC}$ | $(a-1)(b-1)(c-1)$ | $MS_{ABC}$ | $\sigma^2 + \frac{n\sum\sum\sum (\tau\beta\gamma)_{ijk}^2}{(a-1)(b-1)(c-1)}$ | $F_0 = \frac{MS_{ABC}}{MS_E}$ |
| Error | $SS_E$ | $abc(n-1)$ | $MS_E$ | $\sigma^2$ | |
| Total | $SS_T$ | $abcn-1$ | | | |

Qualitative and quantitative factors:

$2^k$ Factorial Design

It is a special case of general factorial design with $k$ factors at all two levels. These two levels can be qualitative or quantitative. There could be $2 \times 2 \times \cdots \times 2 = 2^k$ observations for a complete design, and it is called $2^k$ factorial design.

The procedure for factorial design, we will follow these steps:

1. Estimate factor effects
2. Formulate model
    1. With replication, use full model
    2. With an unreplicated design, use normal probability plots
3. Statistical testing (ANOVA)
4. Refine the model
5. Analyze residuals (graphical)
6. Interpret results

In this design, it is assumed that, the factors are fixed, the design is randomized, and normality assumptions are satisfied. The basic model of $2^k$ design is with two factors, and it is called $2^2$ design. These two levels can be low and high.
For example, there two factors, factor $A$ and factor $B$. The interaction is $AB$. The levels of factors can be denoted by "-" when the level is low and "+" when the level is high.

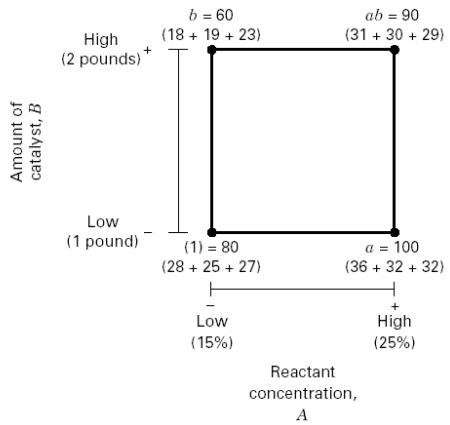



Figure 4. 8. Factor A and B in the example

Figure 4.8 shows that $a$ represents the combination of $A$ at the high level and $B$ at the low level, $b$ represents of $B$ at the high level and $A$ at the low level, $ab$ represents the both factors at high level, and 1 is both factors at low levels. The table 4. 4 is about, algebraic signs for calculating effects in $2^2$ design (Montgomery, 2005).

Table 4. 4. Algebraic signs for calculating effects in $2^2$ design.

| Treatment Combination | Factorial Effect | | | |
|---|---|---|---|---|
| | *I* | *A* | *B* | *AB* |
| (1) | + | − | − | + |
| *a* | + | + | − | − |
| *b* | + | − | + | − |
| *ab* | + | + | + | + |

The first step is to estimate factor effects and determine their signs and magnitudes. In forming the initial model, we usually choose full model, where at least one of the design points has been replicated. In step three, the analysis of variance is applied to test for significance of main effects and interactions. In step four, we remove non significant variables from the full model. In step five, we make residual analysis to check the models adequacy. The last step, we interpret the results according to interaction plots, response surface and contour plots.

We will describe an example for factor effects, $A, B$and $AB$ by taking the difference in the average response of two treatment combinations on sides of square. For the effect of factor $A$, the difference should be found, between right hand side of values(where $A$ is ta high level, $\overline{y}_{A^+}$) and left hand side values(where $A$ is at low level, $\overline{y}_{A^-}$). For the effect of factor $B$, the difference is found between the top of the square (where $B$ is at high level, $\overline{y}_{B^+}$) and the bottom side of square (where $B$ is at low level, $\overline{y}_{B^-}$)

$$A = \overline{y}_{A^+} - \overline{y}_{A^-} = \frac{ab + a}{2n} - \frac{b + (1)}{2n}$$

$$= \frac{1}{2n}[ab + a - b - (1)] \qquad (4.\ 10)$$

$$B = \overline{y}_{B^+} - \overline{y}_{B^-} = \frac{ab + b}{2n} - \frac{a + (1)}{2n}$$
$$= \frac{1}{2n}[ab + b - a - (1)] \quad (4.\ 11)$$

For the interaction effect $AB$, the difference is found between the average of right-to-left diagonal [$ab$ and (1)] and the average of the left to right diagonal ($a$ and $b$);

$$AB = \frac{ab + (1)}{2n} - \frac{a + b}{2n}$$
$$= \frac{1}{2n}[ab + (1) - a - b] \quad (4.\ 12)$$

We could also use regression model, to determine the results of experiments. In regression model above, $x_1$ and $x_2$ are coded variables and $\beta$'s are regression coefficients. After $x_1$ and $x_2$ are chosen, the fitted regression model can be obtained. The regression model can be used to get the value of predicted or fitted value of $y$ at the design.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \epsilon \quad (4.\ 13)$$

When we calculate the predicted value from the regression model, there is a difference between predicted values and observed values. The difference between the observed and fitted values of $y$'s are residuals. The Figure 4. 9 shows an example of a normal probability plot of residuals and plot of the residuals versus predicted values (Montgomery, 2005).

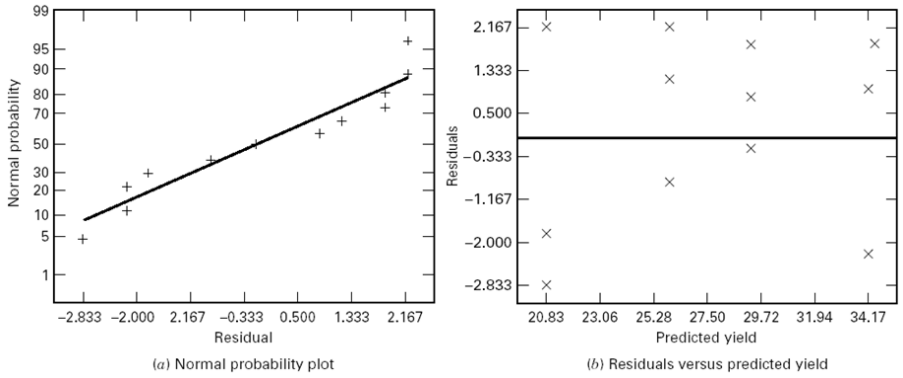



Figure 4. 9. Normal probability plot of residuals and plot of the residuals versus predicted values.

Figure 4. 10 shows that when there are 3 factors, $A, B,$ and $C$, and each has two levels, this design is called $2^3$ design. There are 8 treatment combinations, and by having "+" and "-" notations (Montgomery, 2005).

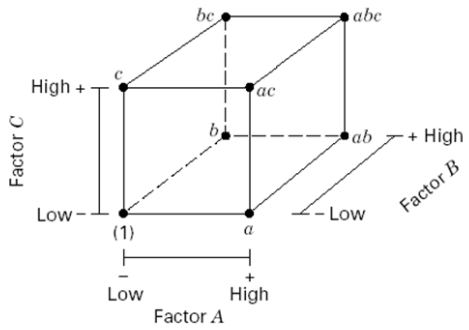



Figure 4. 10. The $2^3$ design

In the Table 4. 5 below we can list the eight runs in $2^3$design, which is called design matrix (Montgomery, 2005).

Table 4. 5. Design matrix of the $2^3$ design

| Run | Factor $A$ | $B$ | $C$ |
|---|---|---|---|
| 1 | − | − | − |
| 2 | + | − | − |
| 3 | − | + | − |
| 4 | + | + | − |
| 5 | − | − | + |
| 6 | + | − | + |
| 7 | − | + | + |
| 8 | + | + | + |

The same procedure will be followed to estimate the main effects. We will find the differences between treatment combinations. Figure 4. 11 shows that the effect of factor $A$, is the difference between the high level of $A$(right face of cube) and the low level of $A$ (the left face of cube) (Montgomery, 2005).

$$A = \overline{y}_{A^+} - \overline{y}_{A^-} \tag{4. 14}$$

$$= \frac{a + ab + ac + abc}{4n} - \frac{(1) + b + c + bc}{4n}$$

$$A = \frac{1}{4n}[a + ab + ac + abc - (1) - b - c - bc]$$

In a similar way, the difference of treatment combinations is taken to estimate the factors.

$$B = \overline{y}_{B^+} - \overline{y}_{B^-} \tag{4. 15}$$

$$C = \overline{y}_{C^+} - \overline{y}_{C^-} \tag{4. 16}$$

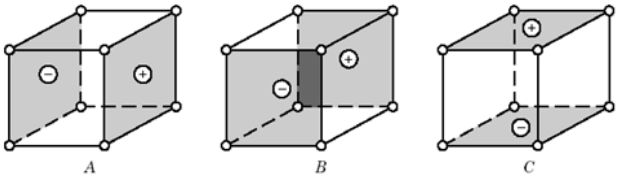



Figure 4. 11. Main effects of the $2^3$ design

Figure 4. 12 shows that the two factor interactions, for example for $AB$ interaction, is the half of difference between the average $A$ effects at two levels of $B$. In the same manner, the other two factor interactions can be formulated (Montgomery, 2005).

$$AB = \frac{abc+ab+c+(1)}{4n} - \frac{bc+b+ac+a}{4n} \quad (4.\ 17)$$

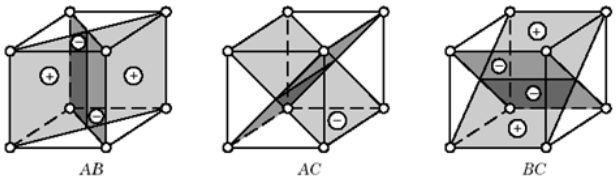



Figure 4. 12. The two factor interaction in $2^3$ design

Figure 4. 13 shows that the $ABC$ interactions is average difference between the $AB$ interactions for the two different levels of $C$(Montgomery, 2005).

$$ABC = \frac{1}{4n}[abc - bc - ac + c - ab + b + a - (1)] \quad (4.\ 18)$$

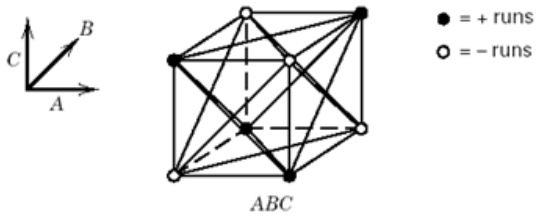



Figure 4. 13. Three factor interaction in $2^3$ design

The general $2^k$ design is a There are $k$ main effects, $\binom{k}{2}$two-factor interactions, $\binom{k}{3}$ three-factor interactions, …,and one $k$-factor interaction.

The table 4. 6 shows the general form of an analysis of variance for a $2^k$ factorial design with $n$ replicates (Montgomery, 2005).

Table 4. 6. Analysis of variance for a $2^k$

| Source of Variation | Sum of Squares | Degrees of Freedom |
|---|---|---|
| $k$ main effects | | |
| $A$ | $SS_A$ | 1 |
| $B$ | $SS_B$ | 1 |
| ⋮ | ⋮ | ⋮ |
| $K$ | $SS_K$ | 1 |
| $\binom{k}{2}$ two-factor interactions | | |
| $AB$ | $SS_{AB}$ | 1 |
| $AC$ | $SS_{AC}$ | 1 |
| ⋮ | ⋮ | ⋮ |
| $JK$ | $SS_{JK}$ | 1 |
| $\binom{k}{3}$ three-factor interactions | | |
| $ABC$ | $SS_{ABC}$ | 1 |
| $ABD$ | $SS_{ABD}$ | 1 |
| ⋮ | ⋮ | ⋮ |
| $IJK$ | $SS_{IJK}$ | 1 |
| ⋮ | ⋮ | ⋮ |
| $\binom{k}{k}$ $k$-factor interaction | | |
| $ABC\cdots K$ | $SS_{ABC\cdots K}$ | 1 |
| Error | $SS_E$ | $2^k(n-1)$ |
| Total | $SS_T$ | $n2^k-1$ |

As the number of factors increases, the number of runs required for experiment increases very quickly. For example, in $2^6$ design, there are 64 runs required. In this design there are only 6 of freedom correspond to the main effects and, 15 of freedom correspond to the two-factor interactions, while the rest of the is about higher factor interactions. If the experimenter can decide that that initially some of factors have little or no effect on the response and the high order interactions are negligible, the fewer runs can be applied to get main effects and lower-order interactions. Therefore the fractional factorial design is applied.

The motivation of why fractional factorial design is applied:

- The sparsity of effects principle: When there are lots of factor, the few of them are important and system is dominated by main effects and low order interactions.
- The projection property: Fractional factorial designs are stronger designs, because they are in subset of significant factors.
- Sequential experimentation: we can add runs to a fractional factorial design to resolve difficulties in interpretation.

The One-Half Fraction of the $2^k$

This is the case when experimenter cannot afford to run all treatment combinations; he can run half of the runs. For example, running four runs, in $2^3$factorial design is one-half fraction of the $2^3$design. Generally this design has $2^k/2,$ so it is referred to $2^{k-1}$ design.

Table 4. 7 shows that, there is plus and minus signs for $2^3$ design (Montgomery, 2005).

Table 4. 7. Algebraic Signs for Calculating Effects in $2^3$ design

| Treatment Combination | Factorial Effect | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *I* | *A* | *B* | *C* | *AB* | *AC* | *BC* | *ABC* |
| *a* | + | + | − | − | − | − | + | + |
| *b* | + | − | + | − | − | + | − | + |
| *c* | + | − | − | + | + | − | − | + |
| *abc* | + | + | + | + | + | + | + | + |
| *ab* | + | + | + | − | + | − | − | − |
| *ac* | + | + | − | + | − | + | − | − |
| *bc* | + | − | + | + | − | − | + | − |
| (1) | + | − | − | − | + | + | + | − |

The $2^{3-1}$ design is formed by treatment combinations which have plus in $ABC$ coloumn. Therefore $ABC$ is called generator of the fraction. The identity column is formed by plus side, so the defining relation is as follows:

$$I = ABC \tag{4. 19}$$

Treatment combinations of main effects and two-factor interactions are:

$$[A] = \frac{1}{2}(a - b - c + abc) \quad (4.\ 20)$$

$$[B] = \frac{1}{2}(-a + b - c + abc) \quad (4.\ 21)$$

$$[C] = \frac{1}{2}(-a - b + c + abc) \quad (4.\ 22)$$

$$[BC] = \frac{1}{2}(a - b - c + abc) \quad (4.\ 23)$$

$$[AC] = \frac{1}{2}(-a + b - c + abc) \quad (4.\ 24)$$

$$[AB] = \frac{1}{2}(-a - b + c + abc) \quad (4.\ 25)$$

Thus, the contrast for estimating the main effect $A$ is the same as the contrast used for estimating the $BC$ interaction. This property is called aliases. In this example Figure 4. 14 shows that $A$ and $BC$, $B$ and $AC$, $C$ and $AB$ are aliases (Montgomery, 2005).

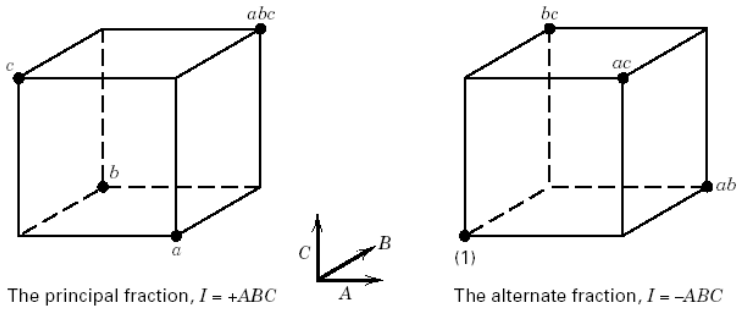



Figure 4. 14. The principle and the alternate fraction

Aliases can be found from defining relation;

$$A \cdot I = A \cdot ABC = A^2BC = BC \quad (4.\ 26)$$

$$B \cdot I = B \cdot ABC = AC \quad (4.\ 27)$$

$$C \cdot I = C \cdot ABC = AB \quad (4.\ 28)$$

The one half fraction, with $I = +ABC$, is called principal fraction. $I = -ABC$ is alternate fraction. If alternate fraction had chosen, $A = -BC, B = -AC, C = -AB$.
In practice, it doesn't matter which fraction is used. Both fractions form a complete $2^3$design.

The one-quarter fraction design is the type of the $2^k$ design which contains $2^{k-2}$runs. The $2^{k-2}$ has two generators; $P$ and $Q$. All four fractions associated in same family, they are $\pm P$and $\pm Q$. Positive values of $P$ and $Q$ are principle fraction. The defining relation consist $P$, $Q$ and the generalized interaction $PQ$.
For example, in the $2^{6-2}$design, $I = ABCE$ and $I = BCDF$ are design generators. Therefore the defining relation is:

$$I = ABCE = BCDF = ADEF. \quad (4.\ 29)$$

If we multiple each effect by each word in defining relation, we find the aliases of effects.

$$A = BCE = ABCDF = DEF \quad (4.\ 30)$$

The basic design is completed by $2^{6-2}$ runs, which is completed by $A, B, C, D$. Then the other two factors are added by determining their plus and minus signs with the interactions $ABC$ and $BCD$.

If we try alternate fractions, they are the fractions with generating relationships:

$I = ABCE$ and $I = -BCDF$; (4. 31)

$I = -ABCE$ and $I = BCDF$; (5. 32)

$I = -ABCE$ and $I = -BCDF$. (4. 33)

The general $2^{k-p}$ fractional factorial design is a type of design that contain $2^{k-p}$runs and $1/2^p$ fraction of $2^k$ design. $p$ independent generators should be required for the design. A criterion to select the generators is such that the resulting $2^{k-p}$ design has the highest possible resolution (Montgomery, 2005).

## 4.3. LITERATURE REVIEW OF FUZZY EXPERT SYSTEMS

Fuzzy approach is applied in many business fields. There are some literature studies that provide information about fuzzy applications. Ghazinoory et al. (2010) made a study that Zadeh made an application of fuzzy calculations for improving portfolio matrices. Fuzzy methodology is applied to extract strategies and it provides to incorporate historical data and subjective/intuitive characteristics into the portfolio analysis models. In the study, industry attractiveness- business strength matrix is examined which is a variation of portfolio analysis matrix. In non-fuzzy methods, the position of the organization is a point; however fuzzy numbers suggests a region in the matrix. In the paper, determining the region, extracting strategies and determining the priority of them is explained.

Bhaskar et al. (2009) examines a fuzzy mathematical programming approach for cross sell optimization in retail banking. They reveal the problem of selecting the optimal list of customers to target for a cross sell campaign in a bank. In this case, target selection involves the estimates of many parameters (expected volume, expected profit from customer, etc. ) and deciding on the list of customers. Fuzzy programming is used for this research. The parameters and constraint are determined as triangular fuzzy numbers. A real life cross sell problem of bank is used as a case study to use this method.

Zandi et al. (2012) made a study which is about strategic cooperative game-theoretic model for market segmentation with application to banking in emerging economies. Zandi reveals that companies have difficulties when deciding the core segment

customers who are the most potential purchasers of their product and services. Marketing segmentation is designed to gain the core-segment customers through an online delivery of the right products to the right market segments at the right price and at the right time. A new fuzzy group multi-criteria method is proposed for market entry and segment evaluation and selection. This method combines bi-level multi-objective optimization with real option analysis and fuzzy cooperative n-person game theory. This method mentions gaps in marketing literature, uses fuzzy logic to represent uncertain information, and it is applicable for market segmentation.

Chan et al. (2012) are focused on market segmentation and ideal point identification for new product design using fuzzy data compression and fuzzy clustering. Central points on markets are always used as ideal points of customer requirements for product design, that reach all customers interests. However, fuzziness also should be considered for customer requirements. A new methodology is proposed to perform market segmentation based on consumers' customer requirements, which consists fuzziness. This method is a combination of a fuzzy compression technique for multi-dimension reduction and a fuzzy clustering technique in order to analyze the collected customers' data. A case study is demonstrated to determine market segments and ideal points of segments.

Yang et al. (2012) is focused on two stage mechanism as a decision support for marketing via customer satisfaction measures. These measures are related to the different services of company. Therefore marketing team of the company establishes a multi criteria evaluation of the company's performance. The method first purifies the services respect to the criteria and then a fuzzy goal programming is applied to solve the multi objective model which provides to determine the services with more profits.

## 4.4. METHODOLOGY OF FUZZY EXPERT SYSTEMS

The goal of this chapter is to introduce Fuzzy Expert Systems. Polish logician and philosopher Jan Lukasiewicz introduced fuzzy or multi-valued logic in the 1930s. He made a representation of fuzziness based on such terms as tall, old and hot. While

classical logic operates study with only two values 1 (true) and 0 (false), Lukasiewicz introduced logic that changes between 0 and 1. This interval represents the possibility that a given statement was true or false.

Philosopher Black (1937) published a paper called ‘Vagueness: an exercise in logical analysis which explains continuum implies degrees. He mentions the vague symbol take part in in language that cannot be equally performed by accurate symbols. The most important part of the paper is, to define a notion of a consistency function to each vague symbol and to measure degrees of vagueness.

In 1965 Lotfi Zadeh, Professor and Head of the Electrical Engineering Department at the University of California at Berkeley, published his famous paper ‘Fuzzy sets’. He rediscovered fuzziness, identified and explored it. He extended his work on possibility theory into mathematical logic. The most important thing that he did is applying natural language terms. This new logic represents fuzzy terms was called fuzzy logic, and Zadeh became the Master of fuzzy logic (Negnevitsky, 2002). Zadeh (1965) explains, Fuzzy logic is determined as a set of mathematical principles for knowledge representation based on degrees of membership rather than on crisp membership of classical binary logic.

Figure 4. 15 shows that Boolean logic is two-valued (Negnevitsky, 2002). However, fuzzy logic is multi-valued. There are degrees of membership and degrees of truth. In Fuzzy logic values changes between 0 and 1. Completely false is represented by 0 and completely true is represented by 1.

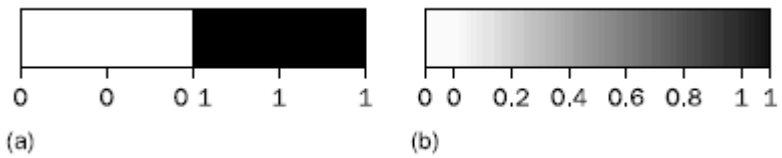



Figure 4. 15. Range of logical values in Boolean and fuzzy logic

In Boolean logic, it is just black and white; in multivalued logic there is spectrum of colors, where things can be partly true and partly false at the same time (Negnevitsky, 2002).

Firstly, fuzzy logic is not fuzzy. Basically, fuzzy logic is a precise logic of approximate reasoning. Fuzzy logic can be researched in two significant human capabilities. First, in an environment of imperfect information, it is about conversing, reasoning, making reasonable decisions, examining possibility, truth and conflicting information. And second, it is related with examining wide variety of physical and mental tasks without any measurements and any computations (Zadeh, 2008).

Crisp set theory consist only two values: true or false. This logic cannot explain uncertain thing because of its form. The basic idea of the fuzzy set theory is that an element belongs to a fuzzy set with a certain degree of membership. Therefore, a case can be both partly true, and partly false with any degree. This degree changes in the interval of [0,1].

We will explain fuzzy set theory with a classical tall men example. To learn the height of a man, the crisp set asks the question, 'Is the man tall?' and determine a limit, say, 180 cm. Tall men are above this height and not tall men below. However, the fuzzy set asks, 'How tall is the man?' The answer is the partial membership in the fuzzy set, for example, he is 0. 82 tall. In the figure below, difference of sets can be understood. In crisp set, a man with height 179 cannot be tall any longer. However, Figure 4. 16 shows that in fuzzy set there is a membership of being tall (Negnevitsky, 2002).

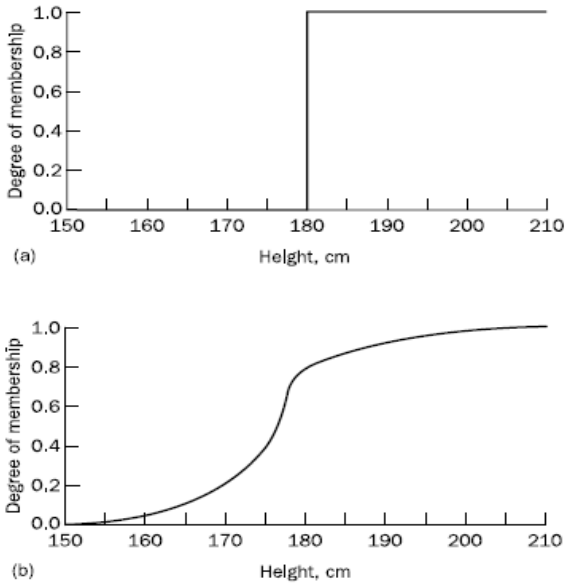



Figure 4. 16. Crisp and fuzzy sets of tall men

A fuzzy set is a set with fuzzy boundaries. Let X be the universe of discourse and its elements be denoted as x. In classical set theory, crisp set A of X is defined as function $f_A(x)$ called the characteristic function of A.

$$f_A(x): X \to 0,1, \tag{4. 34}$$

where

$$f_A(x) = \begin{cases} 1, if\ x \in A \\ 0, if\ x\ is\ not \in A \end{cases}$$

In the fuzzy theory, fuzzy set A of universe X is defined by function $\mu_A(x)$ called the membership function of set A.

$$\mu_A(x): X \to [0,1], \tag{4. 35}$$

where

$\mu_A(x) = 1\ if\ x\ is\ totally\ in\ A;$

$\mu_A(x) = 0\ if\ x\ is\ not\ in\ A;$

$0 < \mu_A(x) < 1\ if\ x\ is\ partly\ in\ A.$

This set allows a continuum of possible choices. For any element $x$ of universe$X$, membership function $\mu_A(x)$ equals the degree which represents the degree of membership and changes between 0 and 1. Linguistic variables are the base of fuzzy set theory. A linguistic variable is a fuzzy variable as well. In fuzzy expert systems, linguistic variables are used in fuzzy rules.

For example,
IF wind is strong
THEN sailing is good

The range of linguistic variables represents the universe of discourse of that variable. For example, the universe of linguistic variable speed might have the range between 0 and 220km per hour and may contain fuzzy subsets as very slow, slow, medium, fast, and very fast (Negnevitsky, 2002).

Georg Cantor described how crisp sets can interact in the late 19th century. These interactions are called operations. Figure 4. 17 shows classical sets (Negnevitsky, 2002).

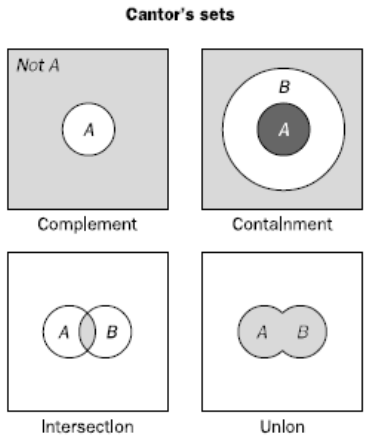



Figure 4. 17. Operations on classical sets

We will examine four operations for fuzzy sets.

Complement: The complement of a set is an opposite of this set. If A is the fuzzy set, its complement: -A can be found as follows:

$$\mu_{\neg A}(x) = 1 - \mu_A(x) \quad (4.\ 36)$$

For example, if we have a fuzzy set of tall men, the fuzzy set of NOT tall men is as follows:

Tall men= (0/180, 0. 25/182. 5, 0. 5/185, 0. 75/187. 5, 1/190) (4. 37)
NOT tall men (1/180, 0. 75/182. 5, 0. 5/185, 0. 25/187. 5, 0/190)

Containment: In fuzzy sets, each element can belong less to the subset than to the larger set. Elements of the fuzzy subset have smaller memberships in it than in the larger set.

Tall men= (0/180, 0. 25/182. 5, 0. 5/185, 0. 75/187. 5, 1/190)
Very tall men (0/180, 0. 06/182. 5, 0. 25/185, 0. 56/187. 5, 0/190) (4. 38)

Intersection: In fuzzy sets, an element may belong to both sets with different memberships. A fuzzy intersection is the minimum membership in both sets of each element.

$$\mu_{A\cap B}(x) = \min[\mu_A(x), \mu_B(x)] = \mu_A(x) \cap \mu_B(x), \quad (4.\ 39)$$

where $x \in X$
Tall men= (0/165, 0/175, 0. 0/180, 0. 25/182. 5, 0. 5/185, 1/190)
Average men= (0/165, 1/175, 0. 5/180, 0. 25/182. 5, 0. 0/185, 0/190)
Tall men ∩average men= (0/165, 0/175, 0/180, 0. 25/182. 5, 0/185, 0/190)

Union: In fuzzy sets, the union is the reverse of the intersection. Thus, it is the maximum of membership values in the set.

$\mu_{A\cup B}(x) = \max[\mu_A(x), \mu_B(x)] = \mu_A(x) \cup \mu_B(x)$, (4. 40)

where $x \in X$

Tall men= (0/165, 0/175, 0. 0/180, 0. 25/182. 5, 0. 5/185, 1/190)

Average men= (0/165, 1/175, 0. 5/180, 0. 25/182. 5, 0. 0/185, 0/190)

Tall men ∪average men= (0/165, 1/175, 0. 5/180, 0. 25/182. 5, 0. 5/185, 1/190)

There some typically used operations as well. They are described below:

Commutativity:

$A \cup B = B \cup A$ (4. 41)

$A \cap B = B \cap A$ (4. 42)

Associativity

$A \cup (B \cup C) = (A \cup B) \cup C$ (4. 43)

$A \cap (B \cap C) = (A \cap B) \cap C$ (4. 44)

Distributivity

$A \cup (B \cap C) = (A \cup B) \cup (A \cup C)$ (4. 45)

$A \cap (B \cap C) = (A \cap B) \cup (A \cap C)$ (4. 46)

Idempotency

$A \cup A = A$ (4. 47)

$A \cap A = A$ (4. 48)

Identity

$A \cup \emptyset = A$ (4. 49)

$A \cap X = A$ (4. 50)

$A \cap \emptyset = \emptyset$ (4. 51)

$A \cup X = X$ (4. 52)

Involution

$\neg(\neg A) = A$ (4. 53)

Fuzzy rules

A fuzzy rule is conditional statement form with linguistic variables.

