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MODELING GSM SWITCHING BEHAVIOR OF CUSTOMERS IN TURKEY WITH AGENT BASED MODELING METHODOLOGY

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MODELING GSM SWITCHING BEHAVIOR OF CUSTOMERS IN TURKEY WITH AGENT BASED MODELING METHODOLOGY

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ABSTRACT

Melike Ateş, Kurtuluş Şahin " Modeling GSM Switching Behavior of Customers in Turkey with Agent Based Modeling Methodology"

By the increase in usage of mobile phones, GSM companies has been diversifying its services for their customers in time. Especially because of the increase in internet usage via mobile phones, customers have a chance to make a selection between the companies. Additionally, operator changing process have gotten easier and customer sensitivity to this changing process have increased in time thanks to the innovation of Mobile Number Portability. (Kutlu Bayraktar, 2013)

The purpose of this study is to model GSM switching behavior of customers by using Agent Based Modeling methodology. The study is prepared by taken into account three GSM companies (Turkcell, Vodafone and Avea) and their three basic services (Speech, Message and Internet). While examining switching approach of customers, the criteria that customers have an importance on are added to the model based on the accurate values comes from company data and BTK statistics.

As a result of this study, operator switching behavior of customers was modeled by taking into consideration demographic characteristics of customers, their usage of services and price policies, brand images, service qualities of companies via Agent Based Modeling. Effect of possible changes in prices of services and switching cost to customers switching behavior was analyzed considering the churn rates and numbers of customers of operators.

ÖZET

Melike Ateş, Kurtuluş Şahin "Ajan Tabanlı Modelleme Methodolojisi ile Türkiyedeki GSM Operatörü Müşterilerinin Operatörlerini Değiştirme Davranışının Modellenmesi"

Türkiye'de cep telefonlarının kullanımının yaygınlaşmasıyla birlikte, GSM operatörü firmaları zaman içerisinde müşterilerine sunduğu hizmetleri genişletmiştir. Özellikle cep telefonlarında internet kullanımının da artmasıyla ve GSM sektörünün büyümesiyle, operatör kullanıcıları üç operatör arasından seçim yapma durumuyla karşı karşıya kalmıştır. GSM sektörüne gelen bir diğer gelişme olan "Numara Taşıma" işlemiyle birlikte müşterilerin bu seçime olan duyarlılıkları artmış ve operatör değiştirme işlemi kolaylaşmıştır.

Bu çalışmanın amacı, GSM müşterilerinin operatörlerini değiştirme davranışının Ajan Tabanlı Modelleme yaklaşımı kullanılarak modellenmesi ve incelenmesidir. Çalışma, Türkiye'deki gerçek koşullara uygun olarak üç GSM operatörünün (Turkcell, Vodafone, Avea) kullanıcılarına sunduğu üç tip hizmet (Konuşma, Mesajlaşma, İnternet) dikkate alınarak hazırlanmıştır. Kullanıcıların operatör değiştirmeye olan tutumu incelenirken dikkate aldıkları kriterler şirketlerin gerçek verilerine dayanarak uygun parametrelerle modele eklenmiştir.

Bu çalışma sonucunda, GSM firmalarınınfiyat politikaları, hizmet kaliteleri, marka imajları ve müşterilerin demografik özellikleri ile hizmetleri kullanım miktarları göz önünde bulundurularak; cep telefonu kullanıcılarının operator değiştirme davranışı Ajan Tabanlı Modelleme yöntemi ile gerçeğe yakın şekilde modellenmiştir. Hazırlanan model ile operatörlerin fiyat politikalarında ve değiştirme maliyetinde yaşanacak değişikliklerin müşterilerin davranışlarına olan etkisiözellikle operatörlerin kullanıcı sayıları ve kayıp oranları karşılaştırılarak incelenmiştir.

Chapter 1 : INTRODUCTION

The study is conducted to understand and evaluate the switching tendency of GSM customers from one GSM operator to another in specific circumstances. In order to simulate this type of environment and actions, Agent Based Modeling approach is selected because of its appropriate modeling techniques that is named Overview - Design - Details protocol. This study is mainly focused on calculation of customers' selection of best GSM company for themselves in the consideration of specific parameters related to customer profile and GSM Company.

To introduce why Agent Based Modeling approach is used for the study it can be said that Agent Based Modeling allows to model environments whose elements/agents pursue different goals from each other and in this environment, each customer tries to choose the best GSM operator based on their specifics. Hence, this modeling approach highly appropriate for this study. Another advantage of Agent Based Modeling is to take network effect into consideration but in GSM industry, because of the advantages that eliminate the cost arising from communication between different operators, the network effect is eliminated and it is accepted as negligible.

In this model, customer profiles is created based on the data published by governmental agencies. By creating customer profiles age and income distribution ranges are obtained from "Address Based Population And Registration System Database" and "Income, Consumption and Poverty Statistics" legally published by Turkish Statistical Institute. Other customer parameter values namely operator type (Turkcell, Vodafone, Avea) and invoice type (pre-paid, post-paid) and customer demand for speech, message and internet are obtained from "The 4th Quarter of 2013 Market Data Statistics Report" published by Information and Communication Technologies Authority. Based on these values, most realistic modeling environment was tried to create. In addition, the model assumes that no new customer enters the environment.

In the experimental phase of this study, model is processed for 36 months time period 100 times. Customers face to face to decide the best operator for themselves at the end of each month and according to the calculations in switching decision of customers that focuses on the utilities customer gain from each operator based on specific criteria and general values namely brand image and price policies. Due to the fact that all factors

that affect the switching behavior cannot be embodied in the model so that the results could be interpreted in reliability, all unpredicted effect are included in the model by adding probability to the model.

As a result, accuracy of model was tested by comparing the findings with real environmental values. After testing, effect of possible changes in price policies of GSM companies and switching cost which affects customers' switching behavior are analyzed by considering the churn rates and number of GSM subscribers.

The thesis is structured as follow: Chapter 2 introduce the GSM industry in Turkey and Agent Based Modeling approach and gives briefs about the GSM operator switching applications and Agent Based study related to GSM sector. Chapter 3 introduce thesis subject and problem definition and methodology that is used and modeling details. Chapter 4 shows the simulation experiment that is setting environment before the model is processed. Lastly, Chapter 5 simulation results shows findings of this study and assessment of the findings. Chapter 6 is conclusion part which explain the study briefly.

