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Simulation of interactive games

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Master of Science in Communication Technology
Submission date: June 2016
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Problem description:

Interactive online games are increasingly popular in today's society, and the industry is growing fast. The games take place in a virtual world and involve interaction with other players. Some online games connect millions of people, and the game studios enjoy enormous revenue utilising different business models. Why do so many people join a particular online game, what factors contribute to making a game successful, and how does the dynamics of adoption and quitting rate of games affect the total number of players during the lifespan of a game?

In this paper, research on successful and well established online games will be conducted, and mechanisms that contributed to their success will be analysed. The student will study empirical data and try to recreate it using System Dynamics, which involves creating theoretical models for known phenomenons. Background information and history will be presented to get a better understanding of the behaviour of the market. This includes studying different business models and identifying trends in the market.

Finally, new and detailed models that include complex relations between competing and cooperating games will be developed to study the temporal behaviour of the market. Several scenarios will be created, and simulations will be run to prove the different outcomes.

Possible problems will primarily involve recreating empirical data. With advanced simulation models, a lot of variables will affect the outcome, and small changes will have a significant impact on the result.

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Abstract

Interactive online games are increasingly popular in today's society, and the industry is growing fast. Games take place in a virtual world and involve interaction with other players. Some online games connect millions of people, and the game studios enjoy enormous revenue utilising different business models. The interactive game market has changed a lot over the years, and player demands have increased concerning functionality, content, and price. As a result, the costs related to development and operation of these games are very high. To justify this price, it is essential that the games become successful, and that they contribute to income even after the initial purchase.

In this paper, factors concerning player behaviour are studied. Factors include finding reasons why people join or leave a particular game, what events contribute to extending the lifetime of a game, how competition and cooperation affect the market evolution, and how game studios can react to change the market outcome. In particular, network effects, Word-of-Mouth (WOM), critical mass, churning, and cooperation are studied, as well as some history to get a better understanding of how the interactive game market has evolved, how it works, and how popular games have gained their position.

System Dynamics (SD) is utilised to simulate and measure different market factors. A model called Buyer Player Quitter (BPQ) model is developed. This model is used to simulate different market scenarios, including a one supplier market, a market with two competing games, and a market with three games including competition and cooperation. Each scenario highlights different effects. In addition, two models specifically designed to recreate empirical data from two existing games are created. These models prove the impact of the discussed market factors in actual Massive Multiplayer Online Game (MMOG)s.

Finally, simulation scenarios are created and conducted, and the results are analysed and discussed. The main findings involve the importance of generating initial adoption to reach critical mass. Once critical mass is reached, network effects and WOM becomes essential to generate a significant player base. Also, updates and expansions help a game reach a bigger audience while competition and cooperation have a major impact on growth and the lifetime of games.

Sammendrag

Interaktive online spill blir stadig mer populære, og spillindustrien vokser fort. Spillene foregår i virtuelle verdener og baserer seg på interaksjon mellom mennesker. Enkelte spill har flere millioner brukere, og spillstudioene tjener svært gode penger på denne sjangeren. Spillmarkedet har de siste årene opplevd store endringer, og spillere krever stadig bedre produkter. Kostnader knyttet til utvikling og drift av online spill er veldig høye, og for å tjene penger må spillene selge godt, samt sørge for inntekter også etter de er solgt.

I denne oppgaven studeres spilleroppførsel og relevante faktorer som påvirker spillere. Hvorfor starter eller slutter en person med et spill, hvilke faktorer resulterer i lang levetid for spillet, hvordan påvirker konkurranse utviklingen til spillet og hvordan kan spillstudioer reagere for å styrke sin posisjon i markedet? I tillegg studeres sentrale begreper som nettverkseffekter, Word-of-Mouth (WOM), kritisk masse, konkurranse og samarbeid. For å få en bedre forståelse for mekanismer i spillmarkedet og hvordan det fungerer, er noe spillhistorie inkludert. Historien omhandler strategiske valg, hvordan business modellene har endret seg, samt historiske hendelser.

I denne oppgaven utvikles en modell kalt Buyer Player Quitter (BPQ). Denne modellen er utviklet ved hjelp av System Dynamics (SD), og benyttes til å simulere forskjellige scenarioer. Scenarioene inkluderer: et marked med en spilltilbyder, et marked med to spilltilbydere og konkurranse, og et marked med tre spilltilbydere samt konkurranse og samarbeid. I tillegg er simulering av to eksisterende spill inkludert.

Til slutt er resultatene analysert og diskutert. Funn inkluderer viktigheten av å nå kritisk masse på et tidlig stadie. Når kritisk masse er nådd, tar nettverkseffekter og WOM over og blir sentrale for å generere en stor spillerbase. I tillegg er oppdateringer og utvidelser viktige da de hjelper spillet å nå en enda større brukergruppe, samt sørger for nytt innhold slik at eksisterende spillerne fortsetter å spille spillet.

Preface

This paper is the final product of the research conducted during the work on my Master's Thesis in the subject TTM4905, carried out during the spring of 2016. The Master's Thesis is the final assignment of my five-year degree to become a Master of Science in Communication Technology (CommTech) with specialisation in Digital-economy. The project is the continuation of preparatory work carried out in the autumn of 2015 and involves a study of player behaviour in game markets. The work has been conducted at the Department of Telematics at the Norwegian University of Science and Technology (NTNU).

I would like to express my gratitude to my supervisor and responsible professor Jan Arild Audestad for his guidance during the research. Your guidance with modelling and assistance through emails has been very helpful and of great importance. Your knowledge in this field has been an invaluable resource, and your help is highly appreciated.

June 06, 2016
Fredrik Heiberg

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List of Acronyms

ARPAnet Advanced Research Projects Agency Network.

BPQ Buyer Player Quitter.

CCP Crowd Control Productions.

CVSM Competitive Video Streaming Model.

EA Electronic Arts.

ESPN Entertainment Sports Programming Network.

FPS First Person Shooter.

FTP Free-To-Play.

MMOG Massive Multiplayer Online Game.

MMORPG Massive Multiplayer Online Role Playing Game.

MUD Multi-User Dungeon.

PLE Personal Learning Edition.

RTS Real Time Strategy.

SD System Dynamics.

SIR Susceptible Infectious Recovered.

TBS Turner Broadcasting System.

VR Virtual Reality.

WOM Word-of-Mouth.

WoW Word of Warcraft.

Chapter 1
Introduction

This chapter introduces the motivation of the topic. Limitations will be discussed, and the approach described. This paper is the continuation of the project assignment [1], and the goal of this study is to continue the development of the simulation model and run several simulations to highlight central effects and explore possible market outcomes. Once simulations are run, the results will be compared with relevant theories. Recreation and analysis of empirical data will be conducted to tie the research to actual events, and relevant history and definitions are included to analyse scenario outcomes and empirical recreation correctly. Some information is based on, and reused from, the project assignment paper.

1.1 Motivation

The interactive video game marked is a fast expanding industry that generates enormous revenue. Game studios invest millions of dollars in creating popular games that players from all around the world play on a large scale. Also, the growth of the industry has spread to other areas as well, and eSports, game hardware manufacturers, and streaming services generate enormous revenue.

Developing massive global games is very expensive, and includes the development of the game, licensing, distribution, story development, actor salaries, and last but not least, marketing. In fact, in 2009, Rich Hilleman, the executive of Electronic Arts (EA), stated that EA typically spends three times as much on marketing and advertising than on the development of the game, to ensure the game enters the top ratings [2]. To make sure that the investments are correctly spent, awareness of market evolution factors is essential. Polygon Staff [3], estimates that in order to break even, millions of units need to be sold, indicating that quick adoption of the games is necessary. To further increase the revenue from each game, a trend in the gaming industry is to offer in-game purchases to ensure that the game generates money even after the initial purchase.

1.2 Contributions

This paper presents a new approach to highlighting the impact of market factors in Massive Multiplayer Online Game (MMOG) markets. In these markets, the interaction between players is crucial, and adoption is highly dependent on network effects. This study investigates market strategies to initiate network effects and other factors that contribute to increased adoption. A System Dynamics (SD) model called Buyer Player Quitter (BPQ) model is developed, and analytic models are derived.

The main contribution of this paper involves the design of the BPQ model and the corresponding analytic models. The uniqueness of the model is its ability to simulate a wide array of different market scenarios, and highlight important growth factors. The BPQ model is developed in several stages, allowing various factors to be investigated. In addition to network effects, Word-of-Mouth (WOM), independent decisions, competition, cooperation, and empirical recreating is included. In this study, the BPQ model is used to simulate several scenarios specifically designed to prove the effect of relevant factors. Recreation of empirical data from actual MMOGs have never been done before and contributes to proving the impact of the discussed market factors.

1.3 Method

The work in this paper was completed in an iterative manner, in several phases. Each phase was completed and later revised multiple times.

1. Phase one involved gathering information about market factors, and deciding what games to simulate. MMOG history and empirical game statistics were studied and combined with the work done in the project assignment.

2. The second phase consisted of further development of the BPQ model, including adding additional functionality, and expanding causal loop diagrams and differential equations to meet the evolved model. Also, new models used to recreate empirical data were developed.

3. In phase three, development of simulation cases was conducted. This included running several test simulations to understand the behaviour of the new models and identifying central factors having an impact on market evolution.

4. Phase four involved running the scenarios and analysing the results.

5. The fifth and final phase consisted of structuring information, discuss the results, give a conclusion to the problem statement, and writing the paper.

1.4 Limitations

The BPQ model presented in this paper is a simplified market model. Consequently, the model does not include all possible market factors. The model proves how individual factors affect a market and gives general information about relevant market factors. To correctly imitate an entire market, detailed market studies must be conducted. Without proper market research, it is hard to identify competitors, collaborators, and market effect factors like adoption rate, leaving rate, churning, etc. Also, a real-life market involves random events that are hard to account for in a theoretical simulation model.

1.5 Report Outline

The remainder of this paper is structured as follows: Chapter 2 presents background information and theory about MMOG, critical mass, WOM, and network effects. The Bass diffusion model is then introduced as an underlying model of temporal market evolution, and complementary games are explained. Chapter 3 presents related work. Chapter 4 provides information about the history of MMOGs and the game market. It also contains the history of two selected games (Word of Warcraft (WoW) and *RuneScape*) Chapter 5 introduces the BPQ model, which is gradually developed from a single supplier market to a market with three games, competition, complementary games, and re-adoption. The model is studied in detail, components are explained, and the structure is explored. The model is then compared with the Bass diffusion model, and analytic models are derived. In Chapter 6, SD modelling is explained, and parameters are defined. AnyLogic, the simulation program, is presented, causal loop diagrams are created to illustrate feedback loops, and the final models are shown. In Chapter 7, scenarios are presented and simulated. Simulation graphs are then shown and compared. Chapter 8 contains simulation analysis and discussions, Chapter 9 presents future work, while Chapter 10 provides the conclusion. Finally, Appendix A contains large representations of the simulation models, and Appendix B contains additional simulations conducted on the complete BPQ model and the empirical models.

Chapter 2
Background

In this chapter, background information about Massive Multiplayer Online Game (MMOG) and effects that influence their evolution will be presented. Relevant terms like network effects, critical mass, and Word-of-Mouth (WOM) will be explained, and underlying models, like the Bass Diffusion model, are presented. This information provides general knowledge about the genre and factors that shape the games evolution.

2.1 Massive Multiplayer Online Games (MMOG)

MMOGs are games where several individuals play simultaneously over the internet [4]. MMOGs are highly social games where players cooperate or compete in different game modes to complete game goals [1].

MMOGs are usually centred around one or several persistent worlds that players can access after purchasing the game [1, 4]. Because player interaction is a big part of these games, game servers are designed to support hundreds or thousands of players [5]. MMOGs are complex games with a lot of content, and to utilise their full potential, a certain amount of players is usually needed [1]. To support this, MMOGs connect people from different parts of the world on a large scale. The genre is very popular, and spans from First Person Shooter (FPS) to Real Time Strategy (RTS) games [1, 4]. Massive Multiplayer Online Role Playing Game (MMORPG) are currently the most popular MMOGs [1].

2.2 Network Effect

Network effect is the phenomenon where the value of a service or a product changes as the number of users change [1, 6]. Network effects affect the value experienced by each consumer and the value of the whole network [7]. Hence, it is possible to separate the value received by the consumers into two distinct parts: one generated by the product itself, even with no other users; and the other, the added value derived from being able to interact with other users [8].

Usually, the more people using the service or product, the higher its value becomes [7]. When the number of users increase, the product becomes more attractive and more useful to the consumers [9]. Network effects are incredibly powerful, and can create a positive feedback loop, enabling a company to get ahead of their competitors [7]. In the adoption of technologies based on interaction with others, network effects are essential [9].

By having the largest network, a company can offer more value to its customers than their competitors [7]. This may lead to an advantage – in markets where network effects exist, people tend to gravitate towards the largest network, knowing it will probably be even bigger in the future [7].

2.2.1 Positive Network Effect

Positive network effect occurs when the product value increases as the number of users increases [1, 10]. The result is improved welfare for the individuals in the network [9]. A classic example of positive network effect is a telephone network [12]. A single telephone provides little value to the owner, but as other people purchase the product, each individual can communicate with more people, and the telephone becomes more valuable for each user [12]. Another popular example is social networking sites like Facebook, Twitter, etc. The mechanics are the same – if there is only one registered user on a social networking site, the value is low; however, as more people join, the value for each individual in the network increases.

Figure 2.1 illustrates network effect. Two telephones provide one single connection, five telephones provide ten connections while twelve telephones give 66 connections.

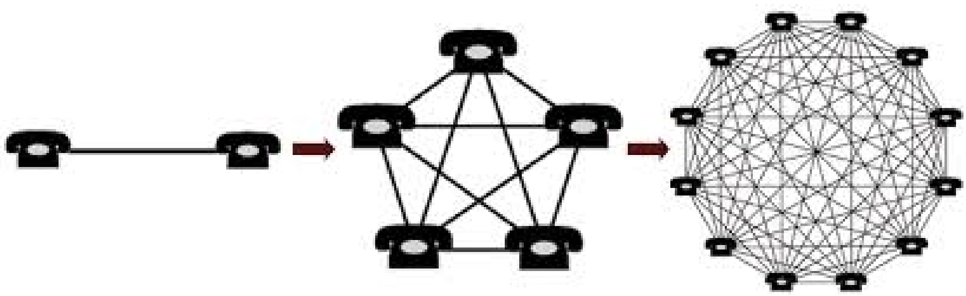

Figure 2.1: Network effect in a telephone network [10].

2.2.2 Critical Mass

The benefit of having a user base does usually not materialise until the number of adopters has accumulated to a substantial amount [13]. This amount is called critical mass, and until it is reached, network effects will have no impact [1]. Economides and Himmelberg [14] define critical mass as the smallest network size that can be sustained in equilibrium. They state that consumers will hesitate to buy a product before critical mass is reached because the current user base is insufficiently small, and they do not expect any positive network effects from the product [14]. When the future rate of adoption becomes self-sustaining, depending on the number of adopters, critical mass is reached [1, 15]. If a product reaches critical mass, the adoption will increase; however, if a product fails to meet its critical mass relatively quickly, it might die out prematurely [1].

2.2.3 Negative Network Effect

Negative network effect occurs when additional users reduce the value of the network [1, 6, 10]. The result is decreased welfare for individuals in the network [9]. Negative network effects can be the result of overpopulated servers, and may cause congestion, delay, and lag. [10]. Negative network effects are usually a problem when a new game is released, or when expansions are introduced. In these cases, the game population often grows considerably, and if the game studio does not predict this correctly, lag, disconnections, etc. might occur. Examples include: the initial release of Word of Warcraft (WoW) in 2004 – long server queues, latency issues and a lot of crashes occurred [16], the opening of the WoW update *Ahn'Qiraj* in 2006 – frame rate problems, and server crashes [17], and the release of the WoW expansion *Warlords of Draenor* in 2014 – overpopulated servers resulted in downtime [18].

2.3 Network Effects in MMOG markets

Network effects are extremely relevant in the MMOG market. As mentioned earlier, MMOGs are centred around interaction between players, and to utilise the game optimally; players have to team up or compete against each other. When people join a particular game, the game becomes more attractive and provides more opportunities for peer-to-peer interactions [13]. The increased population leads to quicker matchmaking and makes it easier to complete in-game goals, resulting in a better gaming experience.

Liu, Mai, and Yang [13], state that network effects are rooted in consumption utility, which is measured by user ratings. Their research proves that the size of the current installed base – the number of people having installed a particular game, can positively affect the individual rating of the game [13]. This has roots in the genre characteristics discussed earlier, and will give the players a better game experience.

As the game receives good critics, and people start recommending it to their friends, additional people will join the game and contribute to a better user experience for every user.

Lui, Mai, and Yang also suggest that network effects present in MMOG markets follow dynamic time variant patterns [13]. Once a game is released, product sales typically experience periods of growth, maturity, and decline [13]. In the early stages, before the game has reached critical mass, the game usually relies on the games attributes and commercials to attract new players. These effects lead to a relatively slow adoption where the marginal impact of one additional user is small [13]. When critical mass is reached, and the adoption enters the growth stage, network effect becomes more substantial, and the impact of an additional user becomes greater [13]. Finally, when the game has been on the market for some time, this effect stabilises and the player base eventually decreases [13].

Another statement in the paper is that the player base can be divided into two groups, experienced and less-experienced users. Less-experienced users are more likely to be affected by network effects and the size of the installed base than experienced users. Players with limited experience usually do not buy a game based on technical specifications and are less likely to explore all game features [13]. Their lack of experience makes them less capable of predicting the potential of a new game, and recommendations are crucial for their choices [13]. On the other side, experienced users rate a game based on product-related features and potential. Consequently, the study argues that until critical mass is reached, advertising and demo of the game are important to initiate growth, and eventually network effect and WOM.

2.4 Word-Of-Mouth (WOM)

WOM is passing on information about a product, brand, or a service, between people [1]. The communication is encouraged by personal experience and opinions, and each person is a non-commercial communicator, meaning there is no reward for their actions [1, 19]. The impact of WOM is called WOM effectiveness, and can be broken down into two factors; WOMs reach and WOMs impact [19]. WOMs reach is the number of people a person communicates with, while WOMs impact is how many of these people being affected, and consequently buy the product [1, 19].

WOM is considered to be the most effective and valuable form of promotion [20, 21]. WOM is based on personal recommendations and is therefore particularly effective. When a person recommends a product, the person's reputation is on the line, with nothing to gain other than the appreciation of the recipient [22]. WOM happens when a customer experiences more value than expected and chooses to share this opinion [22]. People tend to trust recommendations from friends and family. According to

Nielsen, 92% of consumers value recommendations from friends and family more than any form of advertising [21, 23].

In today's society, WOM through social media, like Facebook, Twitter, and YouTube, has become increasingly popular. This effect is called Word-of-Mouse and uses a variety of innovative techniques to reach people quickly on a large scale [24]. Word-of-Mouse has become an important source for customers to consult before they purchase a product or adopt a service. As a result, review sites and forums are important sources of information, and consequently, social media and user experience sites are considered fruitful arenas to generate buzz about a product [24]. In essence, the consumers are promoting the product, and it is very effective. In the remainder of this paper, WOM and Word-of-Mouse will be referred to as the same effect.

To make an MMOG successful, WOM is essential. Because MMOGs are centred around cooperation and competition, the more people that play a particular game, the more fun it is to play. If a person enjoys a game, it gives a great incentive to recommend this game to friends, and be able to play it with them. According to Fahey [23], 33% of game purchases were the result of friends or family influence, while advertising and promotions only influenced 11%. Also, the survey identifies a subset of gamers called "Influential Multipliers" [23]. Influential Multipliers are experienced, hard-core players, that people consult and trust when deciding which new game to purchase [23, 25]. It is essential to reach this group to generate buzz around a game.

To create WOM about a game, Whitler [21], identifies three E's: Engage, Equip, and Empower. Engage involves listening to the customers, and be a part of the conversations, for instance, responding to fans on social media. Equip means giving customers a reason to talk about the product, including excellent service, fantastic product, etc. Empower consists of letting customers know that they are important. For instance, creating public votes to change the product and show that user opinions are valuable.

2.5 Bass Diffusion Model

The Bass diffusion model is a widely used model that predicts growth rate. It was developed by Frank M. Bass in the 1960s and consists of a simple differential equation that describes product adoption in a market [26]. The model is based on assumptions about market size, and innovators and imitators to discover market evolution over time [1, 27, 28]. Innovators are individuals that adopt a new product independently of other people's decisions while imitators are people that adopt a product based on influence or pressure from others [1, 28].

The Bass diffusion model describes a socially driven adoption process with algebraic formulations [1, 9]. It is used to explain a theory or a dynamic hypothesis for growth and saturation and is based on two interacting feedback loops, one positive loop representing WOM adoption and one balancing loop representing market saturation [1, 9].

In this paper, the developed Buyer Player Quitter (BPQ) model is based on the Bass diffusion model, and all flows function according to this model.

In a one supplier market, the Bass diffusion model takes the basic form:

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

N represents 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 y, p is the coefficient of innovation, while q is the coefficient of imitation [1, 28].

2.6 Complementary Games

Complementary games are two or more games that are linked together in some way. Examples include games that provide rewards for another game, or two separate games capable of communicating with each other. The goal is to attract additional players to each game by introducing rewards and create curiosity for another game, and to have the social aspect of communicating with friends in other games.

An example is Blizzard's 2011 campaign that consisted of buying a one-year subscription to their MMORPG WoW, and getting a free copy of their new game Diablo III [29]. Diablo III was not yet released, and the campaign contributed to a boost in the number of players while Blizzard also secured many subscribers for their existing game. Blizzard has since used similar strategies, introducing rewards across their catalogue of games to attract players to other games [30, 31]. Also, Blizzard has added game chat across their catalogue of games. Friends add each other to their social gaming network and chat even when they are not playing the same game. The goal is to allow social interactions, even if players do not like the same games.

Complementary games may also be games that depend on each other. An example is Blizzard's WoW and the game expansions. To play an expansion, the player needs the original game as well as any previous expansions. The original game will still be playable without the expansions; however, the player will not have access to the additional content. The result is a strong incentive to purchase the expansion pack.

Another example is the game studio Crowd Control Productions (CCP)'s two games *Eve online* and *Dust 514*. *Eve online* is a MMORPG, while *Dust 514* is an FPS. CCP decided to create a shared universe between the two games, including a common economy, political and social impact, and the possibility to communicate with each other [32]. The goal was to connect players from two different genres, and consequently, make it possible for friends that enjoy different types of games to play together.

Chapter 3
Related Work

In this chapter, work that was studied during the writing of this paper will be presented. This paper is the extension of the project assignment [1], written as preparatory work, and some content from this paper will be reused. The subject studied during the production of this paper remains the same as in the project assignment; however, additional material is added. The subjects include the introduction to diffusion models, utilisation of System Dynamics (SD), and empirical recreation. Finally, a study about network externalities in MMOG markets is included.

3.1 Project Assignment Paper

The project assignment paper [1], was the preparatory work and the foundation for this study. It introduces early evolutions of the BPQ model and includes test simulations that illustrate how essential components interact. Also, some relevant history and information are presented.

3.2 Diffusion Models

Diffusion models are used as strategic tools to forecast the demand for a new product, capture the life cycle dynamics of a new product, and help to make strategic choices during pre-launch, launch, and post-launch [33]. The Bass diffusion model is a popular model used to describe how new products get adopted in a market. It emphasises how early adopters (innovators) and potential adopters (imitators) influence the market. The Bass diffusion model is further explained in Section 2.5

In Morecrofts book, $StrategicModellingandBusinessDynamics$ [9], a complete Bass diffusion model including advertising is developed and explained. Another diffusion model with similar feedback loops but different equation formulations is then developed, representing an economy air carrier market. This model shows WOM, network effects, and advertising, and accounts for a firm-level model where diffusion of low-cost air travel happens in competition with established airlines. This paper utilises some of the components in these two models, particularly network effects and WOM.

3.3 Utilising System Dynamics

SD is a powerful tool used to study the non-linear behaviour of complex systems over time. It can be used in social, managerial, economic, or ecological systems, and is based on interaction and information feedback. SD is presented in Chapter 6.

In the work of Chichakly [34], a competitive Bass model was implemented using SD. The impact of network effects and WOM is included in the model and is used to analyse the market evolution with multiple competitors. Evolution based on pressure from competitors is considered, meaning that competitive pressure restricts the WOM multiplier and the marketing effectiveness. Finally, churning between competitors is included using constant switching rates. This model also considers the timing of the release of a product compared with its competitors.