IF x is A
THEN y is B

Where x and y are linguistic variables; and A and B are linguistic values determined by fuzzy sets on the universe of X and Y.

Fuzzy reasoning has two parts: first is the rule antecedent (the IF part of the rule) and the result to the consequent part (the THEN part of the rule). In fuzzy systems, if the antecedent is true to some degree of membership, then the consequent is also true to that same degree.

The antecedent of a fuzzy rule can have multiple parts, all antecedents calculated at the same time, and solved in single number, for example:

IF service is excellent
OR food is delicious
THEN tip is generous

The consequent of a fuzzy rule can have multiple parts as well; all parts of the consequent are affected by the antecedent equally and we get a single solution at the end, for example:

IF temperature is hot
THEN hot_water is reduced;
cold_water is increased

The single number is got by aggregating all output fuzzy sets into a single output fuzzy set, and then defuzzifing the result to get a single number.

Fuzzy inference is a process of mapping from a given input to an output with using the theory of fuzzy sets.

We will examine Mamdani-style inference method which is used for this paper.

In 1975, Professor Ebrahim Mamdani made first fuzzy systems to control a steam engine and boiler combination. He applied a set of fuzzy rules that is called The Mamdani-style fuzzy inference. This method has 4 steps: fuzzification of the input variables, rule evaluation, aggregation of the rule outputs, and defuzzification.
We will examine this method and each step with a simple example. The example below has three two-input one output rules:

Rule: 1
IF x is A3
OR y is B1
THEN z is C1

Rule: 2
IF x is A2
AND y is B2
THEN z is C2

Rule: 3
IF x is A1
THEN z is C3

Rule: 1
IF project_funding is adequate
OR project_staffing is small
THEN risk is low

Rule: 2
IF project_funding is marginal
AND project_staffing is large
THEN risk is normal

Rule: 3
IF project_funding is inadequate
THEN risk is high

where x, y and z (project funding, project staffing and risk) are linguistic variables; A1, A2 and A3 (inadequate, marginal and adequate) are linguistic values determined by fuzzy sets on universe of discourse X (project funding); B1 and B2 (small and large) are linguistic values determined by fuzzy sets on universe of discourse Y (project staffing); C1, C2 and C3 (low, normal and high) are linguistic values determined by fuzzy sets on universe of discourse Z (risk).

Step 1: Fuzzification

The first step is to take the crisp inputs, x1 and y1 (project funding and project staffing), and determine the appropriate fuzzy sets of each input. The crisp input is always a numerical value limited to the universe of discourse. In this example, we determine x1 and y1 are limited to the universe of discourses X and Y. Once the crisp inputs, x1 and y1, are obtained, they are fuzzified against the appropriate linguistic fuzzy sets.

Let's say, the crisp input x1 (project funding) is related two membership functions A1 and A2 (inadequate and marginal) to the degrees of 0. 5 and 0. 2, respectively, and the crisp input y1 (project staffing) is related to two membership functions B1 and B2 (small and large) to the degrees of 0. 1 and 0. 7, as well. Therefore, each input that we determined is fuzzified over all the membership functions. The Figure 4. 18 shows the part of fuzzification (Negnevitsky, 2002).

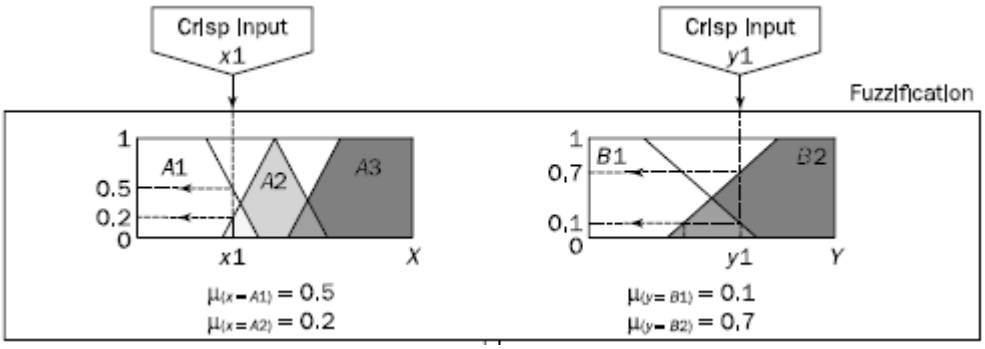



Figure 4. 18. Fuzzification

Step 2: Rule evaluation

The second step is to use membership values and apply them to the antecedents of the fuzzy rules. If a fuzzy rule has more than one part, the fuzzy operators (AND or OR) is used to obtain a single number as a result of evaluation. Then, this number is then applied to the consequent membership function.

The fuzzy operator OR is as using classical fuzzy operation union.

$$\mu_{A\cup B}(x) = \max[\mu_A(x), \mu_B(x)] \quad (4.\ 54)$$

Similarly, the fuzzy operator AND is as using classical fuzzy operation intersection.

$$\mu_{A\cap B}(x) = \min[\mu_A(x), \mu_B(x)] \quad (4.\ 55)$$

If we apply these operators, for our example:

$$\mu_{(X=A1)} = 0.5 \quad (4.\ 56)$$
$$\mu_{(X=A2)} = 0.2$$
$$\mu_{(y=B1)} = 0.1$$
$$\mu_{y=B2)} = 0.7$$

For first rule:

Rule: 1

IF x is A3 (0. 0)

OR y is B1 (0. 1)

THEN z is C1 (0. 1)

$$\mu_{C1}(z) = \max[\mu_{A3}(x), \mu_{B1}(y)] = \max[0.0,0.1] = 0.1 \quad (4.\ 57)$$

Rule: 2

IF x is A2 (0. 2)

AND y is B2 (0. 7)

THEN z is C2 (0. 2)

$$\mu_{C2}(z) = \min[\mu_{A2}(x), \mu_{B2}(y)] = \min[0.2,0.7] = 0.2 \quad (4.\ 58)$$

After the result of the antecedent evaluation is determined, it can be applied to the membership function of the consequent. The Figure 4. 19 shows rule evaluation part (Negnevitsky, 2002).

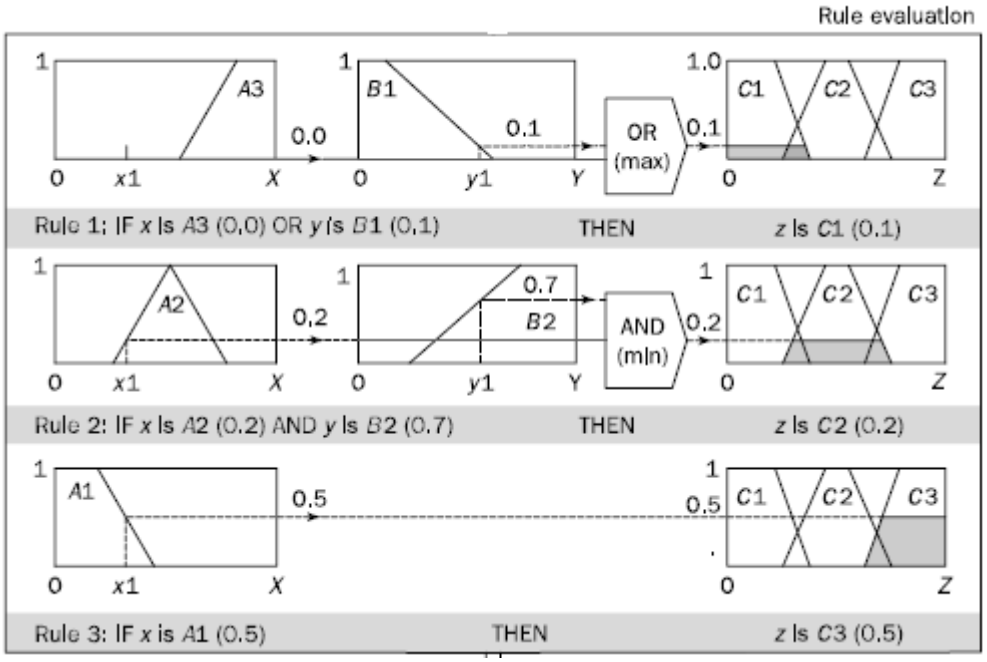



Figure 4. 19. Rule evaluation

Step 3: Aggregation of the rule outputs

Aggregation is the part of taking all membership functions of all rule consequents previously and combines them into a single fuzzy set. We get the output which is one fuzzy set for each output variable. The Figure 4. 20 shows the part of aggregation (Negnevitsky, 2002).

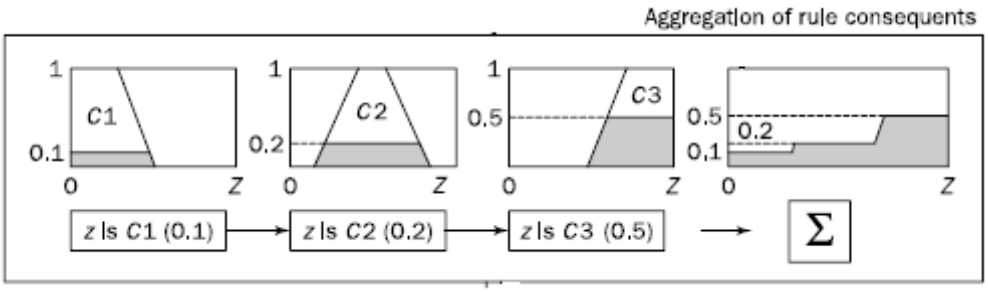



Figure 4. 20. Aggregation of rule consequents

Step 4: Defuzzification

The last step in the fuzzy inference process is defuzzification. The final output of a fuzzy system has to be a crisp number. Therefore we use one of defuzzification method, to get a crisp value. Input for the defuzzification process is the aggregate output fuzzy set and the output is a single number as the Figure 4. 21 shows in below (Negnevitsky, 2002).

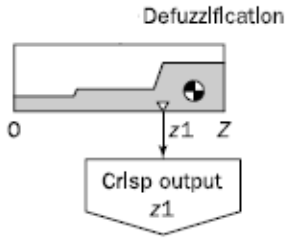



Figure 4. 21. Defuzzification

In fuzzy logic control systems, the defuzzification step involves the selection, from the output fuzzy set, as the best representative element of the fuzzy output set. There are many defuzzification methods, some of them are:

In the maximum defuzzifier, the defuzzified value is the numerical value which has the highest membership grade (Mendil & Benmahammed, 2001). There are different maxima methods, with different solution ways, e. g. , first of maxima (FOM), last of maxima (LOM), mean of maxima (MOM) (Nurcahyo et al. , 2003).

The center of gravity (COG) defuzzifier takes as output the center of gravity of the fuzzy output. Mendil et al. (2001) indicates that for a discrete fuzzy set, the following formula is used:

$$COG = \frac{\sum_{x=a}^{b} \mu_A(x)x}{\sum_{x=a}^{b} \mu_A(x)} \qquad (4.\ 59)$$

COG can be expressed as the formula below to find a point in the center of gravity of the fuzzy set on the interval ab (Negnevitsky, 2002).

$$COG = \frac{\int_a^b \mu_A(x)xdx}{\int_a^b \mu_A(x)dx} \quad (4.\ 60)$$

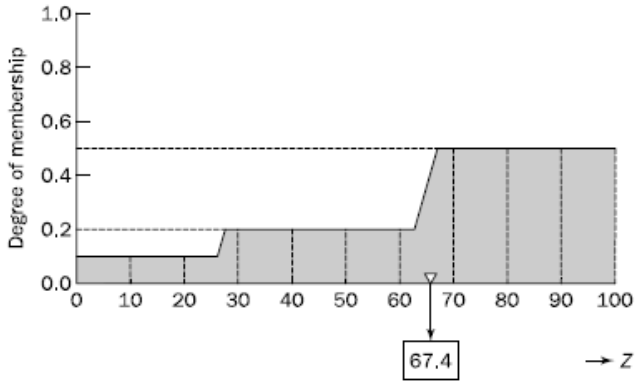



Figure 4. 22 Defuzzifying the solution variables fuzzy set

In our example, we used COG defuzzifier. The center of gravity is calculated. The table 4. 22 shows that the crisp value is found, at the end of the defuzzification. Crisp output z1, is 67. 4 (Negnevitsky, 2002).

## 5. CASE STUDY

In this study, we aim to increase the sales and profitability of private pension and life insurance company in Turkey and we develop a decision support system to achieve our aim.

Firstly, in this paper, we focused on insurance and private pension sector in Turkey, because both it is a fast growing sector and it contributes to the development of Turkey along 3 dimensions. Here are the benefits of insurance and pension systems to Turkey,

- Insurance and pension system support the country's economy and reinforce financial system of country.
- Insurance system supports government by reducing financial responsibility of social welfare, covering cost of catastrophes, and financing government activities.
- Providing social welfare.

Moreover, the other advantages of the systems are; being a major tool to boost the savings. The study of Association of Insurance and Reinsurance Companies of Turkey shows that, countries with high insurance and pension penetration have high level of long maturity savings.

The most important effect of this system is, having social and personal impact which is about providing social welfare.

- Reducing ambiguity: supporting people to plan for uncertainties and risks.
- Creating awareness for long term pension planning: making people aware of their future and future needs.
- Creating social harmony: pooling the risks of large number of people and covering the risk of them.

- Sustaining fairness in the society: protecting people from being below poverty line when risks happen.

If we examine this sector in terms of Turkey, Turkey is a potential market. SWOT analysis can describe the strengths, opportunities, weakness and threats of insurance and pension market in Turkey.

- Strengths: There are many foreign companies in the market, double-digit growth across all main business lines.
- Weaknesses: Low penetration across business lines and weak customer awareness.
- Opportunities: Strong growth across increasing consumption and industrial production and investments. Large, young, and growing population is potential customer group for companies to sell insurance and pension products. Regulatory actions provide growth of the sector. Also, usage of new technologies for sell channels is another advantage of this sector.
- Threats: lack of cultural mindset is an obstacle for selling products. Limited number of talented resources to sell products is another disadvantage of these systems.

Association of Insurance and Reinsurance Companies of Turkey made a study to examine the future of insurance and pension sector. According to this study,

- Life and pension market could grow up to TL 408 billion by 2023.
- Turkey can be the 30. biggest pension and savings insurance in 2023 with estimated fast growth in pension system.
- Term-life market will be growing with the growth of credit market which will be about TL 10-16 billion by 2023.
- In 2023 improvements should continue for term-life penetration.

Moreover, they determined four key items to achieve the targets until 2023 for insurance and pension sector.

- Applying more customer focused approach to increase customers' confidence and trust.

- Being incorporation with government to search for options to increase savings and protection from financial distress caused by accidents.
- Offering customer oriented, high quality service to customers by different sales channels with greater focus on customer needs.
- Increasing efficiency and standardization (Insurance Association of Turkey, 2012).

The company that we examine has great experience in this industry and strong financial structure and technological infrastructure. Moreover it has a customer-oriented approach. The company aims to reach its sales target, by applying one of the key items to be successful; offering customer oriented, high quality service to customers by sales channels with greater focus on customer needs. Developing channel strategy, leveraging alternative channels are one of the most important items for applying this method.

In this paper, according to key items to be successful in future, we especially focused on developing new sales opportunities. The company that we examine is one of the pension and life insurance companies of Turkey. It is mostly focused on sales, and service. It performs its sales in two main steps. First part involves salesmen working in the field. Salesmen are situated in the partnership bank. They find their customers there and also from their own customer portfolios. The other part involves, call center employees. Call center employees both carry out sales and offer service for current customers. Both salesmen and call center employees have sales targets, such as two pension contracts and two life insurance policies a day. Call center employees need customer information to call them, which they mostly get from partnership bank and current products. During most of the day, they provide services to existing customers, such as making changes in the contracts and policies, giving detailed information about current products, and making calls to remind the day of payment. Therefore, sales penetration of call center is not as much as salesmen's are in the field. Under these conditions, we use cross selling strategy to boost the sales of call center with the principle of using different sales opportunities.

In cross selling implementing phase, we thought about which products could be used for this strategy. The company has two product groups, first is pension products and the other is life insurance products. In this case, the company has three alternatives to apply cross-selling; pension product sales for current life insurance customers, life insurance product sales for current pension customers, or both of cross selling strategies for all current customers. We have decided to apply both of cross selling strategies for all current customers, because both of the products are equally important. Private pension system is a growing sector and the company has great market share in this system; for life insurance products, company is the insurance partnership of the one of biggest banks in Turkey. Therefore, profits of these two systems are almost same for the company. Besides, developing cross selling decision support system is more profitable for future.

We decided to apply cross selling strategy in this manner, when call center of the company phone the customer to sell a product for the first time, or phone the current customer who has already a product in the system, the agent of call center should be able to offer cross selling product in the system.

Call center employees can get in contact with customers to offer cross selling in two ways. The first one is, call center can call all of the current customers in the system and offer them cross selling. However it is not possible to do it, because the company has approximately 150 employees and call center staff is not enough to call approximately three million customers in the system. If we aimed to call all current customers in the system, then, the number of employees working in the call center would be increase. However, the company cannot afford this cost.

As a result, we decided to eliminate the customer data that will be called by call center for cross selling. Our elimination criterion is based on finding the best customer in pension system and life insurance system separately. Therefore, we aim to find the best customer in pension system and life insurance system with Design of experiments method. The second way to get in contact with customer is, when the customer calls the call center to get information about his current product. In this phase, if the customer is

appropriate according to cross selling conditions, call center employee should be able to offer cross selling as well. In the offering phase, it is important to know that the customer meets the requirements of cross selling. Because, if the customer is in the bad customer group in cross selling system, then he could cancel the product in a short time, and the sale of this product may cause cost for the company. For example, under the terms of company that we examine, if a life policy cancels in 30 days, all the payments from customer is given back to customer by company, as well as the cost of printing hard copy of policy, service calls, SMS and e-mail services cause costs for the company. In this phase, decision support system is needed for the call center employee that he will be able to decide whether offer cross selling or not. This system is explained in Cross selling decision support system part of the paper.

## 5.1. APPLICATION OF DESIGN OF EXPERIMENTS METHOD

We used Design of Experiment methodology by Design Expert 7. 0. Design Expert, to find best customer in private pension and life insurance systems. This software provides highly efficient design of experiments for:

- Factorial designs: That part identifies the vital factors that affect our process. Then we can make improvements.
- Response Surface Methods: that part finds the ideal process settings to achieve optimal performance.
- Mixture Design Techniques: that part discovers the optimal formulation.
- Combined Designs: this is about combining variables, mixture components and categorical factors in one design.

Our aim is the find a best customer in the both private pension and life insurance system.

After determining our objective, identifying responses that we want to measure, maximizing or minimizing them, is the next part to decide. Identifying quantifiable responses is the most crucial step of Design of Experiment Method.

In our case, we determine the responses for pension system and life insurance system separately. First we examine the private pension system, and carry out all steps for this system. Then we follow the same procedure for life insurance system as well.

For private pension system, the best private pension customer is the one who makes more profit than the others to the company. We assume that if we determine and offer cross selling to this type of customer, the company will have high sales.

We assume that the responses of best private pension customer are as follows;

1. The customer who stays in the private pension system as long as possible, he could be the best customer. Because, the company earns from administration and fund management fees. These fees are paid by customer in every contribution payment as a specific proportion of the contribution. The proportion is related to company decision. However Pension Monitoring Center has maximum and minimum limits for these proportions. That means, the customer, who has a long duration in the system, pays more fees for the company. The duration of stay in pension system is quantifiable. In design expert we evaluate this, as in days.

2. The customer who has more pension savings than the others, he could be best customer. Contribution amount is an amount that customer pays regularly to the private pension company to stay in the system. The payment periods could be months or longer. The contribution is directed to the fund investment by company and when it is funded, it is called pension saving. The company cut specific proportion of contribution as administrative and fund management fees, which are determined by company decision. These fees are the most important source for income of the company. Therefore a customer, who pays more contributions, gets more pension savings. High pension saving provides company to get more fees. This response is quantifiable and we evaluate this as in currency of TL.

Table 5. 1. Responses of Private Pension System

| Name | Units |
|---|---|
| duration of stay | days |
| pension savings | TL |

After, we determine the responses; the next part is determining the factors and levels. The factors that could possibly influence any of the responses, we want to measure. While selecting the factors, we decide that whether it may have an influence on the response or not. Also, we add the factors which are easily controllable, so we can change them according to the result, because if it is difficult to control, then our experiment has no benefit for us. Another important issue is, not including absolutely everything in experiment. Once we have determined the factors to study, then we decide a range for each one. We think about to observe the difference in the responses, while deciding on levels. The factor range should be set so that it could cause this amount of change in the response. According to the information about identifying factors and levels, for private pension system we selected the factors that may have an influence on responses.

- Contribution payment per month: The contribution amount may have an influence on being best customer because it has a direct effect on pension savings. We examine this factor in TL currency type. It is determined as categorical type with 2 levels: contribution amount lower than or equal to 100 TL and higher than 100 TL.
- Age of customer: Age of customer may have an influence on being best customer. According to the age, pension saving amount and duration of stay in system may change. We examine this factor in unit of year. It is determined as categorical type with 2 levels: customer age lower than or equal to 45 and higher than 45.
- Place, where contract is sold: The place of where contract is sold may have an influence on being best customer. We examine this factor as categorical type with 2 levels, in unit of parts: east of Turkey and west of Turkey.
- Gender of customer: Gender of customer may have an influence on being best customer. According to the gender, pension saving amount and duration of stay

in system may change. We examine this factor in unit of type. It is determined as categorical type with 2 levels: man and woman.

- Currency of contract: The currency of pension contract may have an influence on being best customer. We examine this factor in unit of currency. It is determined as categorical type with 2 levels: TL and Foreign currency.
- Payment type: The payment type of contract may have an influence on being best customer. Payment type of contract can be for each month, for each year, or other installments. We examine this factor in unit of month, and it is categorical with 2 levels: monthly installment and not monthly installment( 3 month/ 6 month/ year installment)
- Marital status: Marital status of customer may have an influence on being best customer. According to the marital status, pension saving amount and duration of stay in system may change. We examine this factor in unit of type. It is determined as categorical type with 2 levels: single/widow/divorced and married.
- Educational status: Educational status of customer may have an influence on being best customer. According to the educational status, pension saving amount and duration of stay in system may change. We examine this factor in unit of type. It is determined as categorical type with 2 levels: elementary/high school education and university/ post grad/ doctor degree education.

Table 5. 2. Factors and Levels of Private Pension System

| | **Name** | **Units** | **Type** | **First Level** | **Second Level** |
|---|---|---|---|---|---|
| **A** | Contribution payment | TL | Categoric | <=100 | >100 |
| **B** | Age | Year | Categoric | <=45 | >45 |
| **C** | Place | Part | Categoric | East | West |
| **D** | Gender | Type | Categoric | Man | Woman |
| **E** | Currency of contract | currency | Categoric | TL | Foreign |
| **F** | Payment type | month | Categoric | monthly installment | 3 month/ 6 month/ year installment |
| **G** | Marital status | Type | Categoric | single/widow/divorced | Married. |
| **H** | Educational status | Type | Categoric | elementary/high school education | university/ post grad/ doctor |

We used factorial design to find main factors and make improvements. Moreover, getting information about two factor interactions is useful for us to make comments about the result. This design is for, 2 to 21 factors where each factor is varied over 2 levels. It is useful for estimating main effects and interactions. It also offers fractional factorial design. This collection of designs provides an effective means for screening through many factors to find the critical few.

Full two-level factorial designs, may run up 9 factors. These designs permit estimations of all main effects and all interactions except blocked ones. Design expert offers a wide variety of fractional factorial designs.

In our experiment, we used fractional factorial design. These designs are as good as a full factorial, generally at a great savings in the number of runs to perform. We have 8 factors and we wanted to study with less number of experiments, so we choose $2^{8-2}$ type of 2-Level factorial Design.

After we determine the design; the next part is determining number of runs. In this part we decide how many runs are necessary to get significant results. This depends on how many factors we have and how much information we want. It is an option to start with small number of runs initially.

If nothing appears significant, we can run the experiment again to gain the additional power. In determining number of replicates, we tell Design Expert how many times each design point should be run. The default is one replicate, which means each design point will be run once.

If we make two replicates, that means, we physically recreate all conditions for that experiment. It is an important note that when using fractional factorial design, it is better to use larger fractional factorial that contains unique combinations than to add replicates. That means the effects are estimated by averaging all of the runs, so by increasing the number of unique results, we can increase the power of the design to detect effects. In this experiment, we decided to use 3 replicates.

Blocking is a technique used to remove the expected variation caused by some change during the experiment. For example, when we expect variations in one factor, may have an effect on the response, but we are not interested in studying that effect at this time. Therefore, this is not a factor, and we should block on it instead. This will remove the effect of the factor, and allow us to better identify the other factor effects.

In Design Expert the default of 1 block means “no blocking. ” In our experiment we don’t determine any factor that we want to block its effect. Therefore, we use the number of block as 1.

Finally we get totally 192 runs, to complete the two responses with customer data. To fill these response areas, we need a set of customer data of company, so we made another study to get these data. First of all, we used customer database for query.

Our query contains, top 20. 000 customers who has pension products with highest pension saving and longest duration of stay. After we got these data, we filled the response areas. However, customer data is not enough to fill all cases in the experiment. 176 rows were filled, in total of 192 rows that means 91,66% percent of response is filled. We start our study over these customer data.

Table 5. 3. Data of Private Pension System in design layout view

| Std | Run | Block | Factor 1 A:Contribution TL | Factor 2 B:Age year | Factor 3 C:Place part | Factor 4 D:Gender type | Factor 5 E:Currency of currency | Factor 6 F:Payment type month | Factor 7 G:Marital statu type | Factor 8 H:Educational s type | Response 1 duration of sta days | Response 2 pension saving TL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 185 | 1 | Block 1 | >100 | <=45 | west | woman | foreign | ( 3 month/ 6 m | single/widow/ | elementary/hig | | |
| 168 | 2 | Block 1 | >100 | >45 | west | man | foreign | ( 3 month/ 6 m | single/widow/ | university/ pos | | |
| 123 | 3 | Block 1 | <=100 | <=45 | east | woman | TL | ( 3 month/ 6 m | single/widow/ | elementary/hig | | |
| 40 | 4 | Block 1 | >100 | <=45 | west | woman | TL | monthly installr | single/widow/ | elementary/hig | | |
| 1 | 5 | Block 1 | <=100 | <=45 | east | man | TL | monthly installr | married. | university/ pos | | |
| 167 | 6 | Block 1 | >100 | >45 | west | man | foreign | ( 3 month/ 6 m | single/widow/ | university/ pos | | |
| 52 | 7 | Block 1 | >100 | <=45 | east | man | foreign | monthly installr | single/widow/ | university/ pos | | |
| 148 | 8 | Block 1 | >100 | <=45 | east | man | foreign | ( 3 month/ 6 m | single/widow/ | elementary/hig | | |
| 45 | 9 | Block 1 | <=100 | >45 | west | woman | TL | monthly installr | single/widow/ | elementary/hig | | |
| 117 | 10 | Block 1 | <=100 | >45 | west | man | TL | ( 3 month/ 6 m | married. | university/ pos | | |
| 107 | 11 | Block 1 | >100 | >45 | east | man | TL | ( 3 month/ 6 m | married. | elementary/hig | | |
| 164 | 12 | Block 1 | <=100 | >45 | west | man | foreign | ( 3 month/ 6 m | married. | elementary/hig | | |
| 99 | 13 | Block 1 | <=100 | <=45 | east | man | TL | ( 3 month/ 6 m | married. | elementary/hig | | |
| 129 | 14 | Block 1 | <=100 | >45 | east | woman | TL | ( 3 month/ 6 m | married. | university/ pos | | |
| 56 | 15 | Block 1 | <=100 | >45 | east | man | foreign | monthly installr | single/widow/ | university/ pos | | |
| 89 | 16 | Block 1 | >100 | <=45 | west | woman | foreign | monthly installr | single/widow/ | university/ pos | | |
| 63 | 17 | Block 1 | <=100 | <=45 | west | man | foreign | monthly installr | single/widow/ | elementary/hig | | |
| 54 | 18 | Block 1 | >100 | <=45 | east | man | foreign | monthly installr | single/widow/ | university/ pos | | |
| 82 | 19 | Block 1 | >100 | >45 | east | woman | foreign | monthly installr | single/widow/ | elementary/hig | | |
| 143 | 20 | Block 1 | >100 | >45 | west | woman | TL | ( 3 month/ 6 m | married. | elementary/hig | | |
| 86 | 21 | Block 1 | <=100 | <=45 | west | woman | foreign | monthly installr | married. | elementary/hig | | |

In Analysis Process, after we have entered our response data in the Design Layout view, we will examine the responses separately. First we deal with the first response: duration of stay.