Chapter 2 : LITERATURE REVİEW

GSM Industry in Turkey

Turkey is one of the biggest GSM market in Central and Eastern Europe, the Middle East and Africa. The GSM market has been illustrate outstanding growth over the past years with the total number of consumers, 69.6 million, implying a 108.5% penetration rate (over 9 years old persons) as of 2013. (BTK, 2013) In this term, 59.5 % of the customers are prepaid and 40.5% are postpaid subscribers. According to number of customers, there are 3 companies in the mobile market where the leading company has 50.5% market share and the other two follows by 28.6% and 20.8%. (BTK, 2013)By December of 2013, 45% of Avea customers and 39.8% of Turkcell customers and 38.3% of Vodafone customers are postpaid subscribers. (BTK, 2013)90.9% of total number of subscribers are individual and 9.1% of them are corporate customers. (BTK, 2013) If it is necessary to mention about the traffic in GSM industry, number of SMS send at last three years is approximately 42 billion and the number of MMS send at the same term is approximately 38 million. By December, 2013, monthly usage (MoU) of Turkcell, Vodafone and Avea are respectively 275 min. 386 min. and 400 min. Also it can be said that with the value of 330 min. average mobile device usage time, Turkey has been the country that uses the mobile phone to speak at most around the Europe. The most significant improvement in Turkish GSM market was the application of Mobile Number Portability in November 2008. (Kutlu Bayraktar, 2013)After the usage of the way, rivalry between GSM companies has raised seriously. By the date of 14th February 2014, 65.218.031 customers changed their operators via "Mobile Number Portability" method.(Kutlu Bayraktar, 2013)

The most important consideration in GSM industry is churn rate. Churn rate is the percentage of subscribers to a service that discontinue their subscription to that service in a given time period. The yearly average churn rate of Turkcell, Vodafone and Avea are respectively 2.6,3.1 and 3.3 at 2013.(BTK, 2013)

Agent Based Modeling And Simulation

What is Agent Based Modeling?

First, "Agent Based Modeling is a version of computational social science."(Gilbert, 2008)"Computational simulations is rely on the idea creating simulations and then utilizing them to interpret the social environments and actions."(Sawyer, 2004)That is, it contains building models that are computer software. The concept of modeling is acquainted with most of the social sciences: Modeler designs some type of simplified representation of ‘‘social reality’’ that handle to express as much as possible the way in which modeler believes that actual states is processing.(Gilbert, 2008)

Agent Based Modeling is a way to make realistic assumptions about behavior, structure and timing. Through Agent Based Modeling, it can be illustrated individual basics of systems and their behaviors rather than defining the variable that represent the system completed. (Gilbert, 2008)In this approach, it is simulated system's individual agents that generally not only communicate with each other but also their surrounding environment. An agent might be animal, person, company or establishment. Each agent is individually different from others in terms of the values such as age, income, location, utility and resources. Communication in surrounding environment implies that agents interact with only the others in their neighbors not with the all agents in simulation. Additionally, agents are self-determining and they pursue their own objectives and act freely. Agent-based models can clearly simulate the complicity deriving from agent's independent behavior that happen in the actual world. Models turn into superior, more correct, if they make predicts that more exactly match the nature of actual word.(Railsback & Grimm, Agent-Based And Individual Based Modeling, 2012)

Agent-based models can be developed using general programming languages, or particularly designed languages (i.e. Net Logo) that consist frequently used tools of Agent Based modeling. Agent Based modeling has been used in an enormous diversity of fields such as; physic, biology, sociology, and management. Availability of collecting data, and computer science give opportunity to make an expanding number of Agent Based models inside different disciplines.(Railsback & Grimm, Agent-Based And Individual Based Modeling, 2012)

Advantages of Using Agent Based Modeling

- Agent Based Models are useful in that they are focuses on two levels and their interactions : they are used to look into not only what changes occurred in the system by reason of what is individuals do but also what happens to the individuals throughout the system processes and their results.(Railsback & Grimm, Agent-Based And Individual Based Modeling, 2012). This advantage is obviously significant in the model in that "the whole is more than the sum of its parts because of the interactions between the parts."(Bonabeau, 2002)

- ABMs are also generally distinct from traditional models in terms of being unsimplified such as illustrating how agents are, and the environmental variables that influence them, or other dimensions. ABMs often consist of processes that we know to be significant and also are too sophisticated to involve more basic simulations.(Railsback & Grimm, Agent-Based And Individual Based Modeling, 2012)

- Agent Based Model support modelers with the chance of simulating heterogeneity that signify it provides one to any numbers of agents that have various characteristics with differentiated variables(Badur, Karakaya, & Aytekin, 2011).

Development of Agent Based Models

ODD - Overview, Design Concepts and Details

In Agent Based Modeling process, we have three purpose to formulate an ABM. The first one is thinking clearly about all parts of the model. Secondly, it is important understanding of model by other colleagues. Thirdly, formulation is necessary for implementation of model.(Railsback & Grimm, Describing and Formulating ABMs: The ODD Protocol, 2012)

A common protocol is used universally to characterize ABM by agent-based modeler, ODD. Overview - Design Concepts - Details protocol has demonstrated beneficial not just for characterizing ABMs but also as a structure for considering about

the models as we shape them. (Railsback & Grimm, Describing and Formulating ABMs: The ODD Protocol, 2012)

ODD and Its Advantages

One well-known way to deal with formulation problems such as wordy mixture of factual description and lengthy justifications, explanations and discussions of all kinds is standardization. With the intention of gain advantage from standardization for ABMs a great group of skillful professionals established the ODD for defining ABMs. ODD is developed to build accurate model information that are comprehensive, effortless to comprehend and arranged to represent accurate and reliable information in a noncontradictory sequence. (Railsback & Grimm, Describing and Formulating ABMs: The ODD Protocol, 2012)

ODD has three fundamental elements namely *Overview, Design Concepts and Details.*

Overview explain what the model is about and how it is designed.

Design Concepts is about how the model implements a set of basic concepts that are standardized way to think about important characteristics of ABM.