Idland [35, 36], presents a competitive model for media streaming market, called Competitive Video Streaming Model (CVSM). More specifically, competition between Netflix and the illegal streaming service Popcorn Time is studied, with the focus on network effects and how individuals affect the overall value of the network where a particular video is being streamed. The model is developed using SD and the AnyLogic software.

3.4 SIR Model

Susceptible Infectious Recovered (SIR) model, is a three-stage model that is used to predict the spread of an infectious disease. People get infected through contact with people that are already infected and recovers after some time.

Chichakly [37], describes the SIR model and explains the behaviour of the system. He introduces limits to growth and describes its relationship with reinforcing and balancing loops. The described model is quite similar to early evolutions of the BPQ model developed in this paper. Susceptible is equivalent to potential buyers, infected represents players, and recovered corresponds to quitters.

3.5 Network Externalities in Online Video Games

Network externalities are central in MMOG markets. Liu, Mai, and Yang [13], argues that network effects are rooted in consumption utility measured by user ratings. Their paper states that a large installed base generates high user ratings. As more people install a MMOG, each player can communicate with more people, leading to a better user experience. When these players rate the game, user ratings become better, and even more people joins the game, further increasing the ratings.

They also argue that network externalities exhibit non-linear dynamics during the product life-cycle [13]. At an early stage, network externalities are non-significant, highly significant in the next stage, and finally less important at a late stage. Also, network externalities differ across consumer segments, and experienced users are more likely to start playing a game based on its attributes than less experienced gamers [13].

Chapter 4
Interactive Game Market

In this chapter, information about MMOG history will be presented. The history provides valuable information about the genre's evolution and popularity, and highlight the different factors that made people interested in the genre. The success of a game depends on many factors. Genre history is essential to understand its evolution, and the history will justify choices made during the construction of the models.

Information about two selected games will also be presented. It provides background information about central factors in their evolution, for instance, what made people start to play or leave a particular game. Analyses of how research and market experience contribute to determining adoption and churning strategies will be included. The selected games stand out from the crowd and provide innovative business models and game-technical decisions which are central to their success. They have also paved way for other games and have been studied to understand subscription behaviour in MMOGs better.

The evolution of these games is also of interest in this study, as it provides information about player behaviour.

4.1 Interactive Game Market

The video game industry is the designation on development, sales, and marketing of video games [1]. It is one of the fastest growing industries in the world, involving huge game studios as and individual indie developers. According to Ramdurai [38], 64% of the U.S. population plays video games on some device.

During the last decade, video games have spread to other arenas. Massive competitions where players compete for millions of dollars in prize money are growing in popularity, and companies are investing heavily in promoting their products. ESports has also earned the status as a 2nd-level Olympic sport alongside other competitions like chess, automobile racing, polo, and cheerleading [1, 39]. With the rapid growth in popularity, and possibility to be a professional gamer earning a living, eSports has become very mainstream. In fact, in 2016, a Norwegian school announced plans to add eSports to their physical education curriculum [40].

One of the main reasons why eSports has become so popular is live streaming. In June 2011, Twitch.tv, a streaming and on-demand platform primarily focusing on video gaming, was developed [41]. Twitch streams playthroughs of video games, editorials, gaming events, eSports competitions, programming and development of games, and introduced interactive content, allowing people who are watching to participate [41]. The site has more than 100 million unique viewers per month, with more than 1.7 million broadcasters [41]. Another big agent is YouTube, which in 2015 introduced YouTube Gaming, a gaming platform for video game enthusiasts. Furthermore, more than 15% of all YouTube videos have game related content [1, 42], and "YouTubers" like PewDiePie earn millions of dollars producing game related videos. In addition to streaming websites, traditional television channels like Entertainment Sports Programming Network (ESPN) and Turner Broadcasting System (TBS) are also broadcasting eSpots [43, 44, 45].

4.2 MMOG History

During the 1970s, two new technologies emerged that changed the entertainment industry [46]. The evolution of network and gaming technologies made it possible for players on separate computers to connect to each other and play together in the same game [46]. In 1974, a game called *Mazewar* was developed [2, 3, 47]. *Mazewar* consisted of a simple graphical world, where players on different computers moved around in first person view shooting at each other [1, 47]. The game used a serial cable to establish a connection, but was soon updated to run over the Advanced Research Projects Agency Network (ARPAnet), a global standard that paved the way for today's Internet [1]. *Mazewar* was created by science organisations and was not meant for general distribution; however, the thought of a virtual world, where people from different parts of the globe could communicate was starting to take shape [46].

In 1978, Roy Trubeshaw from the University of Essex created what is considered the predecessor of the MMOGs of today [46]. Trubeshaw created a text-based game inspired by the board game *Dungeons and Dragons*, called Multi-User Dungeon (MUD). Trubeshaw wanted to play this game with his friends, and together with Richard Bartle, they created a framework where multiple users could play together over the university internal network. The game proved very popular, and a lot of students found a new spare time hobby [46]. In 1980, the university network was connected to the American ARPAnet. This expansion introduced MUD to a much bigger audience, and the game was quickly adopted in the USA. As the popularity of the genre increased, similar games that supported hundreds of players on each server were developed [46].

In 1985, the game *Island of Kesmai* was created. *Island of Kesmai* was the first commercial online world and utilised very simple graphics where players manoeuvred through a dungeon [46]. This game also introduced quests – directed objectives that the players could perform [46]. To play the game, a player had to connect to a proprietary network and pay a fee. As the game was a part of an exclusive network, the player needed to be a paying customer in this network to play the game [46]. The total costs of playing a game were about $6 to $12 per hour [46]. Today, *Island of Kesmai* is considered the game that created the business around MMOGs.

In 1986, LucasFilm created a game called *Habitat* [46]. *Habitat* consisted of a persistent online world where players created a fictional version of themselves, called an avatar [46]. The game allowed interaction between players from different parts of the world and included several mini games [46]. During the beta, LucasFilm experienced that players pushed through content much faster than the developers managed to create it. To cope with the lack of content, they introduced weapons in the game. Now, players started to kill each other, and even players that only wanted to play the mini games were slaughtered. Incredibly, this did not affect the number of players, proving that the game was so addictive, even dying over and over again was not enough to make players quit. Eventually, the game was shut down because it generated about 1% of the network capacity, and if the game were ever to come out of beta, the whole network would be flooded by game traffic [46].

In 1991, MUD was re-released under the name *Neverwinter Nights*. The game now included graphics, and despite an hourly cost of $4 to $8, the number of new players exploded. Game studios experienced that these kind of games were so popular that even with a high price tag, people wanted to play them. In 1996, *Meridian 59* was released [46]. This game is considered the game that introduced the modern business model to the genre [46]. *Meridian 59* was a separate program that connected to the modern and open Internet. As the Internet was growing fast during the mid-1990s, the potential user base was a lot bigger than earlier. The game also introduced a fixed monthly fee of $10, and players could play as much as they wanted during this month without worrying about the price tag [46]. The game gained about 25 000 active players and is considered the first modern MMOG [46].

During the same year, the game studio Origin released a beta for their new MMOG, *Ultima Online* [48]. Origin estimated that a couple of hundred players would play the beta, but within a few days, 50 000 people had signed up. Later, Richard

Garriot, the founder of Origin, stated: "That was the day the future changed" [48]. Once again, players powered through the game material faster than the developers managed to create it, and player behaviour proved hard to predict. Because the game lacked content, people once again started to kill each other [48]. This behaviour was repelling for many new players, and many people lost interest in the game. To solve this problem, Origin later created dedicated servers where players could not kill each other. *Ultima Online* did not consist of any quests or structure, but was based on "do what you want". The game peaked at about 250 000 players and helped the genre becoming more accepted in the society. A study showed that many players came from a country newly introduced to the Internet – South Korea [45]. A culture of Internet-cafés was evolving, making adoption through WOM very effective. Games that involved cooperation lead to players asking people sitting next to them to join the game and help out. This social activity expanded the number of players even further.

In 1998, the Asian company NCSOFT created a game called *Lineage*, explicitly directed towards Internet-cafe societies. Adoption of the game became exponential and reached an incredible 3 million players overall [48]. This enormous number increased the focus on the genre, and in 1999, Sony Entertainment introduced *Everquest*. *Everquest* required a dedicated graphics card, a luxury most personal computers did not have at that time. However, the game had beautiful graphics, which helped it stand out from the crowd. Unlike *Ultima Online*, the game also included quests and the mechanics was easy to learn, helping it reach 500 000 active players [48]. Once again, the popularity of the genre was confirmed, and the social aspect of these games was here to stay. Also, these games brought the studios much higher income than traditional games, due to their monthly fee.

Despite the very successful business model used by most games in the genre, a game studio Jagex decided to create a MMOG financed through advertisement and in-game purchases [49]. They also wanted to create a game that everybody who owned a computer could play, unlike games like *Everquest*. The result was a game called *RuneScape* [49]. *RuneScape* was based on the genre characteristics of MMOGs, but was Free-To-Play (FTP), and it was possible to play the game through a standard Internet browser. The game became a phenomenon, and is still one of the most played free MMOG on the market, reaching 10 million players at its peak [49]. During the early 2000s, MMOGs spread to other genres as well, for instance, FPS and sci-fi. As the popularity of MMOGs continued to grow, studios wanted to capitulate on the situation, and this resulted in new versions of popular games like *Everquest*. However, it was soon clear that creating new versions of popular games did not have the expected outcome. The new games were not connected to the old games in any way, which lead to the division of the player base. In fact, the new games never reached the number of players as the original games, and when a new version of a game was released, players left the old game as well [49].

In 2001, Blizzard Entertainment announced their first MMOG, *World of Warcraft* (WoW). The game was an immediate success, and the game will be further analysed in Section 4.3 As a result of the major success of WoW, game studios had to reconsider their approach [50]. Consequently, free subscription with in-game purchases inspired by the RuneScape model became popular [50]. While other MMOGs lost players during the rise of WoW, *RuneScape* actually experienced growth [50]. Changing the business model of an already released MMOG was risky – if nobody used money in-game, the game was forced to shut down. Surprisingly, games that changed their model to FTP experienced increased income, because players used more money on in-game purchases than they would have used on a monthly subscription [50]. In addition, the number of players increased quickly.

4.3 World of Warcraft

In 2001, Blizzard Entertainment announced their first ever MMORPG based on their well-established *Warcraft* universe [51, 52]. The genre was in rapid growth, and many studios were looking for the opportunity of make money on the growing market [52]. The developers at Blizzard were active players of other games like *Ultima Online* and *Everquest*, and even though they loved these games, they saw opportunities for improvements and thought it would be possible to create a more polished game [51, 52].

Blizzard had previously released two popular RTS games based on the *Warcraft* universe [51, 52]. These games enjoyed great success and respect in the gaming community, and the developers felt that the universe was deep enough to be further explored [51, 52]. The announcement of the game, named WoW, was unexpected, but due to the good reputation of Blizzard, very well received among the fans [52].

Upon release, Blizzard estimated sales at about 400 000 copies during the first month and was hoping to reach one million within the first year [51, 52]. However, this estimate proved very wrong. During the first day, WoW sold more than 200 000 copies, and within the first four months, the sales numbers reached one million [51, 52]. In fact, the enormous sales numbers meant trouble for Blizzard's infrastructure, and they had to restrict sale to make sure that the game was operational, and not suffering from negative network effects.

As time passed, the game proved to be much bigger than its competitors [52]. The game evolved into a phenomenon and got attention from other media as well.

One of the first big internet “memes” was a result of a YouTube video called "Leroy Jenkins", and South Park created a whole episode dedicated to WoW [51]. All this extra attention made the game even bigger, and a household name.

In 2007, more than 8 million people were playing WoW. To give players more content, and to further attract new customers, Blizzard released the first game expansion – the *Burning Crusade* [53]. Unlike Blizzards competitors, the game expansion built on the existing game, making sure not to divide the player base. The expansion broke sales records and quickly increased the games dominating position. During the same year, WoW was released in Russia and Latin America, further contributing to the games growth [54]. At this point, the number of players increased by a staggering one million every 6th month, to reach 11 million players before the second expansion, the *Wrath of the Lich King*, was released in 2008 [52, 53, 54]. Once again, the new expansion broke sales records.

During the following two years, before the release of the third expansion in 2010, *Cataclysm*, the number of players slowly increased to reach its provisional highest value at about 12 million players [52, 53, 55]. It was, however, clear that the adoption had flattened considerably; in fact, the growth eventually turned into a decline in subscribers [56]. By the time the fourth expansion, *Mist of Pandara*, was released in 2012, the number of players had dropped to about 9 million [53]. The release of the new expansion generated brief growth in subscription numbers; however, this growth was shortly followed by a steep decrease, falling to about 7.5 million players in 2013.

In 2014, the fifth and so far final expansion, *Warlords of Draenor*, was released. Blizzard managed to create a lot of buzz around this title, and at the release, the number of players had once again increased to 10 million. Unfortunately for Blizzard, these numbers were very transient, and by the second quarter in 2015, the player base had once again fallen to about 5.5 million [56].

Even though WoW lost millions of players, it is still the largest MMORPG in the world. Blizzard has recently announced a new expansion, *Legion*, scheduled to be released late August 2016 [57]. The number of players will probably raise again, but for how long remains to be seen.

The major success of WoW is the result of many different factors. First of all, the timing of the release was almost perfect. In the early 2000s, MMOGs became very popular, and the genre became mainstream [58]. Also, popular book series like J.R.R Tolkien’s *Lord of the Rings*, and J.K Rowling’s *Harry Potter*, had just been released as movies, making fantasy stories and universes mainstream [59, 60].

MMOGs was in its starting phase, and during the development of WoW, the developers benefited from their experience playing similar games. Existing games suffered from a lot of downtime, meaning players used a lot of time recovering from death, or travelling through the world [52]. To avoid these problems in WoW, Blizzard focused on creating a lot of content before the game was released. WoW also solved the problems related to player death and made it much easier and less costly to recover from it [51]. Blizzard ensured that the game was relatively easy to pick up and play, even if the player had not previously played any MMORPGs. WoW quickly gained the reputation as "the MMO that is actually fun to play", and as a result, WoW reached more people than any previous games [61]. Another factor that shaped the evolution of the game was the decision to create expansions rather than creating a whole new game, ensuring that the player base was not divided. Also, the expansions contributed to updating the game to meet new criteria from players [50].

WOM was central to the quick adoption of WoW. Frank Pearce, the Co-founder and chief of development officer at Blizzard Entertainment, stated that "The biggest driver has to have been Word-of-Mouth" [52]. The game benefited from brand recognition and Blizzards excellent reputation of creating games, which lead to a big hype among the fans even before the release. When the game was released, satisfied players shared their experience of the game with their friends, and influenced them to start playing as well. As more bought the game, this effect severely increased, resulting in even bigger sales.

Over the years, the popularity of WoW has decreased considerably. Some people feel that the game has changed for the worse and that it is too easy. Others state that Blizzard does not provide new content fast enough, while some people think that the game is too old and that objectives repeat themselves even when new content is added. The third and most important reason why people leave WoW is the fact that when their friends quit the game, the social aspect is gone. Consequently, when people start leaving the game, even more people decide to leave. The game has clear signs of classic dynamic behaviour, including growth, maturity, and decline stages.

During later releases of expansions, Blizzard has relied on deep stories and cinematic trailers. Consequently, an increase in subscription numbers has occurred for small periods but is usually followed by a considerable decrease. All in all, the game still has about 5.5 million active subscribers and is considered the most successful MMORPG ever created.

4.4 RuneScape

In January 2001, a game studio called Jagex, founded by the brothers, Andrew and Paul Gower, and Constant Tedder, released a browser-based MMORPG called *RuneScape* [62, 63, 64]. The game was originally a text-based MUD developed by Andrew during his studies at the University of Cambridge, but it quickly attracted a big audience and became an icon in the industry. *RuneScape* consisted of simple 2D graphics and was FTP financed by advertising. Andrew originally wanted to keep this business model, but as the player base increased, and the dot-com bubble began to collapse, it became harder to find advertisers, and too expensive to drift the game and the required servers [63].

To continue development of the game, Jagex introduced paid subscription like other games in the genre. *RuneScape* was still FTP in its basic form, but paying subscribers received extra in-game rewards [63]. Jagex estimated that they needed 5 000 paying subscribers to keep the game going, which proved no problem. *RuneScape* attracted 2 000 within the first hour, reaching their goal within the first week [63]. Jagex was now earning money, and they chose to reinvest in the game; the more they invested, the more the game grew [63].

Jagex decided to keep the game in the Internet browser to reach as many people as possible. Also, this strategy differentiated the game from its competitors [63]. People without a computer could log in to the game at school, at the library, or other places with a public computer, only by instaling a simple browser plug-in [63]. Constant Tedder has pointed at this aspect as a key factor in their success: "We can generate an audience anywhere in the world without having to have CD-Rom distribution in each market. That makes it easier for a company of our size to roll the product out" [64]. Another key factor in the success of *RuneScape* was the frequent updates. The developers added new content every second week, a trend they have continued to this day [63, 65, 66]. New content is layered on top of the original game to ensure that they do not split the player base on separate games [65].

In 2003, *RuneScape 2*, later called *RuneScape*, was released [65]. The update included a complete overhaul of the game engine, which now supported 3D graphics [65, 67, 68]. Players got the option to migrate their avatar, items, and skills from the old version, now called *RuneScape Classic*, which most of them did [65]. The original game was still supported until 2006 when only paying customers had access to this version of the game [67].

RuneScape's popularity grew with each new update, and in 2007 a German version of the game was released, helping *RuneScape* reach a whole new audience [65, 69]. Jagex soon followed up by launching a French version as well. Later that year, Jagex introduced trade limit and modified a popular zone called the *Wilderness*. These updates were not well received by the players and resulted in a riot and a significant drop in subscriber numbers [67].

In 2012, Jagex introduced *RuneScape*'s first microtransaction [70]. The service included a mini game that consisted of spinning a wheel to win in-game prizes and a general store where players could buy different items [70, 71]. Players quickly reacted to this update, stating that they felt betrayed by the new policy [70]. Jagex later explained that the update was necessary to secure the future development of the game [72]. They also stated that the update was well thought through, and would not have a significant impact on the game. Later in 2012, a big update that made a lot of old players return to the game was released [67]. In 2013, *RuneScape 3* was launched, introducing major graphic updates and allowed players to customise the user interface [62, 67].

Today, *RuneScape* is one of the oldest MMOGs in the world. It has passed the test of time and proven that renovation and step-by-step updates are successful tools to attract players, and to get a loyal player base. Over the years, Jagex has consulted their customers when releasing new content to ensure that the players stay happy, sometimes with success, other times not. As of May 5, 2016, more than 247 million accounts have been created, and the Guinness World Records recognise the game as the world's most prolifically updated MMORPG [73, 74]. The game has paved the way for other MMOGs and has proven that a FTP business model can be very profitable.

Chapter 5

Buyer Player Quitter (BPQ) Model

In this chapter, the developed models will be presented and explained in detail. First, a simple model representing the basic interactions will be shown before gradual evolutions will be explained. Analytic models will then be derived to describe transactions in the model.

5.1 Model Components

In this paper, a model called BPQ is developed. The model represents a game market, and consists of three stages, Buyers (B), Players (P), and Quitters (Q), representing respectively potential adopters of a particular game, the number of players of the game, and the number of players who have quitted the game. The BPQ model can be used to simulate the temporal evolution in the population of a game. Figure 5.1 represents the foundation for the BPQ model which will be further developed and explained later in this chapter.

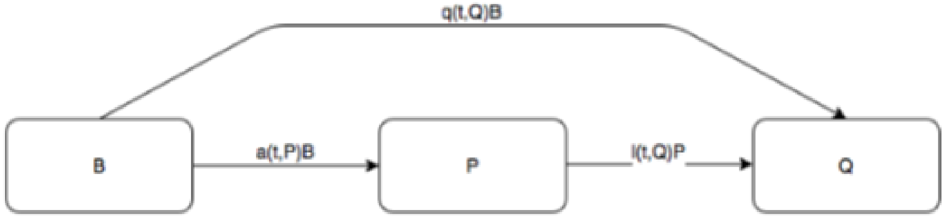

Figure 5.1: Buyer Player Quitter Model with one supplier.

Before the simulation has started, all individuals in the market (N) exist in the B section of the model. As time goes on, people either adopt the game, becoming a part of the P section, or reject the game, moving them directly to the Q section. After the game is released, ($t > 0$), individuals who have adopted the game might want to quit, moving them to the Q section of the model. As a result, at time infinity, all individuals end up in the Q section. The evolution is shown in Table 5.1, providing the initial and final values of $B(t)$, $P(t)$, and $Q(t)$ and their derivatives:

	t = 0	t = ∞
$B(t)$	N	0
$B'(t)$	$-aN$	0
$P(t)$	0	0
$P'(t)$	aN	0
$Q(t)$	0	N
$Q'(t)$	0	0
$B(t) + P(t) + Q(t)$	N	N

Table 5.1: Initial and final values of $B(t)$, $P(t)$, $Q(t)$, $B'(t)$, $P'(t)$, and $Q'(t)$.

Each state of the model is connected by flows representing the fraction of the market moving from one section to another as a function of time [1]. $a(t, P)$ is the intensity of new players buying the game, and may depend on time and the number of current players (positive network effect/WOM) [1]. $l(t, Q)$ is the intensity of players quitting the game, and may depend on time and the number of players that have already left the game and the number of current players [1]. $q(t, Q)$ is the intensity of people who are not interested in the game, hence, will never buy it [1]. This function may depend on the number of players that have already quitted the game [1].

In the BPQ model, we assume the following [1, 75]:

- A person buys at most one copy of a particular game
- The number of people buying the game is so big that we can describe the dynamics of the market by treating the dependent variables as continuous functions of time
- Constant market size (N)

5.1.1 Re-Adoption

In successful MMOGs, content updates or game expansions are common during the lifetime of the game. As Figure 5.2 illustrates, new content usually leads to increased adoption because people who have quitted the game tend to start playing again [1].

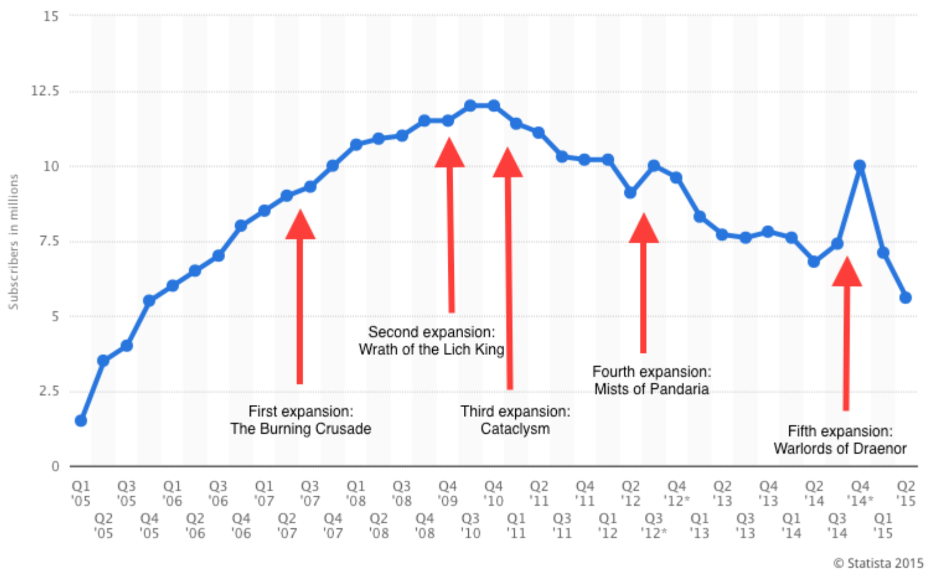

Figure 5.2: World of Warcraft expansion reactions [76].

To capture this effect in the BPQ model, a re-adoption flow is introduced. This flow, represented by $r(t)$ in the evolved model illustrated in Figure 5.3, represents a recurring function dependent on time. Re-adoption occurs at some given intervals specified during simulation and moves individuals from the Q section to the P section. In this model, the size of P does not affect the re-adoption rate because it is assumed that re-adoption is motivated by the new content, not by the size of the player base.

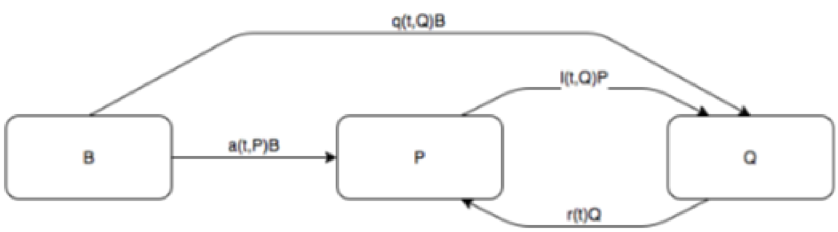

Figure 5.3: Buyer Player Quitter Model with re-adoption.

