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System dynamic market models for mobile services

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Title:	System dynamic model for mobile services
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Problem description:

In mobile markets, customers may churn between different service providers; that is, the customer may buy the service from one service provider for some period of time for thereafter to buy the service from another provider.

In this project the task is to develop a system dynamic model for the temporal evolution of competing service providers in the mobile phone market taking into account adaptation of new customers and churning of existing customers between mobile service providers. The student will explore empirical data for churning. The purpose of the model is to develop a tool by which different types of churning behavior can be studied in order to predict the future of these markets.

Work plan:

- Explore empirical data for churning, and what happens in the mobile marked when we have churning.
- Continue the development of a model to study the churning behavior between a limited number of mobile service providers using analytical tools and simulation models.

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Abstract

The mobile service market has gone through a major change in the last several years. The market has evolved from a traditional monopolistic situation to a situation with a variety of different service providers. The competition in the mobile service market has grown at an exceptional rate in the past several years, and customers can now freely migrate form one service provider to another. With fewer new subscribers to sign up for mobile services, managing customer churn has become one of the most critical challenges for the mobile service providers. The focus has now switched from acquiring new customers to rather retaining existing ones. The aim of this paper is to study the competition between mobile service providers, and examine different types of churning behavior in order to predict the future of the market.

In particular, the study looks at what happens in the mobile service market when we have churning. Customer churning behavior plays an important role in the market, and in order to predict the future of the mobile service market, it is critical to understand what drives customers to churn. This study, investigates different churning determinates that affects the churning behavior. The research also includes network effects and word-of-mouth effect.

The study proposes a model, called the Competitive Mobile Service Model (CMSM), to model the competition between service providers in the mobile service market. The model is taking into account the adoption of new customers and churning between mobile service providers. The CMSM model was implemented in AnyLogic with system dynamics, and tested with three different scenarios to analyze the temporal evolution of the mobile service market.

The main findings in this study show that churning in the market matters, and the churning rate significantly affects the temporal evolution of adopters in the mobile service market.

Sammendrag

Mobil tjenestemarkedet har gått igjennom en stor endring de siste årene. Markedet har utviklet seg fra en tradisjonell monopol situasjon til en situasjon med ett mangfold av forskjellige tjenesteleverandører. Konkurransen i mobiltjeneste markedet har vokst med en eksepsjonell stor fart de siste årene, og kunder kan nå fritt gå fra en leverandør til en annen. Med færre nye abonnenter til å kjøpe mobiltjenester har administrering av kundeavgang blitt en av de mest kritiske utfordringene for leverandørene. Fokuset har endret seg fra å prøve å få nye kunder, til heller å beholde de eksiterende. Formålet med denne artikkelen er å studere konkurransen mellom mobiltjenesteleverandører, og utforske forskjellige typer kundeoppførsel for å forutse fremtiden til markedet.

Denne masteroppgaven prøver å se på hva som skjer i mobiltjeneste markedet når vi har churning. Oppførselen til kundene spiller en stor rolle i markedet og for å kunne forutse fremtiden til markedet er det kritisk å forstå hva som gjør at kunder bytter leverandør. Denne oppgaven undersøker forskjellige årsaker som påvirker churning. Forskningen utforsker også nettverkseffekter og WOM effekter.

En modell som kalles Competitive Mobile Service Model (CMSM) blir utviklet og presentert for å modellere konkurransen mellom tjenesteleverandører i markedet. Modellen ser på både adopsjonen av nye kunder og churning mellom tjenesteleverandørene. CMSM modellen ble implementert med systemdynamikk i AnyLogic og ble testet med tre ulike scenarioer for å analysere utviklingen i mobiltjeneste markedet.

Hovedfunnene i masteroppgavene viser at churning er viktig, og at churning-satsen påvirker utviklingen av kundene i markedet i stor grad.

Preface

This paper is the final product of the work I have been doing for my master thesis, TTM4905, during the spring of 2016. The master thesis is an obligatory part of my five-year program studying for a Master of Science in Communication Technology with specialization in Digital Economy. The work has been carried out at the Department of Telematics at the Norwegian University of Science and Technology (NTNU).

I would like to thank my supervisor and responsible professor Jan Arild Audestad for his guidance in modeling work, and assistance through meetings and e-mails. This has been very helpful. Your expertise in the field has been most appreciated. Your feedback and quick answers has been helping me a lot and made a big difference. It is highly appreciated.

August 9, 2016
Kristoffer Skuggedal

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Chapter 1
Introduction

This chapter will provide the motivation of the problems for the master thesis, and give a general introduction to the relevant topics for this paper. It will start by providing some understanding about why the topics matters, and give some information about churning in the mobile service market. It is then followed by the discussion of the main contributions of this thesis and an overview of the methods that is used to complete this study. The chapter ends with an outline of the rest of the paper.

1.1 Motivation

It is the end of the monopolistic era in the mobile service market. The market has elapsed from a traditional one-provider market, to a market where customers can choose among a variety of different service providers and exercise their rights of switching from one provider to another [26]. The competition in the mobile service market has grown at an exceptional rate in the past several years and mad it possible for customers to be discerning. In the competitive market, customers demand tailored products and better services at lower prices. The search for better rates and services has become an important factor for customers, and many customers are frequently switching from one provider to another.

The biggest revenue leakages in the telecommunication industry are the increasing numbers of customers that is churning. In telecommunications customer churning is the process where the customers move to a competitor in the market [27]. The annual churn rate ranges from 20 % to 50 % in most of the global mobile service providers companies [17]. Retaining customers has become one of the most critical challenges in the maturing mobile telecommunication service industry [17]. It is stated that it is much cheaper to retaining an existing customer than to acquiring a new one [18], so the focus has now switched form acquiring new customer to rather retaining the existing ones.

Since the major source of profit for mobile service providers are customers, customer churn plays a significant role in the survival and development of the telecommunication industry [20]. The importance of studying churning behavior and detect such customers well in advance has become very important since such customers creates an undesired financial burden for the service provider. Therefore, it is important to study the evolution of the market and to predict the future of the mobile service market where we have adoption and churning between different service providers.

1.2 Problem Statement

In mobile service markets, customers may churn between the different providers in search for better services and rates. That is, the customer may subscribe to a service provider for some period of time for thereafter subscribe to another provider. In order to predict the future of the mobile service market it is important to study the churning behavior of customers in the market. Churning is a costly process, where it is stated that the cost of acquiring new customers is far more than retaining existing ones [20].

The temporal evolution of competing service providers in the mobile service market must taking into account both the adaption of new customers and churning of existing customers between mobile service providers. In the early stages of the mobile service market, the focus was on acquiring new customers, but in the last several years the focus has switched to rather retaining the existing ones.

In Norway, the mobile service market has elapsed from a monopolistic situation, with Telenor as the only service provider, to a situation with a variety of different service providers. The competition has grown at an exceptional rate in the past several years, and the growth in the mobile service market is not only due to the greater number of customers, but also the greater variety of services that are offered.

Due to the variety of different service providers, customers can now freely choose the best suitable service provider and benefit from signing up with a new carrier (e.g. such as receiving the latest cellular phone) [6]. It is estimated that the average churn rate for mobile service providers is 2.2 % per month, so the effects from churning has a big influence on the mobile service market. Customer churn is a big concern for telecommunication service providers due the cost of losing customers [19]. It has become a common problem for mobile service providers, because it reduces the company's probability and hurts the brand image of the company [21].

1.3 Contributions

In response to the problem statement set above, this report proposes information to get a better understanding of what happens in the mobile service market when we have churning. Where there is competition in the market, customers can freely migrate from one service provider to another for many reasons. Being able to manage customer churn is an important factor for the service providers. This study investigates churning prediction and reasons for customer churn in the mobile service market.

The main contribution of this study is the design of the proposed CMSM model. With the CMSM model it is possible to study the future of the mobile service market using different scenarios and parameters. What makes the model unique is that it can simulate the competition in the mobile service market, while including adoption and churning between different service providers. By using the model it is possible to identify and measure the effects of both spontaneous and simulated churning, where there is market feedback or not. The CMSM model is implemented using system dynamics and tested using several scenarios. The scenarios were designed to test the strength of different types of churning in the market.

1.4 Method

The work done in this master thesis was completed in four different phases. Gathering information, developing the CMSM model, implementing the model using system dynamics, performing simulations, analyzing and presenting the thesis. The phases was performed in the order below, but was revisited at least once as the work was done in a iterative manner.

1. The fist phase consisted of gathering background information and gaining knowledge about the topic and relevant fields. To get a better understanding of how to market worked, the phase included research about the mobile service market and information about customer churning. More precisely, get an understanding of why customers churn, and then gathering knowledge on how to predict churning. Additionally, an understanding of existing simulation and analytical tools and models, which included the Bass diffusion model.

2. The second phase consisted of developing the Competition Mobile Service Model (CMSM), including examination of relevant effects and parameters for the model. The work and developing of the model in the second phase naturally depended on the knowledge obtained in phase one.

3. The third phase consisted on building the CMSM model with system dynamics. This included creating causal loop diagrams and implementing the model using

AnyLogic software. Additionally, simulations were performed with three main scenarios to test the model.

4. The fourth and last phase consisted on analyzing the results through the different scenarios in phase three. Then the rest of the work consisted of writing the report. This included structuring the information in a logically way.

1.5 Limitations

The CMSM is a simplified model for the temporal evolution of the mobile service market based on system dynamics. In this model, only competitions between three and four providers are studied, and it is based on a few basic parameters to give a general evolution of the market. The real market is of course much more complicated, with more service providers and many more parameters. In order to fully reproduce the behavior of the market, a lot of other considerations must be included. In the model there is also no quitting, which means that after a customer have adopted the market, it will never leave. This is of course possible in the real market, although in the reality in today's world when a customer starts using a mobile phone, he will never quit using it. However, a general model for the mobile service market is achieved and it will predict some of the behavior of the market. The most important is that the model analyses the competition between service providers with adoption and churning coefficients.

1.6 Report Outline

The remaining of the report is structured as followed. Chapter 2 provides the relevant background theory that this thesis is based on. This includes information about churning, the mobile service market, network effect, Word-of-Mouth (WOM), and the Bass diffusion model. Chapter 3 provides the related work, including studies about churning in dynamic market models, diffusion models, and how to utilize system dynamics. Chapter 4 provides information about churning in the mobile service market. The chapter introduces the churn business problem, and presents information about why customer is churning, how to reduce it, and how to predict churning in the mobile service market. Chapter 5 introduces the Competitive Mobile Service Model (CMSM), and presents a detailed description of the relevant components and functions that is used in the model. Chapter 6 presents how to CMSM model was implemented using system dynamics, including some scenarios to test the model. The chapter also presents the development in AnyLogic, and causal loop diagrams are created. Chapter 7 presents the results that where obtained in the scenarios from chapter 6, including analysis of the results. In chapter 8 the results are discussed, as well as further discussions and improvement points related to the model. Chapter 9

outlines some of the future work within the same field of study, and finally, chapter 10 concludes the work done in this thesis.

Chapter 2
Background

This chapter presents information about the mobile service market and basic concepts that is used in this paper. It starts by explaining the concepts of churning in the mobile service market, including some of the relevant terms to get a better understanding. It also elaborates how relevant terms like network effect affects the mobile service market, and how Word-of-Mouth (WOM) effect can change the subscribers' decisions. It also presents information about the underlying model that is used in this paper, the Bass diffusion model. This background study will provide a basis to get a better understanding if the ideas that is presented in the next chapters.

2.1 Churning

Churning is when a customer changes from one supplier to another. If there are more than one suppliers of a good or service, churning may take place. Churning may be spontaneous or stimulated. In spontaneous churning the probability that a customer changes from a supplier to another is independent of the behavior of other customers in the market. This means that there is no feedback from the market that affects the behavior of the churning customers. Stimulated churning means that a customers churning behavior depends on the behavior of other customers in the market, which means that the behavior depends on market feedback. A supplier could experience that both spontaneous and stimulated churning may take place at the same time [4].

Churn is a big problem for any supplier of a subscription service or a service that require recurring purchases. It is shown that the cost of acquiring new customers is much higher than retaining existing ones [35]. Managing and retaining customers is one of the most critical challenges for the mobile telecommunications service industry. Especially those who have invested a lot on the subscriber site in the network [5].

Many customers frequently churn from one supplier to another in search for better rates and services [6]. There are several determinants why users change suppliers, but the most common reasons are as follows:

- Price differences: Customers are very pricing sensitive. The customer would most likely choose the cheapest option if the product is the same.
- Attractive offers for new customers (free devices): A new supplier could use attractive offers to attract new customers.
- Unsatisfying service: Customer is not pleased with the service, and is tempted by better services from other suppliers.

Churning in the mobile service market is discussed further in chapter 4.

2.2 Mobile Service Market

2.2.1 The evolution in the market

It is the end of a monopolistic era in telecommunication services. The situation has from a single provider situation evolved to a situation with many different providers. This means that customers can now freely migrate from a one provider to another. In Norway, the competition in the mobile service market started in 1985, when the Norwegian government advocated free competition between Televerket (Telenor) and private companies for the delivery of various telecommunication services. Until 1985, the Norwegian Televerket had monopoly on telecommunication services. The intention of the decision was to make free competition, which would benefit the customers [8]. In 1994, Netcom became the first competitor with the developing of the GSM network.