Details consists of initialization, input data and sub-models.(Railsback & Grimm, Describing and Formulating ABMs: The ODD Protocol, 2012)

Table 2.1 Elements Of Overview Design Details Protocol

Elements of ODD Protocol	
Overview	1. Purpose
	2. Entities , State Variables and Scale
	3. Process Overview and Scheduling
Design Concepts	4. Design Concepts ✓ Basic Principles ✓ Emergence ✓ Adaptation ✓ Objectives ✓ Learning ✓ Prediction ✓ Sensing ✓ Interaction ✓ Stochasticity ✓ Collectives ✓ Observation
Details	5. Initialization
	6. Input Data
	7. Sub-models

Source:(Railsback & Grimm, Agent-Based And Individual Based Modeling, 2012)

GSM Applications Of Agent Based Modeling

Until today, many research about GSM sector and switching behavior of customers has been conducted. Some of these studies are based on the factors that affect switching such as customer loyalty, customer satisfaction and switching cost. Three of these studies is explained to illuminate these studies.

The Relation Between Customer Loyalty, Satisfaction And Switching Cost In GSM Sector

This study assert that customer switching cost is important to ensure customer loyalty. However, it is not possible to neither manage of this cost professionally nor eliminate it. The aims of this study is to improve a simulation by using different constructs of customer switching cost to analysis the relationship among customer loyalty, customer satisfaction. The data was obtained from GSM users via questionnaire. The results obtained from the data evaluated via exploratory and confirmatory factor analysis and significant relationship is found among variables as expected.(Aydın, Özer, & Arasil, 2005)

Customer Loyalty And The Effect Of Switching Costs As A Moderator Variable

In the GSM sector, customer loyalty is the fundamentals of saving customers and an important necessity to protect brand life in long term. To reach this goal, customer satisfaction and trust have to be measured and evaluated to identify switching cost. The main purpose of this study is to identify the accurate effects of customer satisfaction and trust on customer loyalty and indirect effect on switching cost on customer loyalty. As a result, according to the findings reached, switching cost factor directly affects loyalty and it has moderate effect on customer satisfaction.(Özer & Aydın, 2004)

Agent Based Modeling of GSM Consumer Behavior

The purpose of the study is to build virtual environment on Agent Based Modeling (ABM) of GSM operator users' attitude for simulation and so as to use the environment for evaluating, identifying and interpreting effects of marketing communication performance and reference group toward consumer behavior changes and its impact to acceptance rate of GSM companies in Indonesia. (Yasik, 2009)

"Consumer behaviors are influence by marketing effort from cellular operators and influence of group reference surrounding the consumers. Those influences are compare with internal threshold within consumer. If the external influence is higher than internal threshold there will be positive changing. However if the external influences are lower than internal consumer threshold there are no changing in consumer behavior. "(Yasik, 2009)

Chapter 3 : MODEL

Modeling The GSM Switching Behavior of Customers Using ODD Protocol

Purpose

The model was designed to analyze switching behavior of customers in the GSM sector through the Agent Based Modeling approach. In Turkey GSM sector, there are three main companies namely Turkcell, Vodafone and Avea. Almost all of the people who are older than nine are customers for one of these companies. The model in this project helps to understand switching process between three operators.

Entities, State Variables and Scale

The model has two kinds of entities namely customers and GSM operators.

Customers: Each customer is an agent in the model, each have specific values for the entity variables.

Table 3.1 Variables Related To Customer in Model

Variable	**Definition**
Customer's Operator Type	The operator that customer is subscribed for.
Customer's Income	Customer's monthly income.
Customer's Age	Customer's age.
Customer's Invoice Type	Payment type of the customer namely invoice-based or prepaid-based.
Customer's Last Operator Switching Time	The number of time steps that passed from last switching of customer from one operator to another.
Customer's Commitment Time	The commitment duration of customer with the operator.
Customer's Speech Demand	Customer's minute-based speech time in each time step.
Customer's Message Demand	Number of message that customer send in each time step.
Customer's Internet Demand	The amount of Internet usage of customer in terms of MB in each time step.
Significance Of Speech For Customer	The importance factor of speech for customer. It is different for each customer.
Significance Of Message For Customer	The importance factor of message for customer. It is different for each customer.

Significance Of Internet For Customer	The importance factor of internet for customer. It is different for each customer.
The Utility That Customer Gain From Turkcell	The utility that customer gain when using Turkcell. It includes speech, message and internet utilities.
The Utility That Customer Gain From Vodafone	The utility that customer gain when using Vodafone. It includes speech, message and internet utilities.
The Utility That Customer Gain From Avea	The utility that customer gain when using Avea. It includes speech, message and internet utilities.
The Switching Probability Of Customer To Turkcell	The switching probability of customer to Turkcell. It is calculated by using related utility.
The Switching Probability Of Customer To Vodafone	The switching probability of customer to Vodafone. It is calculated by using related utility.
The Switching Probability Of Customer To Avea	The switching probability of customer to Avea. It is calculated by using related utility.

GSM operators: There are three GSM operator namely Turkcell, Vodafone and Avea. These are not agents in the model and their characteristics hold as global variables.

Table 3.2 Variables Related To GSM Operator in Model

Variable	**Definition**
Number Of Turkcell Customer	Number Of Turkcell Customer
Number Of Vodafone Customer	Number Of Vodafone Customer
Number Of Avea Customer	Number Of Avea Customer
Prestige Of Turkcell	Brand image of Turkcell
Prestige Of Vodafone	Brand image of Vodafone
Prestige Of Avea	Brand image of Avea
Price Factor Of Turkcell	It symbolizes price factor of Turkcell
Price Factor Of Vodafone	It symbolizes price factor of Vodafone
Price Factor Of Avea	It symbolizes price factor of Avea
Churn Rate Of Turkcell	It is a measure of the number of Turkcell customers switching to another operator over a time step.

Churn Rate Of Vodafone	It is a measure of the number of Vodafone customers switching to operator another over a time step.
Churn Rate Of Avea	It is a measure of the number of Avea customers switching to another operator over a time step.
Churn Number Of Turkcell	It is a number of Turkcell customers switching to another operator over a time step.
Churn Number Of Vodafone	It is a number of Vodafone customers switching to another operator over a time step.
Churn Number Of Avea	It is a number of Avea customers switching to another operator over a time step.
Different Operator Switch Cost	The parameter that is symbolizes barriers to switching

Process Overview and Scheduling

Whereas the previous elements of ODD is about the structure about of a model, here we deal with dynamics: the processes that change the state variables of model entities.