5.1.2 Competition

Competition is highly relevant in today's game market. Many game studios compete to attract a growing gaming audience, and this affects the evolution of these games. To capture competition in the BPQ model, an additional game is added, as well as churning flows between the two competing games.

In this evolution of the model, illustrated in Figure 5.4, a few things have changed. First of all, each game has its own Q section; $Q1$ and $Q2$ respectively. Also, people who are not interested in playing neither of the games will move directly to a separate Q section. The flow of not interested individuals is represented by $q(t, TQ)$, where TQ is the total number of quitters (the sum of Q, $Q1$, and $Q2$). Each Q section also has a linked stage, $TQ1$ and $TQ2$, representing the sum of people who are not interested in neither of the games, and the number of quitters in that particular game. To capture correct re-adoption in each of the two games, it is important to separate their quitted sections. Only people who have left a particular game can start playing it again, but the number of people who are not interested affects the leaving rate of both games.

Finally, churning between the competing games is added. Churning is represented by the two churning functions $c(t)P1$ and $C(t)P2$. Churning direction and size depend on a churning parameters specified during the simulation of the model.

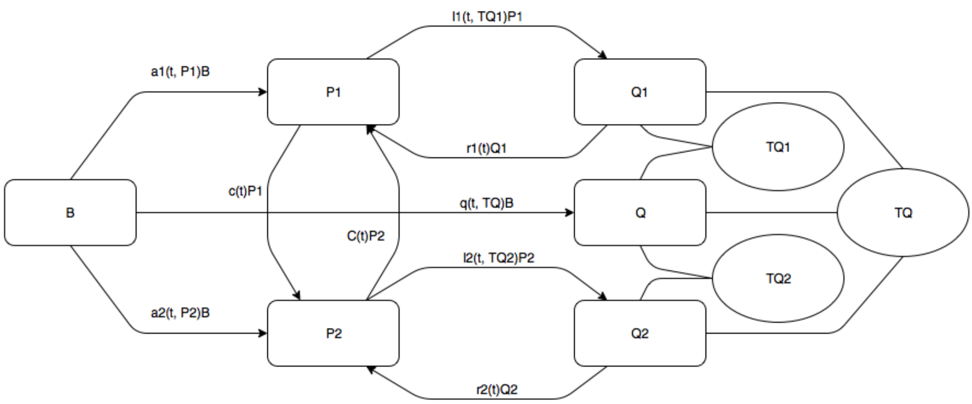

Figure 5.4: Buyer Player Quitter Model with two suppliers and re-adoption.

5.1.3 Complementary Games

As mentioned earlier in this paper, some games cooperate to attract additional players. To capture this effect in the BPQ model, a third game with relation to game two is added. The flows and stages of game three are represented in the same way as the two existing games, with the alteration of an index of 3. In addition, a combined stage of $P2$ and $P3$ is added ($P2A3$), with a corresponding quitters stage ($Q2A3$), and linked quitters stage ($TQ2A3$). $P2A3$ represents the players who play both games and is connected to the original player stages by the flows $pb1(t)P2$, $pb2(t)P3$, $q2(t, Q2)P2A3$, and $q3(t, Q3)P2A3$. $Q2A3$ is connected by a leaving rate and a re-adoption rate similar to the regular quitters and players states.

$pb1(t)P2$ and $pb2(t)P3$ respectively represent the adoption rate of game two and game three when an individual already plays one of the games. These flows depend on a factor that represents an incentive to start playing both games; for instance, studio campaigns. $q2(t, Q3)P2A3$ and $q3(t, Q2)P2A3$ respectively represents the rate at which people who play both games decide to quit game two or game three. $q2(t, Q2)P2A3$ depends on the leaving rate of game two while $q3(t, Q3)P2A3$ depends on the leaving ratio of game three. When people who play both games decide to quit one of the games, the leaving ratio is equal to that particular games leaving ratio, which depends on the number of quitted players in that game.

To capture correct adoption in the evolved model, a variable equal to the sum of $P2$ and $P2A3$ ($P2T$) is added. $P2T$ ensures that adoption occurs based on the total amount of players in game two. $P2T$ is also important in other aspects of the model, for instance when calculating churning direction. Churning direction occurs according to specified formulas presented in Chapter 6. A similar variable ($P3T$) is added, representing the total number of players in game three.

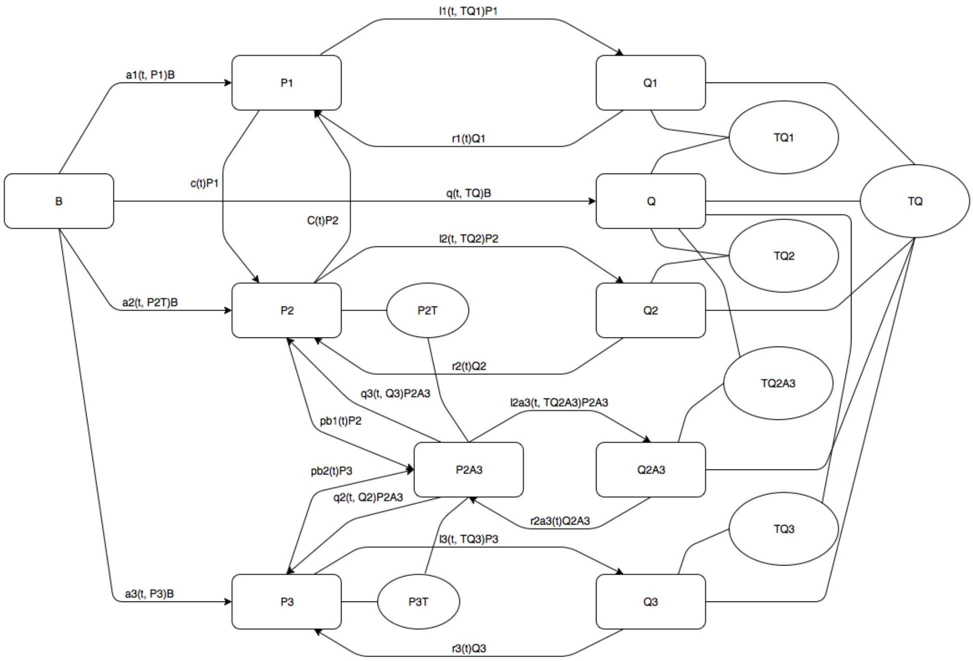

Figure 5.5: Buyer Player Quitter Model with competition, complementary games, and re-adoption

5.1.4 Independent Decisions

The BPQ model presented in this paper is based on the Bass diffusion model, and is used to determine the temporal market evolution over time [1]. To generate growth and trigger network effects, innovators/influential multipliers play important roles. This group inspires other individuals to start playing a game and is crucial to reaching critical mass. If a game fails to meet its critical mass, network effects will not be triggered, and the game might die prematurely.

5.2 Analytic Model

As shown in Section 2.5, the Bass diffusion model with a single supplier can be expressed as: [1].

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

To customise this function so it is valid in the BPQ model, some modifications are needed. The following equations represent the number of people in each section at time t:

$$\frac{dB}{dt} = -a(t, P)B(t) - q(t, Q)B(t) \tag{5.2}$$

$$\frac{dP}{dt} = a(t, P)B(t) - l(t, Q)P(t) \tag{5.3}$$

$$\frac{dQ}{dt} = l(t, Q)P(t) - q(t, Q)B(t) \tag{5.4}$$

Potential adopters are affected by the adoption rate and the not-interested rate. People either move to the players or the quitters section, hence; these sections grow as potential adopters shrink. The players section also lose players through the leaving rate, further increasing the quitters section.

The players section gains a bigger population from potential buyers via the adoption rate and reduces its population to the quitters section via leaving rate. The quitters section increases from both the potential buyers section and the players section.

To include re-adoption in the model, the following changes are made:

$$\frac{dP}{dt} = a(t, P)B(t) + r(t)Q(t) - l(t, Q)P(t) \tag{5.5}$$

$$\frac{dQ}{dt} = l(t, Q)P(t) + q(t, Q)B(t) - r(t)Q(t) \tag{5.6}$$

The re-adoption rate allows individuals to move from the quitters section to the players section [1]. Players move through the re-adoption flow according to re-adoption functions.

In the next instance of the model, a second game is introduced, as well as churning. Consequently, the following equations are derived:

$$\frac{dB}{dt} = -a\,(t, P1)\,B\,(t) - A\,(t, P2)\,B\,(t) - q\,(t, TQ)\,B\,(t) \tag{5.7}$$

$$\frac{dP1}{dt} = a\,(t, P1)\,B\,(t) + \mathrm{C}\,(t)\,P2\,(t) + r\,(t)\,Q1\,(t) - l\,(t, Q1)\,P1\,(t) - c\,(t)\,P1\,(t) \tag{5.8}$$

$$\frac{dP2}{dt} = A\,(t, P2)\,B\,(t) + c\,(t)\,P1\,(t) + R\,(t)\,Q2\,(t) - L\,(t, Q2)\,P2\,(t) - c\,(t)\,P2\,(t) \tag{5.9}$$

$$\frac{dQ}{dt} = q\,(t, TQ)\,B\,(t) \tag{5.10}$$

$$\frac{dQ1}{dt} = l\,(t, Q1)\,P1\,(t) - r\,(t)\,Q1\,(t) \tag{5.11}$$

$$\frac{dQ2}{dt} = L\,(t, Q2)\,P2\,(t) - R\,(t)\,Q2\,(t) \tag{5.12}$$

Each game has its own adoption and leaving rate, and the population of each game is affected by the individual adoption and leaving flows, and by the positive and negative churning flows between the two games [1]. Each churning flow is determined by churning functions specified during the simulation. Potential adopters are now affected by the individual adoption rates of game one and two, as well as the not-interested rate. Three quitters stages are present. $Q1$ and $Q2$ are affected by their respective leaving and re-adoption rates, while the Q section is only affected by the not-interested rate.

To meet the final model that also includes complementary games, the following equations are derived:

$$\begin{aligned}\frac{dB}{dt} = & - a\left(t,P1\right)B\left(t\right) - a2\left(t,P2T\right)B\left(t\right) \\ & - a3\left(t,P3\right)B\left(t\right) - q\left(t,TQ\right)B\left(t\right)\end{aligned} \tag{5.13}$$

$$\begin{aligned}\frac{dP1}{dt} = & \, a1\left(t,P1\right)B\left(t\right) + \mathrm{C}\left(t\right)P2\left(t\right) + r1\left(t\right)Q1\left(t\right) \\ & - l1\left(t,Q1\right)P1\left(t\right) - c\left(t\right)P1\left(t\right)\end{aligned} \tag{5.14}$$

$$\begin{aligned}\frac{dP2}{dt} = & \, a2\left(t,P2T\right)B\left(t\right) + c\left(t\right)P1\left(t\right) + r2\left(t\right)Q2\left(t\right) + q3\left(t,Q3\right)P2A3\left(t\right) \\ & - l2\left(t,Q2\right)P2\left(t\right) - \mathrm{C}\left(t\right)P2\left(t\right) - pb1\left(t\right)P2\left(t\right)\end{aligned} \tag{5.15}$$

$$\begin{aligned}\frac{dP3}{dt} = & \, a3\left(t,P3\right)B\left(t\right) + r3\left(t\right)Q3\left(t\right) + q2\left(t,Q2\right)P2A3\left(t\right) \\ & - l3\left(t,Q3\right)P3\left(t\right) - pb2\left(t\right)P3\left(t\right)\end{aligned} \tag{5.16}$$

$$\begin{aligned}\frac{dP2A3}{dt} = & \, pb1\left(t\right)P2\left(t\right) + pb2\left(t\right)P3\left(t\right) + r2a3\left(t\right)Q2A3\left(t\right) - q3\left(t,Q3\right)P2A3\left(t\right) \\ & - q2\left(t,Q2\right)P2A3\left(t\right) - l2a3\left(t,Q2A3\right)P2A3\left(t\right)\end{aligned} \tag{5.17}$$

$$\frac{dQ1}{dt} = l1\left(t,Q1\right)P1\left(t\right) - r1\left(t\right)Q1\left(t\right) \tag{5.18}$$

$$\frac{dQ2}{dt} = l2\left(t,Q2\right)P2\left(t\right) - r2\left(t\right)Q2\left(t\right) \tag{5.19}$$

$$\frac{dQ3}{dt} = l3\left(t,Q3\right)P3\left(t\right) - r3\left(t\right)Q3\left(t\right) \tag{5.20}$$

$$\frac{dQ}{dt} = q\left(t,TQ\right)B\left(t\right) \tag{5.21}$$

$$\frac{dQ2A3}{dt} = l2a3\left(t,Q2A3\right)P2A3\left(t\right) - r2a3\left(t\right)Q2A3\left(t\right) \tag{5.22}$$

In the final instance of the analytic model, one additional supplier is added, as well as a section containing players playing both games two and three. Game three has the same adoption, leaving, and re-adoption flows as the two other games. Consequently, potential buyers are also affected by the adoption of game three.

Game two and game three are also affected by the rates concerning people starting to play both games, and rates concerning people who plays both games and decide to leave one of them. The state that represents players playing both games has similar leaving and re-adoption rates to each game.

The differential equations presented in this section are nonlinear. Consequently, analytic solutions will only be possible in a few simple cases, and to solve them, numerical methods like Runge-Kutta's method for coupled first order differential equations can be used [1, 77].

Chapter 6
System Dynamics

In this chapter, information about the SD modelling process and the simulation tool used during the simulations will be provided. Also, the models will be presented, and the parameters explained. Causal loop diagrams will be developed to explain the mechanics in the models.

6.1 Structure

SD is an approach used to understand nonlinear behaviour over time in complex systems [1, 78]. The approach dates back to the 1950s and utilises stocks and flows, internal feedback loops, and time delay to understand industrial processes [1]. SD is often used in a strategic context on dynamic systems characterised by interdependence, mutual interaction, information feedback, and circular causality to explore feedback effects and stock accumulation [1, 79].

SD involves defining problems dynamically in terms of graphs over time and identify the accumulation in each stock (section of the model) as well as the rate at which people join and/or leave the stocks. It also involves connecting the events of the real life problems to continuously interconnected loops of information feedback, and formulating a model that can reproduce the dynamic problem on its own [1, 79].

In SD, stock accumulation is central because dynamic behaviour occurs when flows accumulate in stocks [1]. A good analogy is a bathroom sink. The sink itself represents a stock, while the water faucet and the water drain filling and draining the sink are flows. If the rate of filling is greater than the rate of draining, water will accumulate in the sink, and dynamic behaviour will occur [1].

Given this analogy, the behaviour of variables in SD can be explained as follows [1, 35]:

- *Stocks* sections that continuously change their value over time and are the result of incoming and outgoing flows
- *Flows* connect the sections together and change the value of stocks
- *Dynamic variables* can change instantaneously and affect the flow rate
- *Parameters* can be defined and altered through events to stimulate dynamic variables and flows

6.2 AnyLogic

AnyLogic is a dynamic simulation tool used in the creation of the BPQ model. AnyLogic is based on the Java environment and allows users to extend simulation models with Java code, as well as it includes a lot of built-in functionality, and a good visual user interface [1, 80, 81]. The software has a growing community and offers excellent guidance through their consulting team [82]. AnyLogic offers a free version for educational purposes, and the software runs on Windows, OS X, and Linux operating systems. During this study, AnyLogic 7.2 Personal Learning Edition (PLE) was installed on an iMac 21" late 2012 running OS X Yosemite version 10.10.5.

6.2.1 Stocks

Stocks represent sections in the model. The size of the population in the model is constant, and during simulation, people move from one stock to another. At time zero, the whole population is located in the buyers stock, and during the simulation, people move to other sections. A person can only move once during each simulation time unit [1]. Stocks are represented by colored squares.

6.2.2 Flows

Flows connect the stocks together and determine how many people who move from one section to another during each time unit. The flows are affected by stocks, dynamic variables, and parameters [1]. Flows are represented by double arrows with an hourglass in the middle.

6.2.3 Dynamic Variables and Parameters

Dynamic variables are variables that change according to certain formulas. In this paper, dynamic variables are affected by network effects and WOM, and contribute in calculating the size of each flow. Parameters are fixed values that can be altered through events and are used to calculate flow values [1]. Dynamic variables are represented by small circles while parameters are small circles with a black triangle.

6.2.4 Events

Events are formulas that change the value of certain parameters. In the BPQ model, only conditional events are utilised, meaning events are triggered if a statement is fulfilled. Events are illustrated by a lightning sign.

6.3 Models

The final model contains all elements discussed earlier in this paper. To create a better understanding of how the complete model works, each instance will be properly introduced, ending up with the complete model. Model assumptions in each instance will also be presented, and the parameter will be explained in Section 6.4. I was not able to change the font size of names in AnyLogic; however, larger representations of the models are included in Appendix A

Figure 6.1 represents the basic one supplier market with re-adoption. In this model, potential adopters may choose to adopt the game through the *AdoptionRate* flow, or choose not to play the game, entering the *Quitters* stage through the *NotInterestedRate* flow. It is assumed that the size of the *Players* and the *Quitters* stages affect the decision of each individual in the market. Hence, the larger each stage becomes, the larger the flows becomes. It is also assumed that network effects and WOM will not take effect unless critical mass is reached. Hence, these effects are neglected until critical mass is reached.

Individuals who already play the game may choose to quit at any time, entering the *Quitters* stage through the *LeavingRate* flow. This decision is, like the decision not to start with the game in the first place, dependent on how many players having quitted the game. Individuals who have quitted the game may also choose to start playing again, moving from the *Quitters* to the *Players* stage through the *ReAdoption* flow. In this model, it is assumed that re-adoption only happens if the developers introduce new content to the game. As a consequence, re-adoption occurs at selected periods of time, when new content is developed.

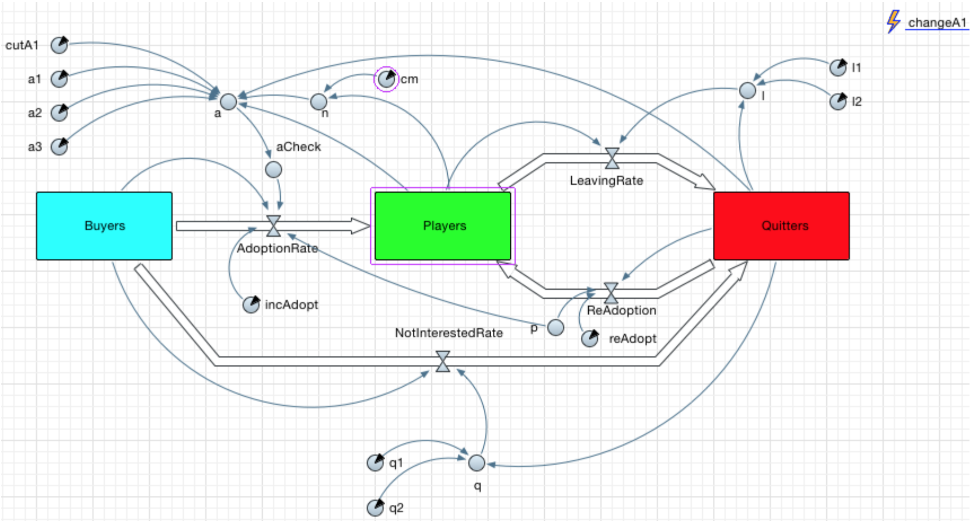

Figure 6.1: AnyLogic BPQ model with re-adoption.

Figure 6.2 introduces competing games with churning. Players may decide to quit one of the games and start playing the other. It is assumed that each game has its own adoption rate, which is determined by individual parameters, the size of that particular game's player base, and how many having quitted the game. Initial churning occurs to the game that has the biggest player base and is represented by the $ChurnRate1$ and $ChurnRate2$ flows. This assumption is based on the fact that a larger player base usually means better network effects. Also, it is assumed that if one of the games become significantly bigger than the other, measures will be taken to even out the odds. To meet this assumption, the model supports conditional events that change churning direction based on simulation preferences. $freeChurn1Event$ and $freeChurn2Event$ represent the conditional events.

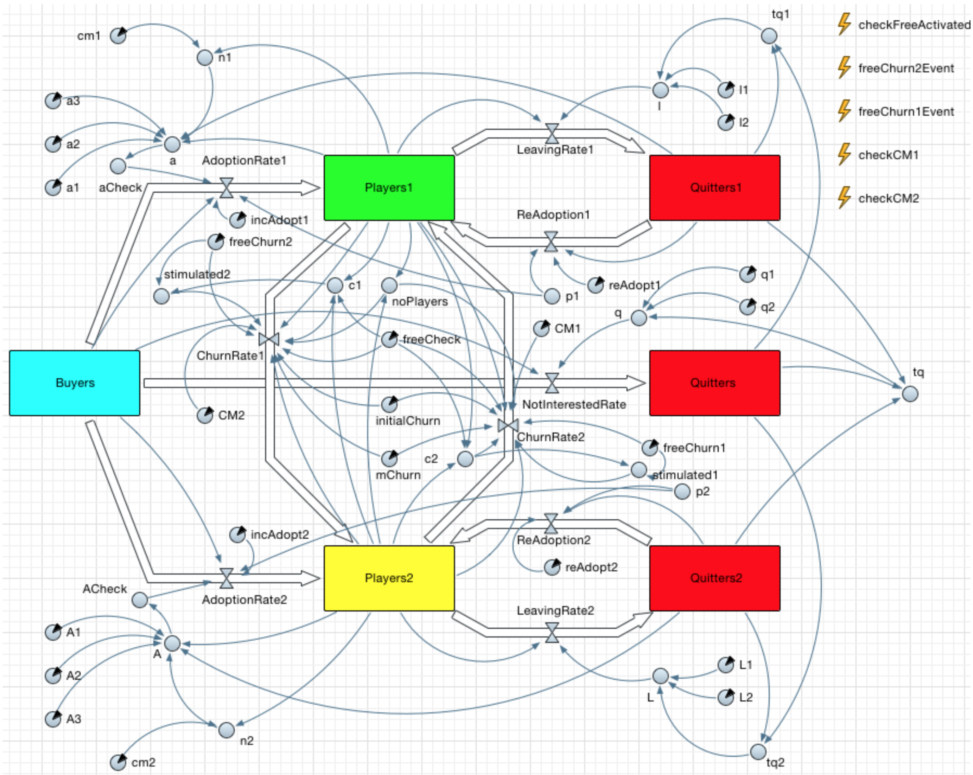

Figure 6.2: AnyLogic BPQ model with churning.

Figure 6.3 presents the final model, which introduces a third game with a relation to game number two. It is assumed that a particular game can increase its player base by cooperating with another game. Players might decide to play multiple games at the same time, and this decision can be inspired by incentives between the two games. In the BPQ model, players start with a complementary game based on a $compFactor$, representing the additional value of playing the games. Players adopt both games through the $PlayBothGames2$ and $PlayBothGames3$ flows.

It is assumed that people who play both games might decide to quit either one, or both of the games. If a player decides to quit one of the games, the decision is inspired by the leaving ratio of that particular game. Leaving one of the games occurs through either the $QuitGame2$ or $QuitGame3$ flow. If a player decides to quit both games, the decision is inspired by a separate leaving ratio, $LeavingRateBoth$, which is determined by the leaving ratio of both games, and the size of $Quitters2And3$.