A transformation is needed to meet the assumptions that make the Anova valid. The transformation of the duration of stay response is power transformation. Design expert suggests us lambda value should be between -3 and +3, and we select lambda 1,86 and constant k as 0. We select lambda according to the Box Cox plot that helps us to determine the most appropriate power transformation to apply to response data. The lowest point on the Box Cox plot represents the value of lambda that results in the minimum residual sum of squares in the transformed model. Therefore we select lambda value as 1,86 which is best lambda value that design expert recommends.

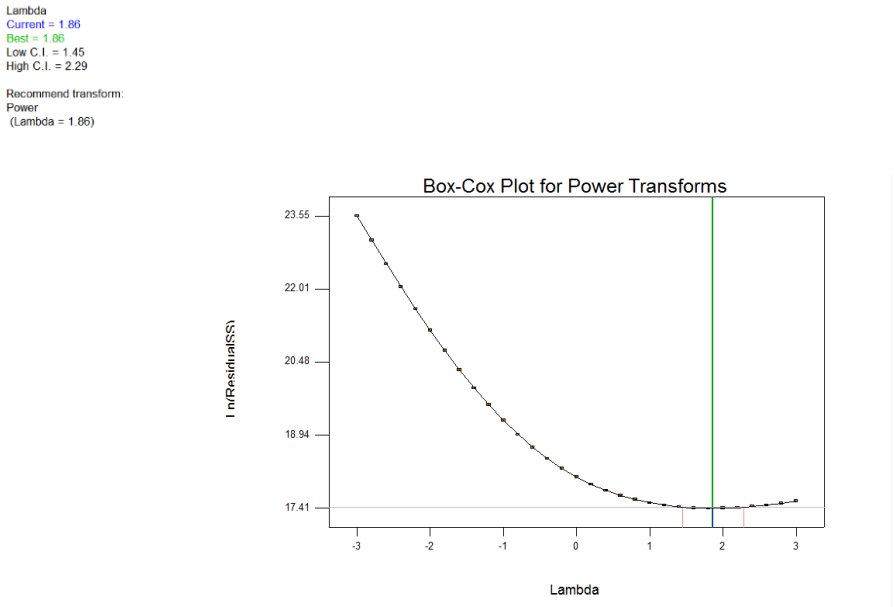



Figure 5. 1. Box-Cox for Power Transforms of duration of stay in Pension System

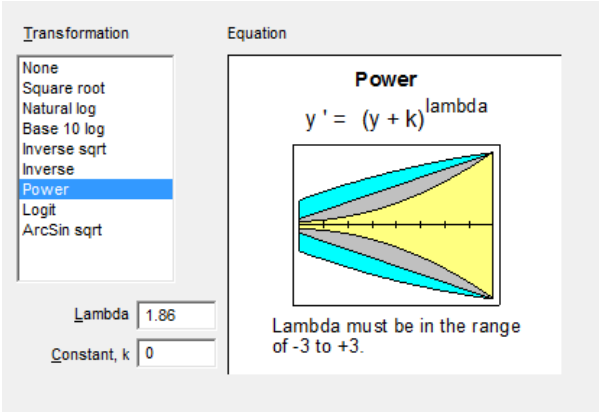



Figure 5. 2. Transformation of duration of stay in Private Pension System

After transformation is determined, selecting effects is the next step. In order to analyze a factorial design, the significant factor effects must be identified and separated from the insignificant effects. Effects button starts the regression calculations to compute a table of effects for all model terms. It produces statistics for comparing the model terms. The effects output can be shown as in normal and half-normal probability report. Effects can be selected from the Effects List report. We include the effects to the model by marking them with 'M'. There is 'e' before terms that are included in the error. A

red tilda mark is aliased terms. Also, for 2-level factorial designs, normal probability plot can be used to choose significant effects. A plot of the ordered values of a sample versus the expected ordered values from the true population is approximately a straight line. Therefore, if the effects represent a sample from a normal population, it would form a straight line on normal probability plot of effects. The outlier points are selected as effects. The half normal probability plot follows the same principle as normal probability plot, except the sign of the effect is ignored in plotting. Thus, outliers are show up in the upper right-hand section of the graph.

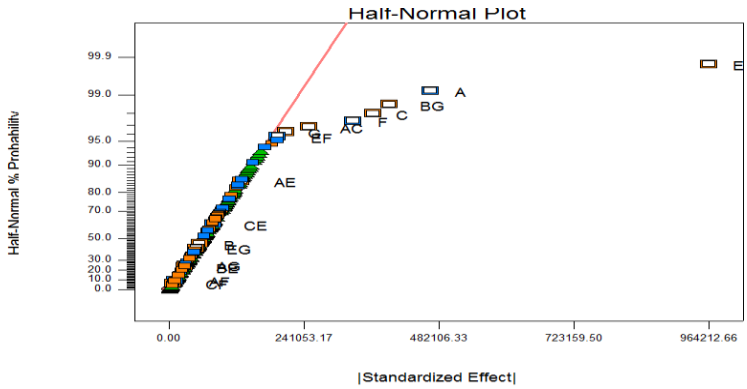



Figure 5. 3. Half Normal Plot of duration of stay in Private Pension System

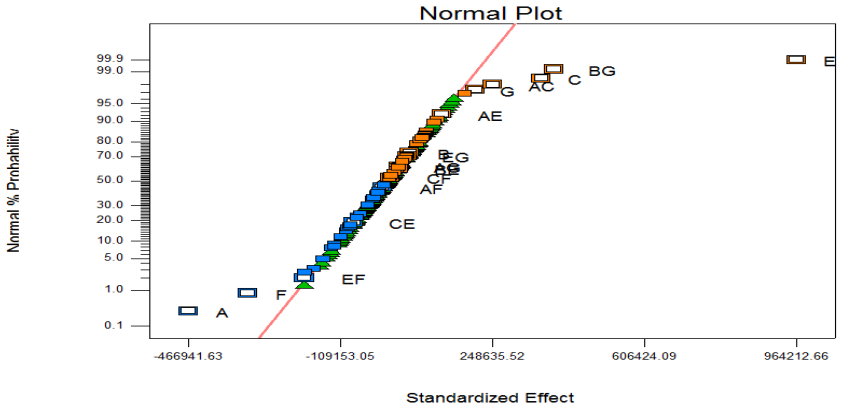



Figure 5. 4. Normal Plot of duration of stay in Private Pension System

The Pareto chart, is an additional graphic to display the t values of the effects. Significant effects can be chosen from this chart as well. There are two different t limits: Bonferroni corrected t and a standard t.

When terms are added or removed from the model, limits are recalculated. We selected significant effects from Pareto chart. We selected the terms that are above the T-value limit which are possibly significant.

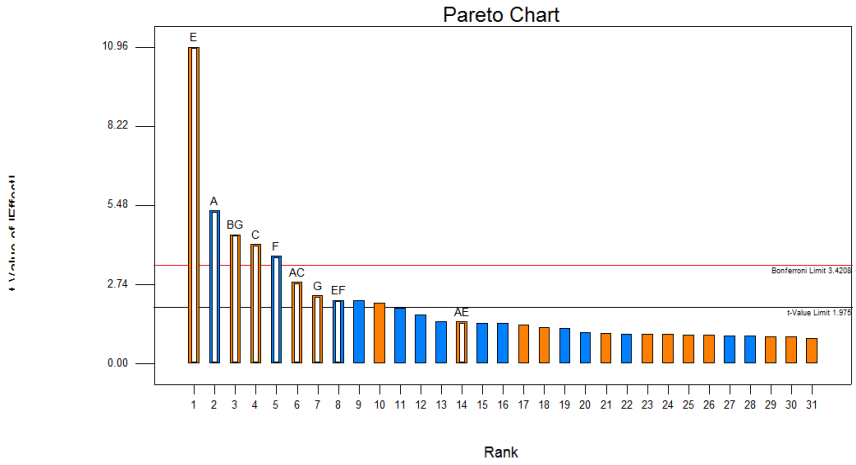



Figure 5. 5. Normal Plot of duration of stay in Private Pension System

Also, alias list shows the alias pattern for the design. It uses the response data and creates the pattern based on the significance of the coefficients.

Aliasing occurs between those terms that are least significant. Aliased terms can be switched in the effects list, so selected aliased term can drop down the list. The figure below shows the aliased terms of factors in the right hand side.

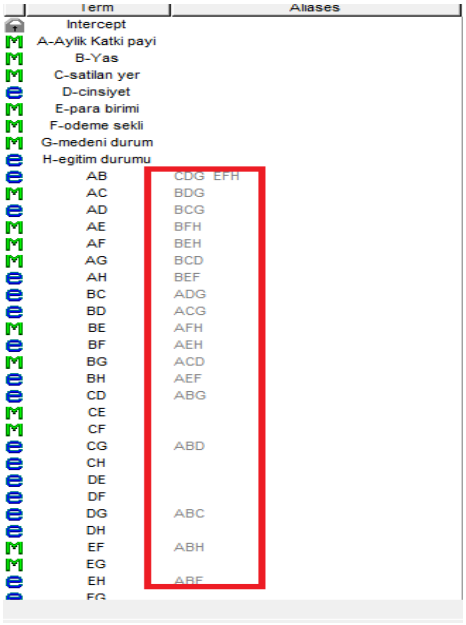
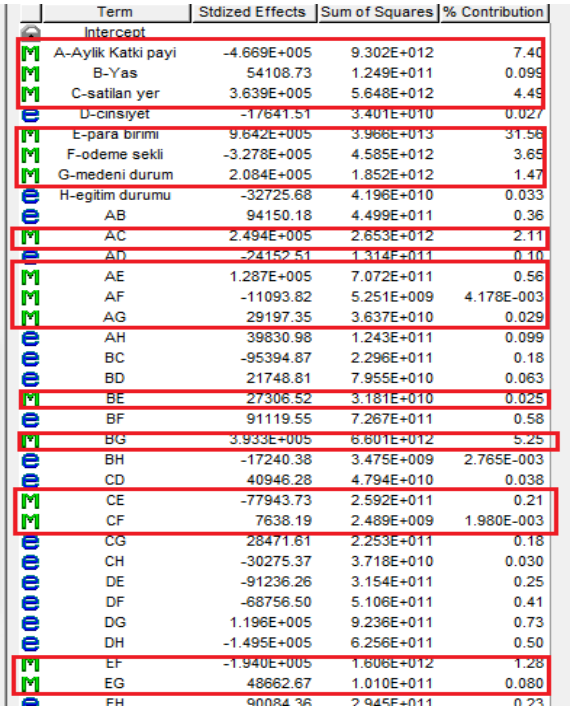



Figure 5. 6. Alias List of duration of stay in Private Pension System

In this study, these terms are selected as main effect: A, B, C, E, F, G, AC, AE, AF, AG, BE, BG, CE, CF, EF, EG. In Pareto chart the term of AE is lower than the T-value limit. However, we take it into account, because AE is the interaction of two main effects.

In such a manner, AF, BE, AG, CE, CF, EG are interaction effects that are chosen as main effects because of high effect of A, C, G, E, F. However their contribution is low. Also, from the effects lists we can see the contribution of the main effects. Main effects have large contribution. B has low contribution, but the interaction of BG is very high, so we included B to main effects as well.



| Term | Stdized Effects | Sum of Squares | % Contribution |
|---|---|---|---|
| Intercept | | | |
| A-Aylik Katki payi | -4.669E+005 | 9.302E+012 | 7.40 |
| B-Yas | 54108.73 | 1.249E+011 | 0.099 |
| C-satilan yer | 3.639E+005 | 5.648E+012 | 4.49 |
| D-cinsiyet | -17641.51 | 3.401E+010 | 0.027 |
| E-para birimi | 9.642E+005 | 3.966E+013 | 31.56 |
| F-odeme sekli | -3.278E+005 | 4.585E+012 | 3.65 |
| G-medeni durum | 2.084E+005 | 1.852E+012 | 1.47 |
| H-egitim durumu | -32725.68 | 4.196E+010 | 0.033 |
| AB | 94150.18 | 4.499E+011 | 0.36 |
| AC | 2.494E+005 | 2.653E+012 | 2.11 |
| AD | -24152.51 | 1.314E+011 | 0.10 |
| AE | 1.287E+005 | 7.072E+011 | 0.56 |
| AF | -11093.82 | 5.251E+009 | 4.178E-003 |
| AG | 29197.35 | 3.637E+010 | 0.029 |
| AH | 39830.98 | 1.243E+011 | 0.099 |
| BC | -95394.87 | 2.296E+011 | 0.18 |
| BD | 21748.81 | 7.955E+010 | 0.063 |
| BE | 27306.52 | 3.181E+010 | 0.025 |
| BF | 91119.55 | 7.267E+011 | 0.58 |
| BG | 3.933E+005 | 6.601E+012 | 5.25 |
| BH | -17240.38 | 3.475E+009 | 2.765E-003 |
| CD | 40946.28 | 4.794E+010 | 0.038 |
| CE | -77943.73 | 2.592E+011 | 0.21 |
| CF | 7638.19 | 2.489E+009 | 1.980E-003 |
| CG | 28471.61 | 2.253E+011 | 0.18 |
| CH | -30275.37 | 3.718E+010 | 0.030 |
| DE | -91236.26 | 3.154E+011 | 0.25 |
| DF | -68756.50 | 5.106E+011 | 0.41 |
| DG | 1.196E+005 | 9.236E+011 | 0.73 |
| DH | -1.495E+005 | 6.256E+011 | 0.50 |
| EF | -1.940E+005 | 1.606E+012 | 1.28 |
| EG | 48662.67 | 1.010E+011 | 0.080 |
| EH | 90084.36 | 2.945E+011 | 0.23 |

Figure 5. 7. Main effects of duration of stay in Private Pension System

After we selected main effects, Analysis of variance is studied. First some terms are explained:

Sum of Squares: Total of the sum of squares for the terms in the model.

DF: Degrees of freedom for the model. It is the number of model terms, including the intercept minus one.

Mean Square: Estimate of the model variance, calculated by the model sum of squares divided by model degrees of freedom.

F Value: It is the test for comparing model variance with residual variance. If the variances are close to the same, the ratio will be close to the one and it is less likely that any of the factors have a significant effect on the response. It is calculated by model mean square, divided by residual mean square.

Prop>F: It is the probability of seeing the observed F value if the null hypothesis is true. (There is no factor effect. ) Small probability values call for rejection of the null hypothesis. The probability equals the proportion of the area under the curve of the F-distribution that lies beyond the observed F value. The F distribution itself is determined by the degrees of freedom associated with the variances being compared. If this value is very small (less than 0,05) then the terms in the model have a significant effect on the response.

Lack of fit: Significant lack of fit means that the variation of the replicates about their mean values is less than the variation of the design points about their predicted values. That shows, either the runs replicate well or their variance is small, the model doesn't predict well, or some combination of the two. If there is a significant lack of fit in the model, replicates and the fitting of the model should be checked.

R-Squares: R square is calculated on the basis of the change in response relative to the total variation of the response over the range of independents factor. That means the measure of the amount of the variation around the mean explained by the model. We focus on the adjusted R-squared and Predicted R-squared values.

The adjusted R-squared is basically plateaus when insignificant terms are added the model, and the predicted R –squared will decrease when there are too many insignificant terms. Adjusted R Squared is the measure of the amount of variation around the mean explained by model, adjusted for the number of terms in the model. It decreases as the number of terms in the model increases if those additional terms don't add value to the model.

Predicted R Squared means, a measure of the amount of variation in new data explained by the model. A rule is that the adjusted and predicted R-squared values should be within 0,2 of each other. If the objective of the experiment is to create accurate model, then high adjusted and predicted R-squared value (more than 0,70) is desired.

Table 5. 4. ANOVA for duration of stay in Private Pension System

| ANOVA for selected factorial model | | | | | | |
|---|---|---|---|---|---|---|
| **Source** | **Sum of Squares** | **Df** | **Mean Square** | **F Value** | **p-value Prob > F** | |
| Model | 7,31728E+13 | 16 | 4,5733E+12 | 13,85087 | < 0. 0001 | Significant |
| A-Contribution payment | 9,30187E+12 | 1 | 9,30187E+12 | 28,17199 | < 0. 0001 | |
| B-Age | 1,24905E+11 | 1 | 1,24905E+11 | 0,378292 | 0. 5394 | |
| C-Place | 5,64816E+12 | 1 | 5,64816E+12 | 17,10623 | < 0. 0001 | |
| E-Currency of contract | 3,96635E+13 | 1 | 3,96635E+13 | 120,1263 | < 0. 0001 | |
| F-Payment type | 4,58529E+12 | 1 | 4,58529E+12 | 13,88719 | 0. 0003 | |
| G-Marital status | 1,85197E+12 | 1 | 1,85197E+12 | 5,608943 | 0. 0191 | |
| AC | 2,65263E+12 | 1 | 2,65263E+12 | 8,033845 | 0. 0052 | |
| AE | 7,07186E+11 | 1 | 7,07186E+11 | 2,141811 | 0. 1453 | |
| AF | 5250577012 | 1 | 5250577012 | 0,015902 | 0. 8998 | |
| AG | 36369037968 | 1 | 36369037968 | 0,110149 | 0. 7404 | |
| BE | 31811017864 | 1 | 31811017864 | 0,096344 | 0. 7567 | |
| BG | 6,60062E+12 | 1 | 6,60062E+12 | 19,99089 | < 0. 0001 | |
| CE | 2,59184E+11 | 1 | 2,59184E+11 | 0,784973 | 0. 3770 | |
| CF | 2489007175 | 1 | 2489007175 | 0,007538 | 0. 9309 | |
| EF | 1,60637E+12 | 1 | 1,60637E+12 | 4,865105 | 0. 0288 | |
| EG | 1,01027E+11 | 1 | 1,01027E+11 | 0,305974 | 0. 5809 | |
| Residual | 5,24988E+13 | 159 | 3,30181E+11 | | | |
| Lack of Fit | 1,48497E+13 | 47 | 3,15952E+11 | 0,939905 | 0. 5858 | not significant |
| Pure Error | 3,76491E+13 | 112 | 3,36153E+11 | | | |
| Cor Total | 1,25672E+14 | 175 | | | | |

According to Anova, the model F value is 13,85 means that model is significant. Values of "Prop>F" less than 0,05 indicate that model terms are significant. In this case, A, C, E, F, G, AC, BG, EF are significant. Values greater than 0,1 indicate model terms are not significant.

The Lack of fit F value 0,94, shows that Lack of fit is not significant relative to the pure error.

The Predicted R-squared is reasonable with the Adjusted R-squared because the values are within 0,2 of each other.

Table 5. 5. R-Squared values for duration of stay in Private Pension System

| | | | | |
|---|---|---|---|---|
| Std. Dev. | 574614,2 | | R-Squared | 0,582254 |
| Mean | 1561887 | | Adj R-Squared | 0,540216 |
| | | | Pred R-Squared | 0,487357 |

After Anova, prediction equations are determined. Here are some descriptions;
Coefficient estimate: Regression coefficient representing the expected change in response y per unit change in x when all remaining factors are held constant. Standard error: The standard deviation, associated with the coefficient estimate.

Table 5. 6. Prediction Equations of factors for duration of stay in Pension System

| **ANOVA and Prediction Equations** | | | |
|---|---|---|---|
| **Factor** | **Coefficient Estimate** | **df** | **Standard Error** |
| Intercept | 1543831 | 1 | 43811,2 |
| A-Contribution payment | -233471 | 1 | 43986,95 |
| B-Age | 26934,25 | 1 | 43791,66 |
| C-Place | 180841,5 | 1 | 43724,11 |
| E-Currency of contract | 480305 | 1 | 43822,59 |
| F-Payment type | -162554 | 1 | 43620,45 |
| G-Marital status | 103606,5 | 1 | 43746,84 |
| AC | 124572 | 1 | 43949,97 |
| AE | 63735,38 | 1 | 43550,19 |
| AF | -5488,3 | 1 | 43522,18 |
| AG | 14581,16 | 1 | 43934,17 |
| BE | 13489,05 | 1 | 43457,92 |
| BG | 196042,4 | 1 | 43846,41 |
| CE | -38721,5 | 1 | 43704,41 |
| CF | 3780,131 | 1 | 43538,17 |
| EF | -95968,5 | 1 | 43509,35 |
| EG | 24215,83 | 1 | 43778,13 |

Anova formula of duration of stay:

$$(duration\ of\ stay)^{1.86} = \quad (5.\ 1)$$

$$1543831{,}35$$
$$-233470{,}813 * \mathrm{A}$$
$$+26934{,}2529 * \mathrm{B}$$
$$+180841{,}524 * \mathrm{C}$$
$$+480304{,}978 * \mathrm{E}$$
$$-162553{,}899 * \mathrm{F}$$
$$+103606{,}539 * \mathrm{G}$$
$$+124571{,}967 * \mathrm{AC}$$
$$+63735{,}3829 * \mathrm{AE}$$
$$-5488{,}29962 * \mathrm{AF}$$
$$+14581{,}1587 * \mathrm{AG}$$
$$+13489{,}052 * \mathrm{BE}$$
$$+196042{,}443 * \mathrm{BG}$$
$$-38721{,}5417 * \mathrm{CE}$$
$$+3780{,}13141 * \mathrm{CF}$$
$$-95968{,}4981 * \mathrm{EF}$$
$$+24215{,}8294 * \mathrm{EG}$$

In this case, we interpret the significant factors: A, C, E, F, G, AC, BG, and EF how they may affect the duration of system.

A-Contribution payment: In the ANOVA formula, factor A has a negative regression coefficient in duration of stay in pension system. That means, when contribution payment increases, duration of stay in the system declines. The reason of that may be the customers with high contribution which is more than 100 TL, may not want to invest his money, because of the long return on investment period of the pension system. Also, if a customer may not afford high contribution payment after a while and he can attempt to exit from the system.

C-Place: In the ANOVA formula, factor has a positive regression coefficient in duration of stay in pension system. For factor C, the first category is east, and the second category is west. That means, if a private pension product is sold in the west part of the Turkey, or customers live in the west part of the Turkey, has high duration of stay in the system. This can be interpreted in this way; if we assume the customers in the west side of Turkey have high income and culture level, they may prefer to spare money for private pension products. Also, because of high level of culture and life standards, they may not exit from the system and keep this product until their retirement. Thus, the duration of the system is high in the west part of the country.

E-Currency of contract: In the ANOVA formula, factor has a positive regression coefficient in the duration of stay in pension system. For factor E, the first category is TL, and the second category is foreign currency. That means, customer, who pays his contribution payment in foreign currency, such as euro and dollar, he may stay longer than the others in pension system. This can be interpreted in this way; foreign currency is a good investment tool. If customer thinks that private pension system is a good way to invest his money, he may choose to pay his contribution payments in foreign currency. Because, the customer thinks private pension system is a profitable investment, he may stay in the system until his retirement. Therefore, for this type of customer, the duration of the stay is higher.

F-Payment type: In the ANOVA formula, factor has a negative regression coefficient in the duration of stay in pension system. For factor F, the first category is monthly installment and the second category is 3 month/ 6 month/ year installments. That means, a customer, who pays his contribution payment with monthly installments; he may stay longer than the others in pension system. This can be interpreted in this way, paying contribution payment in monthly installments means that customer may have a regular certain income for each month, so he prefers to pay contribution payment in a regular way. The other payments types can be preferred, when a customer gets high amount of money which is not regular, not fixed and he wants to invest this money in private pension system. Customer with regular payment type may want to stay in the system until the retirement, because he may think private pension is a good investment and he

pays regular money, to earn the return of his investments, so for this type of customer, his duration of the stay is higher.

G-Marital status: In the ANOVA formula, factor has a positive regression coefficient in the duration of stay in pension system. For factor G, the first category is being single/widow/divorced, and the second category is being married. That means, customer who is married; he may stay longer than the others in pension system. This can be interpreted in this way, married people have a family, and married person may think he has more responsibilities for his wife and children. Therefore, in retirement period, he may want his family to live with the same standards as they were before. And he may prefer to stay in private pension system until he retires and get his investments back, so for this type of customer, the duration of the stay is higher.

Also, there are significant interaction effects:

AC: AC is the interaction effect of Contribution payment and place. AC has a positive regression coefficient in the duration of stay in pension system. That means, customers who live in the east part of the Turkey and pays high contribution which is lower than the 100 TL, have longer duration in the private pension system.

BG: BG is the interaction effect of Age and marital status of customer. BG has a positive regression coefficient in the duration of stay in pension system. That means, a customer whose age more than 45, and his marital status is married, he has longer duration in the private pension system

EF: EF is the interaction effect of Currency of contract and Payment type. EF has a negative regression coefficient in the duration of stay in pension system. That means, a customer who pays his contribution amount in foreign currency (dollar and euro) and pays this amount in monthly installments, he has longer duration in the private pension system.

After Anova is applied and significant factors determined, Diagnostics will be made for duration of system response. Graphical summaries are better way to understand how well the model satisfies the assumptions of the analysis of variance.

There are some model diagnostic plots:

Normal Probability Plot: The normal probability plot shows that whether the residuals follow a normal distribution, in which case the points will follow a straight line. For duration of system, we can see that, residuals follow a straight line that means residuals follow a normal distribution. And for main factors, normal plot of residuals shows us, the residuals follow a normal distribution.

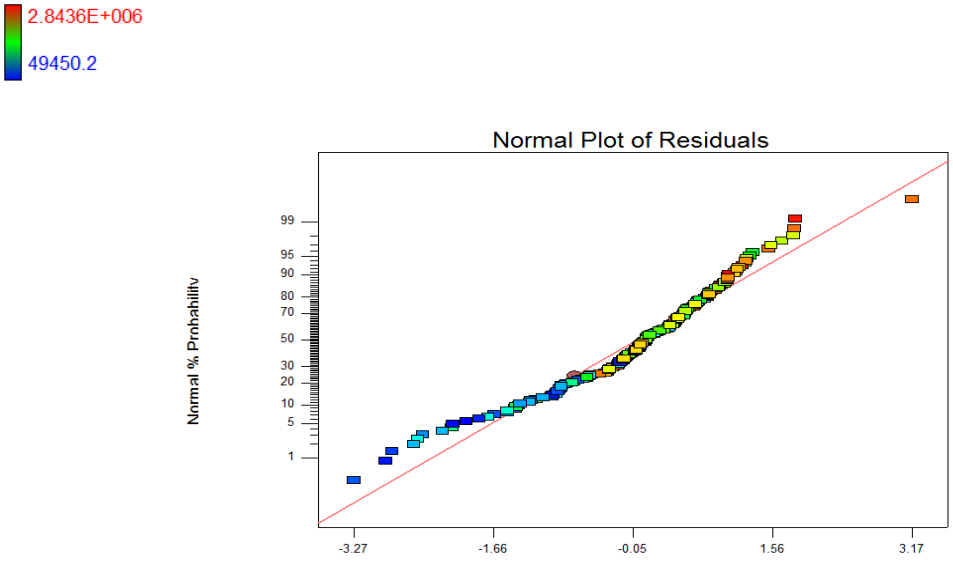



Figure 5. 8. Normal Plot Residuals of duration of Stay in Private Pension System

Residuals and predicted plot: This is a plot of residuals versus the ascending predicted response values. It tests the assumption of constant variance. The plot should be in a random scatter. (Constant range of residuals across the graph. ) For duration of stay the graph shows us, variance is constant.

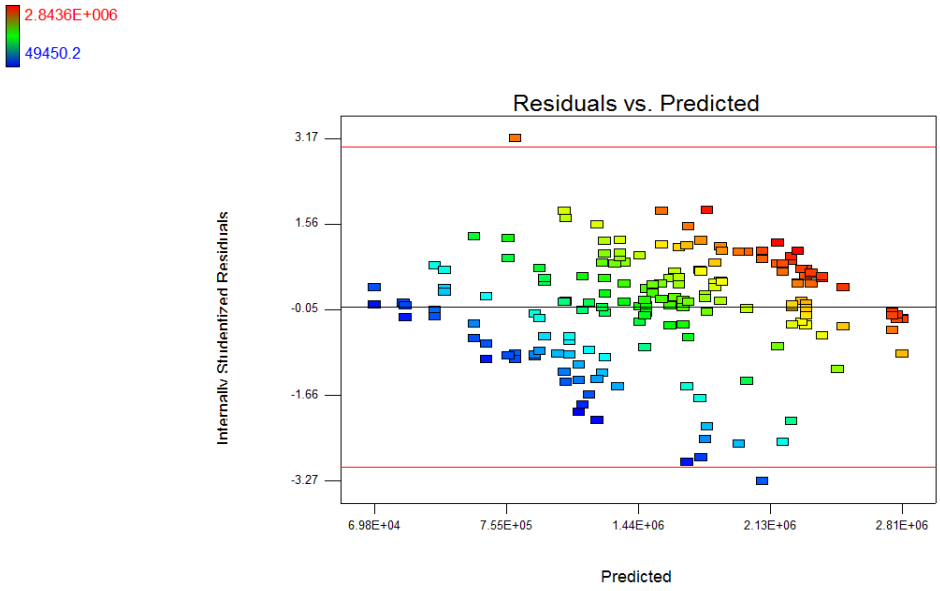



Figure 5. 9. Residuals and predicted plot of duration of Stay in Pension System

Residuals vs. Run plot: This is a plot of the residuals versus the experimental run order. It checks for hidden variables that may have influenced the response during the experiment. The plot should show a random scatter. Trends indicate a time-related variable hidden in the background. For duration in the system response, the plot is in random scatter, so we can say that there is no variable hidden between the runs.