The most important process in the model is customer's switching behavior between GSM operators on each time step. It depends on utilities that customers gain from operators.

This process occurs in a sequence like below:

1. For each customer, the model calculates total utility that consist of speech, message and internet utilities for each operator, prestige of operator and total switch cost for two operator which are not using by customer.
2. After utility calculation, the model calculates switching probability that depends on utilities for each customer and for each of operators via logit function.
3. Lastly customers change operator based on the probabilities calculated previous step.

Table 3.3 Variables And Abbreviations Used In Utility Formulas

Variables At Utility Formula	Abbreviations
Total Utility	Ut
Speech Utility	Us
Message Utility	Um
Internet Utility	Ui
Total Switch Cost	CostTotal
Different Operator Switch Cost	CostD
Age Cost	CostA
Income Cost	CostI
Commitment Cost	CostC
Last Time Changed Cost	CostL
Speech Demand	Ds
Message Demand	Dm
Internet Demand	Di
Significance of Speech	Ss
Significance of Message	Sm
Significance of Internet	Si
Price Factor Of Operator	Po
Brand Image of Operator	Bo

Utility Formula

Total Utility consists of Speech Utility, Message Utility, Internet Utility, Prestige of Operator and Total Switch Cost. In addition, Total Switch Cost consists of Different operator switch cost, Age Cost, Income Cost, Commitment Cost and Last Time Changed Cost.

TotalUtility

$$\boldsymbol{TotalUtility} = \begin{pmatrix}\boldsymbol{Speech}\\ \boldsymbol{Utility}\end{pmatrix} + \begin{pmatrix}\boldsymbol{Message}\\ \boldsymbol{Utility}\end{pmatrix} + \begin{pmatrix}\boldsymbol{Internet}\\ \boldsymbol{Utility}\end{pmatrix} + \begin{pmatrix}\boldsymbol{Brand}\\ \boldsymbol{image}\\ \boldsymbol{of}\\ \boldsymbol{Operator}\end{pmatrix} - \begin{pmatrix}\boldsymbol{Total}\\ \boldsymbol{Cost}\end{pmatrix}$$

$$\boldsymbol{Ut} = \boldsymbol{Us} + \boldsymbol{Um} + \boldsymbol{Ui} + \boldsymbol{Bo} - \boldsymbol{CostTotal}^{*}$$

*For the operator that customer is using at present, "CostTotal" is 0.

SpeechUtility

$$\boldsymbol{Speech\ Utility} = \left(\begin{pmatrix}\boldsymbol{Significance}\\ \boldsymbol{of}\\ \boldsymbol{Speech}\end{pmatrix} * \sqrt{\begin{pmatrix}\boldsymbol{Speech}\\ \boldsymbol{Demand}\end{pmatrix}}\right) - \left(\begin{pmatrix}\boldsymbol{Price}\\ \boldsymbol{Factor}\\ \boldsymbol{of}\\ \boldsymbol{Operator}\end{pmatrix} * \sqrt{\begin{pmatrix}\boldsymbol{Speech}\\ \boldsymbol{Demand}\end{pmatrix}}\right)$$

$$\boldsymbol{Us} = \left(\boldsymbol{Ss} * \sqrt{\boldsymbol{Ds}}\right) - \left(\boldsymbol{Po} * \sqrt{\boldsymbol{Ds}}\right)$$

MessageUtility

$$\boldsymbol{MessageUtility} = \left(\begin{pmatrix}\boldsymbol{Significance}\\ \boldsymbol{of}\\ \boldsymbol{Message}\end{pmatrix} * \sqrt{\begin{pmatrix}\boldsymbol{Message}\\ \boldsymbol{Demand}\end{pmatrix}}\right) - \left(\begin{pmatrix}\boldsymbol{Price}\\ \boldsymbol{Factor}\\ \boldsymbol{of}\\ \boldsymbol{Operator}\end{pmatrix} * \sqrt{\begin{pmatrix}\boldsymbol{Message}\\ \boldsymbol{Demand}\end{pmatrix}}\right)$$

$$\boldsymbol{Um} = \left(\boldsymbol{Sm} * \sqrt{\boldsymbol{Dm}}\right) - \left(\boldsymbol{Po} * \sqrt{\boldsymbol{Dm}}\right)$$

InternetUtility

$$\boldsymbol{InternetUtility} = \left(\begin{pmatrix}\boldsymbol{Significance}\\ \boldsymbol{of}\\ \boldsymbol{Internet}\end{pmatrix} * \sqrt{\begin{pmatrix}\boldsymbol{Internet}\\ \boldsymbol{Demand}\end{pmatrix}}\right) - \left(\begin{pmatrix}\boldsymbol{Price}\\ \boldsymbol{Factor}\\ \boldsymbol{of}\\ \boldsymbol{Operator}\end{pmatrix} * \sqrt{\begin{pmatrix}\boldsymbol{Internet}\\ \boldsymbol{Demand}\end{pmatrix}}\right)$$

$$\boldsymbol{Ui} = \left(\boldsymbol{Si} * \sqrt{\boldsymbol{Di}}\right) - \left(\boldsymbol{Po} * \sqrt{\boldsymbol{Di}}\right)$$

TotalSwitchCost

$$\boldsymbol{TotalSwitchCost} = \begin{pmatrix}\boldsymbol{Different}\\ \boldsymbol{Operator}\\ \boldsymbol{Switch}\\ \boldsymbol{Cost}\end{pmatrix} + \begin{pmatrix}\boldsymbol{Age}\\ \\ \boldsymbol{Cost}\end{pmatrix} + \begin{pmatrix}\boldsymbol{Income}\\ \\ \boldsymbol{Cost}\end{pmatrix} + \begin{pmatrix}\boldsymbol{Commit}\\ \boldsymbol{ment}\\ \\ \boldsymbol{Cost}\end{pmatrix} + \begin{pmatrix}\boldsymbol{Last}\\ \boldsymbol{Operator}\\ \boldsymbol{Switching}\\ \boldsymbol{Time}\end{pmatrix}$$

$$\boldsymbol{CostTotal} = \boldsymbol{CostD} + \boldsymbol{CostA} + \boldsymbol{CostI} + \boldsymbol{CostC} + \boldsymbol{CostL}$$