After Telenor´s monopoly was revoked, different service providers attempted to enter the market, but it was difficult to get started. One of the reasons was the high price of interconnection from Telenor, which made it almost impossible to enter the market. In 1996, Tele 2 tried a new strategy to acquiring customers from Telenor by launching “Dial up Internet”. The goal was to get customers from Telenor to call Tele 2´s model pool, and by doing this they could charge high prices from Telenor and force Telenor to change their own interconnection prices. With low starting prices and “free” modems Tele 2 quickly obtained many customers, and Telenor had to change their interconnection prices [9].

Today, the market consists of both network service providers and Mobile Virtual Providers (MVNO). Mobile Virtual Provider is a service provider that does not own its own infrastructure, but receives instead connection and bandwidth from existing network service providers. New providers can then enter the market without investing a lot of finances in new infrastructure. This is to achieve more competition in market, which would benefit the customers with better prices and services.[10][11]

2.2.2 Competition

The competition in the mobile service market has grown at a remarkable rate in the past several years. From a traditional monopolistic situation with only one provider, customers can now choose in a variety of different service providers. The growth in the mobile service market is not only due to the greater number of customers and subscribers, but also the greater variety of different services that are offered such as short message service (SMS) and Internet. In the mobile service market the focus has now switched from acquiring new customers to retaining existing ones now as the market has matured. Acquiring customers in todays market often means taking them away from other competitors, which requires much more effort to make those switch. Therefore it is shown that retaining existing customers is much cheaper and makes more sense financially for an organization than to focus on acquiring new customers [7]. Churning and competition in the mobile service market is discussed further in chapter 4.

2.3 Network Effect

A network effect is a phenomenon where the value of a good or service depends on the number of people who are using it. Consumers are afraid of uncertainty and are therefore more likely to be influenced by other choices [29]. Usually, network effects are positive, where the value of the good or service increases as the number of users increases, but network effects could also be negative.

Network effect is certainly very relevant in the mobile service market. In a mobile service market the value of the network increases with the number of subscribers. The more people who subscribe to a service provider, the more the service provider can invest in the network. This will in example result in better service, coverage, availability, and prices, for the subscriber, and again increase the value of the network.

This was maybe even more relevant in the mobile service market some years ago. In the early stages of the market there were different prices for the subscribers when calling inside the network, than calling to another network. In the presence of this situation, mobile service subscribers would prefer to choose the provider with the largest number of users [30].

2.3.1 Positive Network Effect

A positive network phenomenon by which a good or service becomes more valuable when more people are using it [2]. Social media and telephones are examples of good examples where we have positive network effects. The value to a potential customer depends on how many others who are using the same service. The effect is often referred to as a direct network effect.

Figure 2.1 shows a simple example of a direct telephone- or Internet network. The figure illustrates how the number of connections increases rapidly with the number of users that are connected to each other. It shows that two users can make only connection, where four users can make 6 connections, and where 8 users can make 28 connections. The positive correlation between users and connections clearly illustrates how positive network effects occur.

Figure 2.1: Network effect in a telephone- or Internet network

2.3.2 Negative Network Effect

If too many people use a service or good, negative network effect could occur. Negative network effect is an effect that reduces the value of a good or service. Regarding Internet and telecommunication, congestion is an example of a negative network effect. If too many users use a network with limited bandwidth, this could lead to congestion and break down in the network. This scenario would decrease the users utility and the value of the service, and negative network effect occurs. [2]

2.4 Word-Of-Mouth (WOM)

Word-of-Mouth (WOM) is often described as the process of transferring information from one person to the other through oral communication [41]. WOM effect is a universal phenomenon in most industries, and has become a key role in a variety of environments such as viral marketing and churn prediction [42]. It has become one of the most important and effective communication channels [41]. The principle of WOM is based on the fact that after a customer adopts a service or product, they are always inclined to tell their friends abouth their experiences [43]. This effect could then influence the information receivers' consumption behaviors. The passing of information is non-commercial communication, which means that the person is

personally motivated in doing so, and not rewarded for his or hers actions. Customer satisfaction, trust and brand commitment is examples of some of the factors that helps drive WOM.

Word-of-mouth is an old concept where a person shares his view with another person, and studies shows that that word-of-mouth can have a strong influence on the psychology of the person. [41] The influence can have both positive and negative aspects. Positive WOM increases the likelihood that a customer adopts a service or product, while negative WOM does the reverse. It is shown that people like to share their negative experiences more than the positive ones; so its much more negative WOM conversations in the market. The high presence of negative WOM often occurs as a major problem for the markets. WOM often involves the major brand organizations, and each day over Americans take part in over 3,5 millions WOM conversations. [41]

The impact on the receiver is known as WOM effectiveness. This could be categorized into two factors: the WOM´s reach and the WOM´s impact. The WOM´s reach is the total number of receivers a person reaches with its communication, while the WOM´s impact is the fraction of the number that is affected by the information. For example, a person talks about and recommends his service provider to his friends, family and coworkers. The number of people receiving the information is the WOM´s reach, and the people who actually switched service provider due to the conversation is the WOM´s impact.

2.5 Bass Diffusion Model

The Bass diffusion model was developed by Frank M. Bass and was first published in Management Science in 1969 [1]. The model describes the process of how products are adopted in a given population. The model explains how early adopters of a new product and potential adopters of the new product influence each other. It uses basic assumptions about market size and behavior of potential new adopters to study and forecast the evolution of the market.

Consumers in a classic Bass diffusion model are divided into two categories: innovators and imitators [44]. Innovators are consumers who decide to adopt a new product without any influence of the number of previous adoptions. Imitators are consumers who decide to adopt a new product or service influenced by other people's prior decisions. When we have imitators in the system it is stated in the model that the more people taking about a product or service, the more other people in the social system will adopt [40]. The key assumption made in the Bass diffusion model is that the adoption of new product or service are driven by WOM communication between existing consumers and those who have not yet adopted it.

With only one supplier, the Bass diffusion model has the basic form:

$$\frac{dA}{dt} = (N - A)(p + qA) \tag{2.1}$$

where N is the total number of potential adopters in the market, dA/dt is the number of adopters per time unit, A is the total number of people having adopted the product at time t, p is the coefficient for innovation, and q is the coefficient for imitation. [1]

Chapter 3
Related Work

This chapter introduces some of the related work that was studied during the work of this thesis. The work done in this thesis builds on papers that were relevant for the subject. The subjects include: diffusion models, churning in dynamic market models, utilizing system dynamics, and churning analysis in mobile telecommunication.

3.1 Churning in Dynamic Market Models

In relation to churning in dynamic market models, Jan Audestad [4] studied the behavior of markets using models expressed as ordinary differential equations. The markets that are considered in the study are markets where each customer buys at most one copy of a good or service. In the mobile service market customers only subscribe to at most one telecommunication provider, which makes these models suitable for this thesis. The underlying model is the Bass diffusion model, where two types of customers are described: innovators and imitators.

This thesis builds on the equations that are defined in Audestad´s research. The research introduces a churning function, which includes both spontaneous and stimulated churning. Spontaneous churning means that the probability of churning is independent of other customer´s behavior, while stimulated churning means that the behavior depends on the behavior of other customers. This thesis utilizes also the periodic churning coefficients that are described in the paper to study oscillating churning.

3.2 Diffusion Models

Diffusion models have traditionally been used in marketing for capturing the lifecycle dynamics of a new product, for forecasting the demand for a new product, and as a decision aid when making pre-launch, launch and post-launch strategic choices [23]. A diffusion model describes how the sale of new product will become adopted by

a social system over time as awareness flows through the communication channels [24]. Since the sale of new product depends on a variety of external influences, it has become very important to develop forecasting tools for making good decisions for managers [23]. The first and most common diffusion model used in marketing is the Bass diffusion model. The Bass diffusion model describes how the probability of a current purchase in the market is dependent on prior purchases. The model uses innovators and imitators to categorize customers in the market. The Bass diffusion model is described in more detail in chapter 2.

A complete Bass diffusion model is developed in the book, Strategic Modeling and Business Dynamics: A feedback systems approach, by John Morecroft [25]. The model describes that there are now two influences on the adoption rate: the adoption from word-of-mouth and adoption from advertising. The model also shows that the adoption from advertising depends on potential adopters, where the advertising has its biggest impact early in the adoption process where there are lots of potential adopters to reach and convert [25]. This thesis utilizes some of the components from this Bass diffusion model.

3.3 Churning Analysis in Mobile Telecommunication

Managing customer churn has become a great concern for the service providers in the mobile telecommunication industry. Customer churning in mobile telecommunication is described as the process where a customer switches from one service provider to another in search for better rates and services [21].

In relation to churning in mobile telecommunication, Nokia Siemens Network [45] explains how churn matters, and what can be done about it. The paper looks at mature and maturing mobile service markets, and shows how the EBIDTA margin is impacted by churn rates. Salford systems [35] seek to identify the best practices for churn modeling in a real world context. Also in relation to customer churn analysis, Ahn, Han and Lee [17] using customer transaction and billing data, to study determinates of churn in the Korean mobile telecommunication service market. The results for this study indicates that there are different factors that influence whether a customer are switching provider or not.

This thesis study about churning in mobile telecommunication is based partly on these papers, and gives a good basis for the knowledge about churning in the mobile service market.

3.4 Utilizing System Dynamics

System dynamics is a methodology and mathematical modeling technique that is used to study nonlinear behavior of complex systems over time [13]. It applies to multiple fields of study, especially dynamic problems that are arising in complex social, management, economic, or ecological systems. System dynamics is presented more in detail in chapter 6.

In relation to utilizing system dynamics, Elisabeth Idland [15] utilized system dynamics when modeling a Competitive Video Streaming Model. The model is developed for modeling the competition between illegal and legal video streaming services. Similarly, this thesis is modeling competition between two or more providers in the same market. The model was developed and presented using system dynamics and the AnyLogic software, which is the same software and tools that are used in this thesis. Idland also addresses WOM effects and network effects in the model.

Chapter 4
Churning in Mobile Service Markets

This chapter elaborates on churning in mobile service markets. It starts with describing the churn business problem and why churning is relevant. This is followed by the churn determinates in the telecommunication industry. How to manage churn and how to retain customers are also described, where churning prediction is explained. Finally, the chapter looks at the social ties in the network, and if the size of the network matter.

4.1 The Churn Business Problem

All industries suffer from customer churning. Churning is defined as the movement of customers from one provider to another in search for better and cheaper services and products [21]. The churning problem is especially true for telephone, cable TV, satellite TV and Internet companies, where the percentage of customers switching from one provider to another is significant month to month [22]. Churn is a problem for any provider of a subscription service or recurring purchasable, since the cost of acquiring new customer and win-back can be very high.

Churn is especially important for mobile service providers, since it is very easy for a subscriber to switch service provider [35]. Therefore retaining customers and maintaining customer churn is on of the most critical challenges for the global telecommunication service provider, and it is becoming a more serious problem as the market matures [17]. The annual churn rate ranges from 20 % to 40 % in most of the global telecommunication service companies [17], and is the biggest revenue leakages.

It is stated that the cost of acquiring a new customer is much higher than retaining existing ones. The importance of the economic value of existing customers is significant. Since the major source of revenue comes from customers, customers play a significant role in the development of the telecommunication industry [20]. Therefore in a high competitive and maturing mobile service market, a defensive strategy has

become more important. Instead of attempting to acquire new customers or lure subscribers away from other service providers, defensive marketing is concerned with reducing customer exit and brand switching [17]. Therefore, in order to be successful, the focus has switched from acquiring new customers to retaining existing customers.

4.2 Churn drivers

Rapid improvements and dynamics in the technology market make customer retention a competitive effort [19]. Especially in market with many service providers, existing providers and newcomers are offering deals and packages for customers, so that they would like to churn to their services. Customers can now freely choose the most suitable service for his communication habits and consumption standards [18].

Customer churn in telecommunication is greatly subjective. Some customers can be satisfied with a service provider, but customer churn can also be caused by subjective factors such as moving to another city and switching jobs. These factors cannot be controlled by the telecommunication provider [18]. Churn can be active and intentional, incidental, or passive and non-voluntary [20].

In relation to churning drivers in telecommunication, Hamelin, Nassali and Harcar [21] studied churning drivers in the Moroccan telecom sector. The paper states that the five factors that significantly contributed to customer churning in the market were: tariffs, transparency level, promotions, technical assistance, and privacy. More in detail, subscribers want to churn because of prices charged by the service providers, and customers that have lost their confidence into their service provider, where more likely to churn to a service provider with high level of transparency. The research also showed that quality of coverage network, customer service quality, response to complaints, and billing errors frequency were insignificantly to the churn behavior. Furthermore, the research showed that the mobile models, gender and education level didn't affect the churning decision. But it showed that the age and the income of the subscriber were associated with churning, and young customers were more willing to churn than older ones.