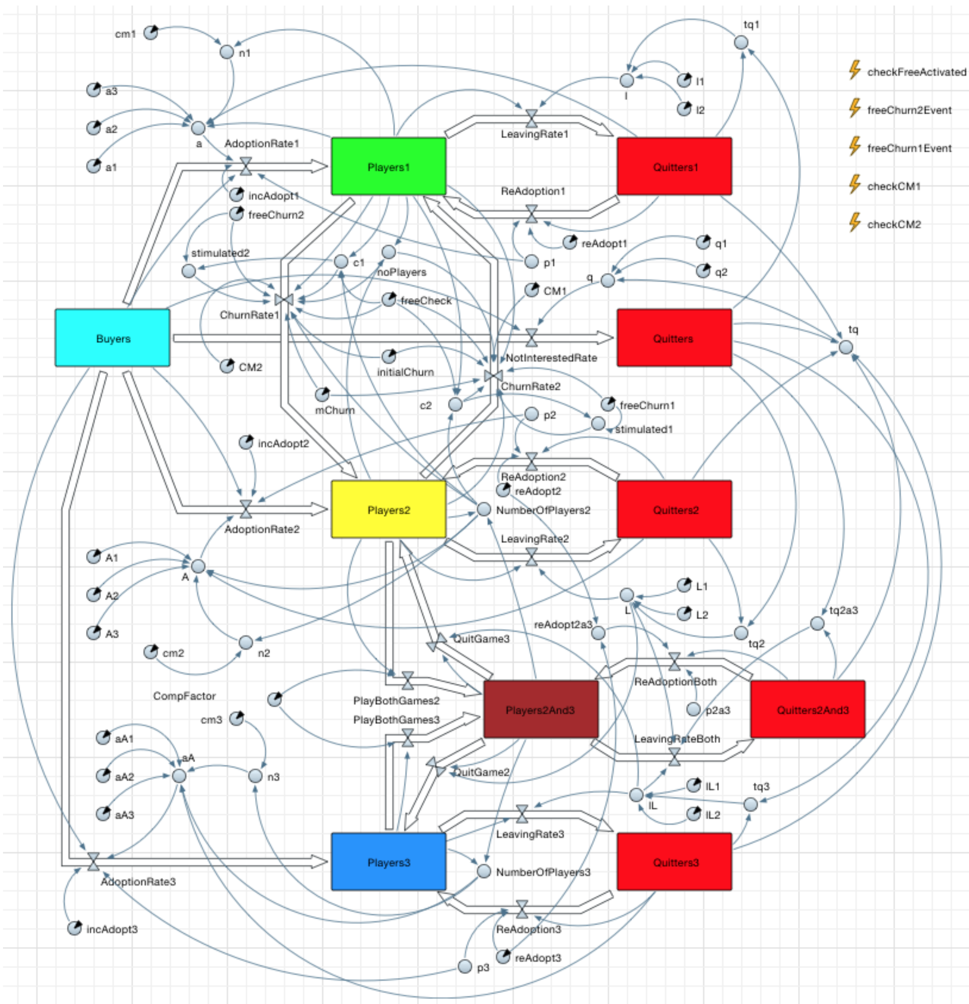

Figure 6.3: AnyLogic BPQ model with churning and cooperation.

6.4 Steps of the Modeling Process

This section describes each parameter, dynamic variable, flow, stock, and event in the final BPQ model. Corresponding values are explained in the same column and are illustrated by the first index. For example, looking at the dynamic variable a, A, and aA, the variable a will be shown. The other variables will contain the same parameters with other indexes.

Parameter	Description
$a1/A1/aA1$	Independent decision to adopt game one/two/three
$a2/A2/aA2$	Network effect/WOM – affect people to adopt game one/two/three
$a3/A3/aA3$	Network effect/WOM – affect people *not* to start with game one/two/three
$cm1/2/3$	Critical mass in game one/two/three
$incAdopt1/2/3$	Adoption due to updates/expansions in game one/two/three
$l1/L1/lL1$	Independent decision to quit game one/two/three
$l2/L2/lL2$	Network effect/WOM – affect players to quit game one/two/three
$q1$	Independent decision to not start with any of the games
$q2$	Network effect/WOM – affect people to not start with any of the games

Parameter	Description
$cutA1$	Initial adoption variable – is altered by the $changeA1$ event if initial adoption is neglected
$reAdopt1/2/3$	Re-adoption due to updates/expansions in game one/two/three
$freeChurn1/2$	Churn direction variable – determines whether churning should occur because a game is significantly bigger that the other. Returns 1 if churning should occur, 0 if not. Is determined by the conditional events $freeChurn1Event$ and $freeChurn2Event$
$initialChurn$	Independent decision to churn
$freeCheck$	Initial churning variable – determines whether churning due to one game becoming significantly bigger than the other is initiated. If so, the variable stops churning from the smallest to the largest game. Returns 1 by default, returns 0 when activated. Is determined by the conditional event $checkFreeActivated$
$mChurn$	Network effect/WOM – affect people to churn between game one/two. Also represents the churning variable in phase two – reaction to one game becoming significantly bigger than the other
$CM1/2$	Churning initialisation variable – once the game reaches critical mass, initiate churning
$compFactor$	Initial adoption of game two and three if a player already plays one of the games

Table 6.1: Parameter descriptions.

Variable	Equation	Description
$a/A/aA$	$a1 + a2 \cdot Players1 \cdot n1 - a3 \cdot Quitters1$	Total adoption rate for each game. Consists of the sum of initial adoption and positive network effect and WOM, minus negative network effect and WOM
$aCheck/Acheck$ $/aACheck$	$(a > 0)\ ?\ a : 0$	Conditional operator to ensure that the total adoption rate is positive
$l/L/lL$	$l1 + l2 \cdot Quitters1$	Total quitting rate from each game
$n1/n2/n3$	$(Players1 > cm1)?\,1 : 0$	Determine whether network effect and WOM should be initiated in adoption. Use a conditional operator, and initiate external effects if the *Player* section is larger than the critical mass
$p1/p2/p3/p2a3$	$pulseTrain(startTime,$ $pulseLength,$ $timeBetweenPulse,$ $endTime)$	Initiate re-adoption at given intervals. Use AnyLogic's *pulseTrain* function
$c1/c2$	$((Players1 < Players2)$ $?\,1 : 0) \cdot freeCheck$	Determine initial churning direction. Use a conditional operator to determine which game has the smallest player base, and start churning from this game. If second phase churning has started, set to 0

Variable	Equation	Description
$noPlayers$	$(Players1 \leq 0 \; \vert\vert Players2 \leq 0) \; ? \, 0 : 1$	Conditional operator that stops churning once one of the games have no players left
q	$q1 + q2 \cdot tq$	Total ratio of not interested players. Includes network effect and WOM
tq	$Quitters1 + Quitters + Quitters2 + Quitters3 + Quitters2And3$	Total number of quitters
$tq1/2/3/2a3$	$Quitters1 + Quitters$	Total number of quitters in each game, plus people who have never played any of the games
$stimulated1/2$	$(freeChurn1 > 0 \; \vert\vert c2 > 0) ? \, 1 : 0$	Conditional operator that checks whether churning occurs because one game is significantly bigger than the other. If so, return 1, else return 0
$NumberOf$ $Players2/3$	$Players2 + Players2And3$	Total number of players in game two or game three
$reAdopt2a3$	$\text{re}Adopt2 \cdot \text{re}Adopt3$	Re-adoption of players who have played and quitted both game two and three simultaneously

Table 6.2: Dynamic variable descriptions.

Stock	Equation	Description
$Buyers$	$-AdoptionRate1$ $-AdoptionRate2$ $-AdoptionRate3$ $-NotInterestedRate$	Potential adopters
$Players1$	$ReAdoption1$ $+ChurnRate2$ $+AdoptionRate1$ $-ChrunRate1$ $-LeavingRate1$	Players of game one
$Players2$	$ReAdoption2$ $+ChurnRate1$ $+AdoptionRate2$ $+QuitGame3$ $-ChurnRate2$ $-LeavingRate2$ $-PlayBothGames2$	Players that only play game two
$Players3$	$ReAdoption3$ $+AdoptionRate3$ $+QuitGame2$ $-LeavingRate3$ $-PlayBothGames3$	Players that only play game three
$Players2And3$	$PlayBothGames2$ $+PlayBothGames3$ $+ReAdoptionBoth$ $-QuitGame2$ $-QuitGame3$ $-LeavingRateBoth$	People who play game two and three simultaneously
$Quitters1/2/3$	$LeavingRate1$ $-ReAdoption1$	Quitters of game one/two/three
$Quitters$	$NotInterestedRate$	People who are not interested in neither of the games

Table 6.3: Stock descriptions

Flow	Equation	Description
$Quitters2And3$	$LeavingRateBoth$ $-ReAdoptionBoth$	Number of players who quitted game two and three simultaneously
$AdoptionRate1/2/3$	$Buyers \cdot aCheck$ $+incAdopt1 \cdot p1 \cdot Buyers$	Combined adoption rate in game 1/2/3
$LeavingRate1/2/3$	$Players1 \cdot l$	Combined leaving rate in game 1/2/3
$LeavingRateBoth$	$L \cdot lL \cdot tq2a3$	Combined leaving rate when quitting game two and three simultaneously
$ReAdoption1/2/3$	$p1 \cdot Quitters1 \cdot reAdopt1$	Combined re-adoption rate in game 1/2/3
$ReAdoptionBoth$	$Quitters2And3 \cdot p2a3 \cdot reAdopt2a3$	Combined re-adoption of game two and three simultaneously
$NotInterestedRate$	$Buyers \cdot q$	Combined rate of people who do not want to play neither of the games
$ChurnRate1/2$	$(Players1 \cdot initialChurn \cdot c1 \cdot freeCheck + Players1 \cdot mChurn \cdot freeChurn2 + Players2 \cdot mChurn \cdot stimulated2) \cdot CM2 \cdot noPlayers$	Combined churn rate in game 1/2
$PlayBothGames2/3$	$Players2 \cdot compFactor$	Combined adoption rate to play game two and three when the player already plays one of the games
$QuitGame2/3$	$lL \cdot Players2And3$	Combined leaving rate of one game when the player plays game two and three simultaneously

Table 6.4: Flow descriptions

Event	Equation	Description
$freeChurn1/2Event$	$(NumberOfPlayers2 > Players1 \cdot 2)$ $\&\&freeChurn2 \neq 1$ $set\_freeChurn1(1)$	Checks whether one of the competing games are significantly larger than the other. If so, set corresponding variable ($freeChurn1/2$) to 1. In this paper, triggered if game two is twice the size of game three
$changeA1$	$Players \geq cm$ $set\_cutA1(0)$	Checks whether the number of players are bigger or equal to the critical mass. If so, stop initial adoption
$checkFreeActivated$	$freeChurn2 > 0$ $\|\|freeChurn1 > 0$ $set\_freeCheck(0)$	Checks whether one of the $freeChurn$ variables are changed. If so set $freeCheck$ to zero to stop original churning
$checkCM1/2$	$Players1 \geq cm1$ $set\_CM1(1)$	Checks whether the corresponding game has reached critical mass. If so, initiate churning

Table 6.5: Event descriptions

6.5 Causal Loop Diagram

Causal loop diagrams are models that are designed to capture interactions and feedback loops in SD [1, 83]. The diagrams show relevant parts of a system and how they interrelate [84]. AnyLogic is used to sketch the diagrams, and textual identifiers and directional links show whether the influence is positive or negative [84].

When reading a causal loop diagram, one looks at a particular instance of the diagram and prove what consequences an increase will have. If an increase of that particular instance leads to an increase in another instance, a positive link is added between the two instances. If an increase leads to a decrease in another instance, a negative link is added. When links between instances create a loop, either a reinforcement or balancing loop is formed. A reinforcement loop is a loop that only contains positive links, while a balancing loop is a loop that includes at least one negative link.

To understand the complete causal loop diagram developed in this chapter, it is advantageous to explain separate instances of the diagram. Figure 6.4 represents the causal loop diagram for the adoption of a game. The diagram consists of a reinforcement loop (R) and a balancing loop (B). In this example, the reinforcement loop represents positive network effect/WOM. As more people adopt the game, the *AdoptionRate* becomes stronger. Also, the stronger the *AdoptionRate* becomes, the more people adopt the game and the player base increases. On the other side of the model, as people decide to adopt the game, and the adoption rate increases, the number of potential adopters decreases due to saturation. Consequently, a negative link between the *AdoptionRate* and $Buyers$ is added. In the last instance of the diagram, an increase in potential buyers will lead to increased *AdoptionRate*.

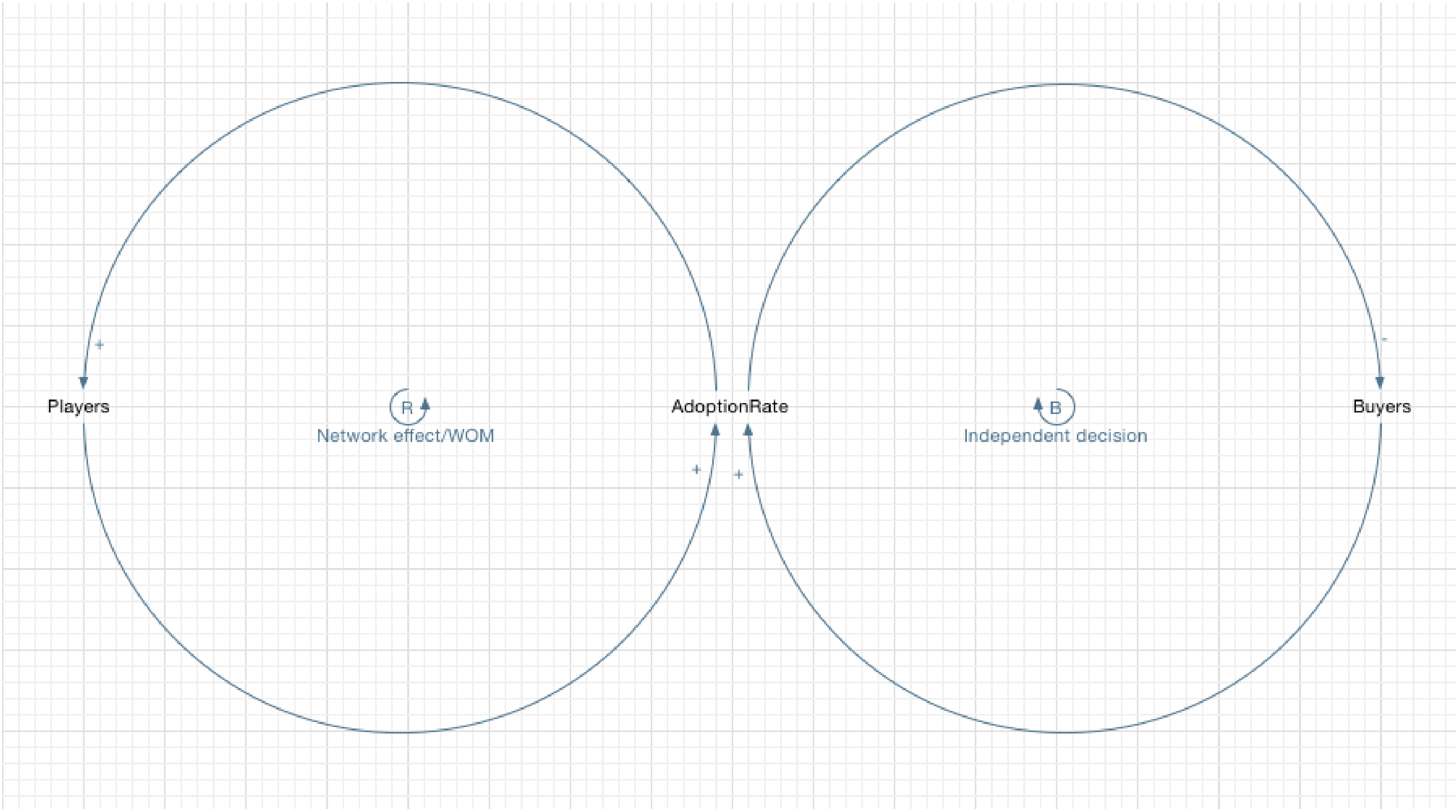

Figure 6.4: Causal Loop Diagram for adoption.

Figure 6.5 represents the first instance of the BPQ model – a single supplier market with re-adoption. Adoption of the game works like in the previous example. As the number of *Players* increases, the *LeavingRate* increases. When the *LeavingRate* increases, more people are leaving the game. The increased *LeavingRate* leads to a decrease in the number of players, forming a balancing loop. Also, the increased *LeavingRate* increases the number of *Quitters*. When *Quitters* increases, the *NotInterestedRate* increases, meaning more people choose not to play the game, and the number of *Buyers* decreases. In addition, *ReAdoption* increases, leading to growth in *Players*. The *LeavingRate* also increases, creating a reinforcement loop. As *ReAdoption* increases; the number of *Quitters* decreases creating a balancing loop; and the number of *Players* increases, completing a reinforcement loop stretching from *Players* through *LeavingRate*, *Quitters*, and *ReAdoption*. Finally, when the *NotInterestedRate* increases; the number of quitters increases, creating a reinforcement loop; while the number of buyers decreases, completing a balancing loop between *Buyers* and the *NotInterestedRate*.

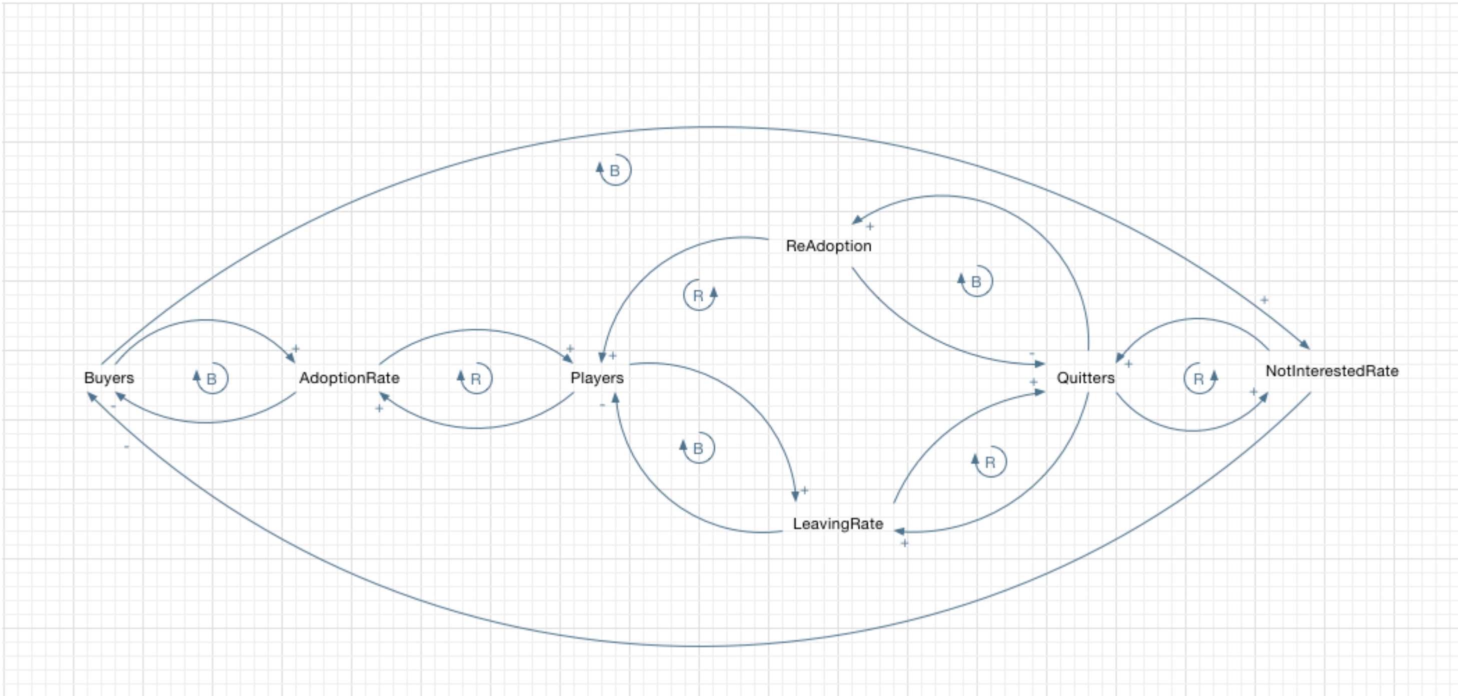

Figure 6.5: Causal Loop Diagram for the BPQ model with re-adoption.

Figure 6.6 represents the BPQ model with two competing games. Most of the connections work like the one supplier market; however, each *Players* stage has new loops introduced. In this diagram, it is assumed that churning occurs from *Players*2 to *Players*1. The churning direction may change, resulting in opposite churning loops. When the number of *Players*2 increases, the *ChurningRate*2 increases, meaning more people leave *Players*2, and more people start playing game one. As network effect and WOM affect the churning rate, increased *Players*1 results in larger *ChurningRate*2. Consequently, a reinforcement loop between *Players*1 and *ChurningRate* is added. As the *ChurningRate* increases, more people move from *Players*2 to *Players*1, resulting in a balancing loop between *Players*2 and *ChruningRate*2. Also, each *Quitters* stage affects a common *Quitters* stage.

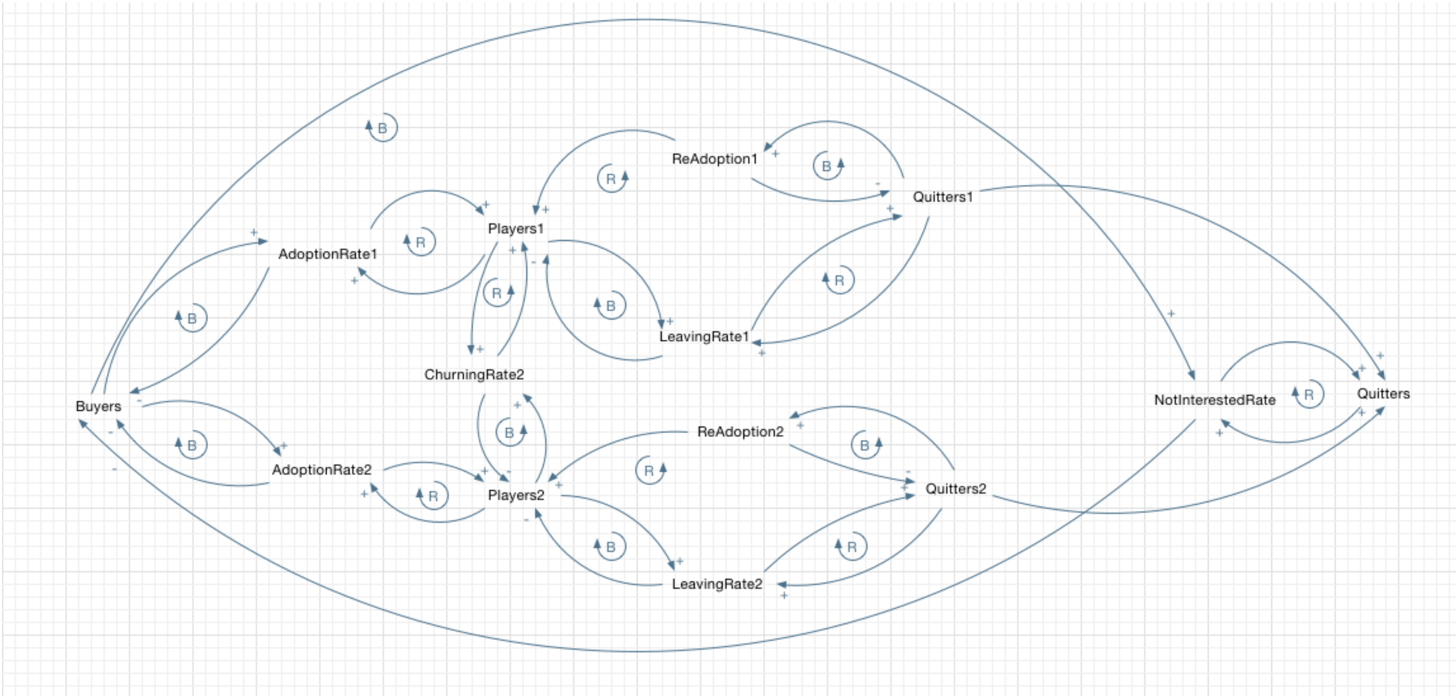

Figure 6.6: Causal Loop Diagram for the BPQ model with competition.

Figure 6.7 represents the complete BPQ model that includes a third game with relations to game two. When $Players2$ and $Players3$ increase, the adoption of both games, $PlayBothGames2$ and $PlayBothGames3$, increases. When these adoption rates increase, the number of $Players2$ and $Players3$ decrease. Consequently, two balancing loops are formed, contributing to an increase in $Players2And3$. It is assumed that the choice of adopting a second game is not dependent on the number of people playing both games, meaning there is no reinforcement loop. $Players2And3$ and $Quitters2And3$ have the same interactions concerning leaving and quitting as previous stages; however, $Players2And3$ also includes positive links to $NumberOfPlayers2$ and $NumberOfPlayers3$, representing the total number of players in game two and three.