Utility formula includes Square roots of demands (speech, message, and internet) because consumer's utility don't increase linear when s/he consume more. By this way, this formula is used to calculate users' marginal utility that is the additional satisfaction that a user obtain from buying an additional unit of a minute, message or internet. The concept implies that the utility to a consumer of an additional part of a service is reciprocally related to the amount of services customer uses.(Marginal Utility, 2014)

In the Utility formula, square roots of demands times significance of demands (significance of speech, message, and internet) effects utility positively on the other hand square roots of demands times price factor of operator effects utility negatively. Price factor of operator and demand factors are significant parameters of the utility formula.

Two of the most important factors that effects consumer's utility are service quality and brand image. In this study, for the sake of simplicity, service quality and brand image of operator was combined in one and added to formula as a positive parameter.

Network and Running out of credit effect are not included in the model. It can be assumed that Network is a negligible effect because GSM companies serve customers with inter- operator speech and message tariffs which are the trends and having the same operator type is not as important as to locate this variable in formula. In addition to this, running out of credit and package is also minimal effect because GSM companies serve customers with top-up credit in a vast range of quantity.

Lastly, the formula contains "total switch cost" as a negative parameter. Total switch cost has 5 parts which are "different operator switch cost", "age cost", "income cost", "commitment cost" and "last time changed cost". This study assumes that when age and income increase switching cost are also increase so "age cost" and "income cost" parameters are parts of "total switching cost" related with age and income of customers. Commitment is making an agreement with GSM operator company up to one year in exchange for price advantages comes from the chosen tariffs. Commitment cost arises from reneging of a contract by customers. The cost would be maximum at 6th month because the customer have to pay the amount that is least for him/her and if reneging of contract realizes at 3th month of one year period the customer would pay only the real amount of first 3 month but after 8th, 9th, 10th, 11th months the customer would pay the campaign amount for remained commitment time.

"Different operator switch cost" is most important parameter of "total switch cost". It is same for all customers and it represents unknown parts of switching costs.

After finished utility calculation, switching probabilities was calculated for three of operators.

Table 3.4 Variables And Abbreviations In Probability Formula

Variables at Probability Formula	**Abbreviations**
Switching probability of Turkcell	Pt
Switching probability of Vodafone	Pv
Switching probability of Avea	Pa
Turkcell utility	Ut
Vodafone utility	Uv
Avea utility	Ua

Switching Probability Of Turkcell

$$\begin{pmatrix}\text{Switching}\\ \text{probability}\\ \text{of}\\ \text{Turkcell}\end{pmatrix} = \frac{\boldsymbol{exp}(\text{Turkcell utility})}{\boldsymbol{exp}(\text{Turkcell utility}) + \boldsymbol{exp}(\text{Vodafone utility}) + \boldsymbol{exp}(\text{Avea utility})}$$

$$Pt = \frac{e^{Ut}}{e^{Ut} + e^{Uv} + e^{Ua}}$$

Switching Probability Of Vodafone

$$\begin{pmatrix}\text{Switching}\\ \text{probability}\\ \text{of}\\ \text{Vodafone}\end{pmatrix} = \frac{\boldsymbol{exp}(\text{Vodafone utility})}{\boldsymbol{exp}(\text{Turkcell utility}) + \boldsymbol{exp}(\text{Vodafone utility}) + \boldsymbol{exp}(\text{Avea utility})}$$

$$Pv = \frac{e^{Uv}}{e^{Ut} + e^{Uv} + e^{Ua}}$$

Switching Probability Of Avea

$$\begin{pmatrix}\text{Switching}\\ \text{probability}\\ \text{of}\\ \text{Avea}\end{pmatrix} = \frac{\boldsymbol{exp}(\text{Avea utility})}{\boldsymbol{exp}(\text{Turkcell utility}) + \boldsymbol{exp}(\text{Vodafone utility}) + \boldsymbol{exp}(\text{Avea utility})}$$

$$Pa = \frac{e^{Ua}}{e^{Ut} + e^{Uv} + e^{Ua}}$$

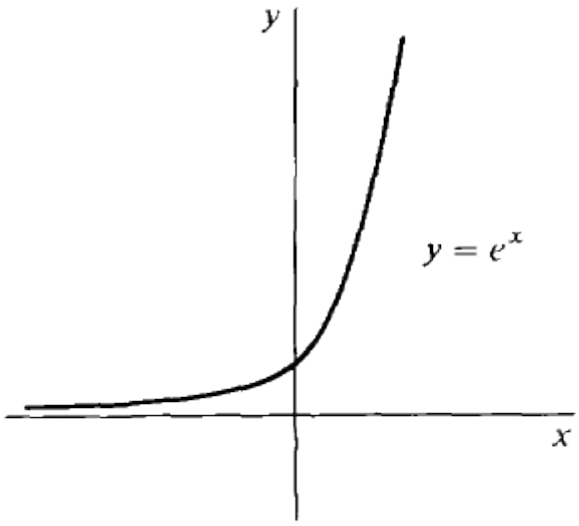

Figure 3.1 The graph of e^x function

At the end of the model customers' operator was changed according to their switching probability or they continue with their operator.

Design Concepts

- ✓ **Basic Principles**

The model assume that:

- Younger customers are more eager to switch their operators than older ones in that they keep the GSM operators' campaigns. Hence age is an important property in switching.
- Commitment duration is another important criteria because it prevents customers to switch their operators.
- The last time that customer switched affects the time next switch for customers would not want to change operators continuously.

- In order to set customer age and income variables beta distribution would be used in the model.
- To include of effects generated by unpredicted variables, after utility calculations multinomial logit function would be used and so probability is included in the model, as well.
- Utility that customers gains from operators' services is represented via $y=\sqrt{x}$ line would be used.
- Except from the criteria explained before, switching cost would be also considered.
- During the simulation, there would not be newcomers to the operators and total number of operator subscribers would be the same.