Churning determinants is also investigated in the study by Ahn, Han og Lee [17], where churn determinants in the Korean mobile telecommunication service industry are researched. The study considered specific customer churn determinates, and proposes the following hypotheses:

- Customer dissatisfaction: The number of complaints is positively associated with the probability of a customer churning.

- Switching cost: Switching cost are factors that prevent customers from freely switching to another provider. In the telecommunication industry in example, loyalty points and membership card programs are the main reason for switching cost. The study states that membership and etc. is negativity associated with the probability of customer churn.

- Service usage: Minutes of use, frequency of use and total number of receivers contacted by the subscriber are service usage patterns that can be measured. The number of unpaid monthly bills is positively associated with the probability of customer churning.

- Customer status: Customers that don't use the service or have a suspended status are considered more likely to churn than a customer with an active use status.

Value added service is another reason for churn. Now almost telecommunication companies are offering the "Triple play" service. Triple play is a service that combines TV, broadband and mobile phone subscriptions, as compared to traditional model with just the phone service. The "Triple play" is an important factor to retain customers and decrease the customer churn. Additionally, to retaining customers, the "Triple play" also increases the Average revenue per user (ARPU) and keeps the revenue of the company at a stable rate [22][28].

4.3 Churn management

Telecommunication industry has suffered from a high churn rate and massive churning loss. Even though the churning loss is unavoidable, churning can still be managed and kept at an acceptable level [20].

4.3.1 Customer relationship management (CRM)

Customers in the telecommunication industry play an important role in Customer relationship management (CRM). The core issues in CRM are: customer acquisition, customer retention, and maximizing the Lifetime Customer Value. Customers are a very unstable group; so retaining customers has become the most significant issue for the telecommunication service providers. All CRM management needs to take churning into account [35].

In CRM, the cost of acquiring a new customer is five times higher than then cost of retaining an old customer [18], and by reducing customer churn profits can be increased to a great extend. It is stated that a satisfied customer can bring eight potential deals to companies, while an unsatisfied customer can affect the purchase of

25 persons. So if a service provider ignore old customers, most companies will in five years have churned half of their customers [18]. From this it is clear how important customer churn is in the telecommunication industry.

4.3.2 Combat with Customer Churn

Due to its associated cost, customer churn is a big concern for telecommunication service providers. The survival of a service provider is based on its ability to retain customers [28]. Therefore, service providers are very keen on retaining their customers as well as attracting new ones [46]. The question is then how to combat customer churn and reduce the loss of existing customers.

Effective communication and measure customer satisfaction is important factors to reduce churn. Churning can be combated by, for example, acquiring more loyal customers initially, taking preventative measures with existing customers, and identifying those with the intention to churn before they act and lead to profit decrease [35][21]. By using predictive modeling and tagging customers most likely to churn, the service provider could use campaigns and "After sales" services to reduce churn. Typical retention campaigns could include incentives such as price breaks, and special services available only to selected customer [35]. This will improve the customer satisfaction, as the user will experience a special appreciation. It is important that the retention campaigns are targeted to the right customers, since it is very costly to offer incentives to customers who would stay regardless of the campaign. The campaign should then be targeted to customers who probably would leave without the incentive. An important factor for reducing customer churn is therefore being proactive and addressing the issues before the customer decides to switch provider.

4.3.3 Churn Prediction

Churn prediction is a method that helps the company in identifying possible churners in advance [20]. By obtaining knowledge and information from the telecom industry it is possible to predict the behavior of a customer, like whether or not the customer will leave the provider. Detecting such customers well in advance and make every effort to retain them could be the key for service providers in the telecommunication industry [27].

To improve and analyze the customer acquisition and retention, CRM tools have been developed to increase the companies profit, and for supporting analytical tasks. One of the CRM tools is Data Mining. Data mining plays a very important role for telecommunication companies in improving their marketing efforts and to better manage the network. Data mining is a technique that is used to extract useful knowledge in form of patters from different databases, files etc., with data from the

market. This technique is applied in telecommunication because of the huge amount of data, the rapid growth in competition and increase in the churn rate [20].

If service providers know which customers who are at high risk of churning and when they probably will churn, they are able to design customized customer communication and to prevent as many customers as possible from churning [26]. Conventional statistical methods like logistics regression, decision tree, and etc. are successful in predicting customer churn, but predicting when customers will churn are much harder for these tools. However, survival analysis like the one proposed by Juanxiang Lu [26] will help telecommunication companies to understand churning behavior.

4.4 Social ties

In "Social Ties and their Relevance to Churn in Mobile Telecom Networks" [47] the authors examined the communication patters of millions of mobile phone users, allowing them to study the social ties in a large-scale communication network. The underlying premise was to study if an individual's probability of churning increased with the number of friends that have already churned to a different network provider. The result from the paper indicates that the number of friends who have churned in previous months significantly influences the probability of churning.

The social ties in relation to churning were maybe even more relevant in the early stages of the mobile service market. Customers were more bound to their service providers through fixed phone number and lines. If a customer switched from one service provider to another, it also had to change phone number. Additionally, a provider charged different prices from different service providers, which meant that it was cheaper to call within the network [30]. Therefore, a customer were more concerned about which provider friends and family subscribed to, so it could save money when calling inside the network. This later evolved to "Free-Family", where a customer could call to family members free of charge, and later to a situation with no charge when calling to another subscriber with the same service provider. Today, prices that are charged are the same across the service providers, and customers can freely retain their number regardless of service provider.

In mobile telecommunication industry, the service providers network effect is weakened because of the interconnection, but still it is showed that the network effect is an important reason of customer churning [29]. Therefore, the size of the network is not that important as it was a few years ago when a customer chooses a service provider.

Chapter 5
Competitive Mobile Service Model

This chapter introduces the Competitive Mobile Service Model (CMSM). The chapter presents how the model is developed and how it can be used to simulate churning and competition in the mobile service market. To get a better understanding of how the model works; it starts with explaining the Bass model as the underlying model for the CMSM. It also introduces some of components and functions that are included in the model. The goal is to create an analytic model by putting the model components together.

5.1 Model Components

As presented in chapter 2, when there is only one supplier, the Bass diffusion model has this basic form

$$\frac{dA}{dt} = (N - A)(p + qA) \tag{5.1}$$

where N is the total number of potential adopters, dA/dt is the number of adopters per time unit, A is the total number of people having adopted the product at time t, p is the coefficient for innovation, and q is the coefficient for imitation. [1]

The Competitive Mobile Service Model (CMSM) is based on the Bass diffusion model, where we in the CMSM assume the following:

- Constant market size (N)
- A customer adopts at most one service provider at the time
- Independent decisions is similar to innovators, and
- The network effect is similar to imitators.

5.1.1 Competition

In the mobile service market, there are multiple service providers. To capture the competition in the market we have to extend the basic form of the Bass diffusion model. When there are more two competitive suppliers in the market, we have the following set of nonlinear-coupled differential equations:

$$\frac{dA_1}{dt} = (N - A_1 - A_2)(p_1 + qA_1) \tag{5.2}$$

$$\frac{dA_2}{dt} = (N - A_1 - A_2)(p_2 + qA_2) \tag{5.3}$$

5.1.2 Independent Decisions

In the CMSM model we assume that a certain number of potential adopters are innovators, which means that they will adapt to a service provider independent of others. These innovators will adapt to a service based on their own preference without being influenced by others. The possible reasons for their choice of service provider can in example be price, coverage, quality of service, etc.

5.1.3 Network Effects

In the mobile service market the adoption to a service provider could be influenced by other peoples previous decisions. When the value of the network increases with the number of customers we have a positive network effect. We could also have negative network effects in the mobile service market. When a service provider has to many customers using a service this could lead to congestion, and a decrease in value of the network for the customer. In the CMSM model we have positive network effect, where the churning rate is dependent on the number of the customers that are subscribed to a service provider.

5.1.4 Churning

Churning implies that a customer moves from one service provider to another (see chapter 2 and 4). The churning may be spontaneous or simulated. Spontaneous churning means that the probability that a customer move from one service provider to another is independent of the behavior of other customers. Simulated churning means that the churning behavior is dependent on the behavior of other customers in the market [4]. In the CMSM model we have both spontaneous and simulated churning. The churning rate is both proportional with the number of customers in the existing and the new service provider, hence there are both spontaneous and simulated churning in the model.

5.2 Analytic Model

The modified Bass diffusion model for two competitors and including churning, can be expressed as two coupled first order nonlinear differential equations:

$$\frac{dA_1}{dt} = (N - A_1 - A_2)(p_1 + q_1 A_1) - c_1 A_1 + c_2 A_2 \tag{5.4}$$

$$\frac{dA_2}{dt} = (N - A_1 - A_2)(p_2 + q_2 A_2) - c_2 A_2 + c_1 A_1 \tag{5.5}$$

where N is the total number of potential adopters, A_i are the number of users that have adopted to service provider i, p_i is the adoption rate for innovators, $q_1 A_1$ are the adoption rate for imitators, $c1$ is the churning rate from service provider 1 to 2, and c_2 is the churning rate from service provider 2 to 1.

With three competitors and churning between them, we get the following equations:

$$\frac{dA_1}{dt} = (N - A_1 - A_2 - A_3)(p_1 + q_1 A_1) - c_1 A_1 + c_2 A_2 + c_3 A_3 \tag{5.6}$$

$$\frac{dA_2}{dt} = (N - A_1 - A_2 - A_3)(p_2 + q_2 A_2) - c_2 A_2 + c_1 A_1 + c_3 A_3 \tag{5.7}$$

$$\frac{dA_3}{dt} = (N - A_1 - A_2 - A_3)(p_3 + q_3 A_3) - c_3 A_3 + c_1 A_1 + c_2 A_2 \tag{5.8}$$

where N is the total number of potential adopters, Ai are the number of users that have adopted to service provider i, pi is the adoption rate for innovators, and $c1$ is the churning rate from SP1 to SP2 and SP3, $c2$ is the churning rate from SP2 to SP1, $c3$ is the churning rate from SP3 to SP1.

The model is later expanded to a market with four competitors. The fourth competitor enters the market after some time period, and acquires customers only through churning from other service providers. With four competitors and churning between them, we get the following equations:

$$\frac{dA_1}{dt} = (N - A_1 - A_2 - A_3 - A_4))(p_1 + q_1 A_1) - c_1 A_1 + c_2 A_2 + c_3 A_3 + c_4 A_4 \tag{5.9}$$

$$\frac{dA_2}{dt} = (N - A_1 - A_2 - A_3 - A_4)(p_2 + q_2 A_2) - c_2 A_2 + c_1 A_1 + c_3 A_3 + c_4 A_4 \quad (5.10)$$

$$\frac{dA_3}{dt} = (N - A_1 - A_2 - A_3 - A_4)(p_3 + q_3 A_3) - c_3 A_3 + c_1 A_1 + c_2 A_2 + c_4 A_4 \quad (5.11)$$

$$\frac{dA_4}{dt} = -c_3 A_3 + c_1 A_1 + c_2 A_2 + c_4 A_4 \quad (5.12)$$

where N is the total number of potential adopters, A_i are the number of users that have adopted to service provider i, p_i is the adoption rate for innovators, $q_1 A_1$ are the adoption rate for imitators, c_i is the churning rate from service provider i to the other service providers.

Chapter 6
System Dynamics

This chapter explains the development of the CMSM model through the use of system dynamics modeling. It starts by giving an overview of system dynamics and the analogy of structure and behavior used in the model. The chapter also describes the steps of the modeling process, casual loop diagrams are created, and the final CMSM model is presented using a simulation tool called AnyLogic. In the last section of the chapter a few scenarios are presented.

6.1 Overview

System dynamics us set of conceptual tools that help us to understand the structure and dynamics of complex systems [13]. By using the system dynamics as a modeling method it enables us to design more effective policies and organizations through computer simulations of complex systems. It applies to dynamics systems that are characterized by interdependence, mutual interaction, information feedback, and circular causality [14]. System dynamics uses stocks, flows, internal feedback loops, and time delay to capture the dynamic aspect of the system, and thereby providing a better understanding of the system behavior over time.

The system dynamics approach involves defining problems dynamically in terms of graphs over time, identifying independent stocks or accumulations and their inflows and outflows in the system, formulating a model that is capable of reproducing the dynamic problem of concern by itself, and deriving understandings and usable policy insights from the finished model [14].

In system dynamics it is stated that the dynamic behavior occur when flows accumulate in stocks. A good analogy is bathtub, where the bathtub represents a stock and the pipeline assembly that fills and drains the bathtub is represent as flows. The principle of accumulation will then happen when the rate of filling is greater than the rate of draining. The water would then flow through the pipelines and later be

collected and accumulated in the bathtub or stock, and dynamic behavior will occur [15].

Given the overview of system dynamics, the behavior of the key variables of system dynamics is explained as follows:

- *Stocks* continuously change their values over time, and they determine the corresponding values of incoming and outgoing flows.
- *Flows* change the value of the stocks.
- *Dynamic variables* can change their values instantly.
- *Parameters* can be defined and changed in order to stimulate flows and dynamic variables.