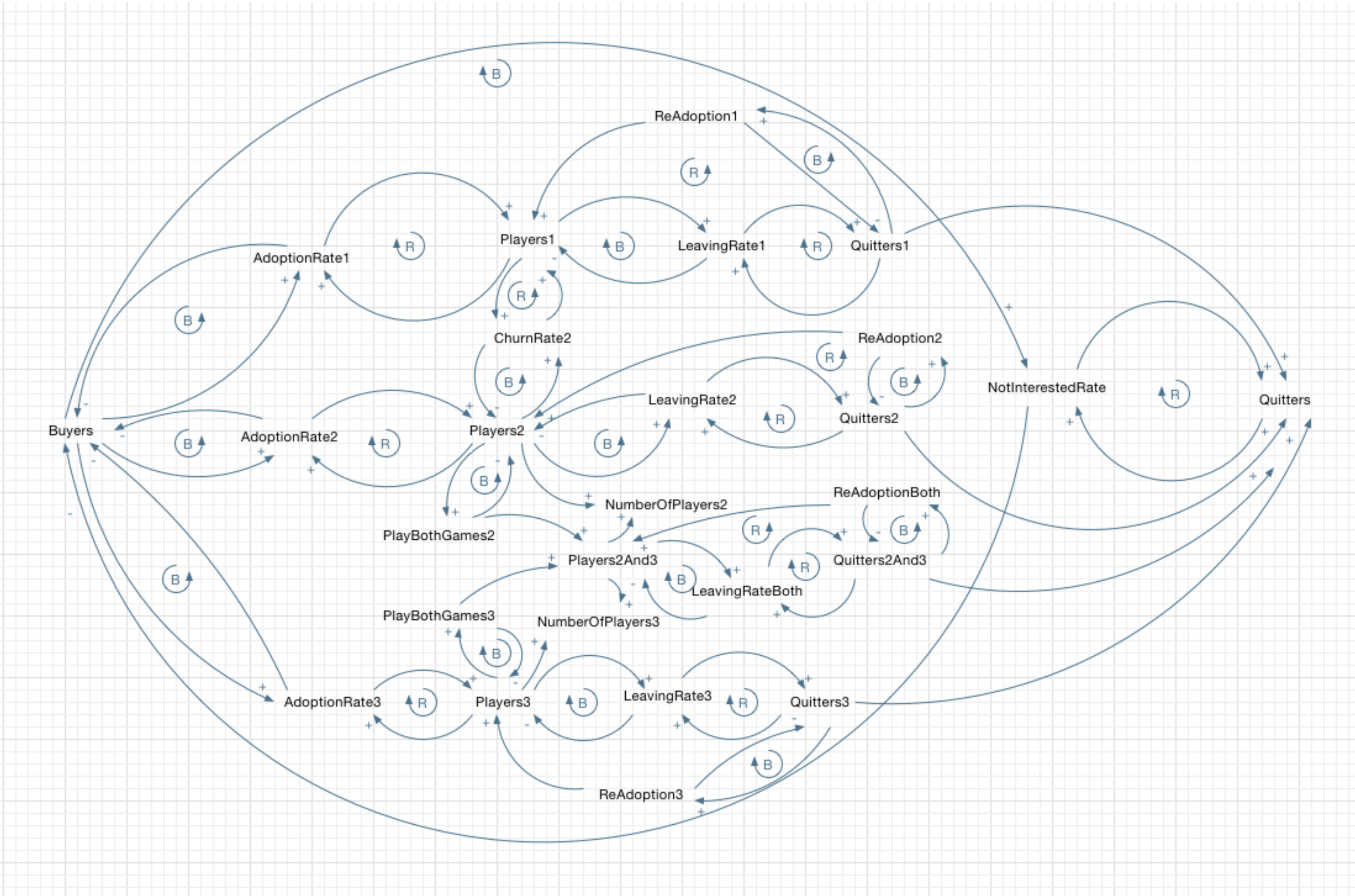

Figure 6.7: Causal Loop Diagram for the BPQ model with competition and cooperation.

Chapter 7
Simulations

In this chapter, some selected simulation scenarios will be presented. The simulations explore how the BPQ model works, and prove the effect of each model factor. In these simulations, the relations between the parameters are of interest, not their exact values. Consequently, parameters are chosen to visualise each effect in a clear and efficient manner.

Simulations of empirical models are also included. The goal of these simulations is to discover central effects that shaped the evolution of a particular game and explore how alterations of these parameters may affect the outcome. Also, the models are used to simulate possible future evolutions.

The simulations conducted in this chapter illustrate possible alternative outcomes. It is important to note that the scenarios do not correctly predict the evolution of the market; however, they give an illustration of how markets may evolve, and what factors affect them.

7.1 Complete Model Simulations

In this section, market evolution in the developed BPQ model is examined. Simulations are conducted in different instances of the model and prove how each iteration affects the market evolution. Parameters are altered to illustrate their individual effect. During the simulations, the x-value in the graph represents one month. In the simulation graphs, *light blue* represents the number of potential buyers, *green* represents the number of players in game one, *yellow* the number of players in game two, *blue* the number of players in game three, *brown* the number of players in both game two and three, while *red* represents the number of quitters.

7.1.1 Case 1

During the first simulation phase, basic model factors will be explored. Simulations will be conducted on a single supplier market with re-adoption represented by Figure 7.1. Table 7.1, 7.2, 7.3, 7.4, and 7.5 show the parameters, the corresponding dynamic variables, and the event formulas that are altered during each simulation. In each scenario, relevant parameters will be highlighted in red.

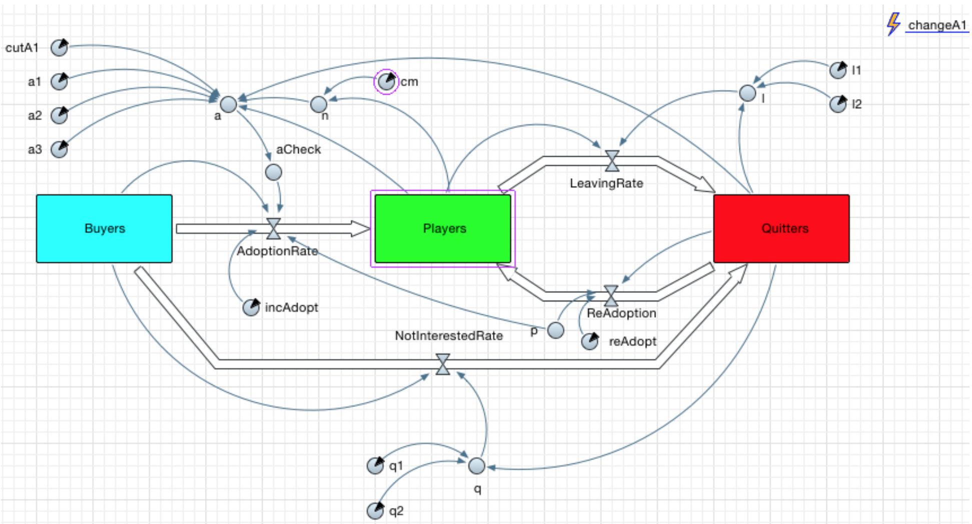

Figure 7.1: Buyer Player Quitter Model with re-adoption.

7.1.1.1 Scenario 1

The first scenario only involves initial adoption, leaving, and not interested rate. All other factors are neglected to prove the market evolution when only innovators/influential multipliers adopt a game. This simulation illustrates market evolution if network effects and WOM does not exist.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.005	0.005	0.0026	0.005	0.005
$a2$	0	0.000002	0.000002	0.000002	0.000002
$a3$	0	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt$	0	0	0	0	0.03
$incAdopt$	0	0	0	0	0.003
cm	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
p	-	-	-	-	pulseTrain (12,2,12,100)

Event	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$changeA1$	-	-	-	Players $\geq$ cm set_cutA1(0)	-

Table 7.1: Case 1 variable values.

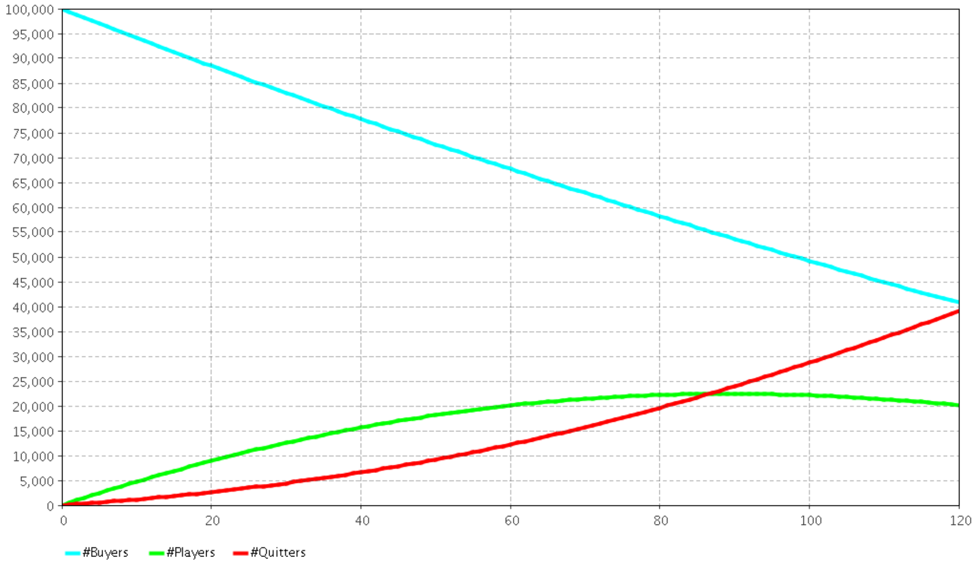

Figure 7.2: Case 1 scenario 1 simulation graph.

As Figure 7.2 illustrates, adoption of the game is slow throughout the whole simulation, and the game peaks at about 23 000 players. However, with the chosen parameters the game seems to have a long lifetime, which is due to the relatively high initial adoption, and low quitting rate.

7.1.1.2 Scenario 2

In the second simulation, network effects and WOM are introduced. Notice that the parameters of these effects are significantly smaller than those concerning initial adoption.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.005	0.005	0.0026	0.005	0.005
$a2$	0	0.000002	0.000002	0.000002	0.000002
$a3$	0	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt$	0	0	0	0	0.03
$incAdopt$	0	0	0	0	0.003
cm	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
p	-	-	-	-	pulseTrain (12,2,12,100)

Event	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$changeA1$	-	-	-	Players ≥ cm set_cutA1(0)	-

Table 7.2: Case 1 variable values.

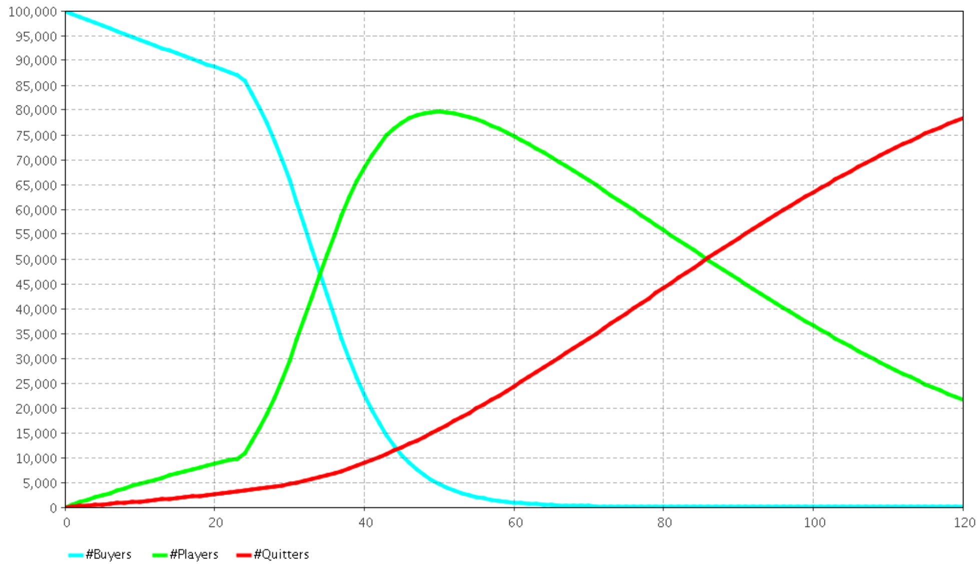

Figure 7.3: Case 1 scenario 2 simulation graph.

Figure 7.3 shows the market evolution when network effects and WOM are added. As the graph shows, once the game reaches its critical mass, network effects and WOM are initialised, and the population experiences rapid growth. The number of players reaches a peak at about 80 000 players, about four times as much as in scenario one. Eventually, the growth flattens and turns into a decline. When the number of players becomes greater, the leaving rate increases, and the number of quitters increases. Also, the quitting rate becomes larger due to WOM. As a result, the growth turns into a decline in population. The decline is quite strong in the beginning because imitators quickly leave the game. Gradually the decline flattens because hard-core fans are more resistant to quit the game.

One interesting observation is that the decline in scenario two is much stronger than in scenario one, resulting in almost the same player base at time $t = 120$. The evolution is dependent on the size of the adoption rate and determines when the game reaches its peak. In scenario two, the adoption is much higher than in scenario one, resulting in market saturation at an earlier stage. When the market approaches saturation, game adoption decreases, while the leaving rate remains high due to the high population. The result is a much larger leaving rate compared to an almost non-existing adoption rate, leading to a steep decline. As the player base in scenario two is much bigger than in scenario one, the decline is much faster. However, scenario two is the most desirable outcome, because it attracts a lot more potential adopters, and can utilise different factors to affect the evolution and extend the lifetime of the game.

7.1.1.3 Scenario 3

The third simulation involves not reaching critical mass. Initial adoption is altered to simulate evolution when a game fails to reach its critical mass.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.005	0.005	0.0026	0.005	0.005
$a2$	0	0.000002	0.000002	0.000002	0.000002
$a3$	0	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt$	0	0	0	0	0.03
$incAdopt$	0	0	0	0	0.003
cm	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
p	-	-	-	-	pulseTrain (12,2,12,100)

Event	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
changeA1	-	-	-	Players $\geq$ cm set_cutA1(0)	-

Table 7.3: Case 1 variable values.

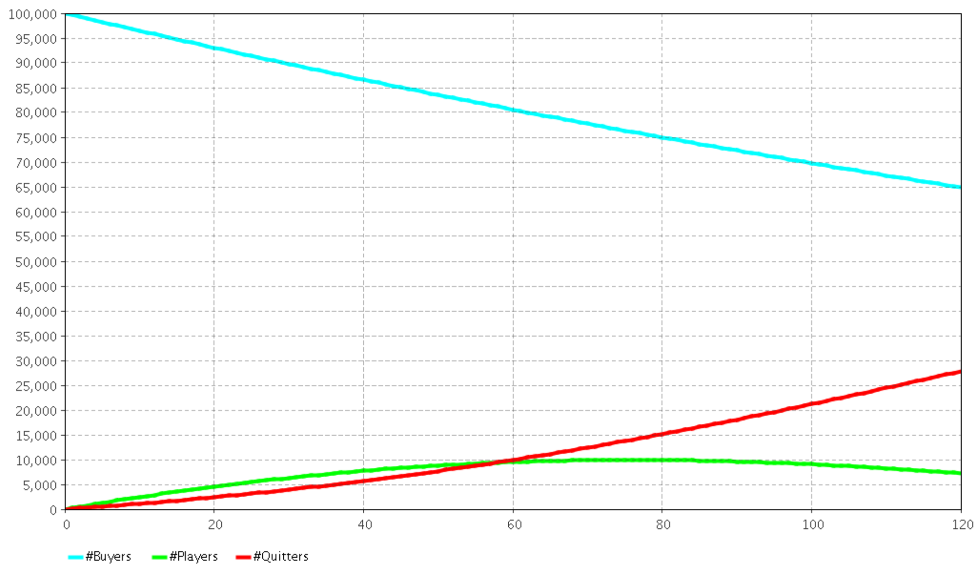

Figure 7.4: Case 1 scenario 3 simulation graph.

The third scenario represents a game that fails to meet its critical mass. As Figure 7.4 illustrates, the game does not have enough initial adopters to initiate network effects and WOM, hence, will not generate increased growth. The game is not big enough to make its growth self-sustaining, and the game dies prematurely. The simulation graph resembles the graph in simulation one and is essentially the same evolution with less initial adoption.

7.1.1.4 Scenario 4

In scenario four, initial adoption is neglected once critical mass is reached. This simulation explores the impact of innovators/influential multipliers when network effects and WOM are initialised.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.005	0.0026	0.005	0.005
$a2$	0	0.000002	0.000002	0.000002	0.000002
$a3$	0	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt$	0	0	0	0	0.03
$incAdopt$	0	0	0	0	0.003
cm	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000
Dynamic Variable	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
p	-	-	-	-	pulseTrain (12,2,12,100)
Event	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$changeA1$	-	-	-	Players $\geq$ cm set_cutA1(0)	-

Table 7.4: Case 1 variable values.

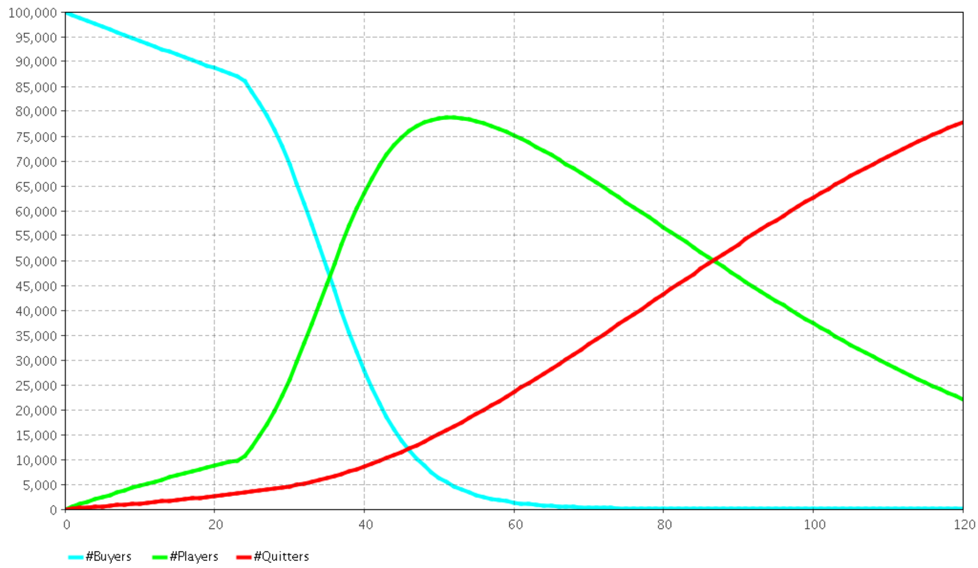

Figure 7.5: Case 1 scenario 4 simulation graph.

During the fourth simulation, illustrated in Figure 7.5, initial adoption is neglected once the critical mass is reached. Comparing this simulation with scenario 7.1.1.2, it is clear that once network effects and WOM are initialised, adoption through initial adopters is insignificant. The peak population is almost the same in both scenarios and more interestingly, due to a lower WOM leaving rate and a later saturation point, the player base at $t = 120$ is almost the same. It is clear that once critical mass is reached, network effects and WOM are the drivers of adoption.

7.1.1.5 Scenario 5

Simulation five introduces re-adoption. This simulation illustrates the evolution when new expansions/updates are developed, and includes increased adoption from potential buyers, and re-adoption from people who have previously quitted the game.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.005	0.0026	0.005	0.005
$a2$	0	0.000002	0.000002	0.000002	0.000002
$a3$	0	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt$	0	0	0	0	0.03
$incAdopt$	0	0	0	0	0.003
cm	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
p	-	-	-	-	pulseTrain (12,2,12,100)

Event	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$changeA1$	-	-	-	Players $\geq$ cm set_cutA1(0)	-

Table 7.5: Case 1 variable values.

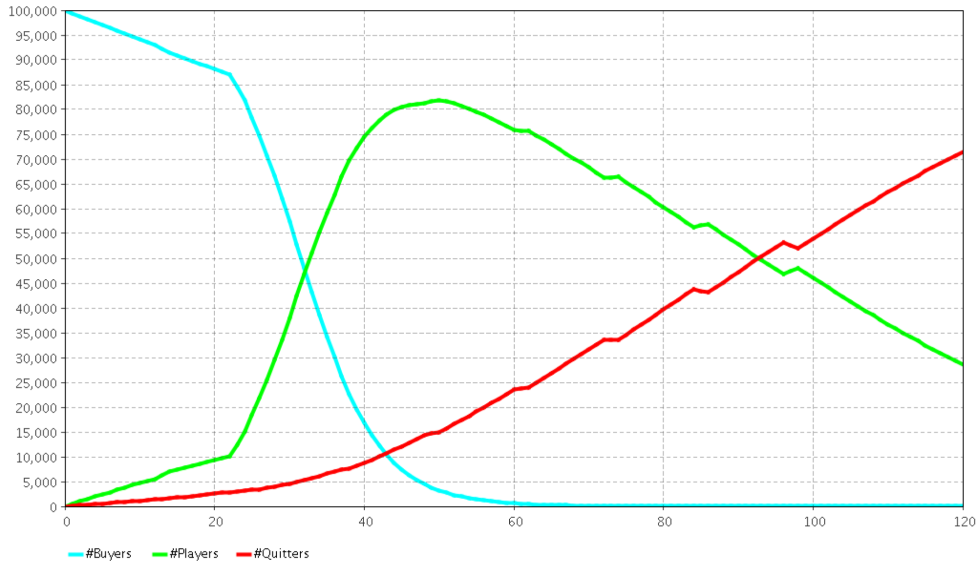

Figure 7.6: Case 1 scenario 5 simulation graph

In scenario five, re-adoption is added. Re-adoption is the result of updates and/or expansions and affects the general adoption of the game as well as inspire people who have previously quitted to start playing again. Re-adoption may help a game reach its critical mass, hence, initialise network effects and WOM. As Figure 7.6 illustrates, this effect results in a higher population peak and slower leaving rate. When comparing this simulation with scenario two, it reaches critical mass at an earlier stage, reaches a slightly higher peak, and has a gentler leaving curve, resulting in a bigger player base at $t = 120$.

As the above cases prove, it is important for a MMOG to reach its critical mass. To make this happen, high initial adoption is needed; however, once the critical mass is reached, adoption through network effects and WOM become so great that initial adopters constitute a small fraction of the total adoption. Also, re-adoption may help a game reach its critical mass quickly, and affects the temporal evolution of the game. The results tell us that, initially, innovators/influential multipliers are important sources of growth, however, once the critical mass is reached, adoption due to network effects and WOM drive growth. Furthermore, continuous updates help a game reach a bigger player base and contribute to a longer lifetime.

7.1.2 Case 2

Case 2 is conducted on the BPQ model with competition. The goal with these simulations is to prove the effect of competition and churning. During the simulations in this section, two churning factors are used. The first phase involves churning from the smallest to the biggest game. The second phase involves measuring the size of the two games, and once one of them become twice the size of the other, churning occurs from the biggest to the smallest game. This represents a game that changes its business model from a paid monthly subscription to FTP. Initial churning is not initialised until the game reaches critical mass.

Table 7.6, 7.7, 7.8, 7.9, and 7.10 show the parameters used in each scenario, the corresponding dynamic variables, and the event formulas that are altered during the simulations. In each scenario, relevant parameters will be highlighted in red.

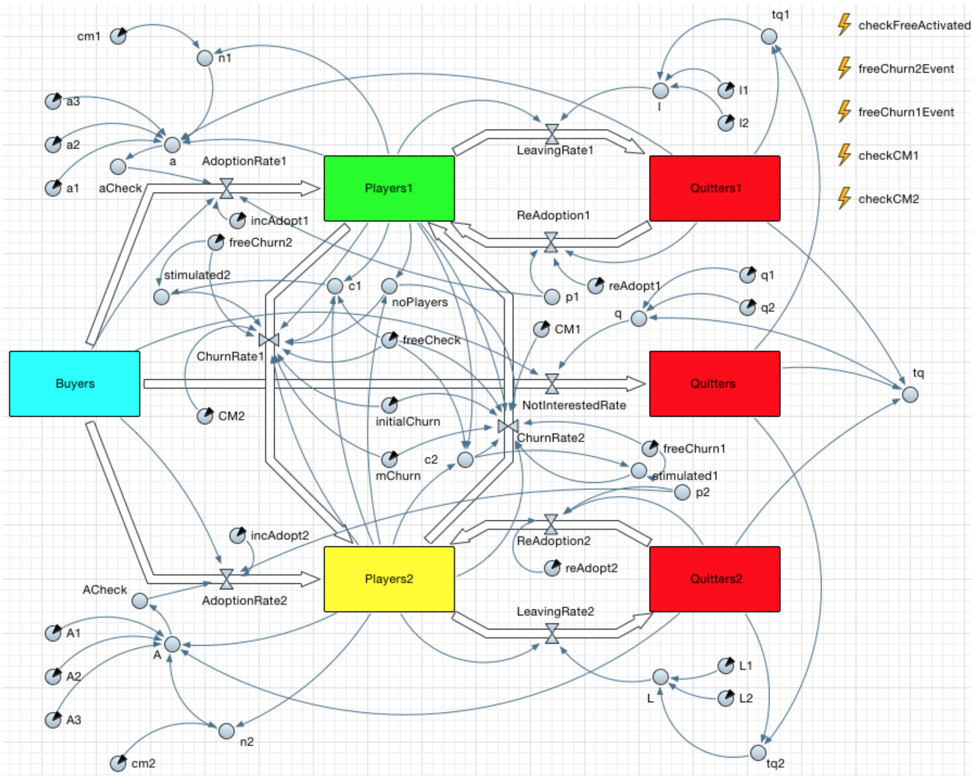

Figure 7.7: Buyer Player Quitter Model with competition.