✓ **Emergence**

Most important result of the model is the churn rate of operators. Churn rate that is generated by the model and the real one are compared and by calibrating the model rational values of the agent properties are obtained. This result comes from the adaptive behavior of the agents in that each customer determines a new operator that match his/her wants and needs and then s/he switch from one to another or keep his/her state.

✓ **Adaptation**

Each customer determines a new operator that match his/her wants and needs and then s/he switch from one to another or keep his/her state.

✓ **Objectives**

In this model agents pursue different goals. For example, some of them want to talk more and use less internet and some other parts want to send more message than talking on the phone. However, all of them can be combined under the same aim which is finding the most suitable operator for them.

✓ **Stochasticity**

Stochasticity is used basically in switching behavior. After calculating switching probabilities based on utilities, customer can change his/her operator according to probabilities.

In addition, customer’s demands change in each time step. They can increase or decrease within the scope of a probability.

✓ **Observation**

To allow observation of number of customers for each GSM operator, model has variables to hold customer numbers that can be monitored from interface of model. In addition, to test the model, comparing churn rate with real values is important.

Table 3.5 Observation Variables

Churn Rate Of Turkcell	The real churn rate value of Turkcell is 2,6 as yearly average at 2013.
Churn Rate Of Vodafone	The real churn rate value of Turkcell is 3,1 as yearly average at 2013.
Churn Rate Of Avea	The real churn rate value of Turkcell is 3,3 as yearly average at 2013.

Initialization

The variables related to customers and operator are illustrated below with the setting values.

Table 3.6 Basic Variables Of Model

Basic Variables Of Model	Initialization
Number Of Customer	It is initialized as 1000 to represent the 69.661.108 GSM operator subscribers around the Turkey.
Operators	It is initialized as 3 to represent 3 GSM company in Turkey.
Number of months	It is initialized as 72. Model will run 72 times.

Table 3.7 Initialization Of Variables Related To GSM Operators

Variables Related to GSM Operators	Initialization
Number Of Turkcell Customer	The value of this variable is approximately 51% of total customers .
Number Of Vodafone Customer	The value of this variable is approximately 29% of total customers .
Number Of Avea Customer	The value of this variable is approximately 21% of total customers .
Prestige Of Turkcell	74,5
Prestige Of Vodafone	57,2
Prestige Of Avea	44,1

Price Factor Of Turkcell	1,572
Price Factor Of Vodafone	1,096
Price Factor Of Avea	0,87
Different Operator Switch Cost	2,7

Table 3.8 Initialization Of Variables Related To Customers

Variables Related to Customers	**Initialization**
Customer's Operator Type	0, 1 and 2 represent respectively Turkcell, Vodafone and Avea
Customer's Income	***There are 10 income groups:*** First group's income is between 850 and 2114 TL Second group's income is between 2114 and 3523 TL Third group's income is between 3523 and 4631 TL Forth group's income is between 4631 and 5739 TL Fifth group's income is between 5739 and 6937 TL Sixth group's income is between 6937 and 8296 TL Seventh group's income is between 8296 and 9760 TL Eighth group's income is between 9760 and 11880 TL Ninth group's income is between 11880 and 15505 TL Tenth group's income is between 15505 and 32420 TL The study assumes that income affects the total switch at the rate of 30 / income.
Customer's Age	***There are 4 age groups:*** First group : % 40 percent of customers. Age : Randomly between 10-30 Second group : %35 of customers. Age : Randomly between 30 - 50 Third group : %19 percent of people. Age : Randomly between 50-70 Forth group : %6 percent of people. Age : Randomly between 70 - 90 The study assumes that income affects the total switch at the rate of age / 10.

Customer's Invoice Type	0 or 1 represent post-paid and pre-paid
Customer's Commitment Time	It was set up for only postpaid customers randomly between 1 to 12
Customer's Last Operator Switching Time	For all customers this value is randomly between 1 to 36.
Customer's Speech Demand	Turkcell customer's speech demand: Randomly with normal distribution at average 186 minutes. Vodafone customer's speech demand: Randomly with normal distribution at average 271 minutes. Avea customer's speech demand: Randomly with normal distribution at average 260 minutes.
Customer's Message Demand	Turkcell customer's message demand: Randomly with normal distribution at average 140 minutes. Vodafone customer's message demand: Randomly with normal distribution at average 296 minutes. Avea customer's message demand: Randomly with normal distribution at average 221 minutes.
Customer's Internet Demand	There are 4 demand groups (no operator difference): First group : % 39,41 percent of customers. Internet Demand : 0 MB Second group : % 7,89 percent of customers. Internet Demand : 30 MB Third group : % 5,68 percent of customers. Internet Demand : 75 MB Forth group : % 9,72 percent of customers. Internet Demand : 175 MB Fifth group : % 21,48 percent of customers. Internet Demand : 625 MB Sixth group : % 14,16 percent of customers. Internet Demand : 2500 MB Seventh group : % 1,66 percent of customers. Internet Demand : 6000 MB
Significance Of Speech For Customer	This parameter was set up randomly between 0-1 for each customer
Significance Of Message For Customer	This parameter was set up randomly between 0-0,2 for each customer

Significance Of Internet For Customer	This parameter was set up randomly between 0-7 for each customer

Input Data

The environment can be changed by “price factors of operator”. “Price factors” are important variable for GSM operators. Customer’s behavior is affected by price. “Price factors” are initialized when model starts and can be changed when model runs. In addition to “price factors”, “different operator switch cost” is significant for customers. It can be changed when model runs, as well. These two parameters are input for the model.

Chapter 4 : SIMULATION EXPERIMENTS

Test Experiment

Testing the model to compare with the real values.