6.2 Steps of the Modeling Process

This section presents and explains the steps of the modeling process using the system dynamic tool. The section includes a description of the parameters, variables, flows and stocks of the CMSM model.

The different symbols represent:

Parameter	Description
p_1	Independent decisions for service provider 1
p_2	Independent decisions for service provider 2
p_3	Independent decisions for service provider 3
q_1	Network effect from service provider 1
q_2	Network effect from service provider 2
q_3	Network effect from service provider 3
th	Threshold for the new service provider to enter the market
f_{ij}	WOM/Market feedback churning parameter from service provider i to service provider j
a_{ij}	Churning parameter from service provider i to service provider j, where i and j is 1, 2, 3 or 4

Table 6.1: Parameter descriptions

Variable	Equation	Description
i_1	$Adopters \cdot p_1$	Adoption rate for service provider 1 from adopters
i_2	$Adopters \cdot p_2$	Adoption rate for service provider 2 from adopters
i_3	$Adopters \cdot p_3$	Adoption rate for service provider 3 from adopters
n_1	$Provider1 \cdot q_1$	Adoption rate from network effect for service provider 2
n_2	$Provider2 \cdot q_2$	Adoption rate from network effect for service provider 2
n_3	$Provider3 \cdot q_3$	Adoption rate from network effect for service provider 3
c_{ij}	$a_{ij} + \epsilon(t)$	Churning variable from service provider i to service provider j, where i and j is 1, 2, 3 or 4

Table 6.2: Dynamic Variable descriptions

Flow	Equation	Description
adoptionRate1	i_1	People who adopt to service provider 1
adoptionRate2	i_2	People who adopt to service provider 2
adoptionRate3	i_3	People who adopt to service provider 3
churn1to2	$c_{12} \cdot Provider1 + f_{12} \cdot Provider2$	People who churn from service provider 1 to 2
churn1to3	$c_{13} \cdot Provider1 + f_{13} \cdot Provider3$	People who churn from service provider 1 to 3
churn1to4	if (time() > th) then $c_{14} \cdot Provider1 + f_{14} \cdot Provider4$, else 0	People who churn from service provider 1 to 4
churn2to1	$c_{21} \cdot Provider2 + f_{21} \cdot Provider1$	People who churn from service provider 2 to 1
churn2to3	$c_{23} \cdot Provider2 + f_{23} \cdot Provider3$	People who churn from service provider 2 to 3
churn2to4	if (time() > th) then $c_{24} \cdot Provider2 + f_{24} \cdot Provider4$, else 0	People who churn from service provider 2 to 4
churn3to1	$c_{31} \cdot Provider3 + f_{31} \cdot Provider1$	People who churn from service provider 3 to 1
churn3to2	$c_{32} \cdot Provider3 + f_{32} \cdot Provider2$	People who churn from service provider 3 to 2
churn3to4	if (time() > th) then $c_{34} \cdot Provider3 + f_{34} \cdot Provider4$, else 0	People who churn from service provider 3 to 4
churn4to1	$c_{41} \cdot Provider4 + f_{41} \cdot Provider1$	People who churn from service provider 4 to 1
churn4to2	$c_{42} \cdot Provider4 + f_{42} \cdot Provider2$	People who churn from service provider 4 to 2
churn4to3	$c_{43} \cdot Provider4 + f_{43} \cdot Provider3$	People who churn from service provider 4 to 3

Table 6.3: Flow descriptions

Stock	Equation	Description
PotentialAdopters	–adoptionRate1 – adoptionRate2 – adoptionRate3	Potential adopters in the market
Provider1	+ adoptionRate1 – churn1to2 – churn1to3 – churn1to4 + churn2to1 + churn3to1 + churn4to1	Adopters to service provider 1
Provider2	+ adoptionRate1 – churn2to1 – churn2to3 – churn2to4 + churn1to2 + churn3to2 +churn4to2	Adopters to service provider 2
Provider3	+ adoptionRate1 – churn3to1 – churn3to2 – churn3to4 + churn1to3 + churn2to3 + churn3to4	Adopters to service provider 3
Provider4	– churn4to1 – churn4to2 – churn4to3 + churn1to4 + churn2to4 + churn3to5	Adopters to service provider 4

Table 6.4: Stock descriptions

6.3 Causal Loop Diagram

To show the basic components and their interactions with one other in the system, a causal loop diagram was created. A causal loop diagram provides a language for understanding the dynamics in the structure of the system [12]. By connecting several loops we can create a coherent story of a particular problem. By understanding the structure of the system it is possible to study the system behavior over a time period.

Figure 6.1 shows the loop diagram for the adoption process for the service provider. The positive reinforcement loop (R) on the left indicates that the more people who adopts Provider X, the stronger is the network effect. The other feedback loop is the negative balancing loop (B). This loop indicates that as more customers adopt ProviderX, the number of potential adopters decreases. Both loops in the diagram acts simultaneously while having different levels of strength.

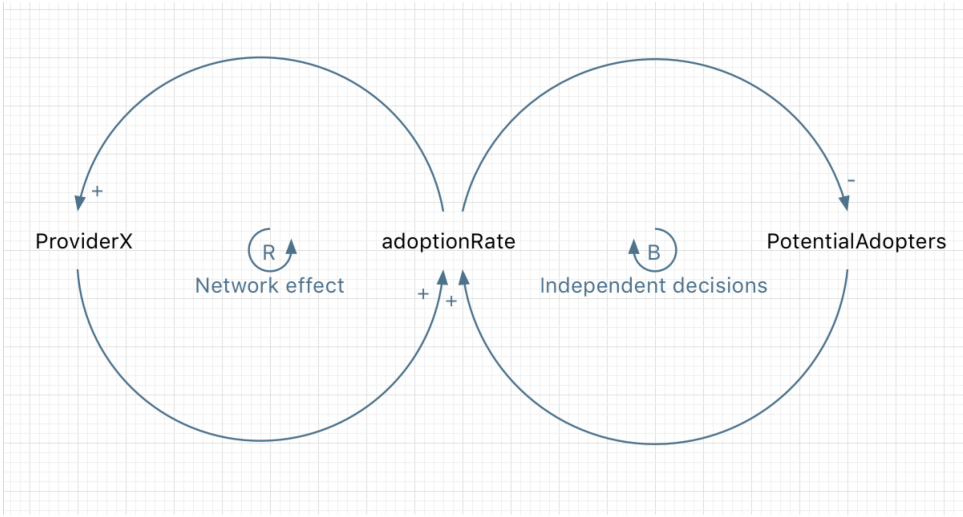


Figure 6.1: Causal Loop Diagram for adoption.

Figure 6.2 shows the loop diagram for the churning rate between provider X and provider Y. The reinforcement loop (R) to the left indicates that the more people who adapts to provider Y, the stronger is the network effect. The second feedback loop represents the balancing loop (B). The loop indicates that as more people are moving from provider X to provider Y, the number of people in provider X decreases. In the diagram, both loops acts simultaneously while having different levels of strength.

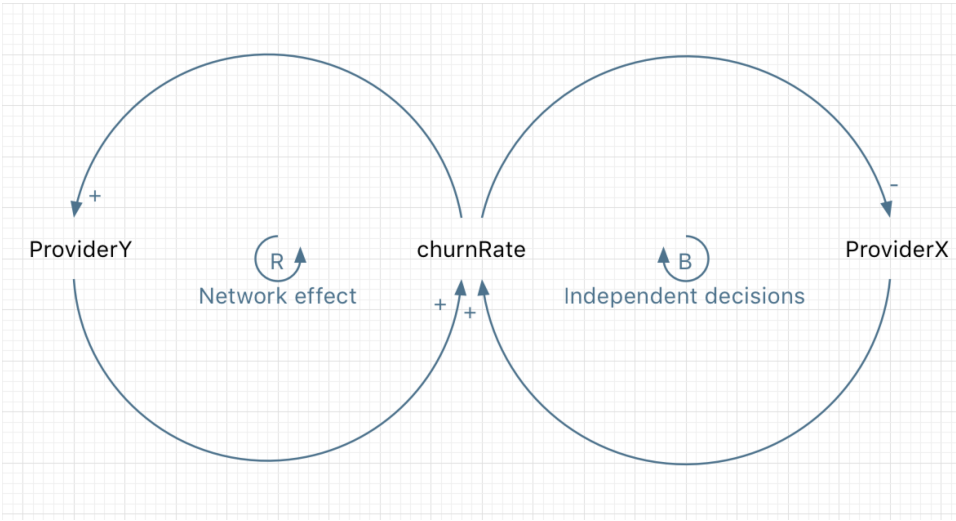


Figure 6.2: Causal Loop Diagram for churning.

6.4 AnyLogic

The CMSM model that is presented in this paper is implemented using the AnyLogic software. AnyLogic is a multimethod simulation software that enables the user to capture the complexity of business, economic and social systems. It is the only simulation tool that supports Discrete Event, Agent Based, and System Dynamics Simulation. AnyLogic is build within the Java environment that supports utilities such as Java code, external libraries and external data sources [16]. In this study, AnyLogic 7 Personal Learning Edition 7.2.0 was used, and installed on a MacBook Pro (Retina, 13", late 2013) running OS X El Capitan version 10.11.5.

Figure 6.3 illustrates a mobile service market with three service providers. This is a marked, before the introduction of the fourth service provider. Stocks are represented as squares and flows are symbolized with double arrows with valves. Dynamic variables are empty circles, while parameters are represented as circles with black triangles in. At last the arrows represent dependencies between the variables.

Figure 6.4 shows the implementation of the complete model with four service providers. This includes adoption and churning, and is used to simulate competition in the market under the different scenarios.

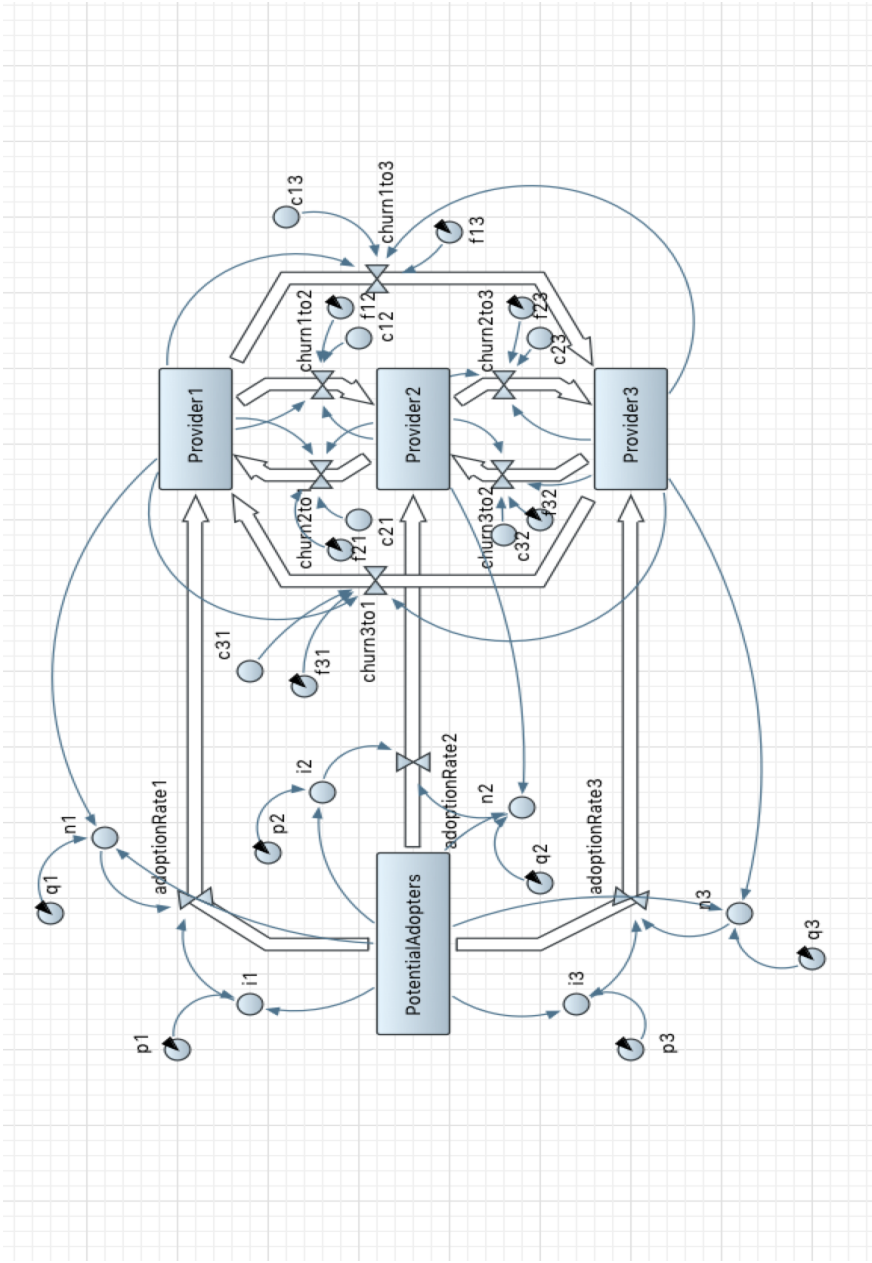


Figure 6.3: Implementation of the CMSM model with three service providers.