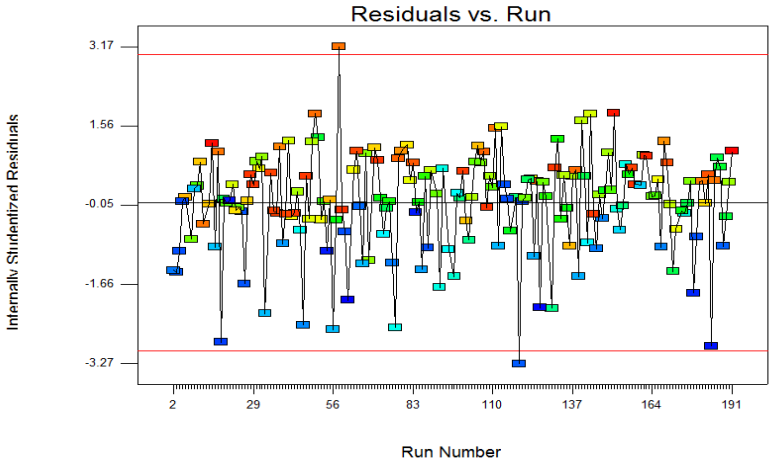



Figure 5. 10 Residuals vs. Run plot of duration of Stay in Private Pension System

Residuals vs. Factors: This is a plot of the residuals versus any factor that we choose. It checks whether the variance not accounted for by the model is different for different levels of a factor. If all is okay, the plot should exhibit a random scatter. For instance, the figure below is the Residuals vs. Contribution Payment Graph.

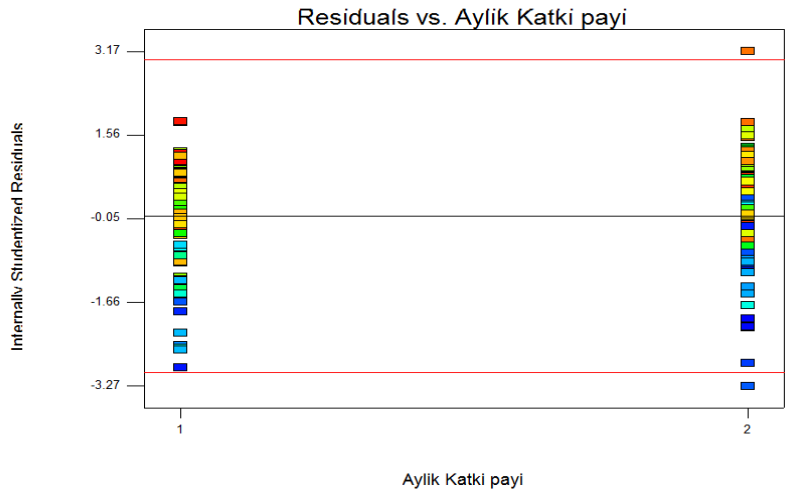



Figure 5. 11. Residuals vs. Run plot of duration of Stay in Private Pension System

After we determine significant values for duration of stay response, we follow the same procedures for the other response, pension savings.

A transformation is needed to meet the assumptions that make the Anova valid. The transformation of pension savings response is inverse transformation. In inverse transformation lambda value is -1. In the Box Cox plot the best lambda value is -0,81, so we don't have to change the lambda value, we proceed with lambda value -1.

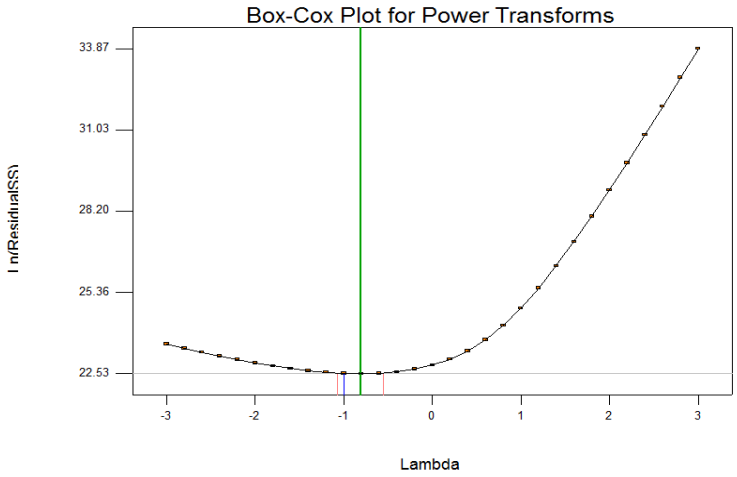



Figure 5. 12. Box-Cox for Power Transform of pension savings in Pension System

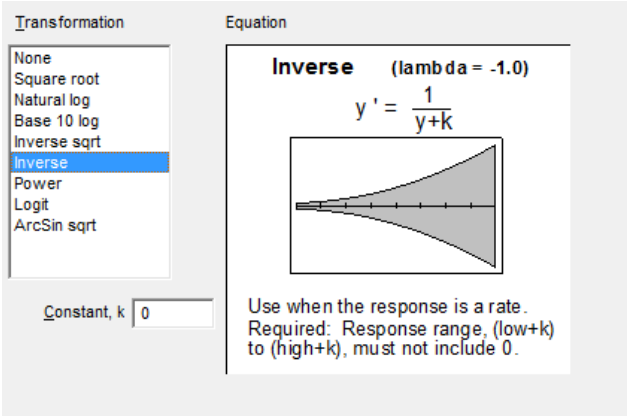



Figure 5. 13. Transformation of pension savings in Private Pension System

Selecting effects is the next step, after transformation is determined. In order to analyze a factorial design, the significant factor effects must be identified and separated from the insignificant effects. In Half Normal and Normal plot, if the effects represent a sample from a normal population, it would form a straight line on normal probability plot of effects. The outlier points are selected as effects. Also, we can use, the Pareto Chart to select the terms that are above the T-value limit which are possibly significant.

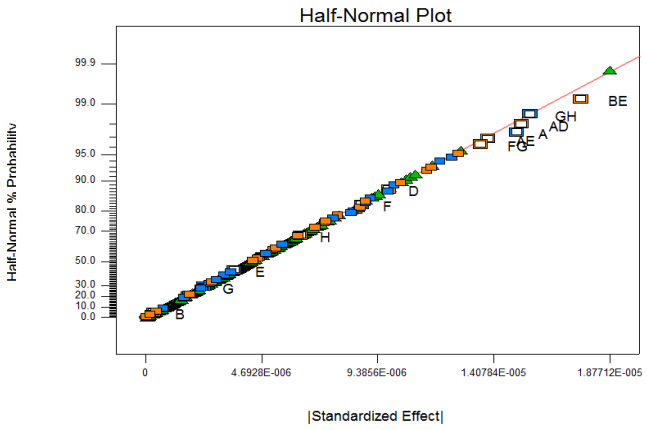



Figure 5. 14. Half Normal Plot of pension savings in Private Pension System

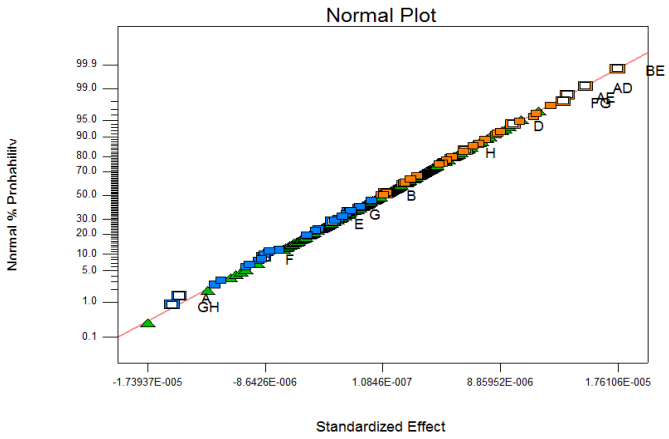



Figure 5. 15. Normal Plot of pension savings in Private Pension System

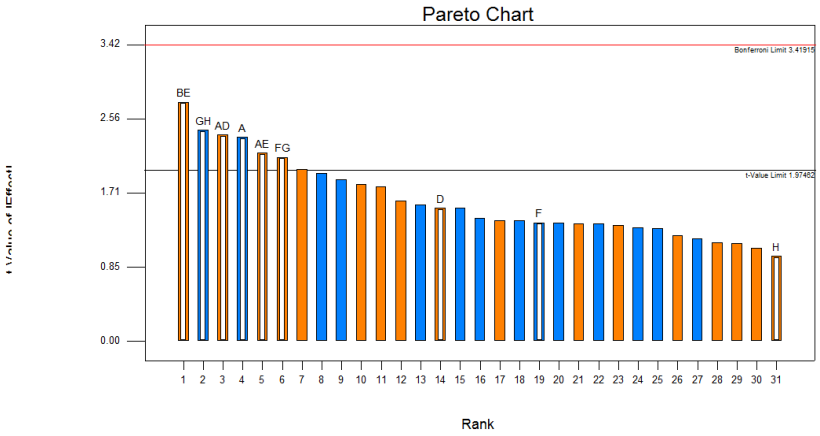



Figure 5. 16. Normal Plot of pension savings in Private Pension System

Effects can be selected from the Effects List report. We include the effects to the model by marking them with 'M'. There is 'e' before terms that are included in the error.

In this study, we select A, B, D, E, F, G, H, AD, AE, BE, FG, GH as main effects. We select the interaction effects, BE, GH, AD, AE and FG as main effects because, in Pareto Chart they have high effects. Also, because of they have high interactions effects; the main effects are selected as well, A, B, D, E, F, G, H. Also, their high contribution can be seen from the contribution column.

| | Term | Stdized Effects | Sum of Squares | % Contribution |
|---|---|---|---|---|
| | Intercept | | | |
| M | A-Aylik Katki payi | -1.502E-005 | 9.813E-009 | 2.73 |
| M | B-Yas | 3.455E-007 | 5.192E-012 | 1.442E-003 |
| e | C-satilan yer | -8.705E-006 | 9.241E-010 | 0.26 |
| M | D-cinsiyet | 9.830E-006 | 4.202E-009 | 1.17 |
| M | E-para birimi | -3.593E-006 | 5.614E-010 | 0.16 |
| M | F-odeme sekli | -8.752E-006 | 3.331E-009 | 0.93 |
| M | G-medeni durum | -2.345E-006 | 2.392E-010 | 0.066 |
| M | H-egitim durumu | 6.264E-006 | 1.706E-009 | 0.47 |
| e | AB | 6.163E-006 | 2.311E-010 | 0.064 |
| e | AC | 5.157E-006 | 5.437E-010 | 0.15 |
| M | AD | 1.521E-005 | 1.006E-008 | 2.79 |
| M | AE | 1.386E-005 | 8.353E-009 | 2.32 |
| e | AF | -7.140E-007 | 6.817E-011 | 0.019 |
| e | AG | 8.562E-006 | 2.520E-009 | 0.70 |
| e | AH | 7.244E-006 | 1.838E-009 | 0.51 |
| e | BC | 4.682E-006 | 4.759E-010 | 0.13 |
| e | BD | -1.239E-005 | 8.634E-009 | 2.40 |
| M | BE | 1.761E-005 | 1.349E-008 | 3.75 |
| e | BF | -8.398E-006 | 1.912E-009 | 0.53 |
| e | BG | -8.660E-006 | 4.849E-009 | 1.35 |
| e | BH | 2.050E-007 | 2.256E-010 | 0.063 |
| e | CD | -1.191E-005 | 4.548E-009 | 1.26 |
| e | CE | -3.187E-006 | 3.041E-010 | 0.084 |
| e | CF | 1.553E-006 | 4.188E-011 | 0.012 |
| e | CG | 1.138E-005 | 3.150E-009 | 0.87 |
| e | CH | 7.772E-006 | 1.240E-009 | 0.34 |
| e | DE | -3.442E-006 | 4.061E-010 | 0.11 |
| e | DF | 1.669E-006 | 8.158E-010 | 0.23 |
| e | DG | -1.733E-006 | 1.926E-013 | 5.351E-005 |
| e | DH | -2.311E-006 | 3.798E-011 | 0.011 |
| e | EF | 3.474E-008 | 6.291E-011 | 0.017 |
| e | EG | -1.558E-006 | 1.385E-011 | 3.847E-003 |
| e | EH | -7.586E-006 | 1.324E-009 | 0.37 |
| M | FG | 1.355E-005 | 7.989E-009 | 2.22 |
| e | FH | -4.673E-006 | 1.330E-009 | 0.37 |
| M | GH | -1.556E-005 | 1.053E-008 | 2.92 |

Figure 5. 17. Main Effects of pension savings in Private Pension System

After we selected main effects, Analysis of variance is studied.

Table 5. 7. ANOVA for pension savings in Private Pension System

| ANOVA for selected factorial model | | | | | | |
|---|---|---|---|---|---|---|
| **Source** | **Sum of Squares** | **df** | **Mean Square** | **F Value** | **p-value Prob > F** | |
| Model | 6,97E-08 | 12 | 5,81E-09 | 3,27 | 0. 0003 | significant |
| A-Contribution payment | 9,81E-09 | 1 | 9,81E-09 | 5,52 | 0. 0200 | |
| B-Age | 5,19E-12 | 1 | 5,19E-12 | 0 | 0. 9570 | |
| D-Gender | 4,20E-09 | 1 | 4,20E-09 | 2,36 | 0. 1261 | |
| E-Currency of contract | 5,61E-10 | 1 | 5,61E-10 | 0,32 | 0. 5749 | |
| F-Payment type | 3,33E-09 | 1 | 3,33E-09 | 1,87 | 0. 1729 | |
| G-Marital status | 2,39E-10 | 1 | 2,39E-10 | 0,13 | 0. 7142 | |
| H-Educational status | 1,71E-09 | 1 | 1,71E-09 | 0,96 | 0. 3286 | |
| AD | 1,01E-08 | 1 | 1,01E-08 | 5,66 | 0. 0185 | |
| AE | 8,35E-09 | 1 | 8,35E-09 | 4,7 | 0. 0316 | |
| BE | 1,35E-08 | 1 | 1,35E-08 | 7,59 | 0. 0065 | |
| FG | 7,99E-09 | 1 | 7,99E-09 | 4,49 | 0. 0355 | |
| GH | 1,05E-08 | 1 | 1,05E-08 | 5,92 | 0. 0160 | |
| Residual | 2,90E-07 | 163 | 1,78E-09 | | | |
| Lack of Fit | 9,69E-08 | 51 | 1,90E-09 | 1,1 | 0. 3297 | not significant |
| Pure Error | 1,93E-07 | 112 | 1,72E-09 | | | |
| Cor Total | 3,59E-07 | 175 | | | | |

According to ANOVA, the model F value is 3,27. It is not 1, so the model is significant. Values of "Prop>F" less than 0,05 means that model terms are significant. In this case, A, AD, AE, BE, FG, GH are significant model terms. Values greater than 0,1 indicate model terms are not significant.

The lack of fit-F value is 1,1 that means Lack of Fit is not significant relative to the pure error. There is 32,97 chance that a Lack of Fit value this large could occur due to noise.

The Predicted R-Squared of 0,0597 is in reasonable agreement with the Adjusted R-Squared value of 0,1346.

Table 5. 8. R-Squared values of pension savings in Private Pension System

| | | | | |
|---|---|---|---|---|
| Std. Dev. | 4,22E-05 | | R-Squared | 0,193906 |
| Mean | 9,67E-05 | | Adj R-Squared | 0,134562 |
| | | | Pred R-Squared | 0,059661 |

After Anova, prediction equations are determined.

Table 5. 9 Prediction Equations of pension savings in Private Pension System

| **ANOVA and Prediction Equations** | | | |
|---|---|---|---|
| **Factor** | **Coefficient Estimate** | **df** | **Standard Error** |
| Intercept | 9,63E-05 | 1 | 3,21E-06 |
| A-Contribution payment | -7,51E-06 | 1 | 3,20E-06 |
| B-Age | 1,73E-07 | 1 | 3,20E-06 |
| D-gender | 4,91E-06 | 1 | 3,20E-06 |
| E-Currency of contract | -1,79E-06 | 1 | 3,19E-06 |
| F-Payment type | -4,37E-06 | 1 | 3,19E-06 |
| G-Marital status | -1,17E-06 | 1 | 3,20E-06 |
| H-Educational status | 3,13E-06 | 1 | 3,20E-06 |
| AD | 7,61E-06 | 1 | 3,20E-06 |
| AE | 6,93E-06 | 1 | 3,20E-06 |
| BE | 8,77E-06 | 1 | 3,19E-06 |
| FG | 6,78E-06 | 1 | 3,20E-06 |
| GH | -7,79E-06 | 1 | 3,20E-06 |

Anova formula of pension savings:

$$1{,}0/(pension\ savings) = \tag{5. 2}$$
$$+9{,}62637\mathrm{E}-05$$
$$-7{,}51055\mathrm{E}-06*\mathrm{A}$$
$$+1{,}73101\mathrm{E}-07*\mathrm{B}$$
$$+4{,}91295\mathrm{E}-06*\mathrm{D}$$
$$-1{,}79129\mathrm{E}-06*\mathrm{E}$$
$$-4{,}37315\mathrm{E}-06*\mathrm{F}$$
$$-1{,}17486\mathrm{E}-06*\mathrm{G}$$
$$+3{,}13388\mathrm{E}-06*\mathrm{H}$$
$$+7{,}61497\mathrm{E}-06*\mathrm{AD}$$
$$+6{,}92832\mathrm{E}-06*\mathrm{AE}$$
$$+8{,}77407\mathrm{E}-06*\mathrm{BE}$$
$$+6{,}77741\mathrm{E}-06*\mathrm{FG}$$
$$-7{,}79177\mathrm{E}-06*\mathrm{GH}$$

In this case, we interpret the significant factors: A, AD, AE, BE, FG and GH how they may affect the pension savings in the system.

A-Contribution payment: In the ANOVA formula, factor A has a negative regression coefficient in pension savings response of pension system. That means, when contribution payment increases, pension savings increases in the system. This comment is logical, because contribution payments, gains a value in funds and when customer retires, he gets pension savings. If he increases his contribution payments, there will be more capital and profit that comes from funding. Therefore, increasing contribution payments provides high pension savings.

AD: AD is the interaction effect of Contribution payment and gender of customer. AD has a positive regression coefficient in pension savings response of pension system. That means customers who are men and pay low contribution payment which is lower than 100 TL, have low pension savings in the system.

AE: AE is the interaction effect of Contribution payment and currency of contribution payment. AE has a positive regression coefficient in pension savings response of pension system. That means customers who pay high contribution payments which are greater than 100 TL and the currency of contribution payment is in TL currency, this customer type has low pension saving in the system.

BE: BE is interaction effect of Age of Customer and currency of contribution payment. BE has a positive regression coefficient in pension savings response of pension system. That means, customer whose age is lower than 45, and the currency of his contribution payment is TL, this customer type has low pension savings in the system.

FG: FG is the interaction effect of Payment type contribution payment and marital status of the customer. FG has a positive regression coefficient in pension savings response of pension system. That means, a customer who is married and pay his contribution payments in monthly installments, this customer type has low pension savings in the system.

GH: GH is the interaction effect of marital status and educational status of the customer. GH has a negative regression coefficient in pension savings response of pension system. That means, customer who is married and has low educational status (educated from high school), this customer type has higher pension savings in the system.

After Anova is applied and the significant factors determined, diagnostics will be made for pension of savings response. Graphical summaries are better way to understand how well the model satisfies the assumptions, of the analysis of variance.

There are some model diagnostic plots:

Normal Probability Plot: The normal probability plot shows that whether the residuals follow a normal distribution, in which case the points will follow a straight line.

For duration of system, we can see that, residuals follow a straight line that means residuals follow a normal distribution. And for main factors, normal plot of residuals shows us, the residuals follow a normal distribution.

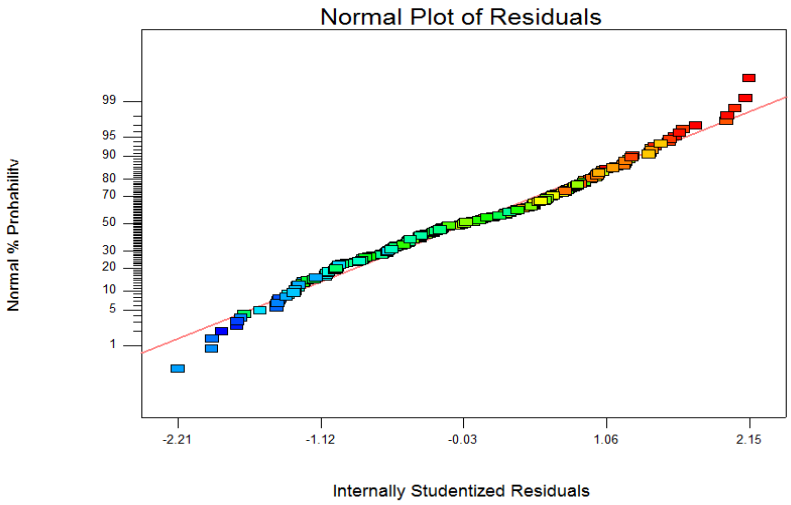



Figure 5. 18. Normal Plot of Residuals for pension savings in Pension System

Residuals and predicted plot: The plot should be in a random scatter. (Constant range of residuals across the graph. )

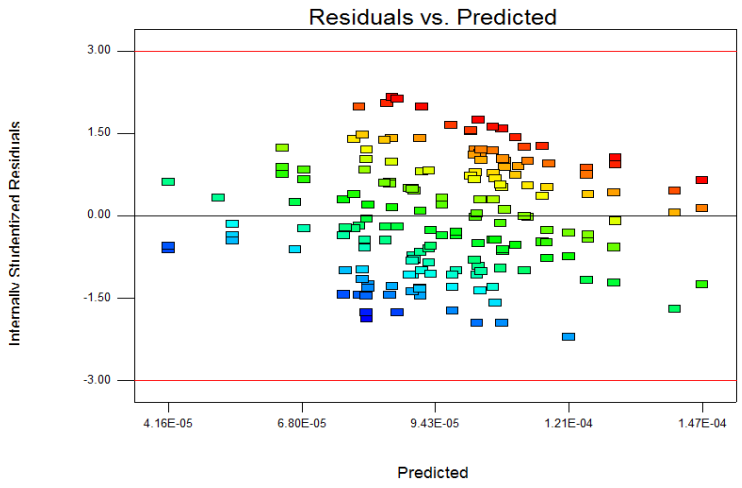



Figure 5. 19. Residual and Predicted Plot of pension savings in Pension System

Residuals vs. Run plot: The plot should show a random scatter. Trends indicate a time-related variable hidden in the background. For pension saving response, the plot is in random scatter, so we can say that there is no variable hidden between the runs.

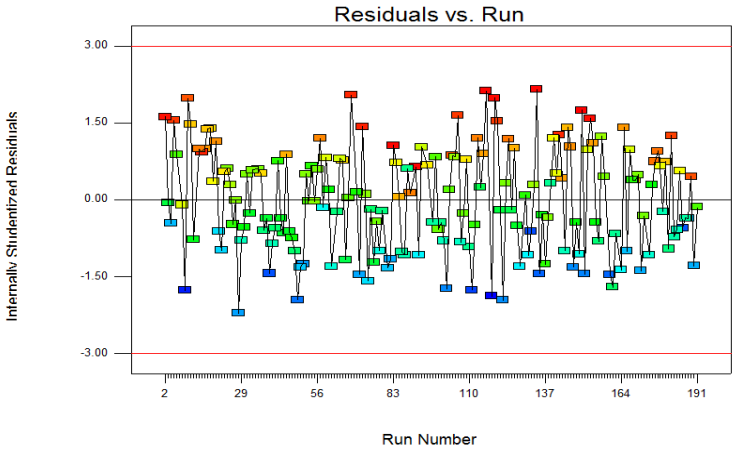



Figure 5. 20. Residual and Run Plot of pension savings in Private Pension System

Residuals vs. Factors: It checks whether the variance not accounted for by the model is different for different levels of a factor. If all is okay, the plot should exhibit a random scatter. For instance, the figure below is the Residuals vs. Educational Status of customer Graph.

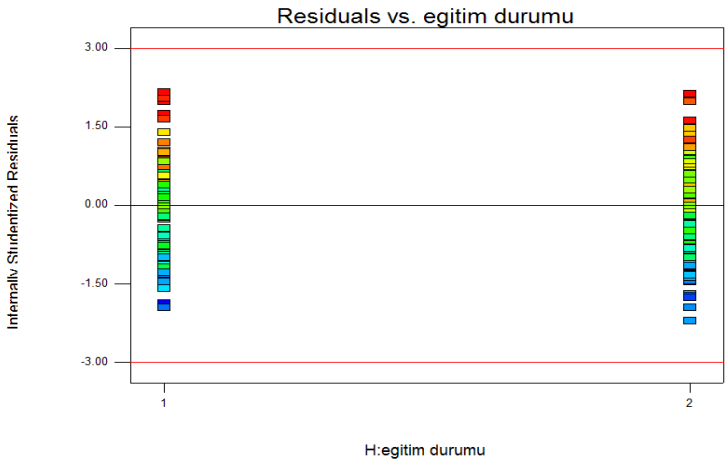



Figure 5. 21. Residual and factor Plot of pension savings in Private Pension System

After we analyzed each response, optimization of all responses simultaneously can be done. We evaluate optimization part with numerical optimization. We choose the desired goal for each factor and response. The possible goals can be: maximize, minimize, and none factors. A minimum and a maximum level must be provided for each parameter included in the optimization.

The "importance "of a goal can be changed in relation to other goals. The default setting is 3 pluses. 5 pluses can be chosen to make the goal more important than the others.

In our study, we use transformed scale of the responses and factors in numerical optimization part. We review the goals of the study again for determining the maximization or minimization of the response. We assume the properties of best private pension customer as follows;

- The customer, who stays in the private pension system as long as possible, could be best customer. Therefore maximization of duration in system response provides us to determine the best customer type in pension system.
- The customer, who has more pension savings than the others, could be best customer. The company gets specific percentage of contribution as administrative and fund management fees. These fees are the most important source of income for the company. Therefore maximization of pension saving response could be used to determine the best customer type in pension system.

For duration of system response, the goal is maximization, so we choose to maximize it in Design Expert. For pension saving response, the goal is maximization. However the pension saving response is in inverse transformed scale, so we choose to minimize it, to maximize the pension savings. In determining the importance phase, default value is 3 pluses, so we leave the factors in 3 pluses importance. For the company in our case, all factors are equally important while determining the best customer in pension system. For duration of system and pension savings, pension saving response is more important than the duration of stay in the system. The reason of that, the company gets specific

percentage of contribution, so if pension saving increases, company earns more money from these fees. Therefore, we give 3 pluses for duration of stay and 4 pluses for pension savings in terms of importance.

For duration of stay:

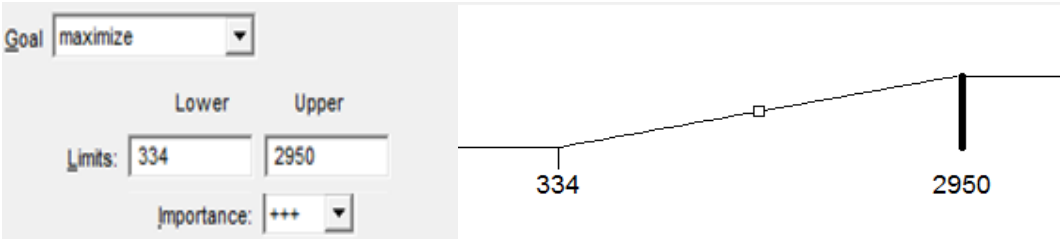



Figure 5. 22. Numerical Optimization criteria of duration of stay in Pension System

For pension saving:

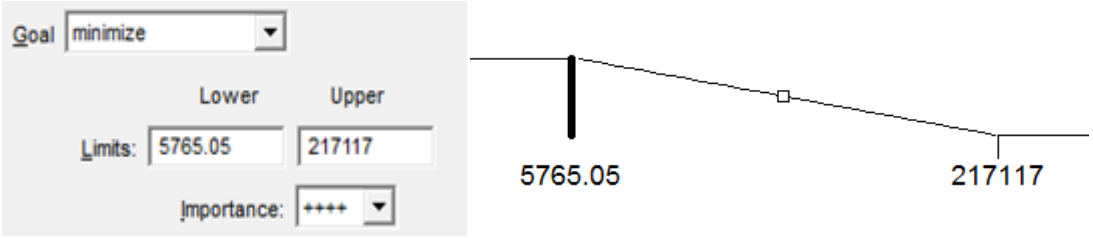



Figure 5. 23. Numerical Optimization criteria of pension saving in Pension System

The constraints are determined for all factors and responses at the table below.

Table 5. 10. Constraints of Responses and Factors in Private Pension System

| Constraints | | | |
|---|---|---|---|
| **Name** | **Goal** | **First Category** | **Second Category** |
| Contribution payment | is in range | <=100 | >100 |
| Age | is in range | <=45 | >45 |
| Place | is in range | East | West |
| Gender | is in range | Man | Woman |
| Currency of contract | is in range | TL | Foreign |
| Payment type | is in range | monthly installment | 3 month/ 6 month/ year installment |
| Marital status | is in range | single/widow/divorced | Married. |
| Educational status | is in range | elementary/ high school education | university/ post grad/ doctor |
| duration of stay | maximize | 334 | 2950 |
| pension savings | minimize | 5765,05 | 217116,6 |

After the criteria's are determined, the numerical optimization is done. We select and reveal first 10 customer types as an example, but totally we get 100 customer types in the solution list. There is a table below that shows first 10 customers. If we make comments about being best customer in private pension system, according to first 10 rows, we can say that;

- Age should be more than 45, because 8 of 10 rows, age of customer is more than 45. That means, while selling a pension product to a customer, age of customer should be noticed. A customer whose age is more than 45, he can stay in system more than the others because the return on investment is very close, there will be

like max. 11 years to retire and also they may have high income and contribute more than the others to the system.