Table 4.1 Test Experiment

	REAL ENVIRONMENT VALUES	SETUP VALUES	EXPECTATION AFTER 36 MONTH	MODEL SHOULD SHOW FINALLY	MODEL RESULTS	DIFFERENCE(between the values that the **model should show** and the values that the **model results**)	DIFFERENCE RATIO
Total Customer	69.660.000	10000	69660000	10000	10000		
Turkcell Customer	35200000	5058	31942000	4585	4569	**-16**	-0,004
Vodafone Customer	19930000	2855	22678000	3256	3361	**105**	0,032
Avea Customer	14530000	2086	15040000	2159	2070	**-89**	-0,041
Turkcell Customer %	0,51	0,51	0,46	0,46	0,46	**0,0016**	---
Vodafone Customer %	0,29	0,29	0,33	0,33	0,34	**-0,0105**	---
Avea Customer %	0,21	0,21	0,22	0,22	0,21	**0,0089**	---
Turkcell Churn Rate	2,63	---	2,63	2,63	2,01	**0,6168**	---
Vodafone Churn Rate	3,06	---	3,06	3,06	3,08	**-0,0213**	---
Avea Churn Rate	3,34	---	3,34	3,34	3,34	**0,0004**	---
Change In Number Of Turkcell Customer	-1086000	---	-3258000	-473	-488	**-16**	---
Change In Number Of Vodafone Customer	916000	---	2748000	400	505	**105**	---
Change In Number Of Avea Customer	170000	---	510000	73	-16	**-89**	---

Text Experiment Explanation

Setup Values :The values which are set by model at start.

Expected After 36 Months :Expected values at real environment after 36 months if the customer number of operators changes at the same number at 2013

Model Should Show Finally : According to the Expectation After 36 Months assumption, the model should show the values at that column after the model processing is finished.

Model Results : The results that the model produces after 100 repetitions of the 36 time period.

Difference : The difference between the values that the model should show and the values that the model shows.

Difference Ratio : Ratio of difference between the values that the model should show and the values that the model shows to total 10000 customers.

%10 Price Increase Experiment

If 3 operators increase prices 10 %

Table 4.2 10 % Price Increase Experiment

	SETUP VALUES	MODEL RESULTS WİTH CURRENT PRICE	MODEL RESULT WİTH %10 PRICE INCREASE	DIFFERENCE (between the values that the **current price results** and the values that the **%10 price increase results**)	DIFFERENCE RATIO
Total Customer	10000	10000	10000		
Turkcell Customer	5058	4569	3697	**-872**	**-0,19**
Vodafone Customer	2855	3361	3653	**292**	**0,09**
Avea Customer	2086	2070	2650	**580**	**0,28**
Turkcell Customer %	0,51	0,46	0,37	**-0,0872**	---
Vodafone Customer %	0,29	0,34	0,37	**0,0292**	---
Avea Customer %	0,21	0,21	0,26	**0,0580**	---
Turkcell Churn Rate	---	2,01	2,51	**0,5012**	---
Vodafone Churn Rate	---	3,08	2,99	**-0,0957**	---
Avea Churn Rate	---	3,34	2,96	**-0,3777**	---
Change In Number Of Turkcell Customer	---	-488,98	-1361	-872	---
Change In Number Of Vodafone Customer	---	505,66	798	292	---
Change In Number Of Avea Customer	---	-16,68	563	580	---

%10 Price Decrease Experiment

If 3 operators decrease prices 10 %

Table 4.3 10 % Price Decrease Experiment

	SETUP VALUES	MODEL RESULTSWİTH CURRENT PRICE	MODEL RESULT WİTH %10 PRICE DECREASE	DIFFERENCE (between the values that the **current price results** and the values that the **%10 price decrease results**)	DIFFERENCE RATIO
Total Customer	10000	10000	10000		
Turkcell Customer	5058	4569	5453	884	**0,19**
Vodafone Customer	2855	3361	3009	-352	**-0,10**
Avea Customer	2086	2070	1538	-532	**-0,26**
Turkcell Customer %	0,51	0,46	0,55	0,0884	---
Vodafone Customer %	0,29	0,34	0,30	-0,0352	---
Avea Customer %	0,21	0,21	0,15	-0,0532	---
Turkcell Churn Rate	---	2,01	1,61	-0,4061	---
Vodafone Churn Rate	---	3,08	3,29	0,2094	---
Avea Churn Rate	---	3,34	3,83	0,4939	---
Change In Number Of Turkcell Customer	---	-488,98	395	884	---
Change In Number Of Vodafone Customer	---	505,66	153	-352	---
Change In Number Of Avea Customer	---	-16,68	-548	-532	---

%20 Different Operator Switch Cost Decrease Experiment

If "different operator switch cost decrease"

Table 4.4 20 % Different Operator Switch Cost Decrease Experiment %20

	SETUP VALUES	MODEL RESULTS WİTH CURRENT PRICE	MODEL RESULT WİTH %10 DİFFERENT OPERATOR SWİTCH COSTDECREASE	DIFFERENCE (between the values that the**current price results** and the values that the **%10 Different Operator Switch Cost decrease results**)	DIFFERENCE RATIO
Total Customer	10000	10000	1000		
Turkcell Customer	5058	4569	4582	13	**0,0028**
Vodafone Customer	2855	3361	3352	-9	**-0,0026**
Avea Customer	2086	2070	2066	-4	**-0,0019**
Turkcell Customer %	0,51	0,46	0,46	0,0013	---
Vodafone Customer %	0,29	0,34	0,34	-0,0009	---
Avea Customer %	0,21	0,21	0,21	-0,0004	---
Turkcell Churn Rate	---	2,01	2,37	0,3576	---
Vodafone Churn Rate	---	3,08	4,08	1,0000	---
Avea Churn Rate	---	3,34	4,00	0,6576	---
Change In Number Of Turkcell Customer	---	-488,98	-476	13	---
Change In Number Of Vodafone Customer	---	505,66	497	-9	---
Change In Number Of Avea Customer	---	-16,68	-21	-4	---

Chapter 5 : SIMULATION RESULTS

Findings and Assessment of Results

The “Test Experiment” at table 4.1 in chapter 4 shows that the model can operate like the real environment. Real churn rates of Turkcell, Vodafone and Avea are respectively 2.62, 3.06, and 3.34, results of model are 2.01, 3.08, 3.34 and difference are 0.61, -0.02, 0.0004. In addition, Ratio of difference between the values that the model should show and the values that the model shows for total 10000 customers are -0.004, 0.032, -0.041 for Turkcell, Vodafone and Avea. This results show that the model can simulate customer switching behavior.