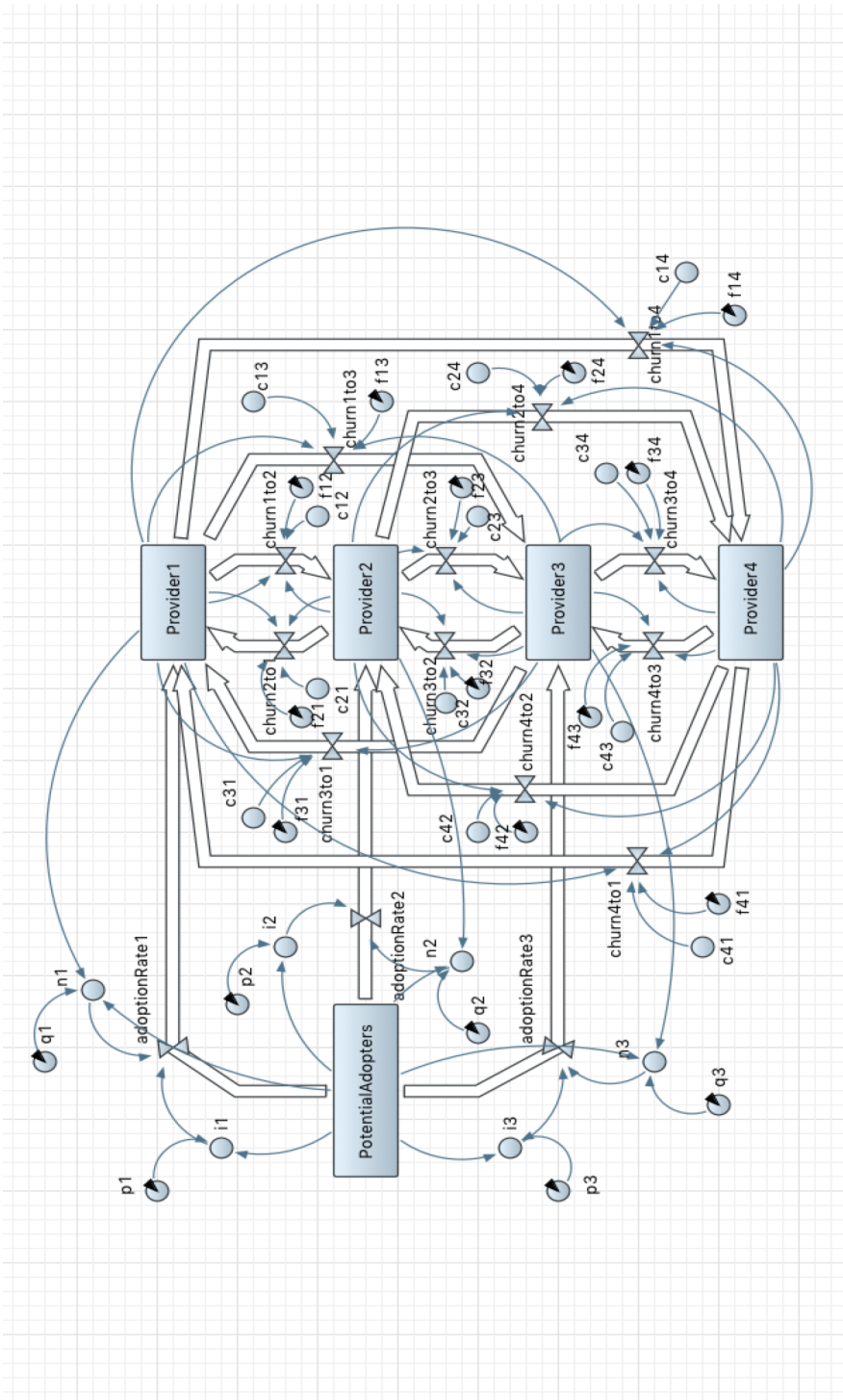


Figure 6.4: Implementation of the CMSM model with four service providers.

6.5 Scenarios

Scenarios analysis is a process of analyzing decisions and future events by considering alternative possible outcomes. It is designed to see the consequences of an action under different sets of factors [31]. This method is used on the CMSM system dynamics. This study uses scenarios to show what could happen to the future of the market under different parameters. It is not used to show the exact picture of the market but rather present several alternative future outcomes. These scenarios does not rely on exact and historical data but rather example data to show the possible outcomes and how the model works. Three scenarios have been analyzed

1. The first scenario examines a market with no churning and how small variations of parameters of independent decisions and network effects affect the temporal evolution of the market.

2. The second scenario examines the effect of churning, and how the introduction of a forth service provider effects the market.

3. The third scenario introduce periodic functions in the churning rate, and investigates what happens when we have feedback from the market (stimulated churning).

Each scenario is divided into tree cases to test different situations. The first case runs initial values, while the other looks at what happens when some parameters and values are changed.

6.5.1 Scenario 1

The first scenario examines a market with no churning between the service providers, and investigates how small variations in the strength of independent decisions and network effects affect the temporal evolution of the market. Since there is no churning in this scenario the fourth service provider will never acquire customers through churning, therefore only three service providers are considered in this scenario. The initial case was running equal values for independent decisions and network effects. The independent decision for service provider 1 was set at 0.01, which indicates that 1 % of the potential adopters will adopt the service provider per day, the same is set for the other providers. Network effects was set at zero in the beginning, and later increased. Table 6.5 shows the values for cases in the first scenario. Column 1.1 holds the value for the initial case, while columns 1.2 and 1.3 only shows the updated values for the specific case.

Scenario 1	Case 1.1	Case 1.2	Case 1.3
N	4,000,000		
T	100		
p_1	0.01	0.05	
p_2	0.01		
p_3	0.01		
q_1	0		
q_2	0		0.1
q_3	0		

Table 6.5: Values for scenario 1

6.5.2 Scenario 2

The second scenario includes churning and introduces a forth service provider. The scenario examines the effects of churning, and how the introduction of a new service provider after a time period affects the market. The initial values are the same as scenario 1, but churning parameters and variables are included. The churning rate for all providers 1, 2 and 3 were set at 0.01, but later increased for service provider 1. The churning rate for service provider 4 is initially set to zero, but later set at 0.01, similarity to the other service providers. Table 6.6 shows the initial values for scenario 1 in column 2.1, while 2.2 and 2.3 only hold the updated value for the cases.

6.5.3 Scenario 3

The third scenario investigates what happens when we introduce periodic functions in the churning rate variables. By using sine functions with different periods it is possible to investigate a market where the churning rate varies. The scenario also looks at what happens where there is feedback from the market, also known as stimulated churning. In this scenario the churning rate also depends on the number of adopters in the service provider it adapts to. In all cases, the initial values for the churning rate for all service providers are set at 0.01, and the WOM effect are 0.01. Table 6.7 shows the initial values in column 3.1, while 3.2 and 3.3 holds only the updated values for the respective cases.

Scenario 2	Case 2.1	Case 2.2	Case 2.3
N	4,000,000		
T	100		
p_1	0.05		
p_2	0.01		
p_3	0.01		
q_1	0.1		
q_2	0.1		
q_3	0.1		
c_{12}	0.01		
c_{13}	0.01		
c_{14}	0	0.01	
c_{21}	0.01		0.05
c_{23}	0.01		
c_{24}	0	0.01	
c_{31}	0.01		0.05
c_{32}	0.01		
c_{34}	0	0.01	
c_{41}	0.01		0.05
c_{42}	0.01		
c_{43}	0.01		

Table 6.6: Values for scenario 2

Scenario 2	Case 2.1	Case 2.2	Case 2.3
N	4,000,000		
T	100		
p_1	0.01		
p_2	0.01		
p_3	0.01		
q_1	0.1		
q_2	0.1		
q_3	0.1		
c_{12}	0.01	0.01 + 0.01*sin(0.1*t)	
c_{13}	0.01	0.01 + 0.01*sin(0.2*t)	
c_{14}	0.01	0.01 + 0.01*sin(0.01*t)	0.01 + 0.01*sin(0.01*t) + e$^{(}$ $-0.15 * t$)
c_{21}	0.01	0.01 + 0.01*sin(0.05*t)	
c_{23}	0.01	0.01 + 0.01*sin(0.02*t)	
c_{24}	0.01	0.01 + 0.01*sin(0.1*t)	0.01 + 0.01*sin(0.1*t) + e$^{(}$ $-0.15 * t$)
c_{31}	0.01	0.01 + 0.01*sin(0.03*t)	
c_{32}	0.01	0.02 + 0.01*sin(0.05*t)	
c_{34}	0.01	0.01 + 0.01*sin(0.01*t)	0.01 + 0.01*sin(0.01*t) + e$^{(}$ $-0.15 * t$)
c_{41}	0.01	0.01 + 0.01*sin(0.02*t)	
c_{42}	0.01	0.02 + 0.01*sin(0.1*t)	
c_{43}	0.01	0.01 + 0.01*sin(0.6*t)	
f_{12}	0.01		
f_{13}	0.01		
f_{14}	0.01		
f_{21}	0.01		0.015
f_{23}	0.01		
f_{24}	0.01		
f_{31}	0.01		0.015
f_{32}	0.01		
f_{34}	0.01		
f_{41}	0.01		0.015
f_{42}	0.01		
f_{43}	0.01		

Table 6.7: Values for scenario 3

Chapter 7
Results and Analysis

This chapter will present the results from the scenarios presented in chapter 6 obtained from the CMSM model. Each scenario is briefly repeated at the beginning of the subsection. Furthermore, each scenario contains tree cases that will be illustrated and analyzed in order to identify what happens in the system under a particular situation. The cases looks at what happens with the market over a time period when changing values of parameters and variables. The results for each simulation are illustrated with two graphs. In the first scenario, the cases are represented with a graph that shows the temporal evolution of adopters, and a graph that contains the adoption rate for the service providers. In the second and third scenario, it is more interesting to look at the churning rate, so the cases are contains a graph for the temporal evolution of adopters, and a graph for churning rate of people per time unit.

For each graph, the x-axis represents the time period in days, while the y-axis illustrates the number of adopters/people.

7.1 Result from Scenario 1

The first scenario examined a market without churning and how small variations in the independent decisions and network effect parameters affect the temporal evolution of the market. Initially, the values for independent decisions are equal and network effects are set to zero. The following cases examined what happened when either the value for independent decisions or network effects were increased. All other parameters and variables remained unchanged as described in Chapter 6.5

7.1.1 Case 1.1

Independent decisions are equal and network effects are zero.

Figure 7.1 shows the temporal evolution of adopters (uppermost figure), and the adoption rate (lowermost figure). With equal independent decisions and no network effects, the adoption in all tree service providers is growing at an equal rate. As customers adopt one of the service providers, the number of potential adopters is decreasing and approaching zero.

The adoption rate for the providers are decreasing as the number of potential adopters is decreasing. After a time period almost all the potential adopters have adopted a service provider, and the number who have adopted each service provider is stabilized at 1/3 of the initialize value of potential adopters. Since there is no churning in the market, the adoption and flow will stop when there are no potential adopters left in the market.

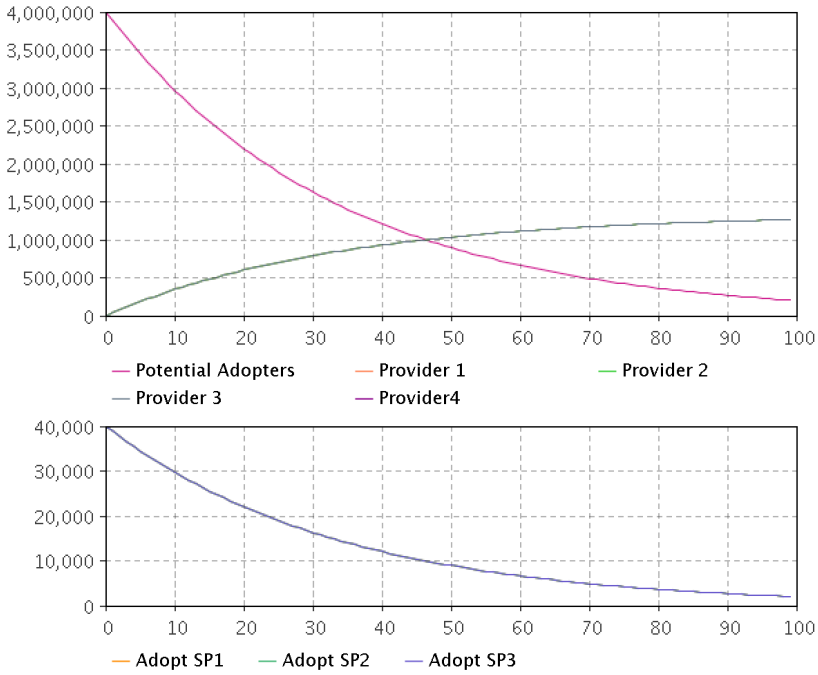


Figure 7.1: The temporal evolution of Adopters and Adoption Rate from case 1.1 (Showing People per Day)

7.1.2 Case 1.2

Increasing the independent decisions for service provider 1

In this case the independent decision for service provider 1 got increased to show a market where more potential adopters independently choose service provider 1 in favor of the other providers. Increasing the rate p1 from 0.01 to 0.05 led to a higher adoption rate for service provider 1. As a result of higher adoption rate, Service provider 1 doubled its customer base from case 1.1. The number of potential adopters is also approaching zero in a much greater rate than in the last case.