7.1.2.1 Scenario 1

The first simulation explores churning factors. To trigger these factors, adoption in game one is larger than in game two. In this simulation, network effects and WOM are increased.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.0055	0.005	0.005	0.005
$a2$	0.0000025	0.000002	0.0000025	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.000002	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.01	0.01	0.01	0.01	0.01
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$p1$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (10,2,12,100)	pulseTrain (12,2,6,100)
$p2$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)

Event	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$freeChurn1Event$	(Players2 > Players1 $\cdot$ 2) && freeChurn2 $!= 1$ set_ freeChurn1(0)	(Players2 > Players1 $\cdot$ 2) && freeChurn2 $!= 1$ set_ freeChurn1(0)	-	-	-
$freeChurn2Event$	(Players1 > Players2 $\cdot$ 2) && freeChurn1 != 1 set_ freeChurn2(0)	(Players1 > Players2 $\cdot$ 2) && freeChurn1 != 1 set_ freeChurn2(0)	-	-	-

Table 7.6: Case 2 variable values.

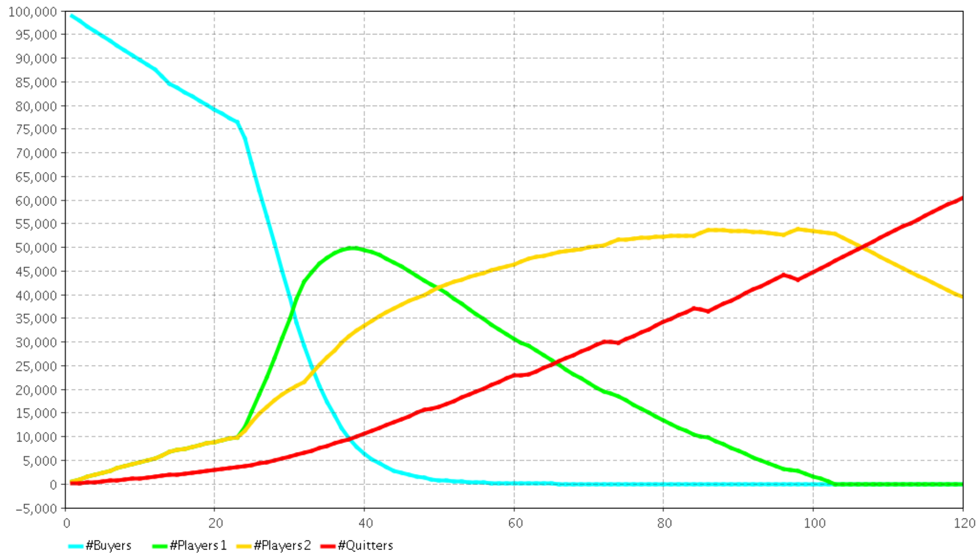

Figure 7.8: Case 2 scenario 1 simulation graph.

As Figure 7.8 illustrates, both games have the same adoption at an early stage of the simulation and reach critical mass at the same time. Once the critical mass is reached, game one experiences larger network effects and WOM than game two. Consequently, game one grows faster than game two, and its player base becomes bigger. Because game one is bigger, churning occurs from game two to game one, further increasing the growth ratio between the two games. However, once game one becomes twice the size of game two, churning direction changes, and the curve of game one quickly flattens and turns into a decline. At the same time, game two receives additional growth, due to the changed churning direction. Eventually, the player base of game two grows bigger than the player base of game one.

Because the market experiences saturation when the churning changes direction, game one immediately experiences a decline. As potential adopters approach zero, the only source of growth is churning. Throughout the rest of the simulation, players of game one either quit the game or churn to game two. As a result, game one quickly dies, while game two experiences an extended period of growth.

Scenario 2

In the second scenario, network effects and WOM are identical in the two games while initial adoption is larger in game one. The simulation proves the effect of increased initial adoption in a market with competition.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.005	0.0055	0.005	0.005	0.005
$a2$	0.0000025	0.000002	0.0000025	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.000002	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.01	0.01	0.01	0.01	0.01
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$p1$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (10,2,12,100)	pulseTrain (12,2,6,100)
$p2$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)

Event	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$freeChurn$ $1Event$	(Players2 > Players1 · 2) && freeChurn2 != 1 set_ freeChurn1(0)	(Players2 > Players1 · 2) && freeChurn2 != 1 set_ freeChurn1(0)	-	-	-
$freeChurn$ $2Event$	(Players1 > Players2 · 2) && freeChurn1 != 1 set_ freeChurn2(0)	(Players1 > Players2 · 2) && freeChurn1 != 1 set_ freeChurn2(0)	-	-	-

Table 7.7: Case 2 variable values.

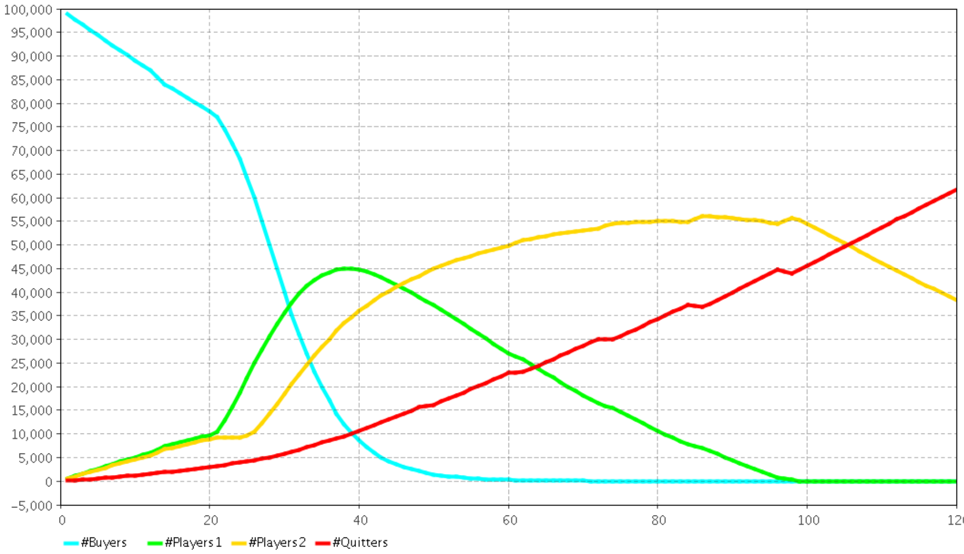

Figure 7.9: Case 2 scenario 2 simulation graph.

Figure 7.9 illustrates the evolution when game one has bigger initial adoption, but network effects and WOM are the same in both games. The graph shows how game one gains an advantage in the early in the simulation and reaches critical mass before game two. Consequently, the player base of game one grows quickly. When game two reaches its critical mass, game one is already twice the size. Churning now occurs from game one to game two; however, because the market is not yet saturated, both games continue their rapid growth. Once the market approaches saturation, the growth of game one stagnates while because of churning, the growth of game two continues.

7.1.2.2 Scenario 3

Simulation three involves neglecting the second phase of churning – the one occurring when one of the games becomes twice the size of the other. In this scenario, the smallest game fails to react to the evolution of the market. To initiate churning, network effects and WOM is larger in game one.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.0055	0.005	0.005	0.005
$a2$	0.0000025	0.000002	0.0000025	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.000002	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.01	0.01	0.01	0.01	0.01
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$p1$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (10,2,12,100)	pulseTrain (12,2,6,100)
$p2$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)

Event	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$freeChurn1Event$	(Players2 $>$ Players1 $\cdot$ 2) && freeChurn2 $!= 1$ set_ freeChurn1(0)	(Players2 $>$ Players1 $\cdot$ 2) && freeChurn2 $!= 1$ set_ freeChurn1(0)	-	-	-
$freeChurn2Event$	(Players1 $>$ Players2 $\cdot$ 2) && freeChurn1 $!= 1$ set_ freeChurn2(0)	(Players1 $>$ Players2 $\cdot$ 2) && freeChurn1 $!= 1$ set_ freeChurn2(0)	-	-	-

Table 7.8: Case 2 variable values.

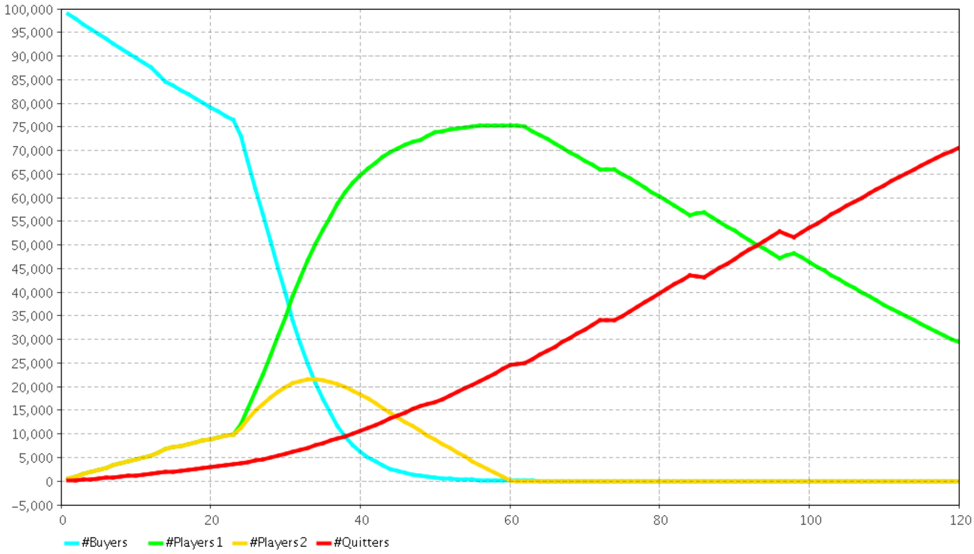

Figure 7.10: Case 2 scenario 3 simulation graph.

Simulation three involves market evolution when only initial churning is considered. As Figure 7.10 illustrates, game one has the advantage of greater network effects and WOM, and churning occurs from game two to game one. In this scenario, game two fails to react to the market evolution and quickly dies. The outcome is a market with one dominating game.

7.1.2.3 Scenario 4

Simulation four explores market evolution with different timing on the release of expansions/updates. In this scenario, game one releases its first expansion/update at an earlier stage than game two. In this scenario, only initial churning is used.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.0055	0.005	0.005	0.005
$a2$	0.0000025	0.000002	0.0000025	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.000002	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.01	0.01	0.01	0.01	0.01
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$p1$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (10,2,12,100)	pulseTrain (12,2,6,100)
$p2$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)

Event	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$freeChurn$ $1Event$	(Players2 $>$ Players1 $\cdot$ 2) && freeChurn2 $! = 1$ set_ freeChurn1(0)	(Players2 $>$ Players1 $\cdot$ 2) && freeChurn2 $! = 1$ set_ freeChurn1(0)	-	-	-
$freeChurn$ $2Event$	(Players1 $>$ Players2 $\cdot$ 2) && freeChurn1 != 1 set_ freeChurn2(0)	(Players1 $>$ Players2 $\cdot$ 2) && freeChurn1 != 1 set_ freeChurn2(0)	-	-	-

Table 7.9: Case 2 variable values.

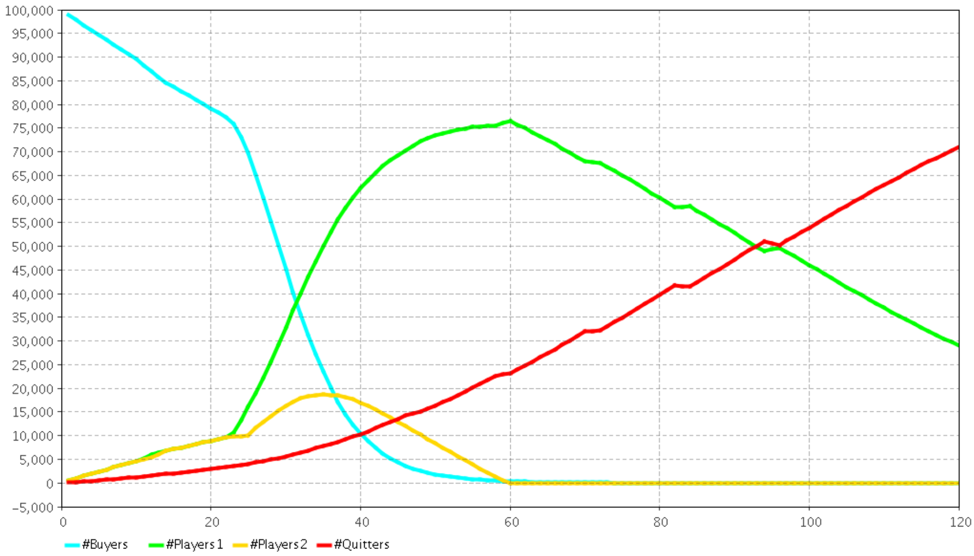

Figure 7.11: Case 2 scenario 4 simulation graph.

In scenario four, game one releases its first game update/expansion before game two. At the time of release, adoption of game one increases and players who have previously quitted the game start playing again. Game one gains the biggest player base, and like in scenario three, churning only occurs to the biggest game. As shown in Figure 7.11, once both games reach critical mass, players start to churn from game two to game one. Because game two fails to react to the situation and does not implement changes, the game quickly loose players and dies.

7.1.2.4 Scenario 5

In the fifth scenario, update/expansion frequency differs between game one and game two. The simulation illustrates the effect of frequent game updates in the market. Once again, only initial churning is used.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.0055	0.005	0.005	0.005
$a2$	0.0000025	0.000002	0.0000025	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.000002	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.01	0.01	0.01	0.01	0.01
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Dynamic Variable	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$p1$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (10,2,12,100)	pulseTrain (12,2,6,100)
$p2$	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)	pulseTrain (12,2,12,100)

Event	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$freeChurn1Event$	(Players2 $>$ Players1 $\cdot$ 2) && freeChurn2 $!= 1$ set_ freeChurn1(0)	(Players2 $>$ Players1 $\cdot$ 2) && freeChurn2 $!= 1$ set_ freeChurn1(0)	-	-	-
$freeChurn2Event$	(Players1 $>$ Players2 $\cdot$ 2) && freeChurn1 != 1 set_ freeChurn2(0)	(Players1 $>$ Players2 $\cdot$ 2) && freeChurn1 != 1 set_ freeChurn2(0)	-	-	-

Table 7.10: Case 2 variable values.

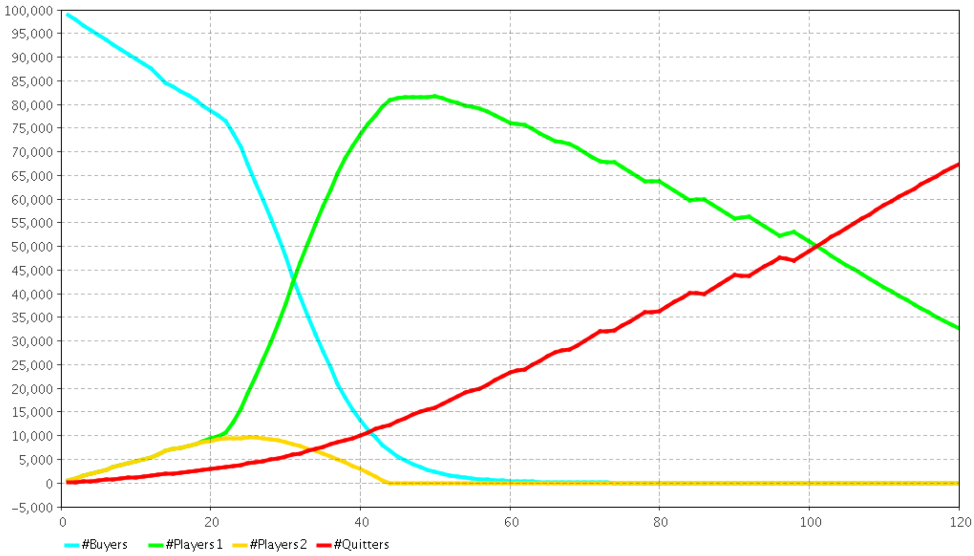

Figure 7.12: Buyer Player Quitter Model with one supplier.

In simulation five, game one releases updates/expansions with higher frequency than game two. When updates/expansions are released, adoption increases and previous players start to play again. As Figure 7.12 illustrates, the increased adoption results in game one reaching critical mass first. Once game one reaches critical mass, players start to churn from game two to game one. In this particular scenario, game two never reaches critical mass and dies prematurely.

In scenario four and five, game one gains a head start and initialise churning, network effects and WOM to increase its position. In these scenarios, game two fails to implement countermeasures, and never manages to recover.

The simulations above prove the effect of churning in a competitive market. Increased initial adoption, early or frequent updates/expansions, and large network effects and WOM all contribute to the success of a game, and may result in a leading market position. If used correctly, this position can kill the competition, however, by reacting and changing the approach, it is possible to turn the trend.

7.1.3 Case 3

Case 3 involves simulations on the full BPQ model – the model with competition and cooperation represented in Figure 7.13. Simulations in this section explore the effects of cooperation between two games, and its consequences on competition and market evolution. During the simulations, only initial churning will be used.

Table 7.11, 7.12, 7.13, 7.14, and 7.15 show the parameters used during the simulations. In each scenario, relevant parameters will be highlighted in red.

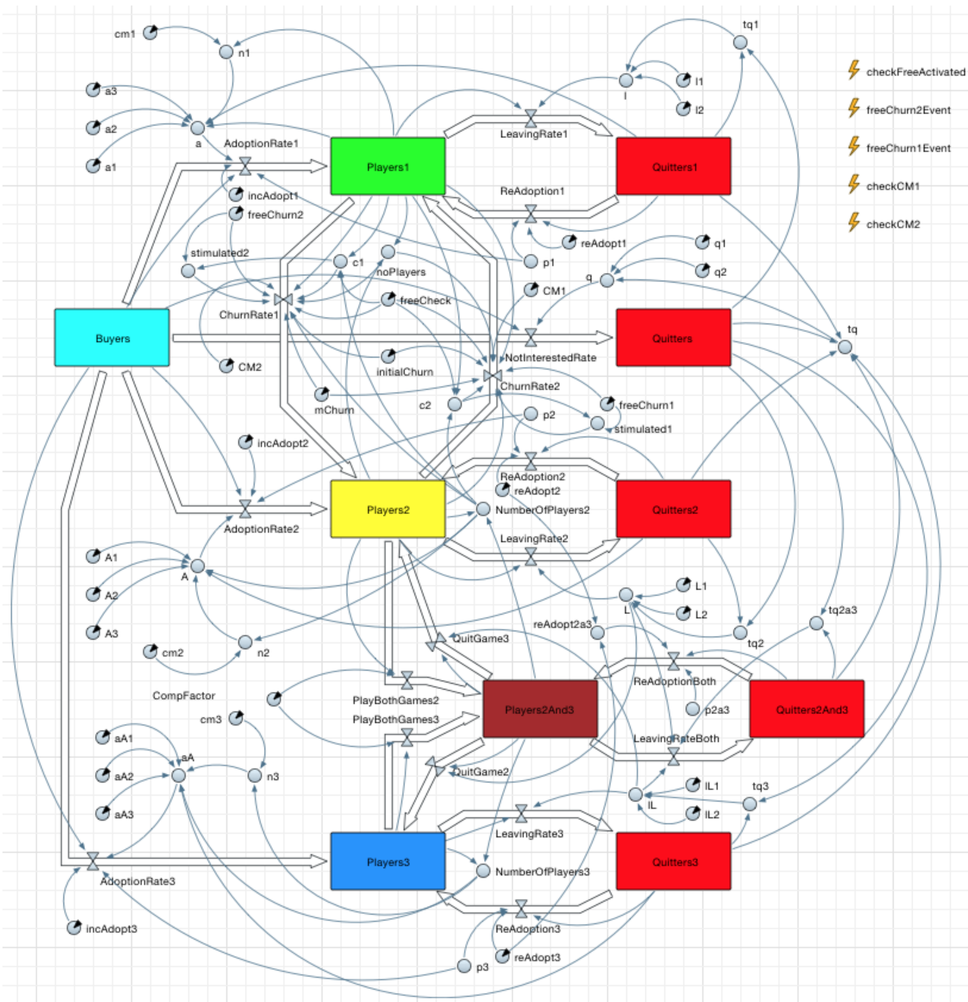

Figure 7.13: Case 2 scenario 5 simulation graph.

7.1.3.1 Scenario 1

In the first simulation, all three games have the same parameters, however, due to churning and cooperation, the evolution of each game differs. The scenario explores how games might benefit from cooperation in a market with competition.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.005	0.005	0.005	0.007
$a2$	0.000002	0.000004	0.000002	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.0000025	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$aA1$	0.005	0.005	0.005	0.005	0.005
$aA2$	0.000002	0.000002	0.000002	0.0000025	0.000002
$aA3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$lL1$	0.005	0.005	0.005	0.005	0.005
$lL2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$reAdopt3$	0.03	0.03	0.03	0.03	0.03
$incAdopt3$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.0008	0.0008	0.0008	0.0008	0.0008
$compFactor$	0.005	0.005	0.005	0.005	0.05

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
initialChurn	0.02	0.02	0.02	0.02	0.02
*cm*1	10 000	10 000	10 000	10 000	10 000
*cm*2	10 000	10 000	10 000	10 000	10 000
*cm*3	10 000	10 000	10 000	10 000	10 000
Buyers	100 000	100 000	100 000	100 000	100 000

Table 7.11: Case 3 parameter values.

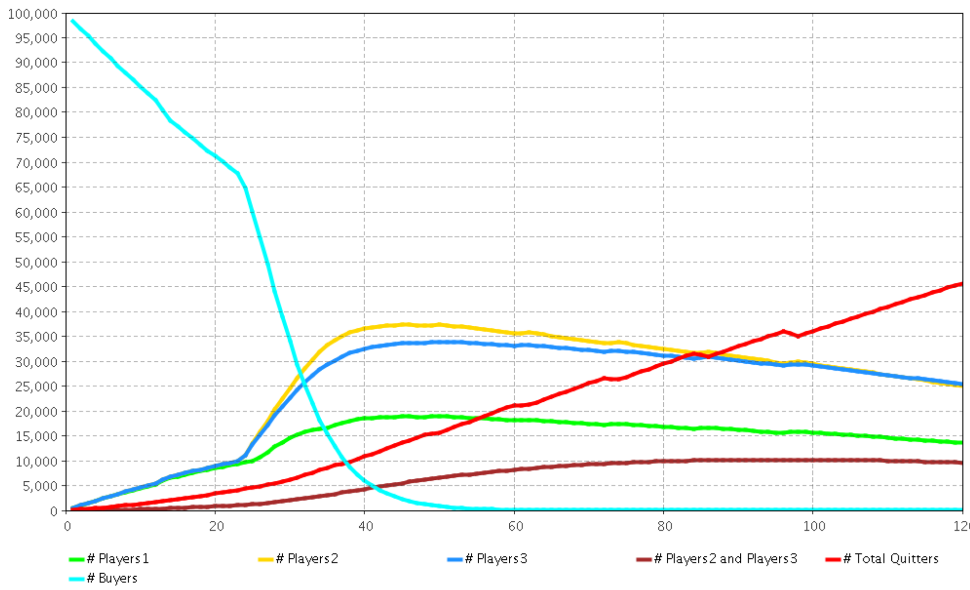

Figure 7.14: Case 3 scenario 1 simulation graph.

In scenario one, game two and three cooperate and benefit from increased adoption. The increased adoption help them reaching critical mass before game one, hence, initiating network effects and WOM first. Also, once the player base of game two becomes larger than the player base of game one, churning from game one to game two starts. As Figure 7.14 illustrates, game two and three gains the market advantage.

7.1.3.2 Scenario 2

The second simulation involves increased adoption through network effect and WOM in game one. This simulation explores how two less popular games can cooperate to affect the market outcome.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.005	0.005	0.005	0.005	0.007
$a2$	0.000002	0.000004	0.000002	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.0000025	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$aA1$	0.005	0.005	0.005	0.005	0.005
$aA2$	0.000002	0.000002	0.000002	0.0000025	0.000002
$aA3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$lL1$	0.005	0.005	0.005	0.005	0.005
$lL2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$reAdopt3$	0.03	0.03	0.03	0.03	0.03
$incAdopt3$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.0008	0.0008	0.0008	0.0008	0.0008
$compFactor$	0.005	0.005	0.005	0.005	0.05

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$cm3$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Table 7.12: Case 3 parameter values.