- Currency of contract should be foreign, because all of the 10 customers have foreign currency products. That means products with foreign currency make company to earn more fees.

- Payment type should be monthly installments, because all of the 10 customers pay contribution payment in monthly installments. That means this group of customer may be better customers than the others, because they may have regular income and contribute the system regularly for each month until they retire.

- Educational status should be university/ post grad/ doctor, because 7 of the 10 customers are educated from university, post grad or doctor. That means, customer with high cultural level, have high belief to the pension system, so they may stay longer in the system and contribute more than the others.

For the other factors, we cannot say anything, because the responses do not depend on their effects.

Table 5. 11. The first 10 customers that is solution of the numerical optimization in Private Pension System

| No | Cont. payment | Age | Place | Gender | Currency of contract | Payment type | Marital status | Edu. status | duration of stay | pension savings | Desirability |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | >100 | >45 | west | woman | foreign | monthly installment | Married. | elementary/ high school education | 2903,16 | 8587,82 | 0,780 |
| **2** | >100 | >45 | west | woman | foreign | monthly installment | single/widow /divorced | university/ post grad/ doctor | 2495,62 | 7214,16 | 0,765 |
| **3** | <=100 | >45 | west | man | foreign | monthly installment | single/widow /divorced | university/ post grad/ doctor | 2564,69 | 7694,98 | 0,753 |
| **4** | <=100 | >45 | west | man | foreign | monthly installment | Married. | elementary/ high school education | 2931,42 | 9277,94 | 0,751 |
| **5** | >100 | <=45 | west | woman | foreign | monthly installment | single/widow /divorced | university/ post grad/ doctor | 2689,61 | 8283,50 | 0,749 |
| **6** | <=100 | >45 | east | man | foreign | monthly installment | single/widow /divorced | university/ post grad/ doctor | 2547,31 | 7694,98 | 0,749 |
| **7** | <=100 | >45 | east | man | foreign | monthly installment | Married. | elementary/ high school education | 2915,94 | 9277,94 | 0,748 |
| **8** | >100 | >45 | west | woman | foreign | monthly installment | Married. | university/ post grad/ doctor | 2903,16 | 9334,61 | 0,742 |
| **9** | <=100 | >45 | west | woman | foreign | monthly installment | single/widow /divorced | university/ post grad/ doctor | 2564,69 | 8028,85 | 0,734 |
| **10** | <=100 | <=45 | west | man | foreign | monthly installment | single/widow /divorced | university/ post grad/ doctor | 2754,47 | 8923,75 | 0,731 |

The numerical optimization finds a point that maximizes the desirability function. Desirability is an objective function that ranges from zero outside of the limits to one at the goal. For several responses and factors, all goals get combined into one desirability function. Desirability value is completely dependent on how closely the lower and upper limits are set relative to the actual optimum. The goal of optimization is to find a good set of conditions that will meet all the goals, not to get a desirability value of 1,0. Desirability is simply a mathematical method to find the optimum. In our case, desirability is 0,78.

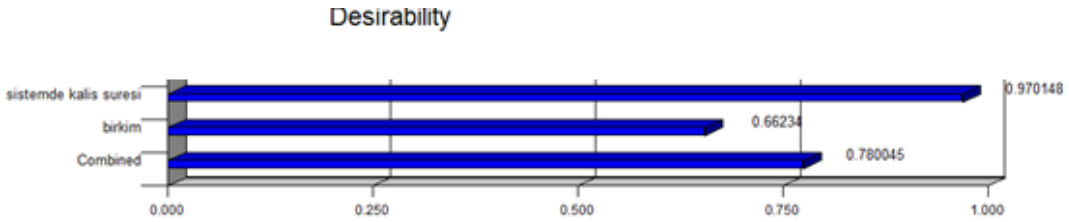



Figure 5. 24. Desirability of Private Pension System

In second phase, we examine life insurance system, and carry out all procedure for life insurance system as well.

First we begin with, determining our aim and responses. Our aim is to find the best customer in life insurance system. For life insurance system, the best life insurance customer is the one that makes more profit than the others to the company. We assume that if we determine and call for selling this type of customer, the company will have high sale rates.

We assume the responses of best customer type in life insurance customer are as follows;

- In life insurance and private pension company we studied, we assume that company sell renewable life insurance products. Renewable policies renew itself at the end of the policy year. All policies have a specific renewal duration that a policy can renew until it reaches at the end of renewal duration. In this company renewal duration changes between 2 years to 30 years. Premium is paid by customer for each year. For life insurance system, the best customer is the one who pays more premiums than the others. That means, the customer who pays the most total premium amount which is calculated by multiplication of premium amount per year and renewal duration of policy, is the best customer in the life insurance system. In this phase we have just one response.

Table 5. 12. The responses of Life Insurance System

| Name | Units |
|---|---|
| Total premium | TL |

After, we determine the response; the next part is determining the factors and levels. The factors could possibly influence any of the responses that we want to measure. While choosing the factors, we think about, it may have an influence on the response or not. We decide to observe the difference in the response, while deciding on levels. The factor range should be set so that we it could cause this amount of change in the response.

- Educational status of customer: Educational status of customer may have an influence on being best customer. According to the educational status, customer may choose policy with different renewal durations, so the total premium amount can change. We examine this factor in unit of type. It is determined as categorical type with 2 levels: elementary/high school education and university/ post grad/ doctor degree education.
- Age of customer: Age of customer may have an influence on being best customer. Customer age can affect premium amount, because when customer gets older, the possibility of getting death compensation increases according to mortality table. We examine this factor in unit of year. It is determined as categorical type with 2 levels: customer age lower than or equal to 45 and higher than 45.
- Place, where policy is sold: The place of where policy is sold may have an influence on being best customer. We examine this factor as categorical type with 2 levels, in unit of parts: east of Turkey and west of Turkey.
- Gender of customer: Gender of customer may have an influence on being best customer. Gender can affect premium amount, because the possibility of getting death compensation may be different in genders according to mortality table. We examine this factor in unit of type. It is determined as categorical type with 2 levels: man and woman.

- Currency of policy: The currency of policy may have an influence on being best customer. We examine this factor in unit of currency. It is determined as categorical type with 2 levels: TL and Foreign currency.
- Payment type: The payment type of policy may have an influence on being best customer. Payment type of policy can be for each month, 3 months, 6 months and for each year of installments. We examine this factor in unit of month, and it is categorical with 2 levels: monthly installment and not monthly installment( 3 month/ 6 month/ year installment)
- Marital status: Marital status of customer may have an influence on being best customer. According to the marital status, customer can choose policy with different renewal durations, so the total premium amount can change. We examine this factor in unit of type. It is determined as categorical type with 2 levels: single/widow/divorced and married.

Table 5. 13. The factors of Life Insurance System

| | **Name** | **Units** | **Type** | **First category** | **Second Category** |
|---|---|---|---|---|---|
| **A** | Educational status | Type | Categoric | elementary/ high school education | university/ post grad/ doctor |
| **B** | Age | Year | Categoric | <=45 | >45 |
| **C** | Place | Part | Categoric | East | west |
| **D** | Gender | Type | Categoric | Man | woman |
| **E** | Currency of policy | Currency | Categoric | TL | foreign |
| **F** | Payment type | Month | Categoric | monthly installment | 3 month/ 6 month/ year installment |
| **G** | Marital status | Type | Categoric | single/widow /divorced | Married. |

We used factorial design which to find main factors and make improvements. Moreover, getting information about two factor interactions is useful for us to make comments about the result. We have 7 factors and we wanted do less experiments in this study. Therefore, we used fractional factorial design and we choose $2^{7-2}$ type of 2-

Level factorial Design. In determining number of replicates, we decide how many times each design point should be run. The default is one replicate, which means each design point will be run once. In this experiment, we decided to use 3 replicates. In our experiment we don't determine any factor that we want to block its effect. Therefore, we use the number of block as 1 which means "no blocking. " Finally we get totally 96 runs to complete the total premium response with customer data. To fill these response areas, we need a set of customer data of company, so we made another study to get these data. First of all, we used customer database for query. Our query contains, top 20. 000 customers who has a non-cancelled life insurance product with highest premium amount and longest renewal duration. After we got these data, we filled the response areas. However, customer data is not enough to fill all cases in the experiment. 91 rows were filled, in total of 96 rows that means 94,79% percent of response is filled.

Table 5. 14. Data Life Insurance System in design layout view

| Std | Run | Block | Factor 1 A:Educational type | Factor 2 B:Age year | Factor 3 C:place part | Factor 4 D:Gender type | Factor 5 E:Currency of currency | Factor 6 F:Payment type month | Factor 7 G:Marital status type | Response 1 Total premium TL |
|---|---|---|---|---|---|---|---|---|---|---|
| 44 | 1 | Block 1 | elementary/ hi | >45 | west | woman | TL | monthly installr | Married | |
| 93 | 2 | Block 1 | elementary/ hi | >45 | west | woman | foreign | monthly installr | single/widow/c | |
| 32 | 3 | Block 1 | elementary/ hi | >45 | East | woman | TL | 3 month/ 6 mor | single/widow/c | |
| 42 | 4 | Block 1 | university/ pos | <=45 | west | woman | TL | monthly installr | Married | |
| 84 | 5 | Block 1 | university/ pos | >45 | East | woman | foreign | monthly installr | single/widow/c | |
| 49 | 6 | Block 1 | elementary/ hi | <=45 | East | Man | foreign | 3 month/ 6 mor | single/widow/c | |
| 65 | 7 | Block 1 | university/ pos | <=45 | west | Man | foreign | 3 month/ 6 mor | single/widow/c | |
| 22 | 8 | Block 1 | university/ pos | >45 | west | Man | TL | monthly installr | single/widow/c | |
| 36 | 9 | Block 1 | university/ pos | >45 | East | woman | TL | monthly installr | Married | |
| 8 | 10 | Block 1 | elementary/ hi | >45 | East | Man | TL | monthly installr | single/widow/c | |
| 91 | 11 | Block 1 | elementary/ hi | >45 | west | woman | foreign | monthly installr | single/widow/c | |
| 37 | 12 | Block 1 | elementary/ hi | <=45 | west | woman | TL | 3 month/ 6 mor | single/widow/c | |
| 20 | 13 | Block 1 | elementary/ hi | >45 | west | Man | TL | 3 month/ 6 mor | Married | |
| 12 | 14 | Block 1 | university/ pos | >45 | East | Man | TL | 3 month/ 6 mor | Married | |
| 23 | 15 | Block 1 | university/ pos | >45 | west | Man | TL | monthly installr | single/widow/c | |
| 34 | 16 | Block 1 | university/ pos | >45 | East | woman | TL | monthly installr | Married | |
| 16 | 17 | Block 1 | university/ pos | <=45 | west | Man | TL | 3 month/ 6 mor | Married | |
| 90 | 18 | Block 1 | university/ pos | <=45 | west | woman | foreign | monthly installr | single/widow/c | |
| 82 | 19 | Block 1 | university/ pos | >45 | East | woman | foreign | monthly installr | single/widow/c | |
| 80 | 20 | Block 1 | elementary/ hi | >45 | East | woman | foreign | 3 month/ 6 mor | Married | |
| 29 | 21 | Block 1 | university/ pos | <=45 | East | woman | TL | 3 month/ 6 mor | single/widow/c | |
| 96 | 22 | Block 1 | university/ pos | >45 | west | woman | foreign | 3 month/ 6 mor | Married | |

In Analysis Process, after we entered our response data in the Design Layout view, we will examine total premium amount response.

A transformation is needed to meet the assumptions to make the Anova valid. Box Cox plot suggests us to log lambda transform which is natural log transformation. Therefore, the transformation of the total premium amount response is natural log transformation. The lowest point on the Box Cox plot represents the value of lambda that results in the minimum residual sum of squares in the transformed model, which is -0,02. In our model we select lambda as zero.

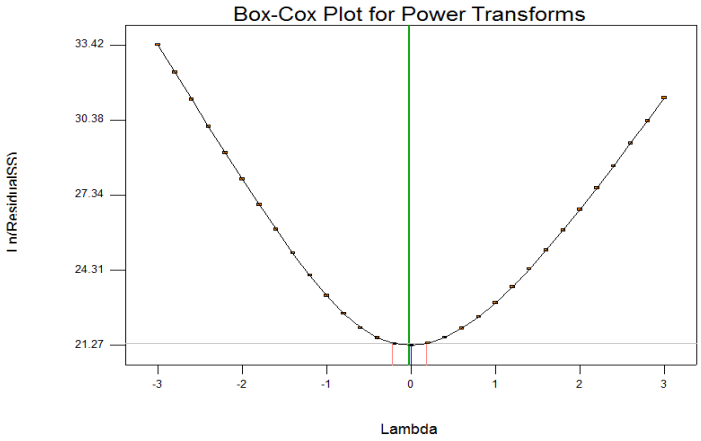



Figure 5. 25 Box-Cox for Power Transforms of Life Insurance System

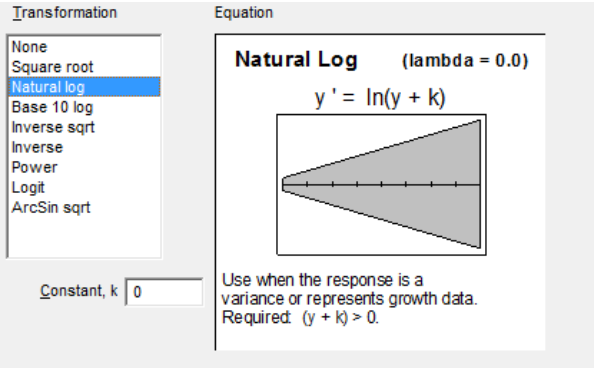



Figure 5. 26. Transformation equation of Life Insurance System

Selecting effects is the next step, after transformation is determined. In order to analyze factorial design, the significant factor effects must be identified and separated from the insignificant effects. We use normal and half-normal probability plot to choose significant effects for 2-level factorial designs. The outlier points are selected as effects.

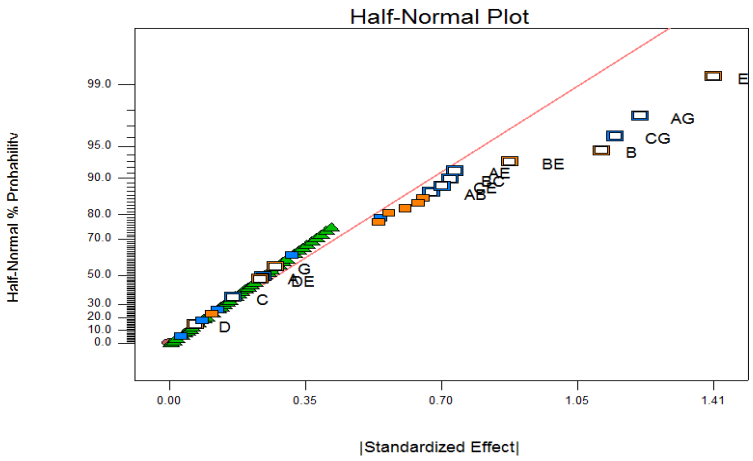



Figure 5. 27. Half Normal Plot of total premium in Life Insurance System

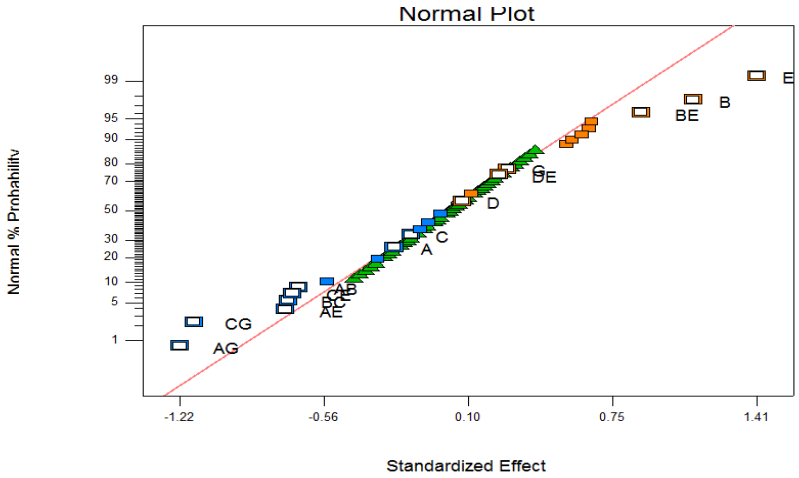



Figure 5. 28. Normal Plot of total premium in Life Insurance System

Also, The Pareto chart helps us to find significant effects. We selected the terms that are above the T-value limit which are possibly significant.

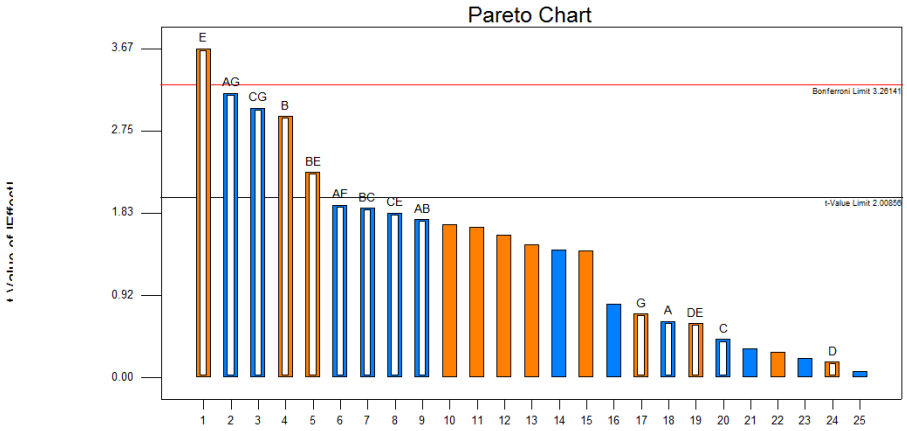



Figure 5. 29. Pareto Chart of total premium in Life Insurance System

In this study, these terms are selected as main effect: A, B, C, D, E, G, AB, AE, AG, BC, BE, CE, CG and DE. In Pareto chart, E, AG, CG, B, BE, AE, BC, CE and AB are higher than the t value limit, so they are selected as main effects. Also, main effects of interaction effects are selected, such as A, G, C are selected as main effects. Moreover, DE and D are selected as main effects. Contribution of main effects can be seen from effects lists.

| Term | Stdized Effects | Sum of Squares | % Contribution |
|---|---|---|---|
| Intercept | | | |
| A-ogrenim | -0.24 | 0.46 | 0.36 |
| B-yas | 1.12 | 9.80 | 7.61 |
| C-satilan yer | -0.16 | 0.21 | 0.16 |
| D-cinsiyet | 0.067 | 0.036 | 0.028 |
| E-para birimi | 1.41 | 15.54 | 12.06 |
| F-odeme sekli | -0.55 | 0.69 | 0.54 |
| G-medeni durum | 0.27 | 0.59 | 0.46 |
| AB | -0.68 | 3.60 | 2.80 |
| AC | 0.66 | 1.27 | 0.99 |
| AD | -0.12 | 0.27 | 0.21 |
| AE | -0.74 | 4.28 | 3.32 |
| AF | -0.030 | 0.49 | 0.38 |
| AG | -1.22 | 11.63 | 9.02 |
| BC | -0.73 | 4.13 | 3.21 |
| BD | 0.64 | 1.98 | 1.53 |
| BE | 0.88 | 6.08 | 4.71 |
| BF | 0.34 | 4.11 | 3.24 |
| BG | 0.57 | 5.02 | 3.90 |
| CD | -0.32 | 0.25 | 0.19 |
| CE | -0.70 | 3.90 | 3.03 |
| CF | -0.085 | 0.19 | 0.15 |
| CG | -1.15 | 10.44 | 8.10 |
| DE | 0.23 | 0.43 | 0.33 |
| DF | | Aliased | |
| DG | | Aliased | |
| EF | | Aliased | |
| EG | | Aliased | |
| FG | | Aliased | |
| ABC | | Aliased | |
| ABD | | Aliased | |
| ABE | | Aliased | |

Figure 5. 30. Main effects of total premium in Life Insurance System

After we selected main effects, Analysis of variance is studied.

Table 5. 15. ANOVA for total premium in Life Insurance System

| ANOVA for selected factorial model | | | | | | |
|---|---|---|---|---|---|---|
| **Source** | **Sum of Squares** | **Df** | **Mean Square** | **F Value** | **p-value Prob > F** | |
| Model | 31,5309317 | 14 | 2,25220941 | 1,95 | 0. 0428 | significant |
| A- Educational status | 0,46019513 | 1 | 0,46019513 | 0,4 | 0. 5307 | |
| B- Age | 9,80076809 | 1 | 9,80076809 | 8,49 | 0. 0053 | |
| C- Place | 0,21232939 | 1 | 0,21232939 | 0,18 | 0. 6699 | |
| D- Gender | 0,03576336 | 1 | 0,03576336 | 0,03 | 0. 8610 | |
| E- Currency of contract | 15,543336 | 1 | 15,543336 | 13,5 | 0. 0006 | |
| G- Marital status | 0,58957495 | 1 | 0,58957495 | 0,51 | 0. 4782 | |
| AB | 3,60176674 | 1 | 3,60176674 | 3,12 | 0. 0835 | |
| AE | 4,27946348 | 1 | 4,27946348 | 3,71 | 0. 0599 | |
| AG | 11,6257888 | 1 | 11,6257888 | 10,1 | 0. 0026 | |
| BC | 4,13121808 | 1 | 4,13121808 | 3,58 | 0. 0643 | |
| BE | 6,07504058 | 1 | 6,07504058 | 5,26 | 0. 0260 | |
| CE | 3,90127524 | 1 | 3,90127524 | 3,38 | 0. 0720 | |
| CG | 10,4431899 | 1 | 10,4431899 | 9,05 | 0. 0041 | |
| DE | 0,4292916 | 1 | 0,4292916 | 0,37 | 0. 5448 | |
| Residual | 57,7286682 | 50 | 1,15457336 | | | |
| Lack of Fit | 18,532264 | 11 | 1,68475127 | 1,68 | 0. 1157 | not significant |
| Pure Error | 39,1964041 | 39 | 1,005036 | | | |
| Cor Total | 89,2595999 | 64 | | | | |

The F value is 1,95 , so the model is significant. Prob>F value is less than 0,05 indicate model terms are significant. In this case, B, E, AG, BE, CG are significant model terms.

The Lack of Fit value of 1,68 means that The Lack of Fit is not significant relative to the pure error.

After Anova, prediction equations are determined.

Table 5. 16. Prediction Equations for total premium in Life Insurance System

| ANOVA and Prediction Equations | | | |
|---|---|---|---|
| **Factor** | **Coefficient Estimate** | **Df** | **Standard Error** |
| Intercept | 9,255335 | 1 | 0,230628 |
| A- Educational status | -0,121 | 1 | 0,191652 |
| B- Age | 0,670116 | 1 | 0,230002 |
| C- Place | -0,08224 | 1 | 0,19177 |
| D- Gender | 0,028375 | 1 | 0,161221 |
| E- Currency of contract | 0,846684 | 1 | 0,23076 |
| G- Marital status | 0,105229 | 1 | 0,147257 |
| AB | -0,33871 | 1 | 0,19177 |
| AE | -0,36897 | 1 | 0,191652 |
| AG | -0,60815 | 1 | 0,191652 |
| BC | -0,36253 | 1 | 0,191652 |
| BE | 0,530005 | 1 | 0,231056 |
| CE | -0,35251 | 1 | 0,19177 |
| CG | -0,57675 | 1 | 0,19177 |
| DE | 0,097384 | 1 | 0,159707 |

Anova formula of total premium in life insurance system:

$$Ln(total\ premium\ amount) = 9{,}255334501 \quad (5.\ 3)$$

$$-0{,}12099649 * \mathrm{A}$$

$$+0{,}670116244 * \mathrm{B}$$

$$-0{,}08223865 * \mathrm{C}$$

$$+0{,}028374651 * \mathrm{D}$$

$$+0{,}846683609 * \mathrm{E}$$

$$+0{,}105228992 * \mathrm{G}$$

$$-0{,}33871055 * \mathrm{AE}$$

$$-0{,}60815319 * \mathrm{AG}$$

$$-0{,}3625274 * \mathrm{BC}$$

$$+0{,}530005321 * \mathrm{BE}$$

$$-0{,}35251226 * \mathrm{CE}$$

$$-0{,}57674989 * \mathrm{CG}$$

$$+0{,}097384433 * \mathrm{DE}$$

In this case, we interpret the significant factors: B, E, AG, BE, CG how they may affect the total premium amount in life insurance system.

B- Age of customer: In the ANOVA formula, factor has a positive regression coefficient for the total premium amount in life insurance system. For factor B, first category is, age of customer <=45 and second category is age of customer >45. That means, customer whose age is more than 45, pays more premium amount than the others. The reason of that should be increasing death risk in older ages according to the mortality table. When the possibility of getting death compensation increases, the company charges the insurer with high amount of premium.

E- Currency of contract: In the ANOVA formula, factor has a positive regression coefficient for the total premium amount in life insurance system. For factor E, first category is TL and second category is foreign currency. That means, a customer, who pays his premiums in foreign currency, such as euro and dollar; the total amount of premium may be higher. That means, because of foreign currency increment, the customer may pay more premium than the others.

Also, there are significant interaction effects:

AG: AG is the interaction effect of Educational status and marital status of a customer. AG has negative regression coefficient for the total premium amount in life insurance system. That means, the customer who is married and educated from elementary/ high school, he may pay lower total premium than the others in life insurance system.

BE: BE is the interaction effect of Age of customer and Currency of contract. BE has positive regression coefficient for the total premium amount in life insurance system. That means the customer whose age more than 45 and pays his contribution in foreign currency, may pay more total premium in life insurance system.

CG: CG is the interaction effect of Place; policy is sold and marital status of a customer. CG has negative regression coefficient for the total premium amount in life insurance

system. That means, if life insurance policy is sold in east of Turkey and the marital status of insurer is married, than he may pay more total premium in life insurance system.

There are some models of diagnostic plots:

Normal Probability Plot: The normal probability plot shows that whether the residuals follow a normal distribution, in which case the points will follow a straight line. For total premium amount, we can see that, residuals follow a straight line that means residuals follow a normal distribution.

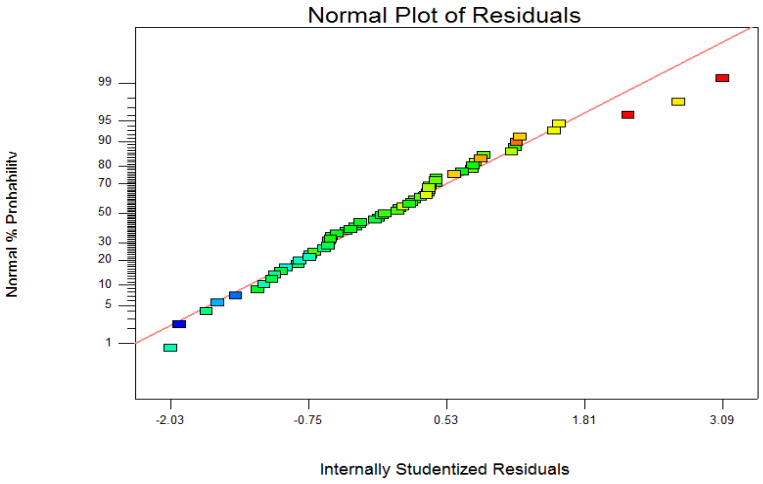



Figure 5. 31. Normal Plot Residuals of total premium in Life Insurance System

Residuals vs. predicted plot: It tests the assumption of constant variance. The plot should be in a random scatter. (Constant range of residuals across the graph. ) For duration of stay the graph shows us, variance is constant.

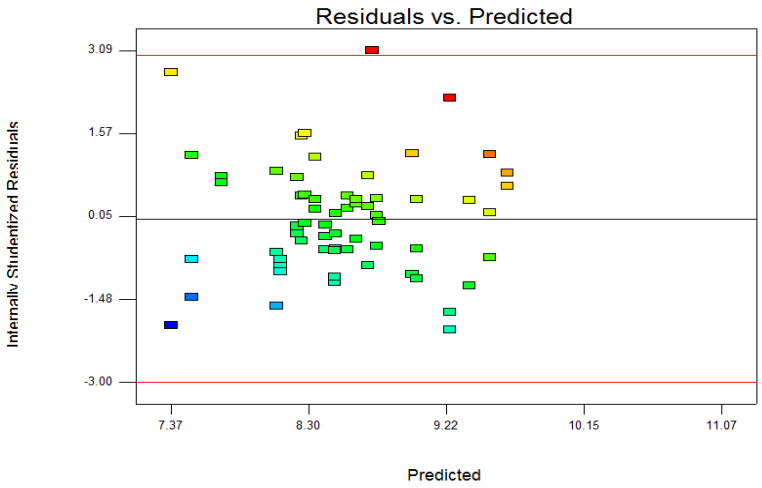



Figure 5. 32. Residuals vs. predicted plot of total premium in Life Insurance System

Residuals vs. Run plot: This is a plot of the residuals versus the experimental run order. It checks for hidden variables that may have influenced the response during the experiment. The plot should show a random scatter.