The adoption rate for service provider 1 is very high at the early phases, as shown in Figure 7.2, but as the number of potential adopters is decreasing the adoption rate is also decreasing. For service provider 1 and 2, the increased value of independent decisions for service provider 1, led to a much lower customer base. Therefore, the results from Case 1.2 shows that a little higher value of independent decisions for one of the service provider improved its competitiveness in the early phases, and results in a much higher customer base.

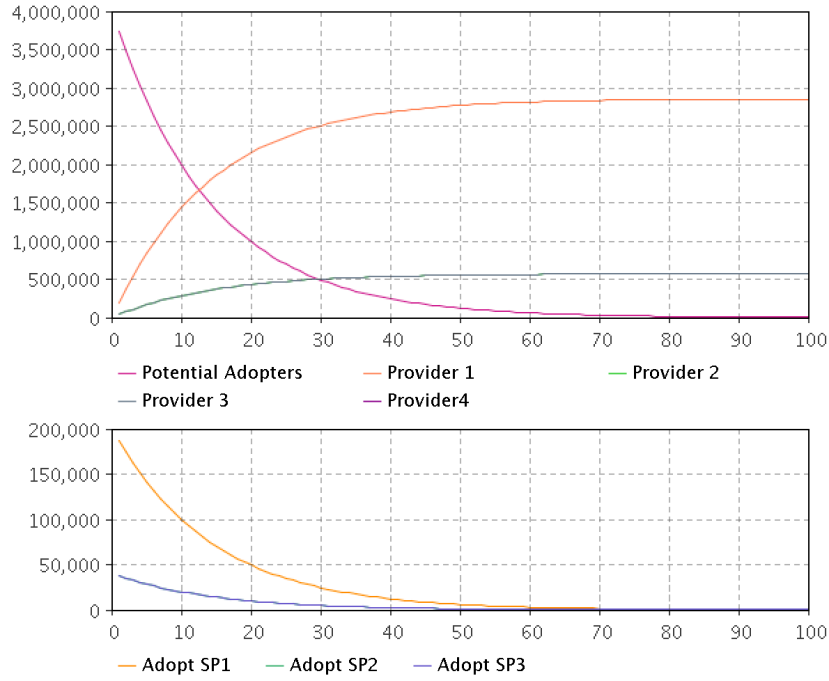


Figure 7.2: The temporal evolution of Adopters and Adoption Rate from case 1.2 (Showing People per Day)

7.1.3 Case 1.3

Increasing the network effect for Service Provider 2

The network effect for service provider 2 was increased in the third case to mimic a market with WOM impact. Figure 7.3 shows that the adoption rate for service provider 2 is much greater than the one in the initial case. The figure shows the rapid growth of service provider 2 adopters with a small network effect. The adoption rate for service provider 2 grows more and more in the early phases, but drops to zero after the potential adopters have entered the market.

With the high adoption rate for service provider 2, the market reaches a stable state much earlier than in the previous cases. After approximately a time period of 20 days, all the potential adopters have adopted the market, and the adoption rate is zero for all the service providers. The high adoption rate for service provider 2 entailed a disadvantage for the other service provider, where it resulted in a lower customer base. The results from Case 1.3 suggest that by increasing the network effect for service provider 2 the provider achieve a much higher customer base, and the market reaches a stable state more quickly.

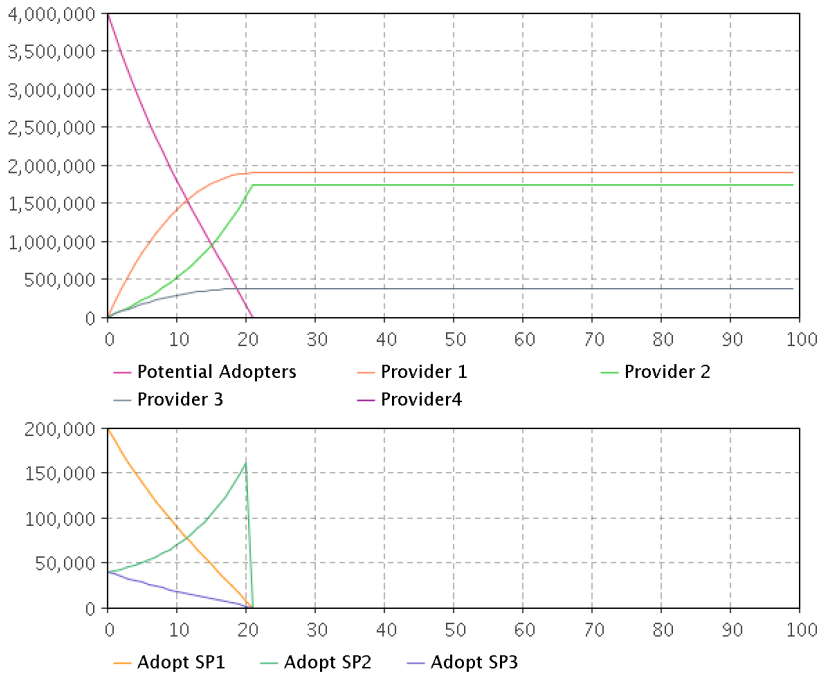
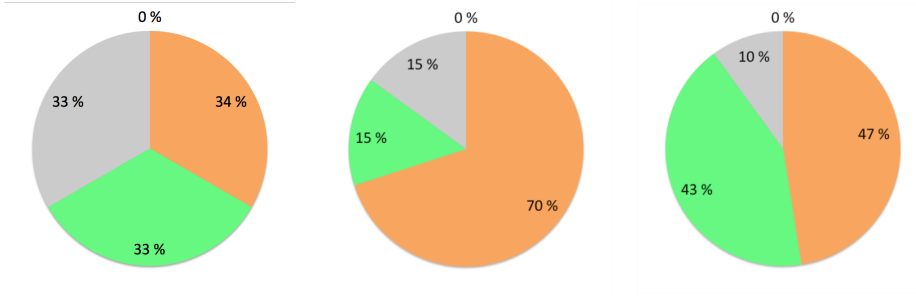


Figure 7.3: The temporal evolution of Adopters and Adoption Rate from case 1.3 (Showing People per Day)



(a) Case 1.1 (b) Case 1.2 (c) Case 1.3

Figure 7.4: Final market share from scenario 1 (Provider 1 (orange), Provider 2 (green), Provider 3 (gray), and Provider 4 (purple)

Key observations from scenario 1:

- The adoption rate and flow reaches zero when there are no potential adopters left in the market
- Small adjustments in the strength of independent decisions for one of the service providers improved its competitiveness, especially in the early phases. This results in a much higher customer base, when there is no churning in the market.
- By increasing the network effect for one service provider, the adoption rate increases rapidly and the provider achives a much higher customer base.

7.2 Result from Scenario 2

The second scenario investigated a market with churning and an introduction of a new service provider. The initial values were the same as in scenario 1, but churning variables were included. The churning rate was later increased for service provider 1 to test the effects of churning in the market. In addition, this scenario tested what happened when a new provider entered the market. The churning rate for service provider 4 was set at the same rate as the other. Later the churning rate for service provider 1 was increased. All other parameters and variables remained unchanged as described in Chapter 6.5.

7.2.1 Case 2.1

Equal churning parameters and different independent decisions parameters

Figure 7.5 shows the temporal evolution of adopters (uppermost figure), and the churning rate (lowermost figure). The churning parameters were set equal, and the independent decisions parameters were different from each other. The figure shows that in the early phases, the strength of independent decisions strongly affects the number of adopters for the service providers. But as the adoption rate decreases and becomes zero, there is only churning left in the market. Since the churning parameters are equal, the number of customer in each service provider will approach each other after time.

The adoption rate is greatest at service provider 1; therefore the churning rate from service provider 1 is also greatest as seen in Figure 7.5. After time the number of adopters approaches a stable state, 1/3 of the potential adopters, similarly the churning rate approaches 1 % of the number.

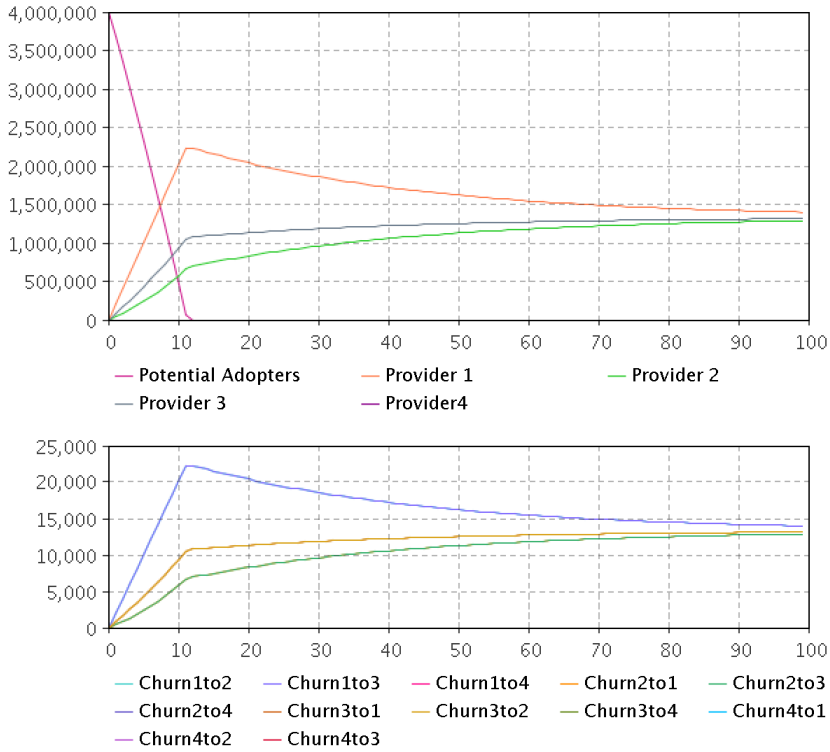


Figure 7.5: The temporal evolution of Adopters and Churning Rate from case 2.1 (Showing People per Day)

7.2.2 Case 2.2

Introducing a new service provider after a time period

In this case a new service provider is introduced in the market after 20 days. The new service provider only acquire customer through churning from the other service providers. After the new service provider enters the market, the churning rate to service provider 4 was very high in the beginning. Therefore, service provider 4 quickly receives a large customer base. In the early phases, the churning rate towards service provider 4 is very high, but as the number of adopters increases the churning rate out from the service provider will also increase.

The Figure 7.6 shows that with equal churning rates, the market will after a time reach a steady state and the adopters in the market will be distributed equally among the providers. The result from Case 2.2 suggest that by introducing a new service provider in the market and with equal churning rates, the service provider will quickly receive a large customer base.

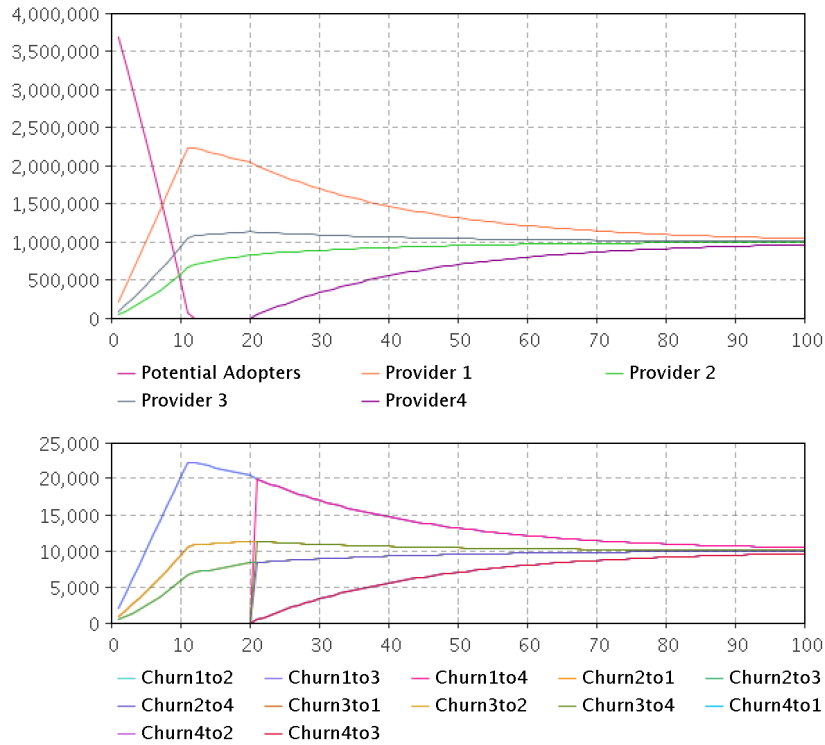


Figure 7.6: The temporal evolution of Adopters and Churning Rate from case 2.2 (Showing People per Day)

7.2.3 Case 2.3

Increasing churning parameters towards service provider 1

The churning parameters towards service provider 1 are increased in the third case to mimic the effect of churning rate. Figure 7.7 shows that the churning rates towards service provider 1 are significantly greater than those of the initial case. The figure shows that the number of adopters in much greater for service provider 1 than the other service providers, and the small increase in the churning parameters had a huge impact of the customers in the market.