The “%10 Price Increase Experiment” at table 4.2 in chapter 4 shows that if operators increase prices %10, how chance churn rates and number of customers of operators. If operators increase prices %10, churn rates of Turkcell, Vodafone and Avea turn to respectively 2.51, 2.99, and 2.96. In addition, we expect that number of customers of costly operator should decrease and number of customers of cheap operator should increase. Model produce results like the expectation. Turkcell, Vodafone and Avea’s number of customers change at ratio -0.19, 0.09, and 0.28 by comparison models current price results.

The “%10 Price Decrease Experiment” at table 4.3 in chapter 4 shows that if operators decrease prices %10, how chance churn rates and number of customers of operators. If operators decrease prices %10, churn rates of Turkcell, Vodafone and Avea turn to respectively 1.61, 3.29, and 3.83. In addition, we expect that number of customers of costly operator should increase and number of customers of cheap operator should decrease. Model produce results like the expectation. Turkcell, Vodafone and Avea’s number of customers change at ratio 0.19, -0.10, -0.26 by comparison models current price results.

The “%20 Different Operator Switch Cost Decrease Experiment” at table 4.4 in chapter 4 shows that if switching cost for operator changing decrease %20, how chance churn rates and number of customers of operators. Churn rates of Turkcell, Vodafone and Avea turn to respectively 2.37, 4.08, and 4.00. In addition, Turkcell, Vodafone and Avea’s number of customers change at ratio 0.0028, -0.0026, -0.0019 by comparison models current price results. This low rates indicate that making operator switching easy does not affect much number of customer of operators.

Chapter 6 : CONCLUSION

The thesis is prepared to simulate and assess the switching behavior of GSM subscribers from one GSM operator to another in certain conditions. In order to model the most actual environment and actions, Agent Based Modeling approach is choosed because of its proper modeling techniques that is named Overview - Design - Details protocol. This study is fundamentally concentrated on utility calculation that comes from customers selection of best GSM operator for themselves in the consideration of certain parameters related to user profile and GSM operator.

To explain why Agent Based Modeling approach is used for the thesis it can be said that Agent Based Modeling allows to simulate environments whose elements/agents follow different aims from each other and in this environment, each user tries to select the best GSM company based on their values. Thus, this modeling technique highly suitable for this study. Another pros of Agent Based Modeling is to take network effect into consideration but in GSM sector, because of the advantages that minimize the cost stemming from communication between different operators, the network effect is decreased and it is evaluated as negligible.

In this model, user profiles is created based on the data launched by governmental agencies. By building user profiles age and income distribution values are acquired from Turkish Statistical Institute. Other user parameter values namely operator type (Turkcell, Vodafone, Avea) and invoice type (pre-paid, post-paid) and customer demand for speech, message and internet are obtained from Information And Communication Technologies Authority. Based on these values, most realistic simulation environment was tried to build.

In the experimental phase of the thesis, model is executed100 times and each of them takes 36 months time period for 4 experiment. First experiment to test accuracy of model, other two for to analyze effects of price changes and last one for analyze the effects of switching cost changes. Customers face to face to choose the best operator for themselves at the end of each month and based on the calculations in switching decisionof users that focuses on the utilities customer obtain from each operator based on specific criteria and general values namely brand image and price policies. Due to the fact that all criteria that affect the switching cannot be included in the model so that the results could

be evaluated in reliability, all uncontrolled factors are embodied into the model as switching cost to different GSM operator.

As a result, accuracy of model was tested by comparing the findings with real environmental values. After testing, effect of possible changes in price policies of GSM companies and switching cost which affects customers' switching behavior are analyzed by considering the churn rates and number of GSM subscribers.

REFERENCES

Aydın, S., Özer, G., & Arasil, Ö. (2005). Customer loyalty and the effect of switching costs as a moderator variable. *Marketing Intelligence & Planning, 23*, pp. 89-103.

Badur, B., Karakaya, Ç., & Aytekin, C. (2011). Analyzing the Effectiveness of Marketing Strategies in the Presence of Word of Mouth: Agent-Based Modeling Approach. *Journal of Marketing Research and Case Studies, 2011* .

Bonabeau, E. (2002). Agent-based Modeling: Methods and Techniques for Simulating Human Systems. *Proceedings of the National Academy of Sciences of the United States of America*, 7280-7287.

BTK. (2013). *TÜRKİYE ELEKTRONİK HABERLEŞME SEKTÖRÜ - Üç Aylık Pazar Verileri Raporu - 2013 Yılı 4. Çeyrek.* Bilgi Teknolojileri ve İletişim Kurumu.

Gilbert, N. (2008). *Agent-Based Models.* Sage Publications Inc.

Kutlu Bayraktar, B. (2013, November). Effects of Mobile Number Portability: Case of Turkey. *International Journal of Business and Social Science*, pp. 120-124.

Marginal Utility. (2014). Retrieved 05 10, 2014, from Encyclopaedia Britannica Online: http://www.britannica.com/EBchecked/topic/364750/marginal-utility

Özer, G., & Aydın, S. (2004, September). Gsm Sektöründe Müşteri Sadakati Memnuniyeti Değiştirme Maliyeti Ve Güven Arasindaki İlişki. *İktisadi ve İdari Bilimler Dergisi*, pp. 157-178.

Railsback, S. F., & Grimm, V. (2012). *Agent-Based And Individual Based Modeling.* Princeton University Press.

Railsback, S. F., & Grimm, V. (2012). *Agent-Based And Individual Based Modeling.* princeton University Press.

Railsback, S. F., & Grimm, V. (2012). Describing and Formulating ABMs: The ODD Protocol. In S. F. Railsback, & V. Grimm, *Agent-Based And Individual Based Modelling* (pp. 35-45). Princeton University Publications.

Sawyer, R. K. (2004). Social Explanation And Computational Simulation. *Philosophical Explorations*, 219-231.

TUIK. (2013). *Gelir, Tüketim Ve Yoksulluk İstatistikleri.* TUIK.

TUIK. (2013). *Yaş Grubu Ve Cinsiyete Göre Nüfus.* TUIK.

Yasik, Y. L. (2009, 11 5). *NetLogo User Community Models.* Retrieved 05 06, 2014, from Northwestern Institute on Complex Systems: http://ccl.northwestern.edu/netlogo/models/community/customerBehavior