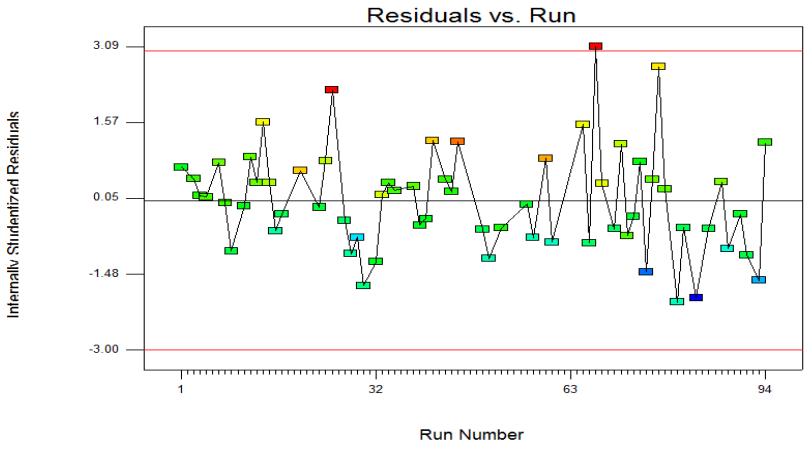



Figure 5. 33. Residuals vs. Run plot of total premium in Life Insurance System

Residuals vs. Factors: This is a plot of the residuals versus any factor that we choose. It checks whether the variance not accounted for by the model is different for different levels of a factor. If all is okay, the plot should exhibit a random scatter. For instance, the figure below is the Residuals vs. Gender of Customer Graph.

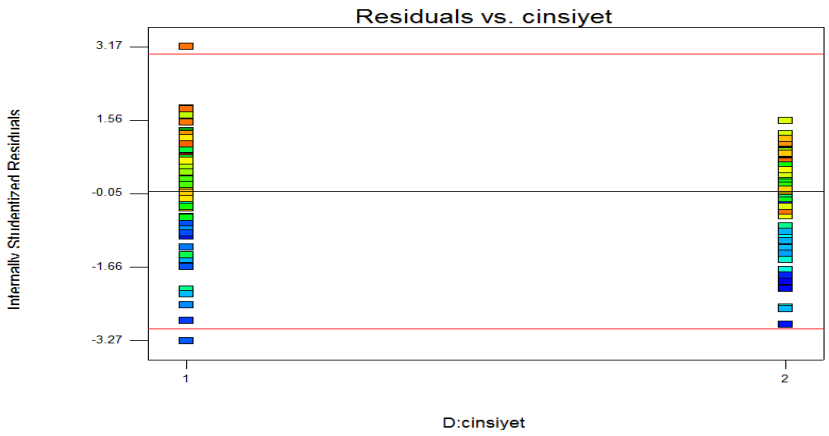



Figure 5. 34. Residuals vs. factor plot of total premium in Life Insurance System

After we analyzed response of total premium amount, optimization of response is done. We evaluate optimization part with numerical optimization. We choose the desired goal for each factor and response. The possible goals can be: maximize, minimize, and none for factors. A minimum and a maximum level must be provided for each parameter included in the optimization.

The "importance" of the goal can be changed according to the other goals. The default setting is 3 pluses.

In our study, we use transformed scale of the response and factors in numerical optimization part. We review the goal of the study again for determining either maximization or minimization of the response. We assume that best life insurance customer is as follows;

- The customer who pays the highest amount of premium in all renewal duration is the best customer in life insurance system.

In determining goal phase, for total premium amount response, the goal is to maximize this value, so we choose maximize. The importance level is default 3 pluses for all factors and response.

For total premium amount:

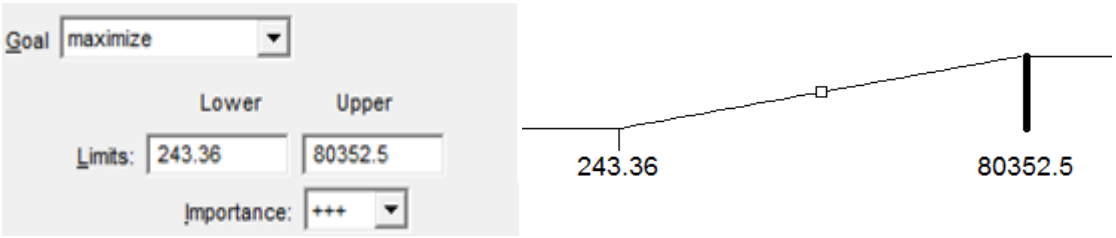



Figure 5. 35. . Numerical Optimization criteria of total premium amount in Life Insurance System

The constraints are determined for all factors and responses as the table below.

Table 5. 17. Constraints of Responses and Factors in Life Insurance System

| Constraints | | | |
|---|---|---|---|
| **Name** | **Goal** | **First Category** | **Second Category** |
| Educational status | is in range | elementary/ high school education | university/ post grad/ doctor |
| Age | is in range | <=45 | >45 |
| Place | is in range | East | west |
| Gender | is in range | Man | woman |
| Currency of contract | is in range | TL | foreign |
| Payment type | is in range | monthly installment | 3 month/ 6 month/ year installment |
| Marital status | is in range | single/widow/divorced | Married. |
| Total premium | maximize | 243,36 | 80352,51 |

After numerical optimization is done, the first 100 customer types are examined. We select and reveal first 10 customer types as an example, but totally we get 100 customers in the solution list. There is table below that shows first 10 customer types that is solution of the numerical optimization. If we make comments about being best customer in private pension system, according to first 10 rows, we can say that;

- Educational status of customer should be elementary/high school education, because in 8 of 10 rows, the education status of customer is elementary/high school education. That means, the customers with low educational status, may need life insurance policies more than the others; also their policies have high renewal duration and high premium amount. They may need life insurance policy, because their work conditions may have high accident risks. We can say that, while selling a life insurance product, educational status of customer should be noticed.
- Age of customer should be more than 45, because the age of all 10 customers is more than 45. The means, there is high risk of death in older ages according to mortality table, so company improves a strategy to protect itself from great number of compensations and they charge more premium amount from customers whose ages are more than the average.
- Place of where policy is sold should be east, because 7 of 10 polices are sold in east. We can say that, while selling a life insurance product, the place of customer should be noticed.
- Currency of contract should be foreign, because all of the 10 customers have foreign currency products. That means products with foreign currency make company to earn more premium amounts, because of increment in foreign currency, so customers actually pay more premiums in TL as the time passes.
- Marital status of customer should be single/widow/divorced. Because 8 of the 10 customers marital status is single/widow/divorced. We can say that, while selling a life insurance, marital status of customer should be noticed.

Table 5. 18. The first 10 customers that is solution of the numerical optimization in Life Insurance System

| No | Edu. status | Age | Place | Gender | Currency of contract | Payment type | Marital status | Total amount of premium | Desirability |
|---|---|---|---|---|---|---|---|---|---|
| 1 | elementary/high school education | >45 | East | Man | foreign | monthly installment | single/widow/divorced | 99928,3 | 1 |
| 2 | elementary/high school education | >45 | East | Woman | foreign | monthly installment | single/widow/divorced | 128505 | 1 |
| 3 | university/ post grad/ doctor | >45 | East | Woman | foreign | monthly installment | single/widow/divorced | 82674,8 | 1 |
| 4 | elementary/high school education | >45 | West | Woman | foreign | monthly installment | single/widow/divorced | 82674,8 | 1 |
| 5 | elementary/high school education | >45 | East | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 99928,3 | 1 |
| 6 | elementary/high school education | >45 | East | Woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 128505 | 1 |
| 7 | university/ post grad/ doctor | >45 | East | Woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 82674,8 | 1 |
| 8 | elementary/high school education | >45 | West | Woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 82674,8 | 1 |
| 9 | elementary/high school education | >45 | East | Man | foreign | monthly installment | Married. | 1319116 | 1 |
| 10 | elementary/high school education | >45 | West | Man | foreign | monthly installment | Married. | 84492,3 | 1 |

The numerical optimization finds a point that maximizes the desirability function. Desirability is an objective function that ranges from zero outside of the limits to one at the goal. In our case, desirability is 1,00.

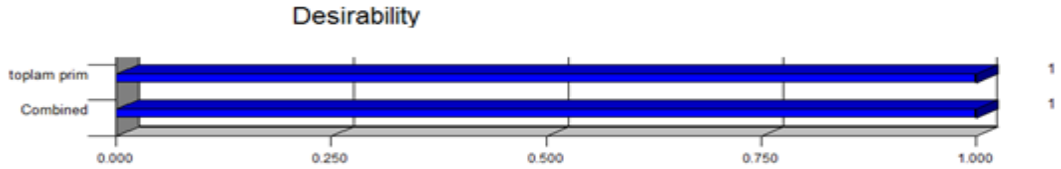



Figure 5. 36. Desirability of Life Insurance System

## 5.2. EXAMINING CUSTOMER DATA

After Design of Experiment method is applied, we find the best customer types according to results. As a result of DOE, 100 customer types are listed in solution list. Customer types are diversified by factors, such as age of customer, currency of the payment etc. While examining these 100 customer types, all of them cannot be examined in the best customer group, because that number of customer types is too much to place them in one group. Our aim is to determine fewer customer types to call and offer cross selling. Otherwise, call center employees won't be enough to call all these types of customers. Therefore, we decided to divide customer types into 3 parts in terms of profitability: good customer group, moderate customer group and bad customer group.

In determining customer groups, with the marketing department of the company's confirmation, we select the first 20 customer types as good customer, medium 50 customer types as moderate customer and last 30 customer types are as bad customers. After we divided the customer types in 3 parts, we can determine the group of whole customers in the system. Therefore, we use a scoring system that we can determine threshold values for each group and we can determine the group of all customers in the system.

In scoring phase, we calculated the score of all 100 customer types for pension system and life insurance system. The first customers in the list supposed to have highest point and the customers at the end of the list supposed to have the least point. We examined the pension system and life insurance system separately in calculation of scores phase.

In private pension system, we calculated the score of customers in two steps; first is for duration of stay and second is for pension savings. We start with duration of stay in pension system. We use the 100 customer types list, and study the factors and their coded factors. Coding reduces the range of each factor to a common scale, in generally -1 and +1, regardless of the relative magnitude. Also, it may be easier to think in terms of changes from low to high for the factors. For example, in our case study, age of the

customer may vary from 0-45 and 45-100, and the other factor is the gender of the customer which can be man or woman. Typical coding has -1 as the lower level of factor, +1 as the upper level of the factor.

Table 5. 19. 2-level Nominal and Ordinal Categoric Factors

| 2-level Nominal and Ordinal Categoric Factors | |
|---|---|
| | [A] |
| Level 1 | -1 |
| Level 2 | 1 |

In our study we use coded variables as the value of factors in Anova equation. At first the coded factors are used in Anova equation of duration of system. In private pension system, the coded factors are in the table below;

Table 5. 20. The coded factors in Private Pension System

| | **Name** | **Coded factor -1** | **Coded factor +1** |
|---|---|---|---|
| **A** | Contribution payment | <=100 | >100 |
| **B** | Age | <=45 | >45 |
| **C** | Place | East | West |
| **D** | Gender | Man | Woman |
| **E** | Currency of contract | TL | Foreign |
| **F** | Payment type | monthly installment | 3 month/ 6 month/ year installment |
| **G** | Marital status | single/widow/divorced | Married. |
| **H** | Educational status | elementary/high school education | university/ post grad/ doctor |

As an example, for the first 10 customers in solution list, the coded values are determined, and then coded values are used as factors in Anova formula of duration of stay.

$$(duration\ of\ stay)^{1.86} = \quad (5.\ 4)$$

$$1543831{,}35$$
$$-233470{,}813 * \mathrm{A}$$
$$+26934{,}2529 * \mathrm{B}$$
$$+180841{,}524 * \mathrm{C}$$
$$+480304{,}978 * \mathrm{E}$$
$$-162553{,}899 * \mathrm{F}$$
$$+103606{,}539 * \mathrm{G}$$
$$+124571{,}967 * \mathrm{AC}$$
$$+63735{,}3829 * \mathrm{AE}$$
$$-5488{,}29962 * \mathrm{AF}$$
$$+14581{,}1587 * \mathrm{AG}$$
$$+13489{,}052 * \mathrm{BE}$$
$$+196042{,}443 * \mathrm{BG}$$
$$-38721{,}5417 * \mathrm{CE}$$
$$+3780{,}13141 * \mathrm{CF}$$
$$-95968{,}4981 * \mathrm{EF}$$
$$+24215{,}8294 * \mathrm{EG}$$

Table 5. 21. The first 10 customers in solution list of duration of stay in Private Pension System

| Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A-Contribution payment | >100 | >100 | <=100 | <=100 | >100 | <=100 | <=100 | >100 | <=100 | <=100 |
| B-Age | >45 | >45 | >45 | >45 | <=45 | >45 | >45 | >45 | >45 | <=45 |
| C-Place | west | west | west | west | west | East | East | west | west | west |
| D-Gender | woman | woman | Man | Man | woman | Man | Man | woman | woman | Man |
| E-Currency of contract | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign |
| F-Payment type | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment |
| G-Marital status | Married. | single/widow/divorced | single/widow/divorced | Married. | single/widow/divorced | single/widow/divorced | Married. | Married. | single/widow/divorced | single/widow/divorced |
| H-Educational status | elementary/high school education | university/post grad/doctor | university/post grad/doctor | elementary/high school education | university/post grad/doctor | university/post grad/doctor | elementary/high school education | university/post grad/doctor | university/post grad/doctor | university/post grad/doctor |
| * A | 1 | 1 | -1 | -1 | 1 | -1 | -1 | 1 | -1 | -1 |
| * B | 1 | 1 | 1 | 1 | -1 | 1 | 1 | 1 | 1 | -1 |
| * C | 1 | 1 | 1 | 1 | 1 | -1 | -1 | 1 | 1 | 1 |
| * E | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * F | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| * G | 1 | -1 | -1 | 1 | -1 | -1 | 1 | 1 | -1 | -1 |
| * A * C | 1 | 1 | -1 | -1 | 1 | 1 | 1 | 1 | -1 | -1 |
| * A * E | 1 | 1 | -1 | -1 | 1 | -1 | -1 | 1 | -1 | -1 |
| * A * F | -1 | -1 | 1 | 1 | -1 | 1 | 1 | -1 | 1 | 1 |
| * A * G | 1 | -1 | 1 | -1 | -1 | 1 | -1 | 1 | 1 | 1 |
| * B * E | 1 | 1 | 1 | 1 | -1 | 1 | 1 | 1 | 1 | -1 |
| * B * G | 1 | -1 | -1 | 1 | 1 | -1 | 1 | 1 | -1 | 1 |
| * C * E | 1 | 1 | 1 | 1 | 1 | -1 | -1 | 1 | 1 | 1 |
| * C * F | -1 | -1 | -1 | -1 | -1 | 1 | 1 | -1 | -1 | -1 |
| * E * F | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| * E * G | 1 | -1 | -1 | 1 | -1 | -1 | 1 | 1 | -1 | -1 |
| score | 2760192,69 | 2083300,75 | 2191813,39 | 2810380,7 | 2394539,03 | 2164277,63 | 2782844,93 | 2760192,69 | 2191813,39 | 2503051,67 |
| normalized score | 48,5 | 26,5 | 30 | 50 | 36,5 | 29 | 49 | 48,5 | 30 | 40 |

As a result, the scores of 100 customer types are calculated. The results are normalized, according to the minimum and maximum scores in the list. There are two responses for private pension system, so we add up of the scores that come from each response.

Therefore, in normalization of the scores, they are calculated in a range between 0-50. After the scores are calculated for duration of stay response, the same procedure is followed for the second response, pension savings.

Anova formula of pension savings:

$$1{,}0/(pension\ savings) = \tag{5. 5}$$
$$+9{,}62637\mathrm{E}-05$$
$$-7{,}51055\mathrm{E}-06*\mathrm{A}$$
$$+1{,}73101\mathrm{E}-07*\mathrm{B}$$
$$+4{,}91295\mathrm{E}-06*\mathrm{D}$$
$$-1{,}79129\mathrm{E}-06*\mathrm{E}$$
$$-4{,}37315\mathrm{E}-06*\mathrm{F}$$
$$-1{,}17486\mathrm{E}-06*\mathrm{G}$$
$$+3{,}13388\mathrm{E}-06*\mathrm{H}$$
$$+7{,}61497\mathrm{E}-06*\mathrm{AD}$$
$$+6{,}92832\mathrm{E}-06*\mathrm{AE}$$
$$+8{,}77407\mathrm{E}-06*\mathrm{BE}$$
$$+6{,}77741\mathrm{E}-06*\mathrm{FG}$$
$$-7{,}79177\mathrm{E}-06*\mathrm{GH}$$

Table 5. 22. The first 10 customers in solution list of pension saving in Private Pension System

| Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| A-Contribution payment | >100 | >100 | <=100 | <=100 | >100 | <=100 | <=100 | >100 | <=100 | <=100 |
| B-Age | >45 | >45 | >45 | >45 | <=45 | >45 | >45 | >45 | >45 | <=45 |
| C-Place | west | west | west | west | west | East | East | west | west | west |
| D-Gender | woman | woman | Man | Man | woman | Man | Man | woman | woman | Man |
| E-Currency of contract | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign |
| F-Payment type | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment | monthly installment |
| G-Marital status | Married. | single/widow/ divorced | single/widow/ divorced | Married. | single/widow/d ivorced | single/widow/ divorced | Married. | Married. | single/widow/ divorced | single/widow/ divorced |
| H-Educational status | elementary/ high school education | university/ post grad/ doctor | university/ post grad/ doctor | elementary/ high school education | university/ post grad/ doctor | university/ post grad/ doctor | elementary/ high school education | university/ post grad/ doctor | university/ post grad/ doctor | university/ post grad/ doctor |
| * A | 1 | 1 | -1 | -1 | 1 | -1 | -1 | 1 | -1 | -1 |
| * B | 1 | 1 | 1 | 1 | -1 | 1 | 1 | 1 | 1 | -1 |
| * D | 1 | 1 | -1 | -1 | 1 | -1 | -1 | 1 | 1 | -1 |
| * E | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * F | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 |
| * G | 1 | -1 | -1 | 1 | -1 | -1 | 1 | 1 | -1 | -1 |
| * H | -1 | 1 | 1 | -1 | 1 | 1 | -1 | 1 | 1 | 1 |
| * A * D | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | -1 | 1 |
| * A * E | 1 | 1 | -1 | -1 | 1 | -1 | -1 | 1 | -1 | -1 |
| * B * E | 1 | 1 | 1 | 1 | -1 | 1 | 1 | 1 | 1 | -1 |
| * F * G | -1 | 1 | 1 | -1 | 1 | 1 | -1 | -1 | 1 | 1 |
| * G * H | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 1 | -1 | -1 |
| score | 0,0001164 | 0,000138616 | 0,000129955 | 0,0001078 | 0,000120722 | 0,000129955 | 0,0001078 | 0,0001071 | 0,000124551 | 0,000112061 |
| normalized score | 27 | 43,5 | 37 | 20,5 | 30 | 37 | 20,5 | 20 | 33 | 23,5 |

After all, in design expert the importance was selected 3 pluses for duration stay and 4 pluses for pension saving in pension system. That means we should focus on this relationship while adding up the scores of these two responses. Therefore, we multiplied the scores of two responses with a percentage which makes the same effect

of pluses in design expert. At the below, there is total scores of first 10 customer in private pension system.

Table 5. 23. The scores of first 10 customers in solution list of Pension System

| No | Contribution payment | Age | Place | Gender | Currency of contract | Payment type | Marital status | Educational status | Total Score |
|---|---|---|---|---|---|---|---|---|---|
| 1 | >100 | >45 | west | woman | foreign | monthly installment | Married. | elementary/high school education | 75,5 |
| 2 | >100 | >45 | west | woman | foreign | monthly installment | single/widow/divorced | university/ post grad/ doctor | 70 |
| 3 | <=100 | >45 | west | Man | foreign | monthly installment | single/widow/divorced | university/ post grad/ doctor | 67 |
| 4 | <=100 | >45 | west | Man | foreign | monthly installment | Married. | elementary/high school education | 70,5 |
| 5 | >100 | <=45 | west | woman | foreign | monthly installment | single/widow/divorced | university/ post grad/ doctor | 66,5 |
| 6 | <=100 | >45 | East | Man | foreign | monthly installment | single/widow/divorced | university/ post grad/ doctor | 66 |
| 7 | <=100 | >45 | East | Man | foreign | monthly installment | Married. | elementary/high school education | 69,5 |
| 8 | >100 | >45 | west | woman | foreign | monthly installment | Married. | university/ post grad/ doctor | 68,5 |
| 9 | <=100 | >45 | west | woman | foreign | monthly installment | single/widow/divorced | university/ post grad/ doctor | 63 |
| 10 | <=100 | <=45 | west | Man | foreign | monthly installment | single/widow/divorced | university/ post grad/ doctor | 63,5 |

After we determined the total score for private pension customers, we divide them in to 3 groups in terms of profitability. The first 20 customer types are as good customer, medium 50 customer types are as moderate customer and last 30 customer types are as bad customers.

After we divided customer types in 3 parts, we determine threshold values for each group.

Table 5. 24. The groups and threshold values of groups in Private Pension System

| | |
|---|---|
| good customer threshold score | 62,3 |
| moderate customer threshold score | 43,56 |
| bad customer threshold score | 10,5 |

We followed the same procedure for life insurance customer types. We calculate the score for total premium response.

We use the 100 customer types list, and study the factors and their coded factors. At first the coded factors are used in Anova equation of total premium amount.

In private pension system, the coded factors are in the table below;

Table 5. 25. The coded factors in Life Insurance System

| | **Name** | **Coded factor -1** | **Coded factor +1** |
|---|---|---|---|
| **A** | Educational status | elementary/high school education | university/ post grad/ doctor |
| **B** | Age | <=45 | >45 |
| **C** | Place | East | west |
| **D** | Gender | Man | woman |
| **E** | Currency of contract | TL | foreign |
| **F** | Payment type | monthly installment | 3 month/ 6 month/ year installment |
| **G** | Marital status | single/widow/divorced | Married. |

As an example, for the first 10 customers in solution list, the coded values are used as factors in Anova formula of total premium amount.

Anova formula of total premium in life insurance system:

$$Ln(total\ premium\ amount) = 9{,}255334501 \quad (5.\ 6)$$
$$-0{,}12099649 * \mathrm{A}$$
$$+0{,}670116244 * \mathrm{B}$$
$$-0{,}08223865 * \mathrm{C}$$
$$+0{,}028374651 * \mathrm{D}$$
$$+0{,}846683609 * \mathrm{E}$$
$$+0{,}105228992 * \mathrm{G}$$
$$-0{,}33871055 * \mathrm{AE}$$
$$-0{,}60815319 * \mathrm{AG}$$
$$-0{,}3625274 * \mathrm{BC}$$
$$+0{,}530005321 * \mathrm{BE}$$
$$-0{,}35251226 * \mathrm{CE}$$
$$-0{,}57674989 * \mathrm{CG}$$
$$+0{,}097384433 * \mathrm{DE}$$

Table 5. 26. The first 10 customers in solution list of total premium in Life Insurance System

| Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Educational status | elementary high school education | elementary high school education | university/ post grad/ doctor | elementary high school education | elementary high school education | elementary high school education | university/ post grad/ doctor | elementary high school education | elementary high school education | elementary high school education |
| Age | >45 | >45 | >45 | >45 | >45 | >45 | >45 | >45 | >45 | >45 |
| Place | East | East | East | west | East | East | East | west | East | west |
| Gender | Man | woman | woman | woman | Man | woman | woman | woman | Man | " |
| Currency of contract | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign | foreign |
| Payment type | monthly installment | monthly installment | monthly installment | monthly installment | 3 month/ 6 month/ year installment | 3 month/ 6 month/ year installment | 3 month/ 6 month/ year installment | 3 month/ 6 month/ year installment | monthly installment | monthly installment |
| Marital status | single/widow /divorced | single/widow /divorced | single/widow/ divorced | single/widow /divorced | single/widow/ divorced | single/widow /divorced | single/widow/ divorced | single/widow /divorced | Married. | Married. |
| * A | -1 | -1 | 1 | -1 | -1 | -1 | 1 | -1 | -1 | -1 |
| * B | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * C | -1 | -1 | -1 | 1 | -1 | -1 | -1 | 1 | -1 | 1 |
| * D | -1 | 1 | 1 | 1 | -1 | 1 | 1 | 1 | -1 | -1 |
| * E | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * G | -1 | -1 | -1 | -1 | -1 | -1 | -1 | -1 | 1 | 1 |
| * A * B | -1 | -1 | 1 | -1 | -1 | -1 | 1 | -1 | -1 | -1 |
| * A * E | -1 | -1 | 1 | -1 | -1 | -1 | 1 | -1 | -1 | -1 |
| * A * G | 1 | 1 | -1 | 1 | 1 | 1 | -1 | 1 | -1 | -1 |
| * B * C | -1 | -1 | -1 | 1 | -1 | -1 | -1 | 1 | -1 | 1 |
| * B * E | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| * C * E | -1 | -1 | -1 | 1 | -1 | -1 | -1 | 1 | -1 | 1 |
| * C * G | 1 | 1 | 1 | -1 | 1 | 1 | 1 | -1 | -1 | 1 |
| * D * E | -1 | 1 | 1 | 1 | -1 | 1 | 1 | 1 | -1 | -1 |
| score | 11,51 | 11,76 | 11,32 | 11,32 | 11,51 | 11,76 | 11,32 | 11,32 | 14,09 | 11,34 |
| normalized score | 54 | 58 | 50 | 50 | 54 | 58 | 50 | 50 | 96 | 51 |

As a result, the scores of 100 customer types are found. The results are normalized, according to the minimum and maximum scores in the list. After we determined the total score of customer types for life insurance system, we divide them into 3 groups in terms of profitability. The first 20 customer types are as good customer, medium 50 customer types are as moderate customer and last 30 customer types are as bad

customers. After we divided the customer types in 3 parts, we determine threshold values for each group.

Table 5. 27. The groups and threshold values of groups in Life Insurance System

| | |
|---|---|
| good customer threshold score | 55,26 |
| moderate customer threshold score | 16,3 |
| bad customer threshold score | 0 |

We continue our study, after we determined the threshold values of customer groups. As a result, we know the properties of good customer and also we know how many points customer should have, to be a good customer. In terms of our aims, we need to know that a good customer in pension system, also a good customer in life insurance system as well. To apply cross selling technique, we need to know this relationship between pension system and life insurance system. If there is a positive correlation between pension system and life insurance system, we can say that good customer in pension system, also a good customer in life insurance system. Therefore call center can offer cross-selling.

First, we decided to examine particular customer data to find the relationship between two systems. This customer data consists, customers who have both non cancelled life insurance products and private pension products; and customer properties such as age, gender; and the properties of products such as currency of policy and contract. We use this data to calculate the scores of customer in pension and life insurance system separately. Scores provides us to put these customers into customer groups. Lastly, we make an estimation of correlation over these groups.

First we get the customer data, which includes both private pension product and life insurance product information from the company database. We get totally 510 customers and information about them. The data pattern that we get is enough to

calculate the scores of customers in both systems. We calculate the scores of customers and put them into groups, each customer is in two groups, one for pension system and one for life insurance system.

First we will examine this relationship over customers who are in pension system groups. There are totally 510 customers in pension system. 136 of them are in good customer group, 305 of them are in moderate customer group and 69 of them are in bad customer group. We examine each group separately and we reveal the percentages of life insurance groups of customers.

- For good customers in pension system, 78 of them are in good and 59 of them are in moderate customer group in life insurance system.

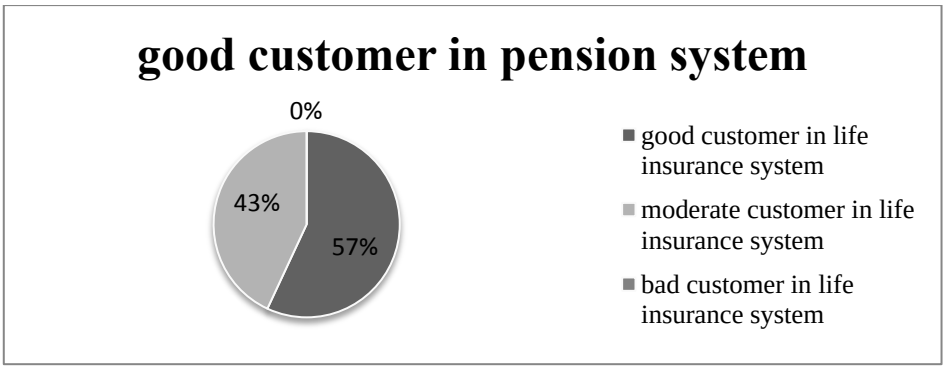



Figure 5. 37. Good customer in pension system

- For moderate customers in pension system, 48 of them are in good, 251 of them are in moderate and 6 of them are in bad customer group in life insurance system.

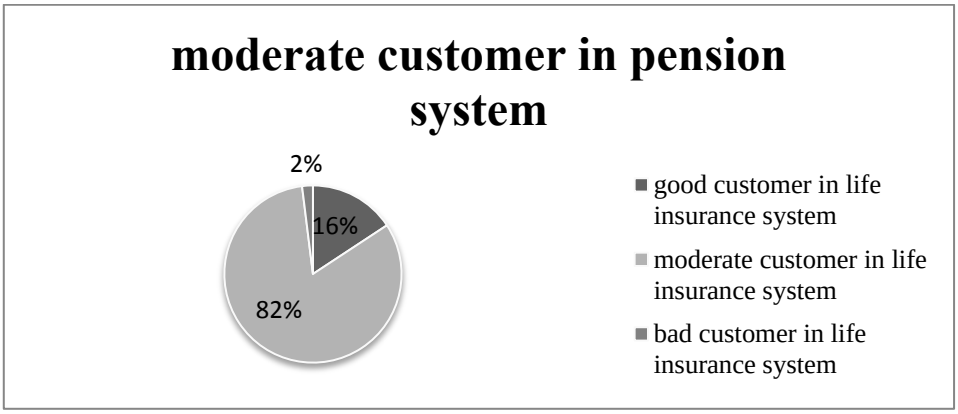



Figure 5. 38. Moderate customer in pension system

- For bad customers in pension system, 5 of them are in good, 64 of them are in moderate customer groups.