The churning rate from all the other providers towards service provider 1 is much higher than the other service providers' experience as inflow. The result from Case 2.3 suggest that by increasing the churning parameters, service provider 1 experienced a rapid growth, but after a while reach a steady state with a much greater customer base than the other service providers.

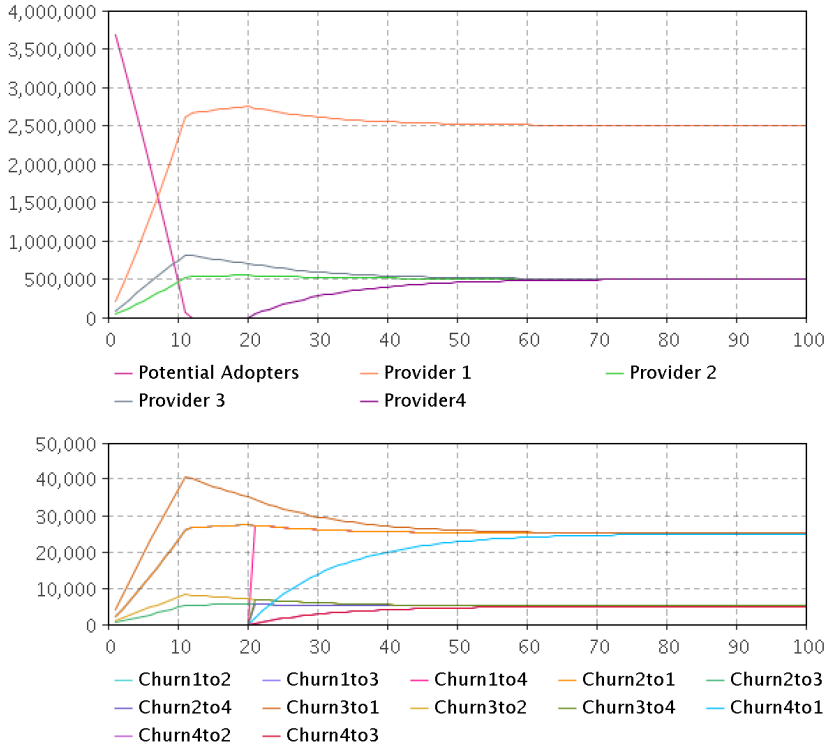
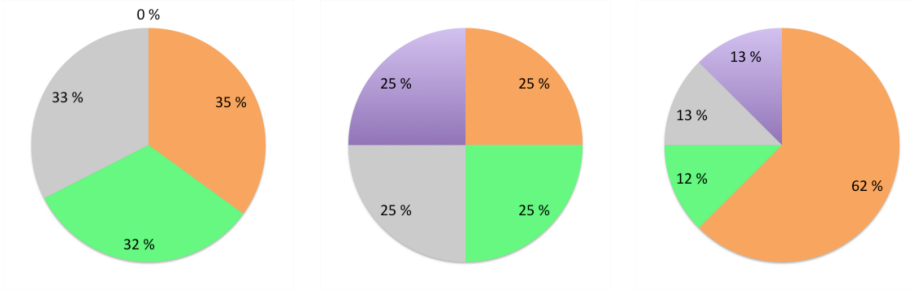


Figure 7.7: The temporal evolution of Adopters and Churning Rate from case 2.3 (Showing People per Day)



(a) Case 2.1 (b) Case 2.2 (c) Case 2.3

Figure 7.8: Final market share from scenario 2 (Provider 1 (orange), Provider 2 (green), Provider 3 (gray), and Provider 4 (purple)

Key observations from scenario 2:

- With equal churning parameters the adopters in the market will distribute it self equally on the three service providers, independent of the adoption rate from potential adopters.
- Introducing a new service provider in the market and with equal churning rates, the service provider will quickly receive a customer base similarity to the other providers.
- By increasing the churning parameters for one of the service providers, the provider experience a rapid growth.
- When there is only equal churning rates in the market, the number of adopters will reach a stable state when the number of potential adopters reaches zero.

7.3 Result from Scenario 3

The third scenario examined what happened in the market when periodic functions were introduced in the churning rate variables. Sine functions with different periods are used to investigate a market where the churning rate varies. The initial values for all the service providers were set at the same value, and the WOM parameter were introduced. This scenario also looked at what happened when there is feedback from the market, also known as stimulated churning. All other parameters and variables remained unchanged as described in Chapter 6.5.

7.3.1 Case 3.1

Introducing periodic churning rate functions

Figure 7.9 shows the temporal evolution of adopters (uppermost figure) and churning rate (lowermost figure). Periodic functions are introduced in the churning rate variables to mimic a market where the churning rate varies. The initial churning parameters and independent decisions are equal, but the churning variables were different. Using different periods in sine functions, led to a more varied churning rate.

As shown in the figure, the churning rate varies and impacts the adopters in the different service providers. The number of adopters in service provider 1 increases at a great rate, before it decreases after approximately day 60, and at day 100 service provider 2 had most adopters. Service provider 4 enters the market after a time period, and after some time it acquires equal number of adopters as service provider 3.

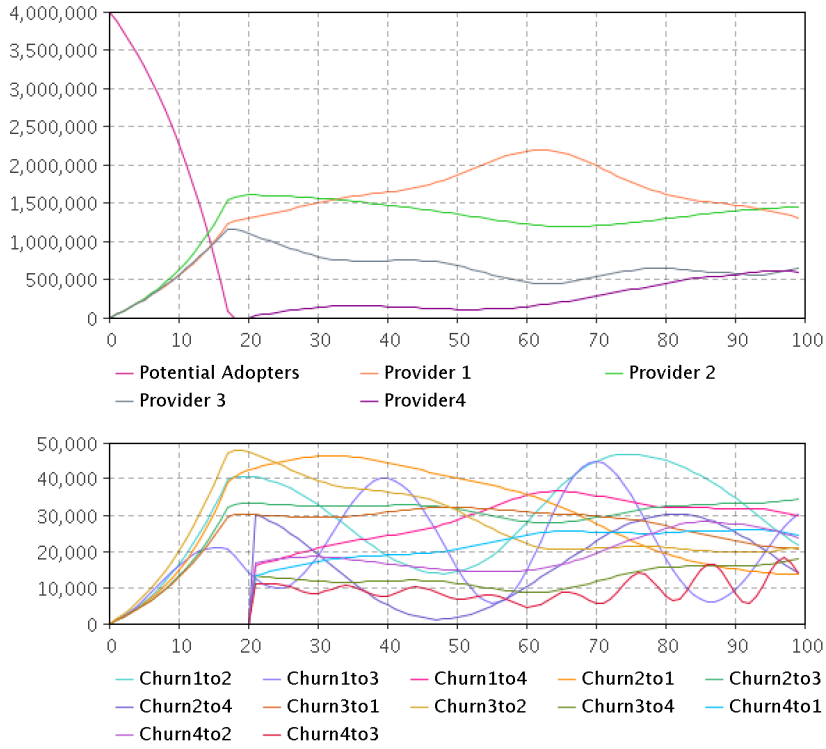


Figure 7.9: The temporal evolution of Adopters and Churning Rate from case 3.1 (Showing People per Day)

7.3.2 Case 3.2

Increase churning variables for service provider 4 with exponential function

The churning parameters for service provider 4 are increased with a function that affect the churning rate so that the churning rate is high in the early phases, and later decreases to a normal rate. This is shown in Figure 7.10, where the churning rate towards service provider 4 experience a rapid growth when it enters the market, but decreases to a normal rate as the market matures.

The churning rate uses an exponential function to mimic high churning in the early phases and after time approach a normal rate as the other service providers. The results from Case 3.2 suggest that by increasing churning variables for a new service provider the service provider improved its competitiveness in the initial phases.

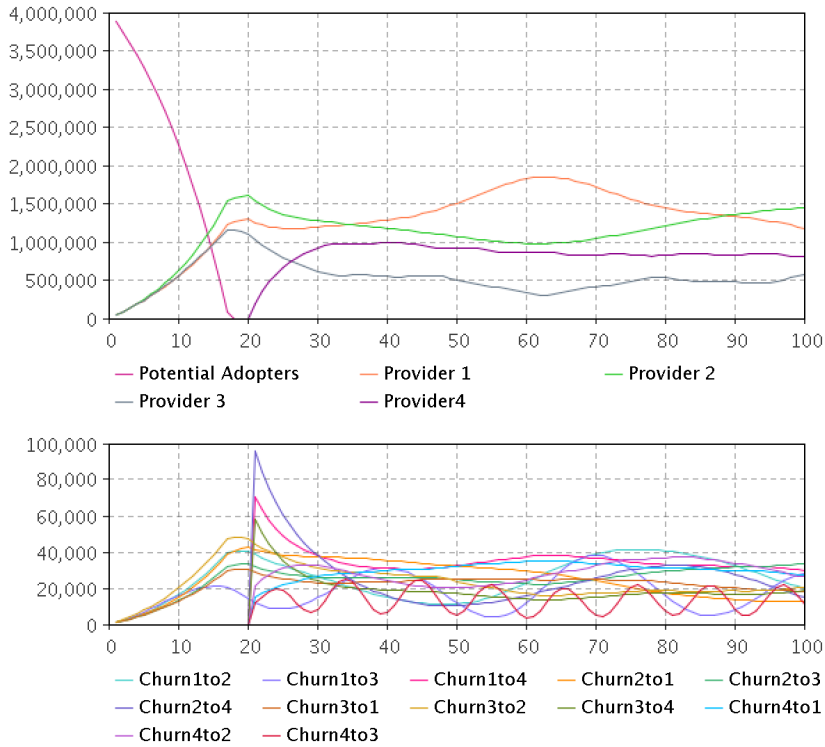


Figure 7.10: The temporal evolution of Adopters and Churning Rate from case 3.2 (Showing People per Day)

7.3.3 Case 3.3

Increasing churning feedback parameters for service provider 1 (stimulated churning)

The churning feedback from the market parameters got increased in the first case to mimic the effects of WOM in churning. Increasing f21, f31 and f31 from 0.01 to 0.015 led to a much higher churning rate towards service provider 1. Figure 7.11 shows that in the early phases, as there is potential adopters left in the market, the effect of WOM in churning is not that impressionable, but as the market matures, the effect from WOM got enormous consequences.

The churning rate towards service provider 1 increases and increases, while the other churning rates are decreasing. The figure also shows that because of WOM, service provider 3 loose all its customers and leaves the market. From this the results from Case 3.3 suggest that by increasing churning feedback parameters for service provider 1 the provider will after a time get all the customers in the market, and some service providers will leave the market.

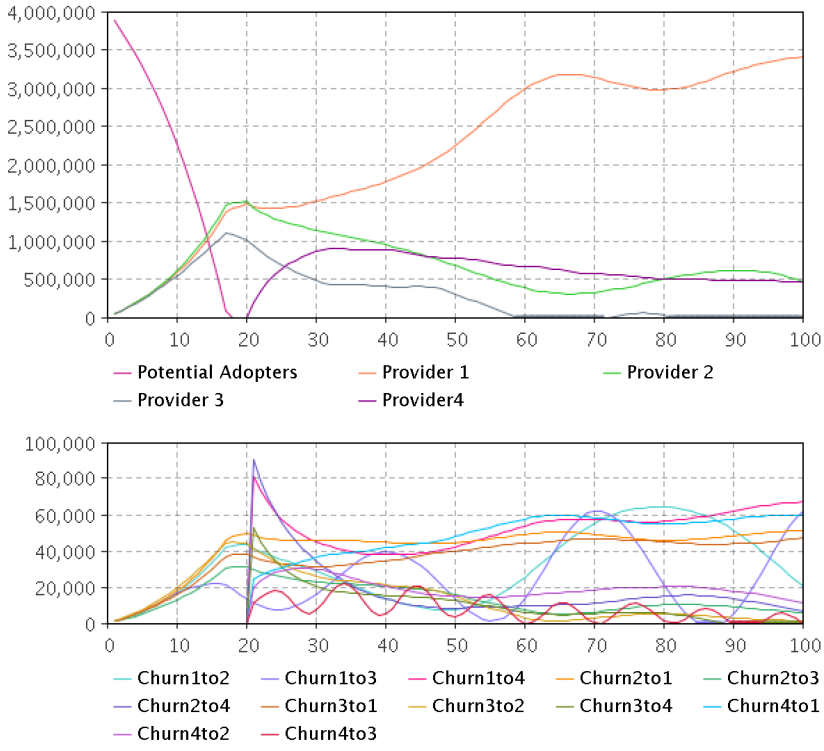
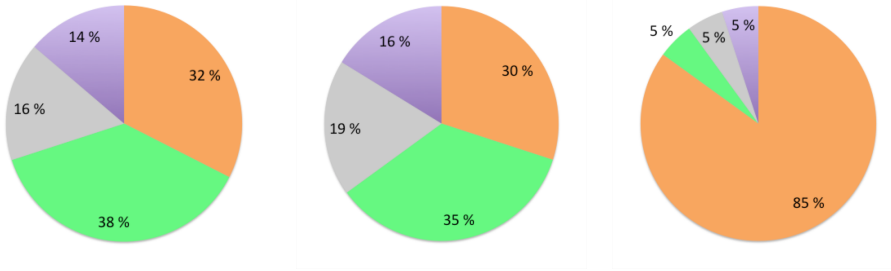


Figure 7.11: The temporal evolution of Adopters and Churning Rate from case 3.3 (Showing People per Day)



(a) Case 3.1 (b) Case 3.2 (c) Case 3.3

Figure 7.12: Final market share from scenario 3 (Provider 1 (orange), Provider 2 (green), Provider 3 (gray), and Provider 4 (purple)

Key observations from scenario 3:

- By introducing periodic churning rate functions one obtain a more realistic market.
- Increasing churning variables for a new service provider improves its competitiveness especially in the initial phases.
- By increasing the churning feedback parameters for a service provider, the provider will after a time get all the customer in the market. Some service providers will leave the market.