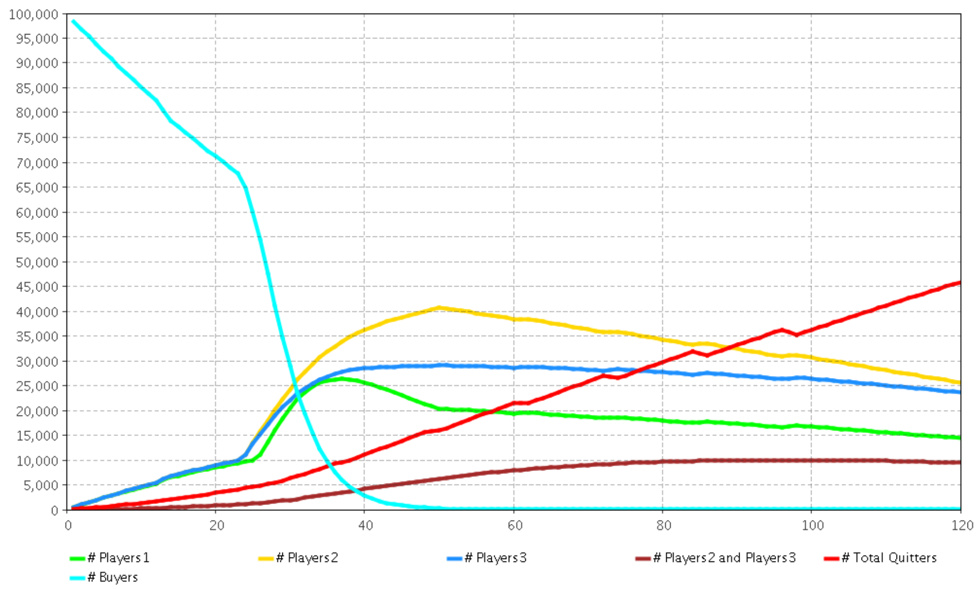

Figure 7.15: Case 3 scenario 2 simulation graph.

Figure 7.15 Illustrates how increased network effects and WOM in game one affect the market evolution. Like in scenario one, game two and three reach critical mass before game one. Game two and three gain an advantage, however, because game one has increased network effects and WOM, it experiences faster growth compared with scenario one. In this scenario, the additional adoption is not enough to catch up with the other cooperating games, however, a bigger increase in network effects and WOM, illustrated in Appendix B.1 Simulation 1, can change this.

7.1.3.3 Scenario 3

Simulation three explores the market evolution when game two, which is affected by competition and cooperation, has increased adoption through network effects and WOM.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.005	0.005	0.005	0.005	0.007
$a2$	0.000002	0.000004	0.000002	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.0000025	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$aA1$	0.005	0.005	0.005	0.005	0.005
$aA2$	0.000002	0.000002	0.000002	0.0000025	0.000002
$aA3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$lL1$	0.005	0.005	0.005	0.005	0.005
$lL2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$reAdopt3$	0.03	0.03	0.03	0.03	0.03
$incAdopt3$	0.003	0.003	0.003	0.003	0.003

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
mChurn	0.0008	0.0008	0.0008	0.0008	0.0008
compFactor	0.005	0.005	0.005	0.005	0.05
initialChurn	0.02	0.02	0.02	0.02	0.02
*cm*1	10 000	10 000	10 000	10 000	10 000
*cm*2	10 000	10 000	10 000	10 000	10 000
*cm*3	10 000	10 000	10 000	10 000	10 000
Buyers	100 000	100 000	100 000	100 000	100 000

Table 7.13: Case 3 parameter values

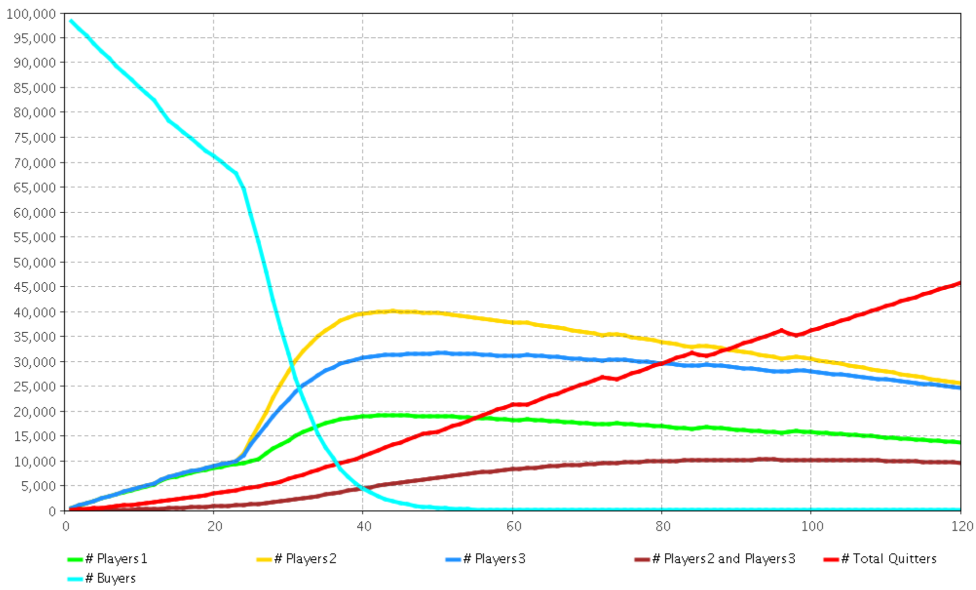

Figure 7.16: Case 3 scenario 3 simulation graph.

In scenario three, network effect and WOM are increased in game two. As Figure 7.16 illustrates, this result in a dominant market position for game two. Game two reaches critical mass before its competitor due to cooperation with game three. Once critical mass is reached, game two enjoys steep adoption, further increased by churning from game one. As more people play game two, adoption of game three increases as well.

7.1.3.4 Scenario 4

In scenario four, game three has increased adoption through network effect and WOM. The simulation highlights the benefit of cooperating with a game with high adoption rate.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.005	0.005	0.005	0.005	0.007
$a2$	0.000002	0.000004	0.000002	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.0000025	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$aA1$	0.005	0.005	0.005	0.005	0.005
$aA2$	0.000002	0.000002	0.000002	0.0000025	0.000002
$aA3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$lL1$	0.005	0.005	0.005	0.005	0.005
$lL2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$reAdopt3$	0.03	0.03	0.03	0.03	0.03

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$incAdopt3$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.0008	0.0008	0.0008	0.0008	0.0008
$compFactor$	0.005	0.005	0.005	0.005	0.05
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$cm3$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Table 7.14: Case 3 parameter values.

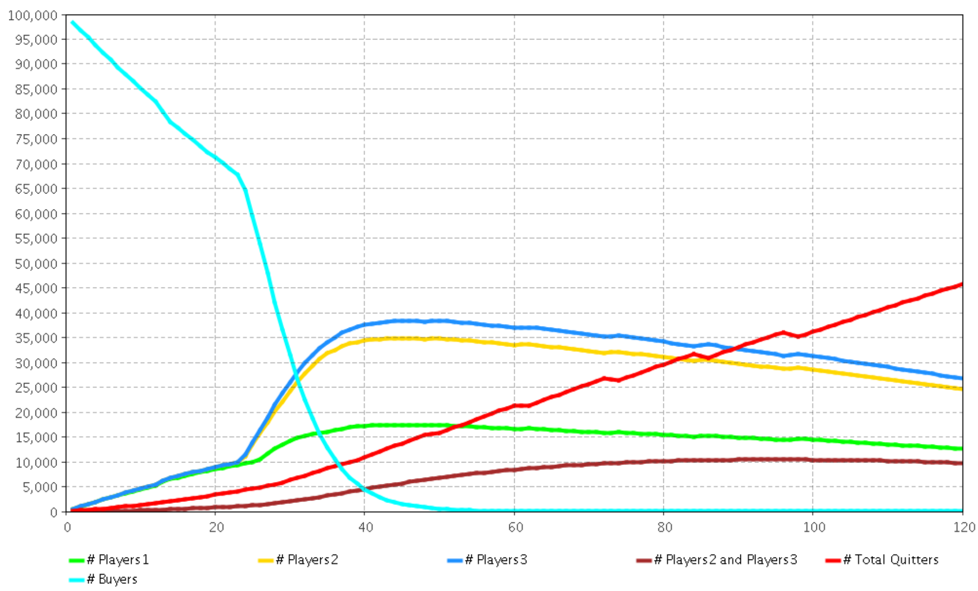

Figure 7.17: Case 3 scenario 4 simulation graph.

In simulation four, game three has increased network effect and WOM. Once game three reaches critical mass, the game enjoys quick adoption. When the player base of game three increases, the adoption rate of game two increases as well due to cooperation. When the population of game two becomes greater than the population of game one, churning occurs. Consequently, game two also enjoys quick adoption. Also, when game two grows, the adoption rate of game three is increased further.

7.1.3.5 Scenario 5

In simulation five, game one has increased initial adoption. This simulation illustrates the evolution when the game that does not cooperate with other games reaches its critical mass first, and shows how cooperation between the two other games can help them catch up. To illustrate these effects, the rate at which people adopt both games two and three ($compFactor$) has been increased.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.005	0.005	0.005	0.005	0.007
$a2$	0.000002	0.000004	0.000002	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.0000025	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$aA1$	0.005	0.005	0.005	0.005	0.005
$aA2$	0.000002	0.000002	0.000002	0.0000025	0.000002
$aA3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$lL1$	0.005	0.005	0.005	0.005	0.005
$lL2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$reAdopt1$	0.03	0.03	0.03	0.03	0.03

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$reAdopt3$	0.03	0.03	0.03	0.03	0.03
$incAdopt3$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.0008	0.0008	0.0008	0.0008	0.0008
$compFactor$	0.005	0.005	0.005	0.005	0.05
$initialChurn$	0.02	0.02	0.02	0.02	0.02
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$cm3$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Table 7.15: Case 3 parameter values.

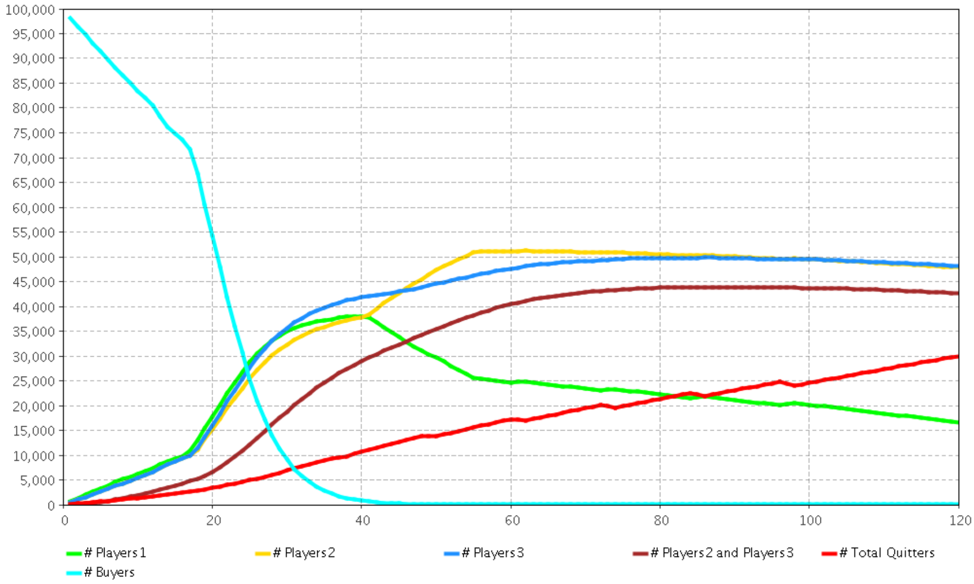

Figure 7.18: Case 3 scenario 5 simulation graph.

Figure 7.18 shows how increased initial adoption in game one affects the market. Due to the increased initial adoption, game one reaches critical mass first, hence initialises network effects and WOM before game two and three. Also, the population of game one becomes greater than the population in game two and churning is initialised. In this scenario, even though game one gains a market advantage, game two and three catch up due to cooperation. However, as illustrated in Appendix B.1 Scenario 2, a greater increase in the initial adoption of game one may generate a result in a different outcome.

As the simulations above prove, cooperation between games may be beneficial for both parties. Cooperation can lead to increased adoption, creating an advantage in the market. If used correctly, this position can be used to squeeze the competing game out of the market. In addition, cooperation may help smaller games grow, and even catch up with existing games. Cooperation may also help big games grow even bigger.

7.2 Empirical Simulations

The games being simulated in this section are the MMORPGs WoW and *RuneScape*. MMORPGs are games with long lifetimes and are played by millions of players. The genre consists of different business models, and adoption is the result of several factors. WoW is the world's biggest MMORPG and has well-documented subscriber numbers because the game requires paid subscription. RuneScape is world's first free large MMORPG. The game has won awards for its continuous updates and was one of the first games to use a FTP business model.

WoW and RuneScape were chosen to study evolution factors on two veteran games within the same genre, with different characteristics and business models.

7.2.1 Basic Simulation Model

During empirical simulations, a slightly modified single supplier model is used. To recreate empirical data, the complete model consists of too many parameters to correctly mimic the behaviour of the player base. Small changes in one of the parameters will spread through the whole model and have an enormous impact on the outcome. Also, recognising relevant competitors and/or collaborators is hard, and requires well-documented subscriber numbers.

A simpler model makes it easier to understand how central factors discussed earlier in this paper affect the evolution of a game. Also, when trying to recreate empirical data from a particular game, it is sufficient to treat players churning to another game as people who have quitted the current game, because we are only interested in the evolution of one specific game.

The basic model being used in this section is illustrated in Figure 7.19. The model consists of basic elements from the BPQ model without the *notInterestedRate*; however, it does include re-adoption. This alteration is done because it is not necessary to include people who have no interest in playing the game. Also, re-adoption is central to most MMORPGs and has a significant impact on their evolution.

The games included in this chapter are subject to the same effects discussed earlier in this paper: network effects, WOM, and initial adoption. This section will focus on game-specific factors which have shaped the evolution of the selected games.

During the simulations, the x-value in the graph represents one month. In the simulation graphs, *light blue* represents the number of potential buyers, *green* the number of players, while *red* represents quitters.

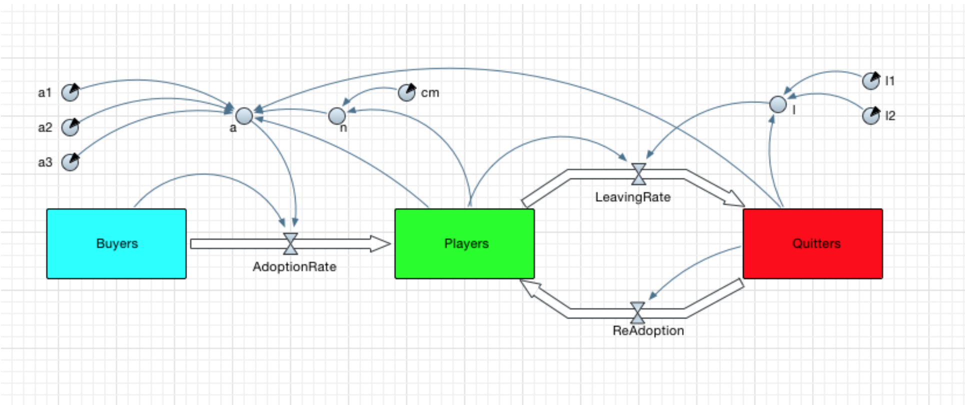

Figure 7.19: Basic empirical BPQ model.

7.2.2 World of Warcraft Simulations

During the simulation of WoW, Figure 7.20 was developed. The model consists of the basic instances presented in Section 7.2.1, as well as an $expansionVariable$ and a $marketChange$ variable. The $expansionVariable$ represents variations in adoption and re-adoption when updates/expansions are released. The $expansionVariable$ is the sum of several expansion variables ($firstExpansion$, $secondExpansion$, etc.) representing the size and the timing of each update/expansion within an expansion period. The timing of each update/expansion is determined by a corresponding release variable and several patch variables ($release1$, $firstPatch1$, etc.). Release variables represent new versions of the game while patch variables represent bug fixes and small updates. The size of the update/expansion is decided by a corresponding $releaseFactor$ and several $patchFactors$.

The $marketChange$ variable represents changes in the market and affects the leaving rate. The $marketChange$ is the sum of several $reactionExpansion$ variables, representing a possible negative reaction to a new expansion. The $expReaction$ parameters determine the size of the impact. Players react differently to changes, and when new content is introduced, and old mechanics are changed, some people choose to quit the game. The $reactionExpansion$ variables capture this reaction and determine the timing.

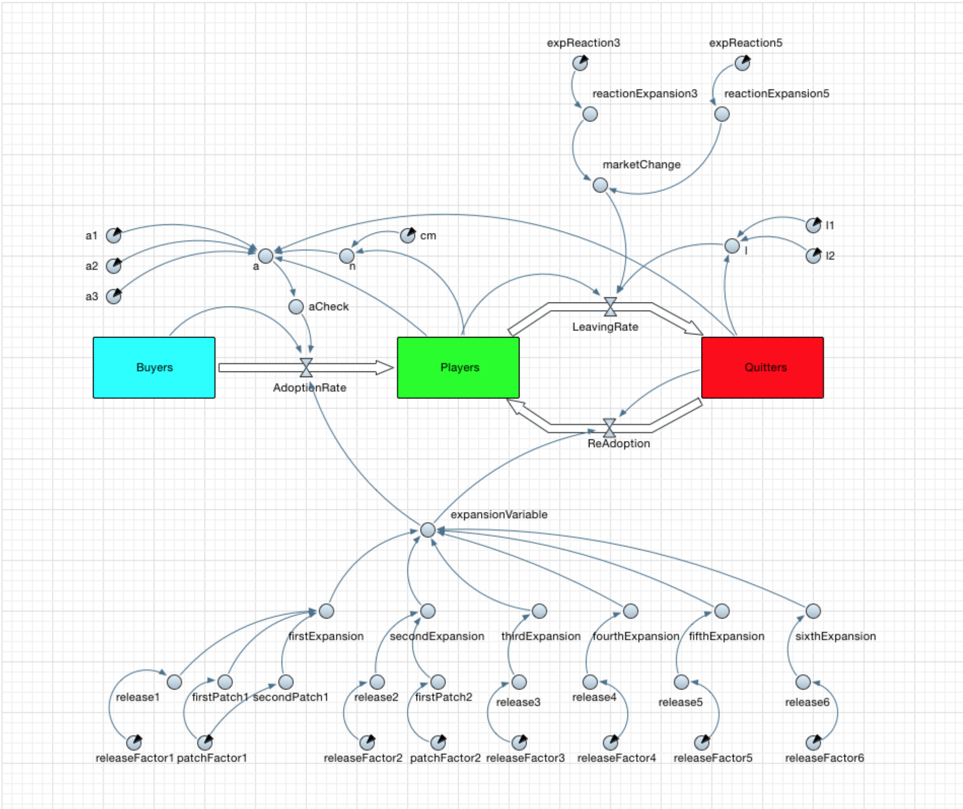

Figure 7.20: World of Warcraft simulation model.

Table 7.16 shows the dynamic variables used in this chapter, while table 7.17, 7.18, 7.19, and 7.20 show the parameters used in each scenario. During all simulations, relevant parameters will be highlighted in red.

Dynamic Variable	**Scenario 1/2/3/4**
$release1$	pulse(22,7) · releaseFactor1
$firstPatch1$	pulse(28,3) · patchFactor1
$secondPatch1$	pulse(33,12) · patchFactor1
$firstExpansion$	release1+firstPatch1+secondPatch1
$release2$	pulse(43,4) · releaseFactor2
$firstPatch2$	pulse(57,9) · patchFactor2
$secondExpansion$	release2+firstPatch2
$release3$	pulse(67,6) · releaseFactor3
$thirdExpansion$	release3
$release4$	pulse(86,3) · releaseFactor4
$fourthExpansion$	release4
$release5$	pulse(109,7) · releaseFactor5
$fifthExpansion$	release5
$release6$	pulse(128,7) · releaseFactor6
$sixthExpansion$	release6
$expansionVariable$	firstExpansion+secondExpansion+thirdExpansion +fourthExpansion+fifthExpansion +sixthExpansion
$reactionExpansion3$	pulse(73,1) · expReaction3
$reactionExpansion5$	pulse(116,4) · expReaction5
$marketChange$	reactionExpansion3+reactionExpansion5

Table 7.16: Dynamic variables in World of Warcraft simulations.

7.2.2.1 Scenario 1

The first simulation involves recreation of empirical data visualised in Figure 7.21. During the creation of this scenario, history related to WoW was studied, and central factors related to changes in the number of players were included in the model.

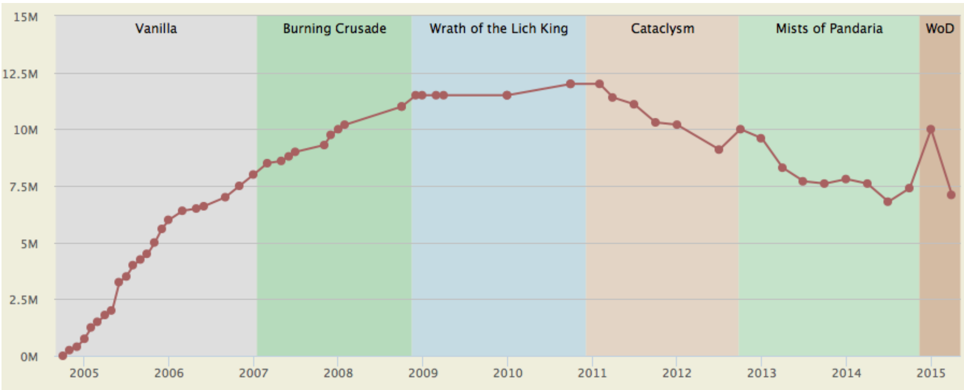

Figure 7.21: Actual World of Warcraft subscriber numbers [85].

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
$a1$	0.027	0.027	0.027	0.027
$a2$	0.0000000053	0.0000000053	0.0000000053	0.0000000053
$a3$	0.000002	0.000002	0.000002	0.000002
$l1$	0.00008	0.00008	0.00008	0.00008
$l2$	0.000000008	0.000000008	0.000000008	0.000000008
cm	2 000 000	2 000 000	2 000 000	2 000 000
$releaseFactor1$	0.055	0	0.055	0.055
$patchFactor1$	0.055	0	0.055	0.055
$releaseFactor2$	0.1	0	0.055	0.1
$patchFactor2$	0.18	0	0.055	0.18
$releaseFactor3$	0.08	0	0.055	0.08
$releaseFactor4$	0.7	0	0.055	0.7
$patchFactor4$	0.18	0	0.055	0.18

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
$releaseFactor5$	0.6	0	0.055	0.6
$releaseFactor6$	0	0	0	0.8
$expReaction3$	0.05	0	0.055	0.05
$expReaction5$	0.06	0	0.055	0.06
$Buyers$	12 000 000	12 000 000	12 000 000	12 000 000

Table 7.17: World of Warcraft simulation parameter values.

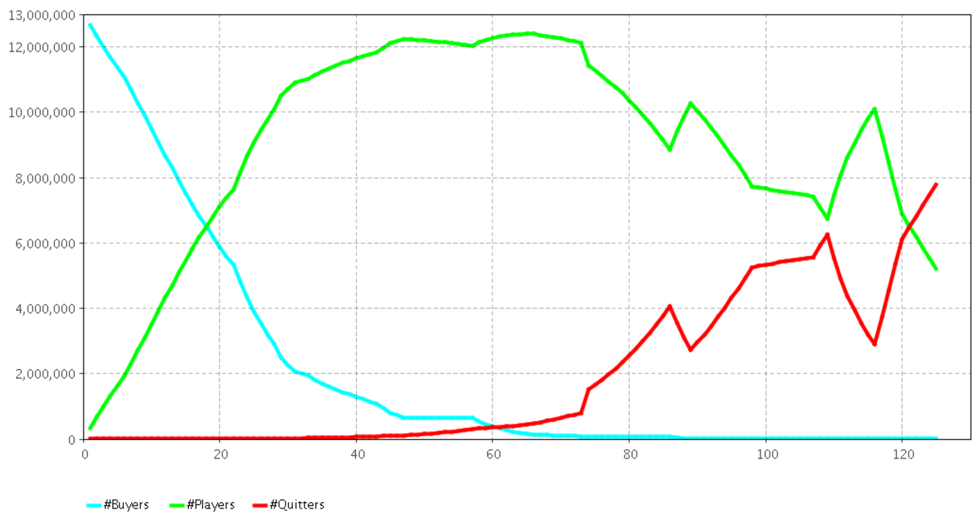

Figure 7.22: Recreation of empirical data in World of Warcraft.