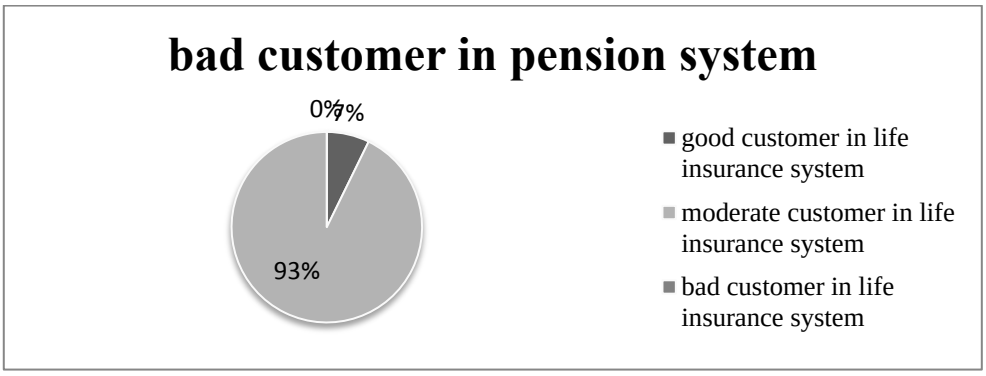



Figure 5. 39. Bad customer in pension system

In terms of life insurance customer groups, there are totally 510 customers in life insurance system. 131 of them are in good customer group, 373 of them are in moderate customer group, and 6 of them are in bad customer group.

- For good customers in life insurance system, 78 of them are n good, 48 of them are in moderate and 5 of them are in bad customer group in pension system.

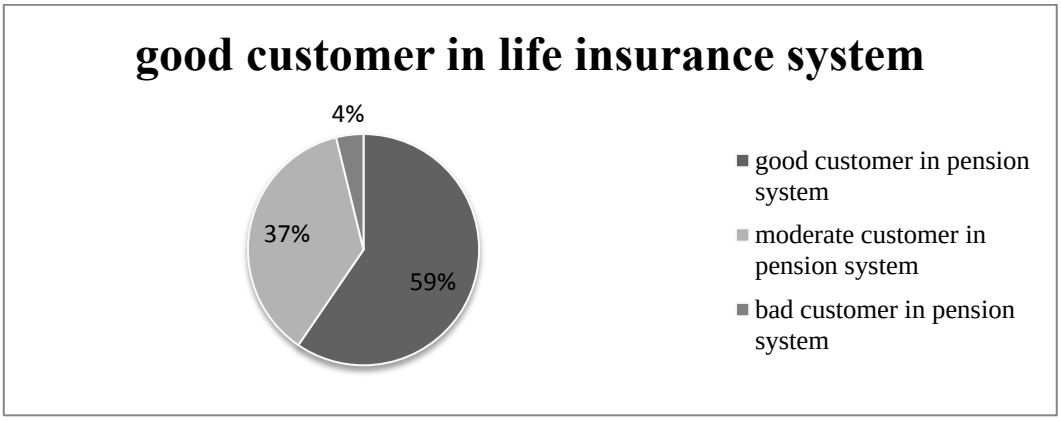



Figure 5. 40. Good customer in life insurance system

- For moderate customers in life insurance system, 58 of them are in good, 251 of them are in moderate and 64 of them are in bad customer group in pension system.

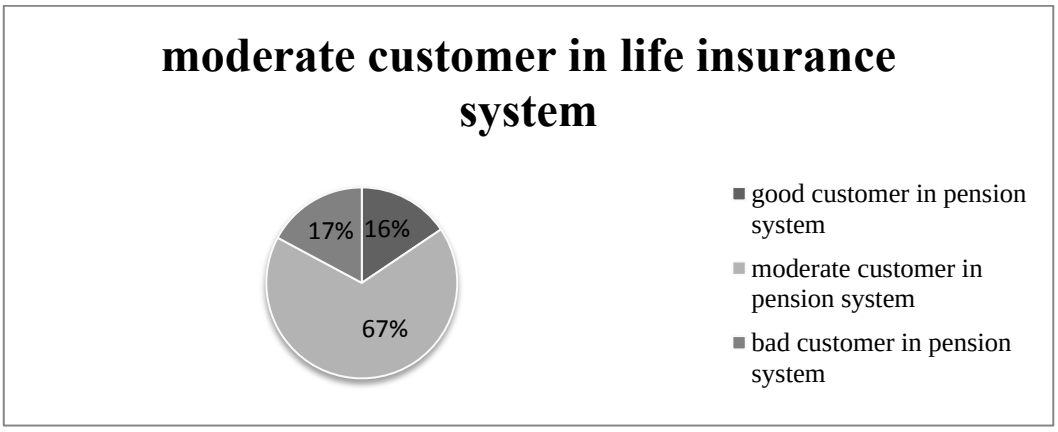



Figure 5. 41. Moderate customer in life insurance system

- For bad customers in life insurance system and 6 of them are in moderate customer group in pension system.

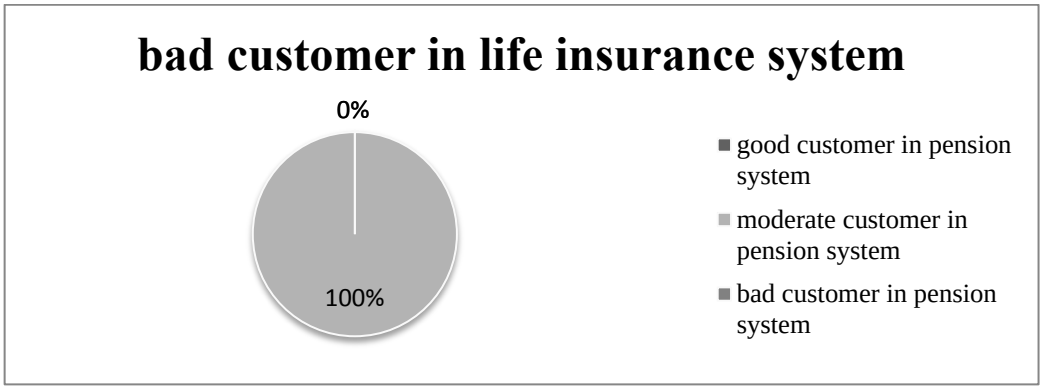



Figure 5. 42. Bad customer in life insurance system

According to figures above, we can make comments about cross selling strategies. For private pension system, it's seen that, a customer who is in the group of good customer can be in good customer group in life insurance system with high possibility. Also, a customer who is in moderate and bad customer groups in pension system can be moderate customer group in life insurance system. For life insurance system, a customer who is in the good customer group can be good customer in private pension system with high possibility. Also, a customer who is in moderate and bad customer groups in life insurance system can be moderate customer in pension system. Therefore, we can say that there is a positive relationship between private pension system and life insurance system. However, we also apply mathematical method to understand this relationship between two systems. For this method, we also use the percentages that we revealed above. In the next section, the method is described.

## 5.3. APPLICATION OF FUZZY EXPERT SYSTEMS

After we examined the customer data of the company, we divided customers into 3 groups in terms of profitability and we made some assumptions about cross selling strategies. However, assumptions may not be correct according to the group of customer, because all customers in one group may not respond the cross-selling strategy in the same way. For example, there are many people in good customer group in pension system, and we cannot say, cross selling strategy will be successful for all them.

Therefore, we won't evaluate cross selling strategies according to the groups of customer. We will evaluate cross selling strategies according to the degrees of membership of the customer groups by a method which is called fuzzy logic.

Zadeh (1965) indicates that Fuzzy logic is determined as a set of mathematical principles for knowledge representation based on degrees of membership rather than on crisp membership of classical binary logic. Fuzzy set can be defined as a set with fuzzy boundaries. After acquiring customer scores, we could produce fuzzy set of good, moderate and bad customers. A customer who is in good customer group with a particular degree of membership, at the same time, he could be also a member of the moderate customer group with another degree of membership. That means a customer has a partial membership in multiple sets. We will represent fuzzy sets of customers groups with fuzzy rules.

We apply fuzzy logic not only to evaluate customers according to their membership degrees but also to make a model that includes two distinct parts, evaluating the rule antecedent and applying the result to the consequent which is called fuzzy rules. It provides us to evaluate the status of the customer in the current system, and reveals the status of the customer in cross-selling system.

Fuzzy rules defined as conditional statement form.

IF x is A
THEN y is B

where x and y are linguistic variables; and A and B are linguistic values determined by fuzzy sets on the universe of X and Y. IF- THEN rules can be represented in fuzzy form. IF part is about evaluating the rule and THEN part is about applying the result. IF-THEN rules may have both multiple antecedent parts and multiple consequent parts. Mostly, fuzzy expert system incorporates several rules that show expert knowledge. The output of each rule is a set, but we want to a precise solution at the end. In our case study, we want to learn the score of the customer in cross selling system. Through

this score, company can determine the group of the customer and decide to apply cross selling.

In our study, we apply Mamdani-style inference to map from a given input to an output, using the theory of fuzzy sets. Mamdani-style inference is applied in four steps: Fuzzification of input variables, rule evaluation, aggregation of the rule outputs and finally defuzzification. Firstly, we form our IF-THEN rule.

After we examined customer data, we got some results about cross selling strategies based on the customer groups. For example, in previous section it is revealed that a customer who is in good customer group in pension system, he can be in good or moderate customer group in life insurance system, so cross selling decisions can be made up to these comments. In this case, we form if-then rules, by using those results.

Firstly, we form if-then rule model for current pension system customers. Input values are the customer groups in pension system and output values are the customer groups in life insurance system. We form totally 9 rules according to proposed weighted double-consequent fuzzy rules method in Alcalas study. Alcala et al. (2003) made an improvement in Linguistic Model is accomplished to make more flexible the learning and the model structure. This is one of the most interesting features of FRBSs and plays a key role in their high performance, being a consequence of the cooperative action of the linguistic rules existing in the fuzzy rule base. Two specific possibilities to relax the model are the following:

- Use of double-consequent fuzzy rules, which involves allowing the model to present rules where each combination of antecedents may have two consequents.
- Consideration of weighted fuzzy rules in which modifying the linguistic model structure an importance factor (weight) is considered for each rule.

We form those rules as we mentioned above:

Rule 1: If a customer is good in pension system
Then he is good in life insurance system

Rule 2: If a customer is good in pension system
Then he is moderate in life insurance system
Rule 3: If a customer is good in pension system
Then he is bad in life insurance system
Rule 4: If a customer is moderate in pension system
Then he is good in life insurance system
Rule 5: If a customer is moderate in pension system
Then he is moderate in life insurance system
Rule 6: If a customer is moderate in pension system
Then he is bad in life insurance system
Rule 4: If a customer is bad in pension system
Then he is good in life insurance system
Rule 5: If a customer is bad in pension system
Then he is moderate in life insurance system
Rule 6: If a customer is bad in pension system
Then he is bad in life insurance system

After if-then rules are completed then, we follow the Mamdani-style fuzzy inference process with fuzzification step. In fuzzification step, we take crisp inputs, and determine the degree of these inputs belong to each of fuzzy sets. Therefore, we use the scores in private pension systems to determine the membership values of crisp values. While drawing the chart, we use threshold values of each customer group in pension system.

According to the fuzzy chart of scores in pension system:

- Bad customer $= (\frac{1}{0}, \frac{1}{33,06}, \frac{0}{40})$
- Moderate customer: $\left(\frac{0}{20}, \frac{1}{43,56}, \frac{0}{70}\right)$
- Good customer: $\left(\frac{0}{50}, \frac{1}{67}, \frac{1}{100}\right)$

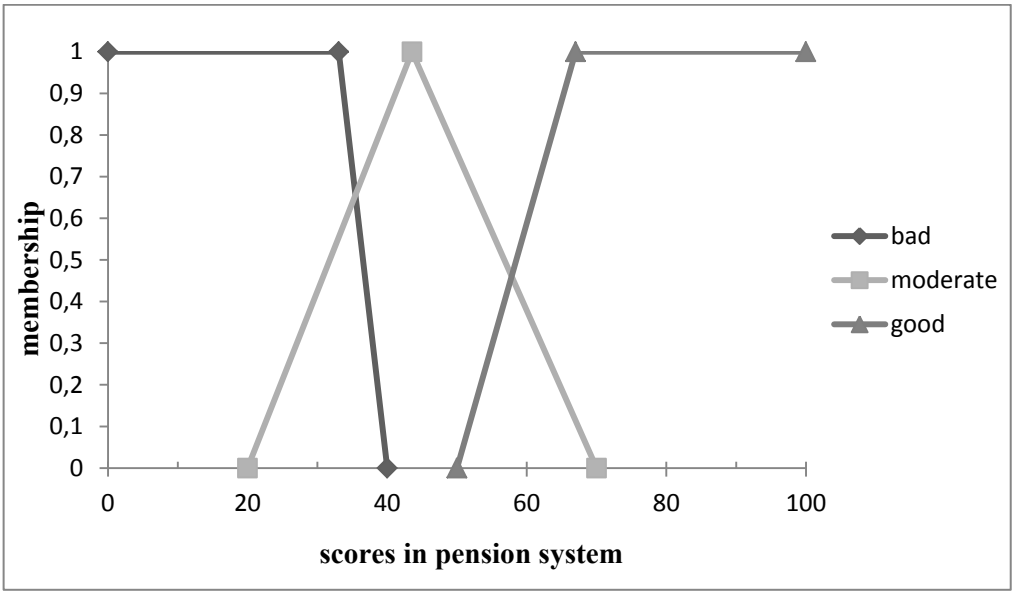



Figure 5. 43. Fuzzy Membership of scores in pension system as input

According to the figure above, the membership degrees of crisp values are found.

The second step, rule evaluation is to use membership values and apply them to the antecedents of the fuzzy rules. If a fuzzy rule has more than one part, the fuzzy operators (AND or OR) is used to obtain a single number as a result of evaluation. Then, this number is applied to the consequent membership function. In our study, there is no fuzzy operator in fuzzy rules, so we just use the membership degree that we found. The output is the chart of scores in life insurance system. Therefore, we will get information about the status of customer in life insurance system as an output. First, we draw the chart of scores in life insurance system with threshold values of each customer group in life insurance system.

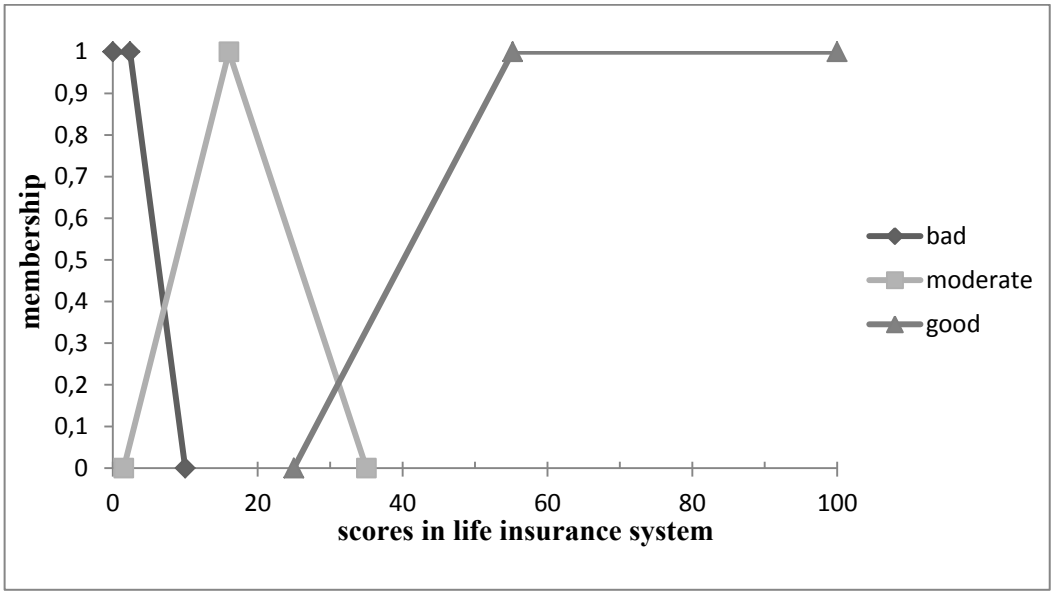



Figure 5. 44. Fuzzy Membership of scores in life insurance system as output

According to the fuzzy chart of scores in life insurance system:

- Bad customer $= (\frac{1}{0}, \frac{1}{2,36}, \frac{0}{10})$
- Moderate customer: $\left(\frac{0}{1,5}, \frac{1}{16,03}, \frac{0}{35}\right)$
- Good customer: $\left(\frac{0}{25}, \frac{1}{55,2}, \frac{1}{100}\right)$

The single antecedent membership degree which is found from the chart of scores in pension system is applied to the output chart which is the scores in life insurance.

The third step, aggregation of the rule outputs is about unification of the all outputs and combining them into a single fuzzy set. The input of aggregation process is a list of consequent membership functions, and the output is one fuzzy set for each output variable. In our case, it is the unification of all outputs in life insurance system.

The last step is defuzzification which is about getting a single crisp value of aggregation of all output fuzzy sets. There are many defuzzification methods; in our case we use the center of gravity (COG) defuzzifier which takes output as the center of gravity of the

fuzzy output. Mendil et al. (2001) indicates that for a discrete fuzzy set, the following formula is used:

$$COG = \frac{\sum_{x=a}^{b} \mu_A(x)x}{\sum_{x=a}^{b} \mu_A(x)} \quad (5.\ 7)$$

COG can be expressed as the formula below to find a point in the center of gravity of the fuzzy set on the interval ab (Negnevitsky, 2002).

$$COG = \frac{\int_a^b \mu_A(x)xdx}{\int_a^b \mu_A(x)dx} \quad (5.\ 8)$$

The score of customer in life insurance system is calculated. Therefore, the score of customer in pension system is enough to know the group of customer in life insurance system and cross selling decision can be made for pension customer by company.

We follow the same procedures for the customers in life insurance system. In this phase, the input chart is scores of customers in life insurance system and the output chart is scores of customers in pension system. First we form totally 9 rules.

Rule 1: If a customer is good in life insurance system
Then he is good in pension system

Rule 2: If a customer is good in life insurance system
Then he is moderate in pension system

Rule 3: If a customer is good in life insurance system
Then he is bad in pension system

Rule 4: If a customer is moderate in life insurance system
Then he is good in pension system

Rule 5: If a customer is moderate in life insurance system
Then he is moderate in pension system

Rule 6: If a customer is moderate in life insurance system
Then he is bad in pension system

Rule 4: If a customer is bad in life insurance system
Then he is good in pension system

Rule 5: If a customer is bad in life insurance system
Then he is moderate in pension system
Rule 6: If a customer is bad in life insurance system
Then he is bad in pension system

After if-then rules are completed, we follow the Mamdani-style fuzzy inference process with fuzzification step. In fuzzification step, we use the chart of scores in life insurance system.

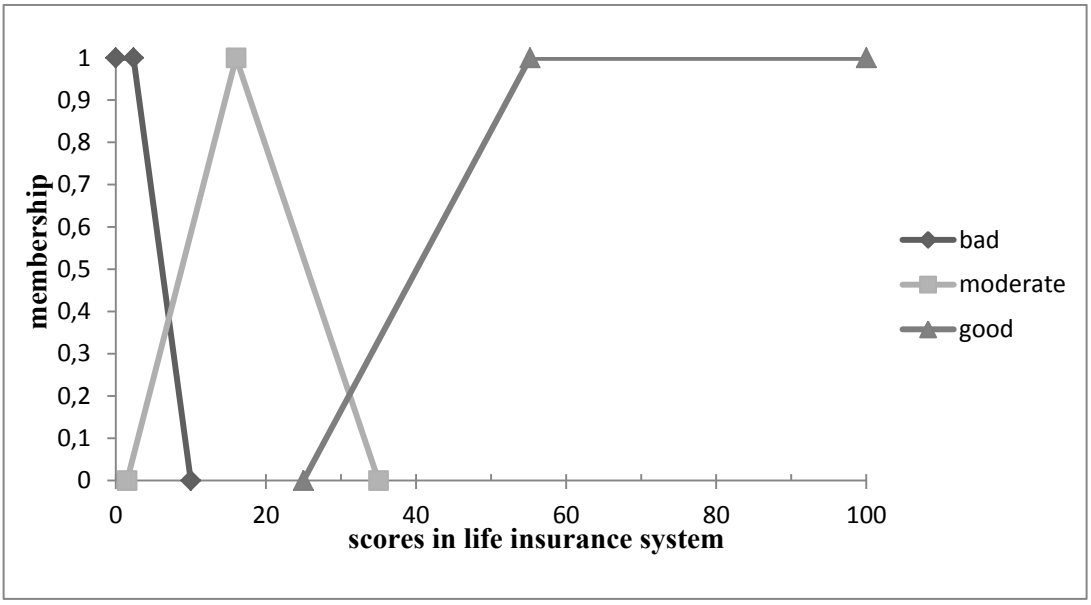



Figure 5. 45. Fuzzy Membership of scores in life insurance system as input.

According to the fuzzy chart of scores in life insurance system:

- Bad customer $= (\frac{1}{0}, \frac{1}{2,36}, \frac{0}{10})$
- Moderate customer: $\left(\frac{0}{1,5}, \frac{1}{16,03}, \frac{0}{35}\right)$
- Good customer: $\left(\frac{0}{25}, \frac{1}{55,2}, \frac{1}{100}\right)$

The membership degrees of crisp values are found according to chart of scores in life insurance system.

The second step, rule evaluation is to use membership values and apply them to the antecedents of the fuzzy rules. We will get information about the status of customer in pension system as an output.

According to the fuzzy chart of scores in pension system:

- Bad customer $= (\frac{1}{0}, \frac{1}{33,06}, \frac{0}{40})$
- Moderate customer: $\left(\frac{0}{20}, \frac{1}{43,56}, \frac{0}{70}\right)$
- Good customer: $\left(\frac{0}{50}, \frac{1}{67}, \frac{1}{100}\right)$

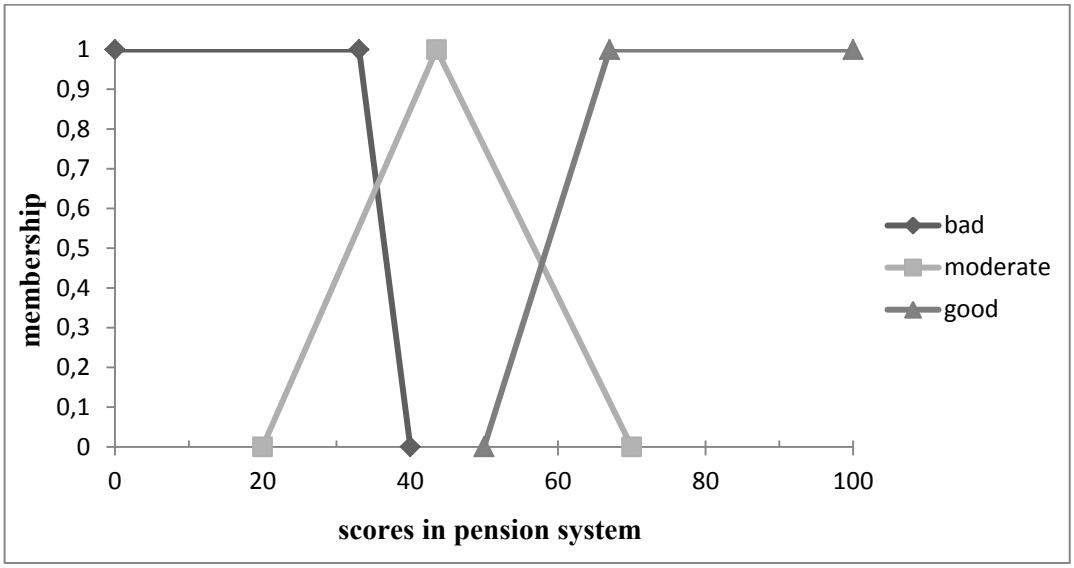



Figure 5. 46. Fuzzy Membership of scores in pension system as output.

The single antecedent membership degree which is found from the chart of scores in life insurance system is applied to the output chart, scores in pension system.

The third step, aggregation of the rule outputs is the unification of all outputs and combining them into a single fuzzy set. In our case, it is the unification of all outputs in scores of customer in pension system.

The last step is defuzzification which is about getting a single crisp value of aggregation of all output fuzzy sets. The score of customer in pension system is calculated with center of gravity (COG) defuzzifier. Therefore, the score of customer in life insurance system is enough to know group of customer in cross selling system and cross selling decision can be made for life insurance customer by company.

## 5.4. DEVELOPMENT OF CROSS SELLING DECISION SUPPORT SYSTEM

After we used fuzzy technique, we can reach the scores of customer in cross selling system. The other important issue is to decide when and how cross selling can be applied. There are two options that call center agent can offer cross selling.

Firstly, call center agent of the company can call the selected data to offer cross selling. The other strategy is; call center agent can make a phone call for some reason about customers' existing product, like taking information about the product and make some changes on the product. At this stage, call center agent, should be able to offer cross selling if customer has enough score in the cross selling system. If the score of the customer is in the group of moderate and good, the call center agent may decide to offer cross selling. In this phase, company can decide to apply cross selling according to the group of customer in cross selling system.

In this section we focus on process of call centers' cross selling offer. As we mentioned before, call center agent can both call the customer to offer cross selling directly and offer cross selling in the conversation if customer is appropriate for it. In this phase, we decided to develop a cross selling decision support system for call center agent to provide him to decide cross selling offer.

Cross selling decision support system is required to perform these activities. Through decision support system, during the conversation, if agent enters the score of customer in the current system, he can get the score of customer in the cross- selling system. Therefore, he can offer cross selling according to these score. Moreover, by decision

support system, call center agent can learn the scores of current customers in cross selling system and call a particular list of customers to offer cross selling.

In this phase, we develop cross selling decision support system, by fuzzy logic tool box of Matlab. First, we begin developing cross selling DSS with pension system as an input system and life insurance system as an output system.

We draw the fuzzy membership function of pension system, by entering the intersection points of customer groups into the fuzzy tool. Likewise, we draw the fuzzy membership function of life insurance system as an output system.

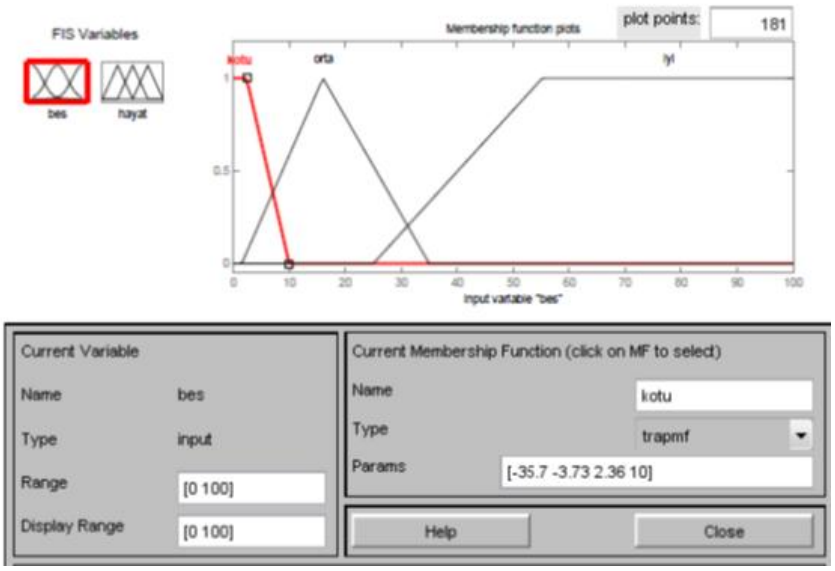



Figure 5. 47. Fuzzy membership of pension system in fuzzy tool box

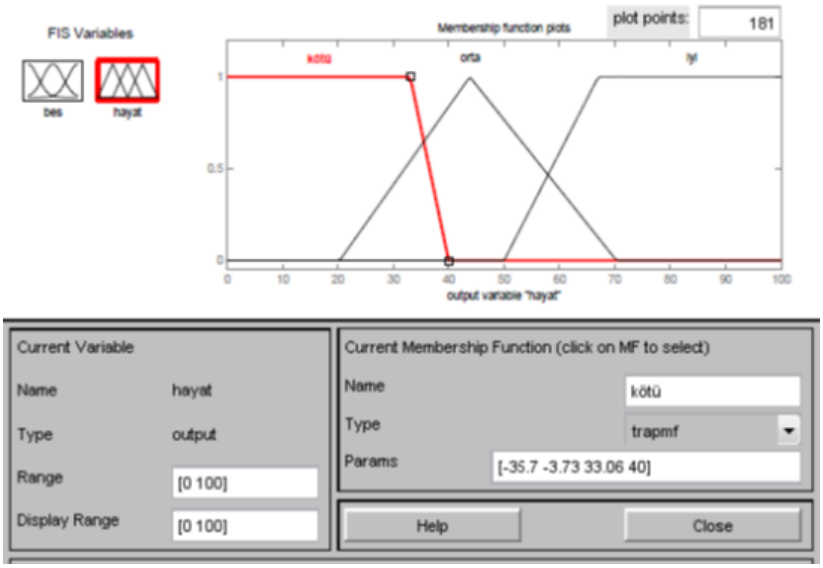



Figure 5. 48. Fuzzy membership of life insurance system in fuzzy tool box

After all, we form if-then rules as we did in previous section. While evaluating the rules, we add weight variable for each rule that reveals the possibility to occurrence. In examining customer data section, we had found percentage values for each customer group who has products in both of the systems. We use normalized form of those percentage values as a weight value for each rule. The figure below shows the rules and weight values in private pension system.