Chapter 8
Discussion

This chapter presents the main findings of this study and discusses the relevance of the results. The results from the study is then compared with data from the mobile service market. This chapter also discusses the uniqueness of the CMSM model. The chapter also present some improvement points of this study.

8.1 The Significance of the Results

8.1.1 Main Findings

The parameter "independent decisions" is especially important for the early phases of the adoption of service providers. A little higher value of "independent decisions", compared to the other service providers, the service provider improves its competitiveness in the early development, which results in a much higher customer base than the other service providers. A seen in the model, when service provider 1 has a higher value of "independent decisions", the majority of the potential adopters in the market will choose service provider 1, and it quickly acquires a large customer base.

The study also found that the adoption of new adopters depends strongly on network effects. Specifically, the study found that by increasing the network effect of service provider 2, the adoption rate of service provider 2 also increases. However, as the number of potential adopters reaches zero, the adoption rate drops to zero. Therefore, when there is no churning and quitting in the market, the market will after time reach a stable state.

It was also found that the churning rate influences the number of adopters in the service providers with great impact. When there are equal churning parameters in the market, the numbers of adopters in each service provider will after time approach each other. This is also seen in the case where a new service provider enters the market. In the beginning, service provider have a very little customer base, but after time the new service provider acquire adopters from the other providers through

churning. It is also found that with a greater churning rate towards one of the service providers, this service provider will acquire a larger customer base than the others. The introduction of new service provider could use marketing and offer packages to acquire new customers.

The study also found, that the introduction of periodic churning functions obtained a more realistic market. The customer base in the service provider is not constant, so a market where there is oscillating churning creates a more realistic market. It also found that by increasing the churning variables for a new service provider, the service provider improved its competitiveness in the early phases. The study also found that increasing churning feedback parameters affects the market with great impact. In example, increasing the churning feedback parameters towards service provider 1, results in a market where service provider 1 after some time will acquire all the customers in the market, and some service providers will leave the market.

8.1.2 Mobile Service Market data

To test the theory of the proposed CMSM model, market shares data from the service providers in the real market are gathered. For instance, service providers share of cell phone subscribers in the American market are illustrated in Figure 8.1. The figure shows the temporal evolution of mobile service subscribers from 2008 to 2011.

The figure shows that Verizon is the leading service provider in the America telecommunication industry, and grows at a very small rate during the time period. Since the market has matured, there are fewer new subscribers to sign up for the service providers. Therefore, there is only small variations in the number of adopters for each service provider, but Figure 8.1 illustrates that the greatest service providers is still greatest after the time period.

Furthermore, Figure 8.2 displays the average monthly churn rate for the top wireless carriers in the United States from 2014 to 2016. For the largest companies the churning rate is stable at a low rate. The average monthly churn rate of Verizon was at 1.26 percent in the fourth quarter of 2013 [33]. But for the smaller service providers the churn rates varies more and are higher through the time period. In relation to the CMSM model, the model illustrates that when a new service provider enters the market the churn rate varies more than the large service providers.

The results from the CMSM model suggest that the number of adopters increases with network effects and feedback from the market. For example, case 3.4 shows that with increasing churning parameters, service provider 1 acquires all the customers in the market. In contrast, the results from Figure 8.1 indicate that the network effects are small. The largest companies increases the most, therefore network effect has an impact of customers when choosing service provider.

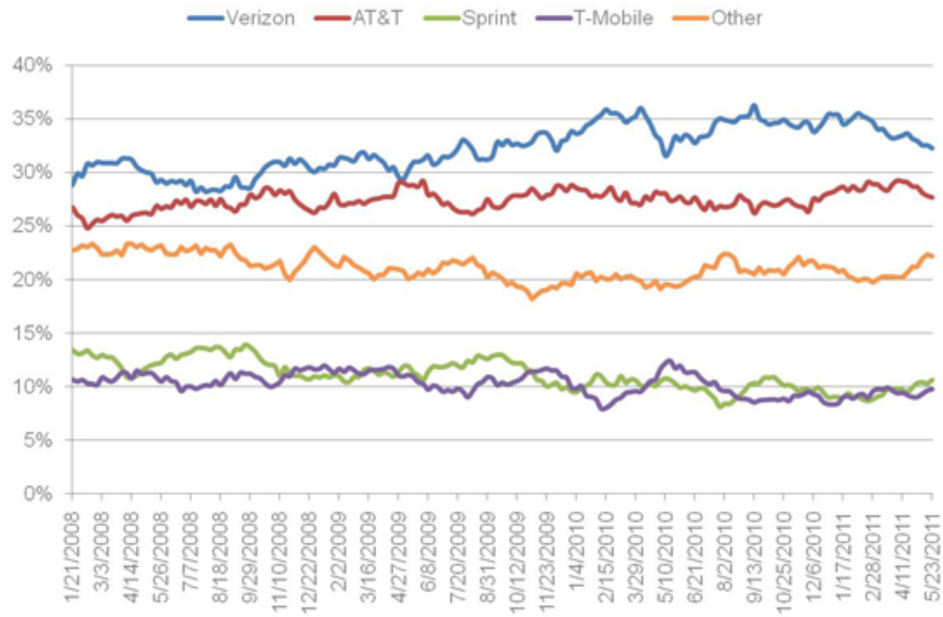


Figure 8.1: Service providers share of cell phone subscribers in United States [34]

8.1.3 Uniqueness of the CMSM Model

The competition between service providers has grown at an exceptional rate in the last several years, and the research about churning and adoption in the mobile service market is well researched. This research was conducted to better understand the competition in the mobile service market, and to get a better understanding of churning behavior for customers in the telecommunication industry.

One of the main areas that make the CMSM Model unique is its ability to model the competition in the market considering several values for variables and parameters in the market. Since it uses network effect and churning, it is possible to look at the temporal evolution of the market. Furthermore, the model utilizes both spontaneous and stimulated churning, and implements periodic functions to study oscillating adoption and churning rate. This gives a more realistic picture of the telecommunication industry, and forecast the evolution of the market.

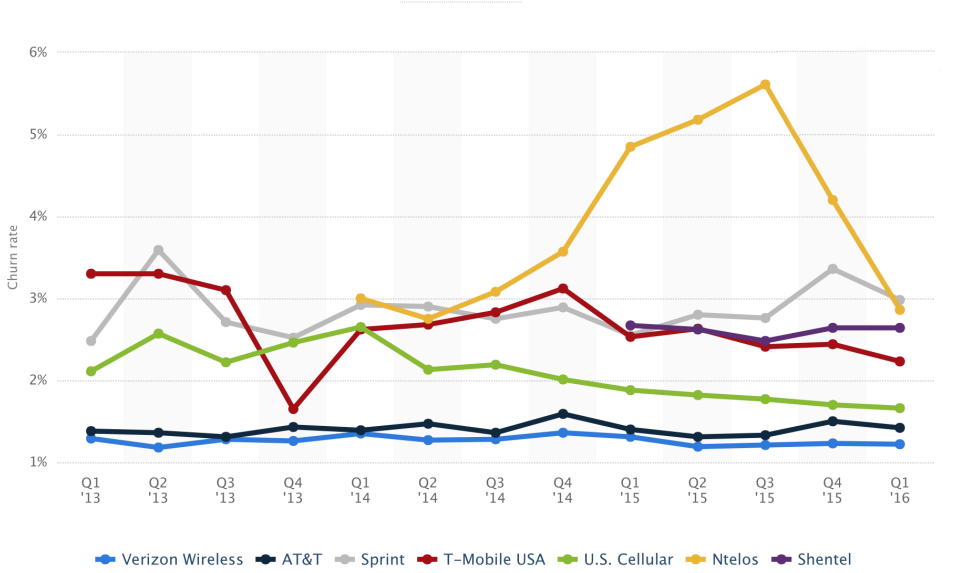


Figure 8.2: Average monthly churn rate for wireless carriers in the United States [33]

8.2 Further Discussions

When there is stimulated churning and market feedback in the market, as seen in the results, it could be very hard for new service providers to enter the market. Because of network effects, the customers will go towards were the other customers are. In such scenario, customers will choose the greatest service providers and it becomes hard for new providers to enter the market. The introduction of new service provider must then use marketing or offering packages to acquire new customers. Hopefully, this will result in a rapid growth in customer base, and after time a competitive service provider in the market. This problem is not only seen in the telecommunication industry, but also other service industries, where it is hard to enter the market because of network effects.

8.3 Improvement Points

The process of comparing and justification of the results, obtained in the scenarios, with real data from the market was more challenging than initially anticipated. It was very hard to find exact data from the mobile service market, especially in the Norwegian market. However, some data from other countries served as an illustration of the competition in the market, and gave a good basis for comparing the results with the real world.

During the design process of the CMSM model, many assumptions were made in order to modeling the essential functions needed in this study. This created certain limitations because the model cannot take all possible values and relationships into account.

Chapter 9
Future Work

This chapter presents ideas for future work that were not included in this thesis. It will start by explaining how negative network effects could be included to improve the model. Then some ideas for how computing more parameters and re-adoption may make the model more accurate. The chapter will also present how the CMSM model may be improved in context of network value.

9.1 Congestion

Positive network effects are an important factor in the CMSM model in determining the adoption and churning rate, but the mobile service market also includes negative network effects. The model can be improved by introducing congestion, where to many customers in one service provider could have negative network effects on the adoption and churning rate. The increased consumption behavior could lead to congestion in traffic, if to many customers uses the same service at the same time. Congestion is not a huge factor in the telecommunication industry, but it could be included in the model to gather more of the realistic picture.

9.2 Re-adoption

In the way the CMSM model is developed and presented, there is no possibility for quitting and re-adoption. Therefore, the model can be improved by introducing re-adoption, where a customer can quit the market and later adopt the market again. The model must then include a quitting rate, where customers leave the market at this rate. However, it is safe to say that when a customer enters the market, it is very rare that a customer quits using a mobile phone. Customers often churn from one service provider to another, but seldom quits the market.

9.3 Computing more Parameters

The CMSM is developed in a way were the adoption and churning rate is depend only on a few created parameters. One of the main parameters that affect the adoption rate is advertising and offers packages. The model could be improved by including more parameters and variables. Then, the churning and adoption rate will depend on more variables. In reality, the rates are of course influenced by more than one or to parameters.

9.4 Network value

The estimated value of a network and its obtained profit is influenced by the temporal evolution of adopters. The revenue and profit will increase as the service provider acquires more and more subscribers. The increased profit gives the service profit the opportunity to expand their network and to increase the quality of services. The opportunity to add new services could also attract new customers. Therefore, an increased network value could influence the market with great influence. This could be included in the CMSM model by letting the network effects be determined by the value of the network.

Chapter 10
Conclusion

The mobile service market has entered a new phase. With fewer new subscribers to sign up for mobile service providers, companies have now switched focus to retaining existing customers and adding values and content to their services [32]. As the competition in the mobile service market has grown at an exceptional rate in the last several years, and customers may now freely migrate from one service provider to another. Therefore, understanding churning-behavior is the key to understand what happens in the mobile service market when we have churning.

This study proposes a model and research to better understand the temporal evolution of competing service providers in the mobile service market, taking into account the adaption of new customers and churning of existing customers between mobile service providers. The Bass model was modified in order to investigate the effects of churning and network effects on mobile service providers.

The model shows that network effects, word-of-moth and churning have a great influence on the market. The customer churn behavior plays an important role, and to predict the future of the mobile service market it is critical to understand what makes people churn. The study, examines different churning determinates that affects the churning behavior for the subscribers.

One important conclusion is that churn matters, and when there is churning in the market, the churning rate significantly affects the temporal evolution of adopters. The result shows that the strength of network effect and independent decisions affects especially the early phases of the time period, while spontaneous and stimulated churning affects the market in the long term.

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