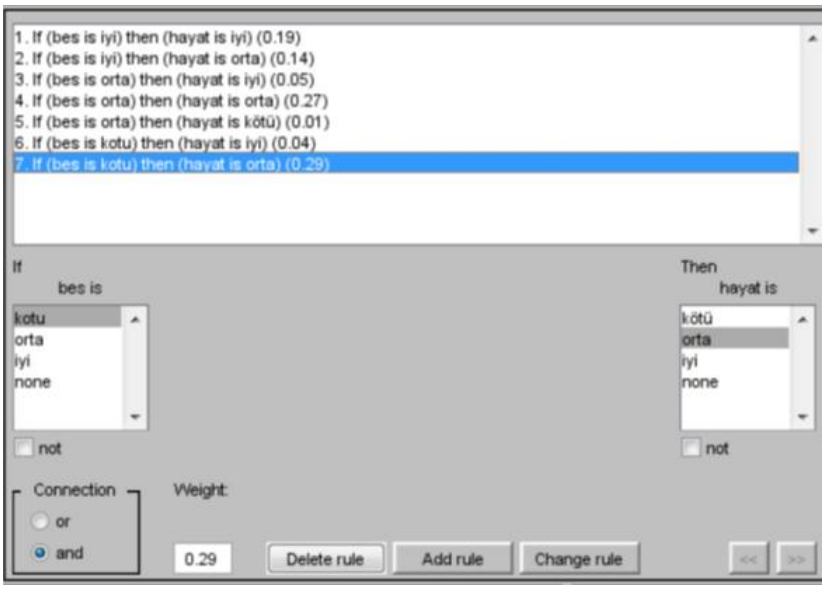



Figure 5. 49. If-then rules of pension system in fuzzy tool box

We follow the same procedure for life insurance system as well. Input system is fuzzy membership function of life insurance and output system is fuzzy membership function of pension system. We form the if-then rules and fill the weight of each rule.

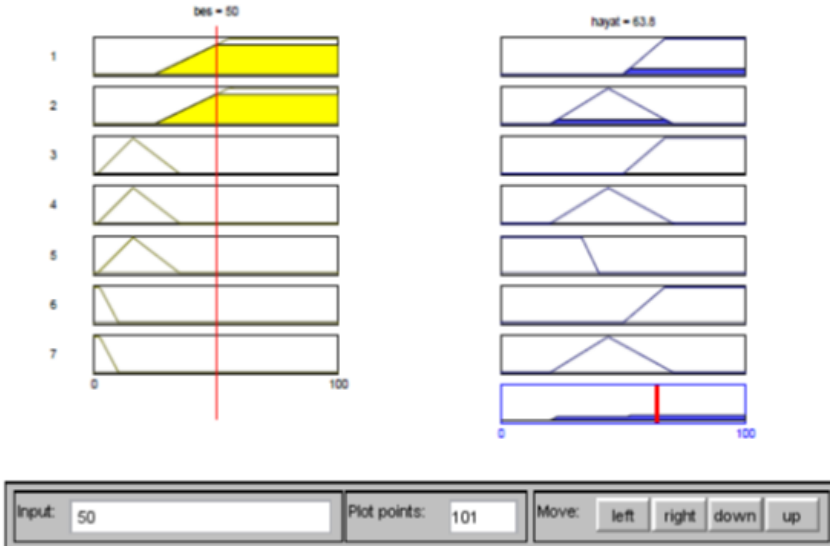



Figure 5. 50. Cross selling DSS in fuzzy tool box

Finally, we develop the cross selling decision support system by fuzzy tool box of Matlab. That provides call center agent to learn the score of customer in cross selling system, if he enters the current score of customer to the decision support system. In the figure below, we enter the 50 points to the system as private pension score of customer, and DSS translates this score to the life insurance score in the right hand side of the figure above.

# 6. CONCLUSION

Private Pension system and life insurance systems are two main financial instruments that are founded because of pursuit of security in people lives. Private pension and life insurance sector through its high growth, Turkey attracts both foreign and Turkish investors. Therefore, there is high rise in the number of domestic and flammable companies which have recently entered the sector and there has been great competition between companies in sales of pension and life insurance products.

Under competitive conditions, increasing sales and profitability are crucial for companies to survive. Cross selling strategy is a common marketing activity to boost the sales of company with the principle of using different sales opportunities. Since there are many various case features in real life scenarios, companies have difficulties in adapting their cross selling strategies.

In order to demonstrate applicability of proposed approach, we have chosen one of the biggest companies in this sector. The most profitable customer profiles are examined by Design of Experiments in order to determine customer profiles. In private pension system, duration of stay and saving amount and; in life insurance system, a total premium amount values are selected to be maximized to find target customer profiles. As a result, target customer profiles are determined after those values are optimized. Customer profiles are divided into 3 groups in terms of profitability, good customer group, moderate customer group and bad customer group based on scores that are calculated using properties of customer and his/her product. After we divided customers into groups; company can choose a target customer group to apply cross selling, if its selling staff is not enough to reach all customers. Fuzzy logic provides to

evaluate customers according to their membership degrees in customer groups. It is applied in order to measure success of sales in cross selling system. Thus, if the score of customer is known in the current system, the achievement score in cross-selling system can be calculated.

We utilized Fuzzy tool box of Matlab, in order to establish Cross selling decision support system which calculates the achievement score of customer in cross selling system.

In this thesis, Cross selling decision support system, based on Design of Experiments, and Fuzzy Expert systems, is introduced to reveal the success of sales for each customer in cross selling area. The proposed DSS can be used by the call center of the company to offer cross selling if customer has enough score in the cross selling system. The usage of Cross selling DSS is very important when there is a lack of sales resource in the company, because instead of reaching all current customers, it aims to find target customer profile. Through this study, by determining target customer profile, company is both increasing its sales and profitability by selling new products to its current customers and profitability is estimated to be long lasting because of selling products to the right customer.

Cross selling is a fruitful subject that can be further studied. In this study, we have illustrated the applicability of the framework through a case study of Private pension and Life Insurance Company. The proposed decision support system is flexible enough to fit other sectors with some specific characteristics changes and to incorporate different criteria in the evaluation process. Moreover, we have calculated customer scores based on pension and life insurance systems. However, that scoring can be based on various products in those systems, so selling right product to right customer can be achieved as well. Furthermore, this study primarily focuses on private pension and life insurance systems. However, other insurance types can be added to this framework, such as health insurance, auto insurance, so selection of appropriate cross selling area for each customer can be added to this model.

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# APPENDICES

## Appendix A- Scores of Customers in private pension system

| Number | Contribution payment | Age | Place | Gender | Currency of contract | Payment type | Marital status | Educational status | pension saving score | duration of stay score | total score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | >100 | >45 | west | woman | foreign | monthly installment | Married. | elementary/high school education | 27 | 48,5 | 75,5 |
| 2 | >100 | >45 | west | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 43,5 | 26,5 | 70 |
| 3 | <=100 | >45 | west | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 37 | 30 | 67 |
| 4 | <=100 | >45 | west | Man | foreign | monthly installment | Married. | elementary/high school education | 20,5 | 50 | 70,5 |
| 5 | >100 | <=45 | west | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 30 | 36,5 | 66,5 |
| 6 | <=100 | >45 | East | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 37 | 29 | 66 |
| 7 | <=100 | >45 | East | Man | foreign | monthly installment | Married. | elementary/high school education | 20,5 | 49 | 69,5 |
| 8 | >100 | >45 | west | woman | foreign | monthly | Married. | university/ post grad/ | 20 | 48,5 | 68,5 |
| 9 | <=100 | >45 | west | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 33 | 30 | 63 |
| 10 | <=100 | <=45 | west | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 23,5 | 40 | 63,5 |
| 11 | <=100 | >45 | East | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 33 | 29 | 62 |
| 12 | >100 | >45 | west | woman | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 30,5 | 31,5 | 62 |
| 13 | <=100 | >45 | west | woman | foreign | monthly installment | Married. | elementary/high school education | 16,5 | 50 | 66,5 |
| 14 | <=100 | <=45 | East | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 23,5 | 39 | 62,5 |
| 15 | <=100 | >45 | East | woman | foreign | monthly installment | Married. | elementary/high school education | 16,5 | 49 | 65,5 |
| 16 | <=100 | >45 | west | Man | foreign | monthly | Married. | university/ post grad/ | 13,5 | 50 | 63,5 |
| 17 | >100 | >45 | East | woman | foreign | monthly installment | Married. | elementary/high school education | 27 | 31,5 | 58,5 |
| 18 | <=100 | <=45 | west | Man | TL | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 50 | 12 | 62 |
| 19 | <=100 | <=45 | west | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 19,5 | 40 | 59,5 |
| 20 | <=100 | >45 | East | Man | foreign | monthly | Married. | university/ post grad/ | 13,5 | 49 | 62,5 |
| 21 | <=100 | >45 | west | Man | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 24 | 34 | 58 |
| 22 | <=100 | <=45 | East | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 19,5 | 39 | 58,5 |
| 23 | <=100 | >45 | East | Man | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 24 | 32,5 | 56,5 |
| 24 | <=100 | <=45 | west | woman | TL | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 46 | 12 | 58 |
| 25 | >100 | >45 | west | woman | foreign | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 23,5 | 31,5 | 55 |
| 26 | >100 | >45 | west | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 27 | 26,5 | 53,5 |
| 27 | <=100 | >45 | west | woman | foreign | monthly | Married. | university/ post grad/ | 9,5 | 50 | 59,5 |
| 28 | <=100 | >45 | west | woman | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 20 | 34 | 54 |
| 29 | <=100 | >45 | East | woman | foreign | monthly | Married. | university/ post grad/ | 9,5 | 49 | 58,5 |
| 30 | <=100 | >45 | East | woman | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 20 | 32,5 | 52,5 |
| 31 | >100 | >45 | west | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 25 | 26,5 | 51,5 |
| 32 | >100 | >45 | East | woman | foreign | monthly | Married. | university/ post grad/ | 20 | 31,5 | 51,5 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 33 | >100 | >45 | west | Man | foreign | monthly installment | Married. | elementary/high school education | 8 | 48,5 | 56,5 |
| 34 | <=100 | >45 | west | Man | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 20,5 | 30 | 50,5 |
| 35 | <=100 | <=45 | East | Man | TL | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 50 | 6,5 | 56,5 |
| 36 | >100 | >45 | East | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 43,5 | 10 | 53,5 |
| 37 | <=100 | >45 | west | Man | foreign | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 17 | 34 | 51 |
| 38 | >100 | <=45 | East | woman | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 30 | 20 | 50 |
| 39 | <=100 | >45 | East | Man | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 20,5 | 29 | 49,5 |
| 40 | <=100 | >45 | East | Man | foreign | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 17 | 32,5 | 49,5 |
| 41 | >100 | <=45 | west | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 14 | 36,5 | 50,5 |
| 42 | <=100 | <=45 | East | woman | TL | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 46 | 6,5 | 52,5 |
| 43 | <=100 | >45 | west | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 16,5 | 30 | 46,5 |
| 44 | >100 | <=45 | west | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 11,5 | 36,5 | 48 |
| 45 | <=100 | >45 | west | woman | foreign | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 13 | 34 | 47 |
| 46 | <=100 | >45 | East | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 16,5 | 29 | 45,5 |
| 47 | >100 | <=45 | west | woman | foreign | monthly installment | Married. | elementary/high school education | 13,5 | 33 | 46,5 |
| 48 | <=100 | <=45 | west | Man | TL | monthly installment | single/widow/ divorced | elementary/high school education | 33,5 | 12 | 45,5 |
| 49 | >100 | >45 | East | woman | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 30,5 | 14,5 | 45 |
| 50 | <=100 | >45 | East | woman | foreign | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 13 | 32,5 | 45,5 |
| 51 | <=100 | <=45 | west | Man | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 7 | 40 | 47 |
| 52 | <=100 | <=45 | East | Man | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 7 | 39 | 46 |
| 53 | >100 | >45 | west | Man | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 12 | 31,5 | 43,5 |
| 54 | >100 | >45 | west | Man | foreign | monthly | Married. | university/ post grad/ | 1 | 48,5 | 49,5 |
| 55 | <=100 | <=45 | west | woman | TL | monthly installment | single/widow/ divorced | elementary/high school education | 29,5 | 12 | 41,5 |
| 56 | <=100 | <=45 | west | Man | TL | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 33 | 8,5 | 41,5 |
| 57 | <=100 | <=45 | west | Man | foreign | monthly installment | Married. | elementary/high school education | 7 | 35 | 42 |
| 58 | <=100 | <=45 | west | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 3 | 40 | 43 |
| 59 | <=100 | <=45 | East | Man | foreign | monthly installment | Married. | elementary/high school education | 7 | 34 | 41 |
| 60 | >100 | >45 | East | woman | foreign | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 23,5 | 14,5 | 38 |
| 61 | <=100 | >45 | west | Man | TL | monthly installment | Married. | elementary/high school education | 20,5 | 17 | 37,5 |
| 62 | >100 | >45 | East | Man | foreign | monthly installment | Married. | elementary/high school education | 8 | 31,5 | 39,5 |
| 63 | <=100 | <=45 | East | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 3 | 39 | 42 |
| 64 | <=100 | >45 | west | Man | TL | 3 month/ 6 month/ year | Married. | elementary/high school education | 24 | 13,5 | 37,5 |
| 65 | <=100 | <=45 | East | Man | TL | monthly installment | single/widow/ divorced | elementary/high school education | 33,5 | 6,5 | 40 |
| 66 | >100 | <=45 | west | woman | foreign | monthly | Married. | university/ post grad/ | 6,5 | 33 | 39,5 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 67 | <=100 | <=45 | west | woman | TL | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 29 | 8,5 | 37,5 |
| 68 | >100 | >45 | East | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 27 | 10 | 37 |
| 69 | >100 | >45 | west | woman | foreign | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 27 | 10 | 37 |
| 70 | <=100 | >45 | west | Man | foreign | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 20,5 | 14 | 34,5 |
| 71 | <=100 | <=45 | west | woman | foreign | monthly installment | Married. | elementary/high school education | 3 | 35 | 38 |
| 72 | >100 | >45 | west | Man | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 8,5 | 26,5 | 35 |
| 73 | >100 | >45 | East | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 25 | 10 | 35 |
| 74 | <=100 | <=45 | East | woman | TL | monthly installment | single/widow/ divorced | elementary/high school education | 29,5 | 6,5 | 36 |
| 75 | >100 | <=45 | west | woman | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 17 | 16,5 | 33,5 |
| 76 | >100 | >45 | west | Man | foreign | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 4,5 | 31,5 | 36 |
| 77 | <=100 | <=45 | west | Man | TL | monthly installment | Married. | elementary/high school education | 33,5 | 3,5 | 37 |
| 78 | <=100 | >45 | west | woman | TL | monthly installment | Married. | elementary/high school education | 16,5 | 17 | 33,5 |
| 79 | >100 | <=45 | East | woman | foreign | monthly installment | single/widow/ divorced | elementary/high school education | 14 | 20 | 34 |
| 80 | <=100 | >45 | west | woman | TL | 3 month/ 6 month/ year | Married. | elementary/high school education | 20 | 13,5 | 33,5 |
| 81 | >100 | <=45 | west | woman | foreign | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 13,5 | 20 | 33,5 |
| 82 | <=100 | <=45 | East | woman | foreign | monthly installment | Married. | elementary/high school education | 3 | 34 | 37 |
| 83 | <=100 | >45 | East | Man | foreign | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 20,5 | 12,5 | 33 |
| 84 | <=100 | >45 | west | Man | TL | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 37 | 0,5 | 37,5 |
| 85 | <=100 | <=45 | west | Man | TL | 3 month/ 6 month/ year | Married. | elementary/high school education | 37 | 0 | 37 |
| 86 | <=100 | <=45 | East | Man | TL | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 33 | 2 | 35 |
| 87 | <=100 | >45 | East | Man | TL | monthly installment | Married. | elementary/high school education | 20,5 | 11,5 | 32 |
| 88 | >100 | <=45 | west | woman | TL | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 35,5 | 0,5 | 36 |
| 89 | >100 | <=45 | East | Man | foreign | monthly installment | single/widow/ divorced | university/ post grad/ doctor | 11,5 | 20 | 31,5 |
| 90 | <=100 | >45 | west | Man | TL | monthly | Married. | university/ post grad/ | 13,5 | 17 | 30,5 |
| 91 | <=100 | >45 | west | woman | foreign | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 16,5 | 14 | 30,5 |
| 92 | <=100 | >45 | west | Man | TL | 3 month/ 6 month/ year | Married. | university/ post grad/ doctor | 17 | 13,5 | 30,5 |
| 93 | <=100 | <=45 | west | woman | TL | monthly installment | Married. | elementary/high school education | 29,5 | 3,5 | 33 |
| 94 | <=100 | <=45 | west | Man | foreign | monthly | Married. | university/ post grad/ | 0 | 35 | 35 |
| 95 | <=100 | <=45 | west | Man | foreign | 3 month/ 6 month/ year | single/widow/ divorced | university/ post grad/ doctor | 7 | 24 | 31 |
| 96 | <=100 | >45 | East | Man | TL | 3 month/ 6 month/ year | Married. | elementary/high school education | 24 | 7 | 31 |
| 97 | >100 | <=45 | East | woman | foreign | monthly installment | Married. | elementary/high school education | 13,5 | 16,5 | 30 |
| 98 | <=100 | <=45 | East | Man | foreign | monthly | Married. | university/ post grad/ | 0 | 34 | 34 |
| 99 | <=100 | <=45 | west | Man | foreign | 3 month/ 6 month/ year | Married. | elementary/high school education | 10,5 | 19 | 29,5 |
| 100 | >100 | >45 | East | Man | foreign | monthly | Married. | university/ post grad/ | 1 | 31,5 | 32,5 |

Appendix B- Scores of Customers in private pension system

| Number | Educational status | Age | Place | Gender | Currency of contract | Payment type | Marital status | total score |
|---|---|---|---|---|---|---|---|---|
| 1 | elementary/high school education | >45 | East | Man | foreign | monthly installment | single/widow/divorced | 54 |
| 2 | elementary/high school education | >45 | East | woman | foreign | monthly installment | single/widow/divorced | 58 |
| 3 | university/ post grad/ doctor | >45 | East | woman | foreign | monthly installment | single/widow/divorced | 50 |
| 4 | elementary/high school education | >45 | west | woman | foreign | monthly installment | single/widow/divorced | 50 |
| 5 | elementary/high school education | >45 | East | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 54 |
| 6 | elementary/high school education | >45 | East | woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 58 |
| 7 | university/ post grad/ doctor | >45 | East | woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 50 |
| 8 | elementary/high school education | >45 | west | woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 50 |
| 9 | elementary/high school education | >45 | East | Man | foreign | monthly installment | Married. | 96 |
| 10 | elementary/high school education | >45 | west | Man | foreign | monthly installment | Married. | 51 |
| 11 | elementary/high school education | >45 | East | woman | foreign | monthly installment | Married. | 100 |
| 12 | university/ post grad/ doctor | >45 | East | woman | foreign | monthly installment | Married. | 53 |
| 13 | elementary/high school education | >45 | west | woman | foreign | monthly installment | Married. | 55 |
| 14 | elementary/high school education | >45 | East | Man | foreign | 3 month/ 6 month/ year installment | Married. | 96 |
| 15 | elementary/high school education | >45 | west | Man | foreign | 3 month/ 6 month/ year installment | Married. | 51 |
| 16 | elementary/high school education | >45 | East | woman | foreign | 3 month/ 6 month/ year installment | Married. | 100 |
| 17 | university/ post grad/ doctor | >45 | East | woman | foreign | 3 month/ 6 month/ year installment | Married. | 53 |
| 18 | elementary/high school education | >45 | west | woman | foreign | 3 month/ 6 month/ year installment | Married. | 55 |
| 19 | university/ post grad/ doctor | >45 | East | Man | foreign | monthly installment | Married. | 49 |
| 20 | university/ post grad/ doctor | >45 | East | Man | foreign | 3 month/ 6 month/ year installment | Married. | 49 |
| 21 | university/ post grad/ doctor | >45 | East | Man | foreign | monthly installment | single/widow/divorced | 46 |
| 22 | elementary/high school education | >45 | west | Man | foreign | monthly installment | single/widow/divorced | 46 |
| 23 | university/ post grad/ doctor | >45 | East | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 46 |
| 24 | elementary/high school education | >45 | west | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 46 |
| 25 | university/ post grad/ doctor | >45 | west | woman | foreign | monthly installment | single/widow/divorced | 43 |
| 26 | university/ post grad/ doctor | >45 | west | woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 43 |
| 27 | university/ post grad/ doctor | <=45 | west | Man | TL | monthly installment | single/widow/divorced | 39 |
| 28 | university/ post grad/ doctor | <=45 | west | Man | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 39 |
| 29 | university/ post grad/ doctor | >45 | west | Man | foreign | monthly installment | single/widow/divorced | 39 |
| 30 | university/ post grad/ doctor | >45 | west | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 39 |
| 31 | elementary/high school education | <=45 | East | woman | foreign | monthly installment | Married. | 38 |
| 32 | elementary/high school education | <=45 | East | woman | foreign | 3 month/ 6 month/ year installment | Married. | 38 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 33 | university/ post grad/ doctor | <=45 | west | woman | TL | monthly installment | single/widow/divorced | 37 |
| 34 | university/ post grad/ doctor | <=45 | west | woman | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 37 |
| 35 | elementary/high school education | <=45 | East | Man | foreign | monthly installment | Married. | 34 |
| 36 | elementary/high school education | <=45 | East | Man | foreign | 3 month/ 6 month/ year installment | Married. | 34 |
| 37 | elementary/high school education | >45 | East | Man | TL | monthly installment | Married. | 30 |
| 38 | elementary/high school education | >45 | East | Man | TL | 3 month/ 6 month/ year installment | Married. | 30 |
| 39 | elementary/high school education | >45 | East | woman | TL | monthly installment | Married. | 28 |
| 40 | elementary/high school education | >45 | East | woman | TL | 3 month/ 6 month/ year installment | Married. | 28 |
| 41 | university/ post grad/ doctor | <=45 | west | woman | foreign | monthly installment | single/widow/divorced | 27 |
| 42 | university/ post grad/ doctor | <=45 | west | woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 27 |
| 43 | university/ post grad/ doctor | <=45 | west | Man | foreign | monthly installment | single/widow/divorced | 23 |
| 44 | university/ post grad/ doctor | <=45 | west | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 23 |
| 45 | university/ post grad/ doctor | >45 | west | Man | TL | monthly installment | single/widow/divorced | 21 |
| 46 | university/ post grad/ doctor | >45 | west | Man | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 21 |
| 47 | university/ post grad/ doctor | >45 | west | woman | TL | monthly installment | single/widow/divorced | 19 |
| 48 | university/ post grad/ doctor | >45 | west | woman | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 19 |
| 49 | elementary/high school education | <=45 | west | woman | foreign | monthly installment | Married. | 16 |
| 50 | elementary/high school education | <=45 | west | woman | foreign | 3 month/ 6 month/ year installment | Married. | 16 |
| 51 | university/ post grad/ doctor | <=45 | East | woman | foreign | monthly installment | Married. | 13 |
| 52 | university/ post grad/ doctor | <=45 | East | woman | foreign | 3 month/ 6 month/ year installment | Married. | 13 |
| 53 | elementary/high school education | <=45 | west | Man | foreign | monthly installment | Married. | 12 |
| 54 | elementary/high school education | <=45 | west | Man | foreign | 3 month/ 6 month/ year installment | Married. | 12 |
| 55 | elementary/high school education | <=45 | west | woman | foreign | monthly installment | single/widow/divorced | 12 |
| 56 | elementary/high school education | <=45 | west | woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 12 |
| 57 | university/ post grad/ doctor | <=45 | East | woman | foreign | monthly installment | single/widow/divorced | 10 |
| 58 | university/ post grad/ doctor | <=45 | East | woman | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 10 |
| 59 | university/ post grad/ doctor | <=45 | East | Man | foreign | monthly installment | Married. | 9 |
| 60 | university/ post grad/ doctor | <=45 | East | Man | foreign | 3 month/ 6 month/ year installment | Married. | 9 |
| 61 | elementary/high school education | >45 | west | Man | TL | monthly installment | Married. | 8 |
| 62 | elementary/high school education | >45 | west | Man | TL | 3 month/ 6 month/ year installment | Married. | 8 |
| 63 | university/ post grad/ doctor | >45 | west | woman | foreign | monthly installment | Married. | 8 |
| 64 | university/ post grad/ doctor | >45 | west | woman | foreign | 3 month/ 6 month/ year installment | Married. | 8 |
| 65 | elementary/high school education | <=45 | west | Man | foreign | monthly installment | single/widow/divorced | 8 |
| 66 | elementary/high school education | <=45 | west | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 8 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 67 | university/ post grad/ doctor | >45 | East | Man | TL | monthly installment | Married. | 7 |
| 68 | university/ post grad/ doctor | >45 | East | Man | TL | 3 month/ 6 month/ year installment | Married. | 7 |
| 69 | university/ post grad/ doctor | <=45 | East | Man | foreign | monthly installment | single/widow/divorced | 6 |
| 70 | university/ post grad/ doctor | <=45 | East | Man | foreign | 3 month/ 6 month/ year installment | single/widow/divorced | 6 |
| 71 | elementary/high school education | >45 | west | woman | TL | monthly installment | Married. | 6 |
| 72 | elementary/high school education | >45 | west | woman | TL | 3 month/ 6 month/ year installment | Married. | 6 |
| 73 | university/ post grad/ doctor | >45 | East | woman | TL | monthly installment | Married. | 5 |
| 74 | university/ post grad/ doctor | >45 | East | woman | TL | 3 month/ 6 month/ year installment | Married. | 5 |
| 75 | university/ post grad/ doctor | >45 | East | Man | TL | monthly installment | single/widow/divorced | 5 |
| 76 | university/ post grad/ doctor | >45 | East | Man | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 5 |
| 77 | elementary/high school education | <=45 | west | Man | TL | monthly installment | Married. | 4 |
| 78 | elementary/high school education | <=45 | west | Man | TL | 3 month/ 6 month/ year installment | Married. | 4 |
| 79 | elementary/high school education | >45 | west | Man | TL | monthly installment | single/widow/divorced | 4 |
| 80 | elementary/high school education | >45 | west | Man | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 4 |
| 81 | university/ post grad/ doctor | <=45 | west | Man | TL | monthly installment | Married. | 4 |
| 82 | university/ post grad/ doctor | <=45 | west | Man | TL | 3 month/ 6 month/ year installment | Married. | 4 |
| 83 | university/ post grad/ doctor | >45 | west | Man | foreign | monthly installment | Married. | 4 |
| 84 | university/ post grad/ doctor | >45 | west | Man | foreign | 3 month/ 6 month/ year installment | Married. | 4 |
| 85 | elementary/high school education | <=45 | East | Man | TL | monthly installment | Married. | 3 |
| 86 | elementary/high school education | <=45 | East | Man | TL | 3 month/ 6 month/ year installment | Married. | 3 |
| 87 | university/ post grad/ doctor | >45 | East | woman | TL | monthly installment | single/widow/divorced | 3 |
| 88 | university/ post grad/ doctor | >45 | East | woman | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 3 |
| 89 | elementary/high school education | <=45 | west | woman | TL | monthly installment | Married. | 2 |
| 90 | elementary/high school education | <=45 | west | woman | TL | 3 month/ 6 month/ year installment | Married. | 2 |
| 91 | university/ post grad/ doctor | <=45 | East | Man | TL | monthly installment | Married. | 2 |
| 92 | university/ post grad/ doctor | <=45 | East | Man | TL | 3 month/ 6 month/ year installment | Married. | 2 |
| 93 | elementary/high school education | >45 | west | woman | TL | monthly installment | single/widow/divorced | 2 |
| 94 | elementary/high school education | >45 | west | woman | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 2 |
| 95 | university/ post grad/ doctor | <=45 | west | woman | TL | monthly installment | Married. | 2 |
| 96 | university/ post grad/ doctor | <=45 | west | woman | TL | 3 month/ 6 month/ year installment | Married. | 2 |
| 97 | elementary/high school education | <=45 | East | woman | TL | monthly installment | Married. | 0 |
| 98 | elementary/high school education | <=45 | East | woman | TL | 3 month/ 6 month/ year installment | Married. | 0 |
| 99 | elementary/high school education | <=45 | west | Man | TL | monthly installment | single/widow/divorced | 0 |
| 100 | elementary/high school education | <=45 | west | Man | TL | 3 month/ 6 month/ year installment | single/widow/divorced | 0 |

**BIOGRAPHICAL SKETCH**

Burçin Yakan, the candidate of Master of Science in Industrial Engineering Department in Galatasaray University, was born in 1986 in Ankara. She started her bachelor education in Industrial Engineering Department in Istanbul Technical University. During her undergraduate education she was rewarded as “High Honor Student” throughout years 2004-2008.