As Figure 7.22 Illustrates, game updates and expansions have a significant impact on the evolution of WoW. During the growth stage, WoW benefits from increased adoption when updates and expansions are released. The increased adoption is the result of increased advertising and the introduction of new functionalities. As the growth flattens, new content is released to generate additional growth. A trend in the development is that once a new expansion is announced, adoption increases.

However, whether players choose to continue playing the game or not depends on the game content. At several stages, expansions are followed by a steep decrease in the number of players. Another trend is that re-adoption is stronger at later stages of the simulation. Because former players are familiar with game mechanics, it is reasonable to believe that they finish the new content fast. Once they have completed the new content, they quit and wait for the next release.

7.2.2.2 Scenario 2

Scenario two involves neglecting all parameters that represent alterations to the game. As a result, the $expansionVariable$ and the $marketChange$ do not have an impact during the simulation. This simulation illustrates the market evolution of the original game version only.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
$a1$	0.027	0.027	0.027	0.027
$a2$	0.0000000053	0.0000000053	0.0000000053	0.0000000053
$a3$	0.000002	0.000002	0.000002	0.000002
$l1$	0.00008	0.00008	0.00008	0.00008
$l2$	0.000000008	0.000000008	0.000000008	0.000000008
cm	2 000 000	2 000 000	2 000 000	2 000 000
$releaseFactor1$	0.055	0	0.055	0.055
$patchFactor1$	0.055	0	0.055	0.055
$releaseFactor2$	0.1	0	0.055	0.1
$patchFactor2$	0.18	0	0.055	0.18
$releaseFactor3$	0.08	0	0.055	0.08
$releaseFactor4$	0.7	0	0.055	0.7
$patchFactor4$	0.18	0	0.055	0.18
$releaseFactor5$	0.6	0	0.055	0.6
$releaseFactor6$	0	0	0	0.8
$expReaction3$	0.05	0	0.055	0.05
$expReaction5$	0.06	0	0.055	0.06
$Buyers$	12 000 000	12 000 000	12 000 000	12 000 000

Table 7.18: World of Warcraft simulation parmeter values.

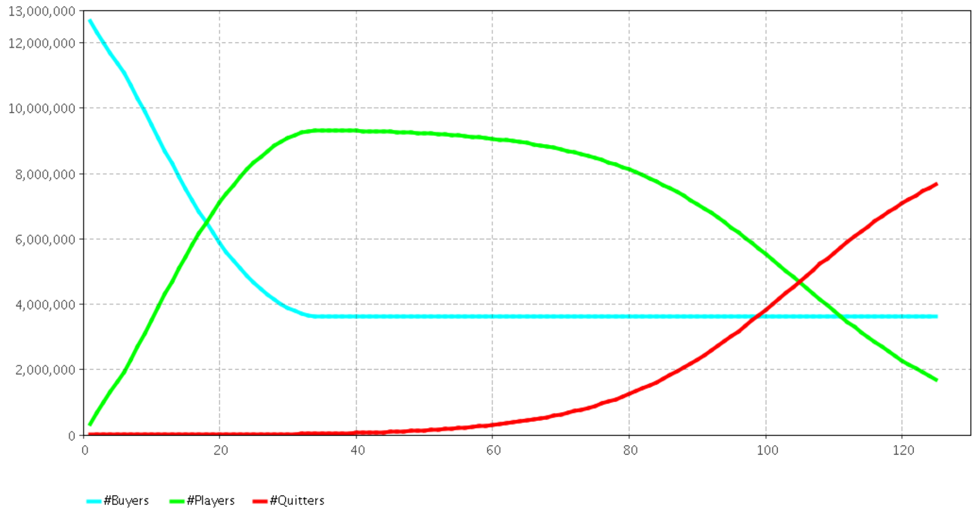

Figure 7.23: World of Warcraft simulation without updates/expansions.

Comparing Figure 7.22 with Figure 7.23, we immediately identify differences. First of all, scenario one reaches a higher maximum number of players and peaks at a later stage than scenario two. Also, simulation one experiences spikes in the population graph when updates and expansions are released. Consequently, simulation one has a bigger player base at time $t = 120$. However, the trend in the two scenarios is the same: steep growth early, followed by stagnation as the market becomes saturated, and finally, decline.

Another interesting observation in simulation two is that the game does not manage to attract all the potential buyers. Adoption stops because the negative network effect and WOM affecting adoption becomes bigger than the positive network effect, WOM, and initial adoption combined. Because the game does not provide new content, it does not reach people who in scenario one joined at a later stage.

7.2.2.3 Scenario 3

Expansions and updates have a different impact on the evolution of the market. Simulation three explores the market evolution when all expansions and updates contribute with the same factor. Consequently, all $releaseFactors$ and $patchFactors$ are equal, and both $expReactions$ are equal.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
$a1$	0.027	0.027	0.027	0.027
$a2$	0.0000000053	0.0000000053	0.0000000053	0.0000000053
$a3$	0.000002	0.000002	0.000002	0.000002
$l1$	0.00008	0.00008	0.00008	0.00008
$l2$	0.000000008	0.000000008	0.000000008	0.000000008
cm	2 000 000	2 000 000	2 000 000	2 000 000
$releaseFactor1$	0.055	0	0.055	0.1
$patchFactor1$	0.055	0	0.055	0.055
$releaseFactor2$	0.1	0	0.055	0.005
$patchFactor2$	0.18	0	0.055	0.18
$releaseFactor3$	0.08	0	0.055	0.08
$releaseFactor4$	0.7	0	0.055	0.7
$patchFactor4$	0.18	0	0.055	0.18
$releaseFactor5$	0.6	0	0.055	0.6
$releaseFactor6$	0	0	0	0.8
$expReaction3$	0.05	0	0.055	0.05
$expReaction5$	0.06	0	0.055	0.06
$Buyers$	12 000 000	12 000 000	12 000 000	12 000 000

Table 7.19: World of Warcraft simulation parmeter values.

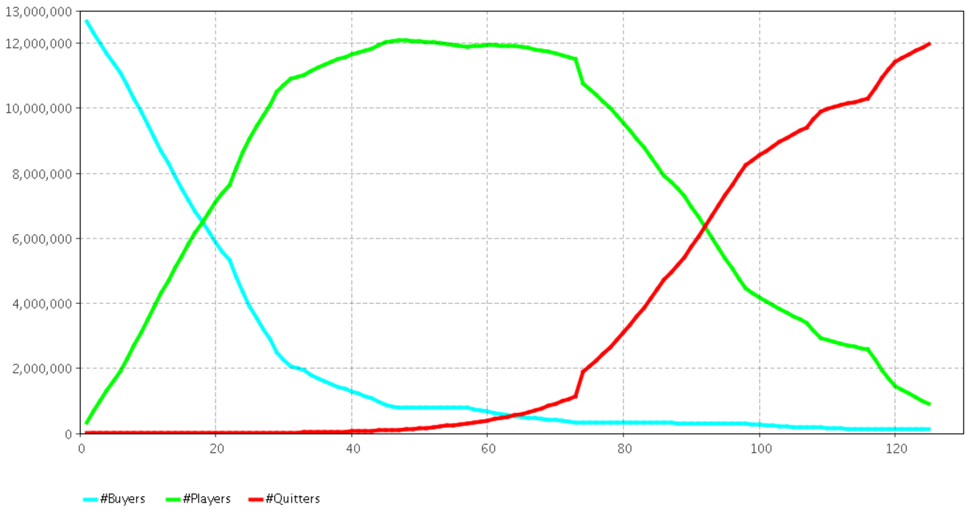

Figure 7.24: World of Warcraft simulation with equal update/expansion variables.

Scenario three explores the market evolution when all updates/expansions have the same impact. As mentioned earlier, empirical data indicates that re-adoption is strongest late in the simulation. Figure 7.24 proves the importance of increased development efforts late in the games lifetime. The simulation shows similar evolution early on, however in this scenario, the game does not manage to impact re-adoption significantly, resulting in a smaller player base.

7.2.2.4 Scenario 4

Simulation four explores possible future market evolution. The simulation is based on the empirical recreation conducted in scenario one. In 2015, a new expansion of the game was announced to be released in August 2016. Consequently, a new expansion is introduced to the model. The expansion factor is increased according to the previous trend, and because the impact of this expansion is not yet known, no reaction variable is introduced.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4
$a1$	0.027	0.027	0.027	0.027
$a2$	0.0000000053	0.0000000053	0.0000000053	0.0000000053
$a3$	0.000002	0.000002	0.000002	0.000002
$l1$	0.00008	0.00008	0.00008	0.00008
$l2$	0.000000008	0.000000008	0.000000008	0.000000008
cm	2 000 000	2 000 000	2 000 000	2 000 000
$releaseFactor1$	0.055	0	0.055	0.055
$patchFactor1$	0.055	0	0.055	0.055
$releaseFactor2$	0.1	0	0.055	0.1
$patchFactor2$	0.18	0	0.055	0.18
$releaseFactor3$	0.08	0	0.055	0.08
$releaseFactor4$	0.7	0	0.055	0.7
$patchFactor4$	0.18	0	0.055	0.18
$releaseFactor5$	0.6	0	0.055	0.6
$releaseFactor6$	0	0	0	0.8
$expReaction3$	0.05	0	0.055	0.05
$expReaction5$	0.06	0	0.055	0.06
$Buyers$	12 000 000	12 000 000	12 000 000	12 000 000

Table 7.20: World of Warcraft simulation parameter values.

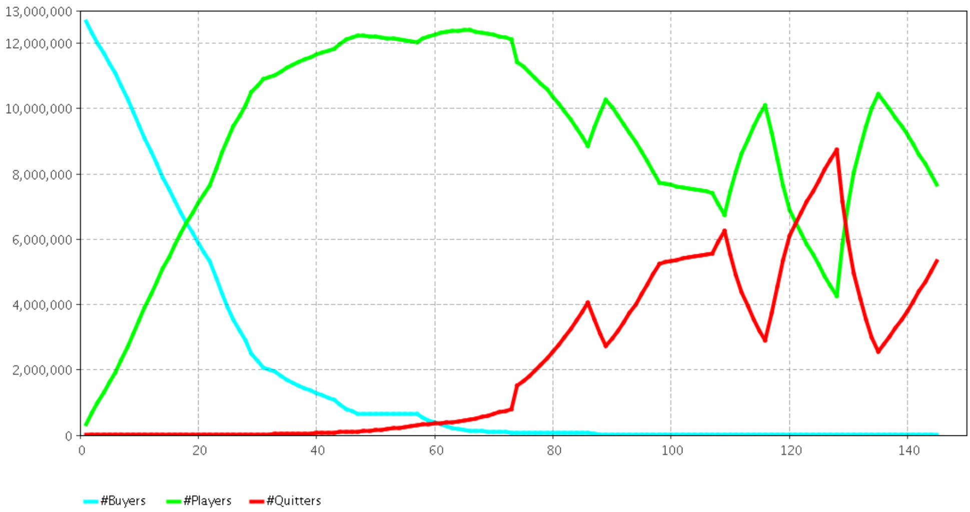

Figure 7.25: Possible future market evolution in World of Warcraft

Simulation four predicts a possible future evolution in WoW. A new game expansion is announced to be released late August 2016, and once again, the game population is expected to grow upon release. Figure 7.25 illustrates the simulated outcome, with re-adoption according to the trend. In this simulation, the game experiences steep growth followed by rapid decline.

The scenarios above prove the importance of initial adoption, network effects, WOM, and expansions/updates in an actual MMOG. The game is affected by the same effects present in the basic BPQ model; however, individual parameters have a significant impact on the evolution. In this particular game, expansions play a major role in keeping the population high. WoW is a game with a well-developed story, and by expanding on this story, and creating great cinematic trailers and advertising, the game has managed to attract a lot of people even at a late stage in its lifetime. However, empirical data indicates that it is hard to keep a high population when a game grows old.

7.2.3 RuneScape Simulations

During the simulations of *RuneScape*, a very similar model is used; only the expansion/update and reaction variables are changed. In this model, a variable called *regularUpdates* is added. *regularUpdates* represents frequent content updates and involves new updates every second month. Relevant update variables are gathered from release notes and game history pages. The model that is used is illustrated in Figure 7.27.

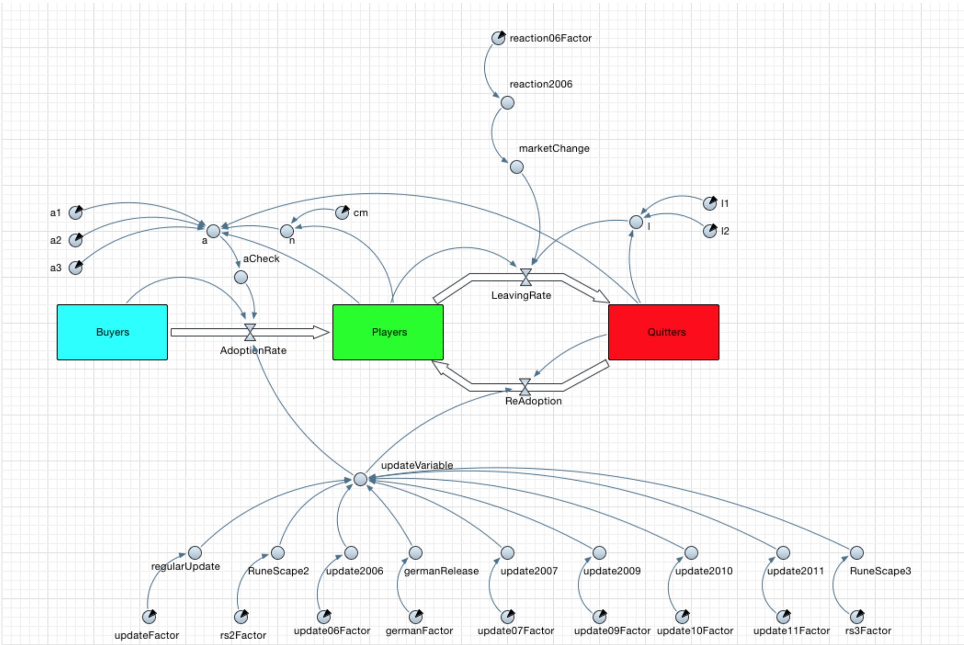

Figure 7.26: RuneScape simulation model.

Table 7.21 shows the dynamic variables utilised in this chapter, while table 7.22, 7.23, 7.24, 7.25, and 7.26 show the parameters used in each scenario. During the simulations, altered parameters will be highlighted in red.

Dynamic Variable	**Scenario 1/2/3/4/5**
regularUpdate	pulseTrain(2,0.5,2,71) · updateFactor
*RuneScape*2	pulse(24, 5) · rs2Factor
*update*2006	pulse(49, 3) · update06Factor
germanRelease	pulse(61,3) · germanFactor
*update*2007	pulse(63,8) · update07Factor
*update*2009	pulse(90,10) · update09Factor
*update*2010	pulse(100,10)· update10Factor
*update*2011	pulse(110,10) · update11Factor
*RuneScape*3	pulse(120,5) · rs3Factor
updateVariable	regularUpdate+RuneScape2+update2006 +germanRelease+update2007+update2009 +update2010+update2011 +RuneScape3
*reaction*2006	pulse(55,3)*reaction06Factor
marketChange	reaction2006

Table 7.21: Dynamic variables in RuneScape simulations.

7.2.3.1 Scenario 1

Simulation one involves recreation of empirical data. Gathering correct empirical data concerning the numbers of players in *RuneScape* proved difficult; however, *MMOData* [86] have documented subscriber numbers from 2002 to 2013, and will be the primary source during these simulations. Figure 7.27 illustrates the empirical evolution of the game. Data was gathered from *MMOData* and recreated in *Excel* to make a graph containing only *RuneScape*.

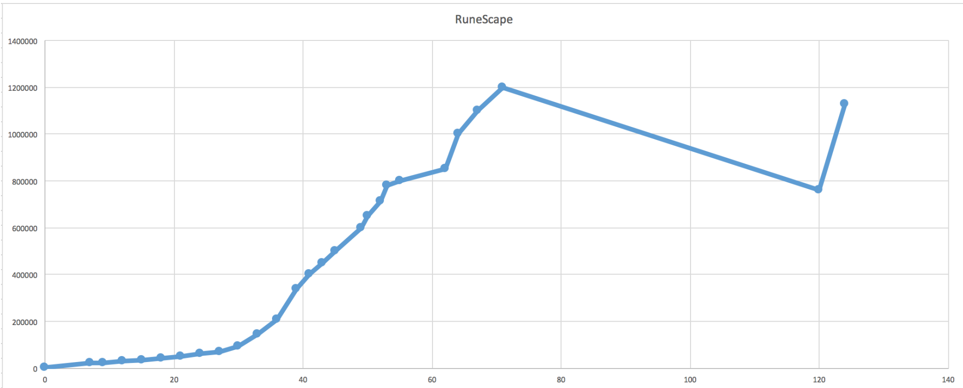

Figure 7.27: Actual RuneScape subscriber numbers [86]

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.001	0.001	0.001	0.001	0.001
$a2$	0.000000073	0.000000073	0.000000073	0.000000073	0.000000073
$a3$	0.000009	0.000009	0.000009	0.000009	0.000009
$l1$	0.00008	0.00008	0.00008	0.00008	0.00008
$l2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
cm	100 000	100 000	100 000	100 000	100 000
$updateFactor$	0.003	0	0	0.003	0.003
$rs2Factor$	0.005	0	0.005	0.005	0.005
$update06Factor$	0.03	0	0.03	0.005	0.03
$germanFactor$	0.003	0	0.003	0.005	0.003
$update07Factor$	0.09	0	0.09	0.001	0.09
$update09Factor$	0.039	0	0.039	0.005	0.039

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$update10Factor$	0.12	0	0.12	0.005	0.12
$update11Factor$	0.21	0	0.21	0.005	0.21
$rs3Factor$	0.8	0	0.8	0.005	0.8
$reaction06Factor$	0.001	0	0.001	0.005	0.001
$Buyers$	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000

Table 7.22: RuneScape simulation parameter values.

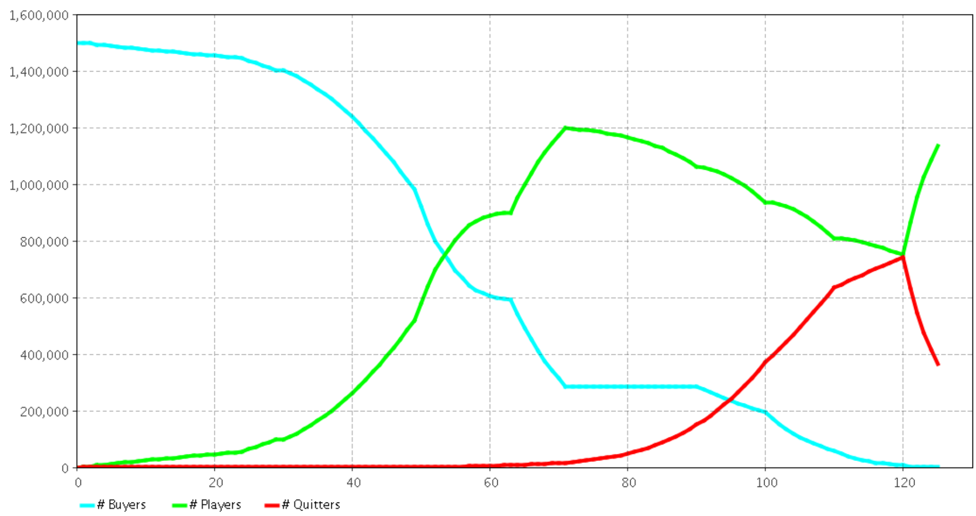

Figure 7.28: Recreation of empirical data in RuneScape.

Figure 7.28 shows the simulation of empirical data. Like in WoW, game updates have a significant influence on the evolution even at an early stage. According to the empirical data, updates account for big increases in growth and are central to the game's evolution.

7.2.3.2 Scenario 2

In the second simulation, $updateVariable$ and $marketChange$ are neglected to explore the evolution without any updates. The simulation proves the importance of providing updates to the game.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.001	0.001	0.001	0.001	0.001
$a2$	0.000000073	0.000000073	0.000000073	0.000000073	0.000000073
$a3$	0.000009	0.000009	0.000009	0.000009	0.000009
$l1$	0.00008	0.00008	0.00008	0.00008	0.00008
$l2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
cm	100 000	100 000	100 000	100 000	100 000
$updateFactor$	0.003	0	0	0.003	0.003
$rs2Factor$	0.005	0	0.005	0.005	0.005
$update06Factor$	0.03	0	0.03	0.005	0.03
$germanFactor$	0.003	0	0.003	0.005	0.003
$update07Factor$	0.09	0	0.09	0.005	0.09
$update09Factor$	0.039	0	0.039	0.005	0.039
$update10Factor$	0.12	0	0.12	0.005	0.12
$update11Factor$	0.21	0	0.21	0.005	0.21
$rs3Factor$	0.8	0	0.8	0.005	0.8
$reaction06Factor$	0.001	0	0.001	0.001	0.001
$Buyers$	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000

Table 7.23: RuneScape simulation parameter values.

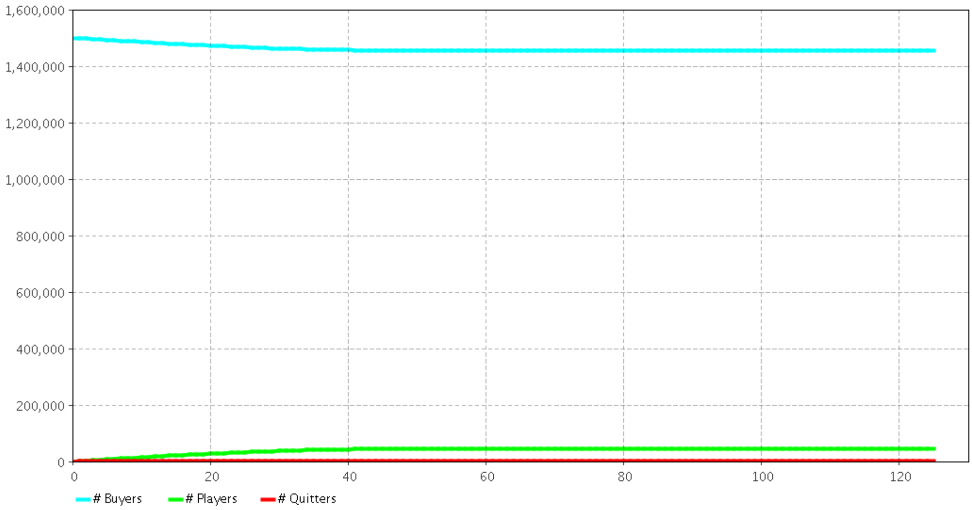

Figure 7.29: RuneScape simulation without updates.

As Figure 7.29 proves, when updates are not included, the game never reaches critical mass. The initial adoption never manages to make growth self-sustaining, and consequently, the game dies prematurely.

7.2.3.3 Scenario 3

Simulation three explores the evolution when constant updates (*regularUpdate*) are neglected. Constant updates are one of the big selling points in *RuneScape*, and this simulation proves its importance.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.001	0.001	0.001	0.001	0.001
$a2$	0.000000073	0.000000073	0.000000073	0.000000073	0.000000073
$a3$	0.000009	0.000009	0.000009	0.000009	0.000009
$l1$	0.00008	0.00008	0.00008	0.00008	0.00008
$l2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
cm	100 000	100 000	100 000	100 000	100 000

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$updateFactor$	0.003	0	0	0.003	0.003
$rs2Factor$	0.005	0	0.005	0.005	0.005
$update06Factor$	0.03	0	0.03	0.005	0.03
$germanFactor$	0.003	0	0.003	0.005	0.003
$update07Factor$	0.09	0	0.09	0.005	0.09
$update09Factor$	0.039	0	0.039	0.005	0.039
$update10Factor$	0.12	0	0.12	0.005	0.12
$update11Factor$	0.21	0	0.21	0.005	0.21
$rs3Factor$	0.8	0	0.8	0.005	0.8
$reaction06Factor$	0.001	0	0.001	0.001	0.001
$Buyers$	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000

Table 7.24: RuneScape simulation parameter values.

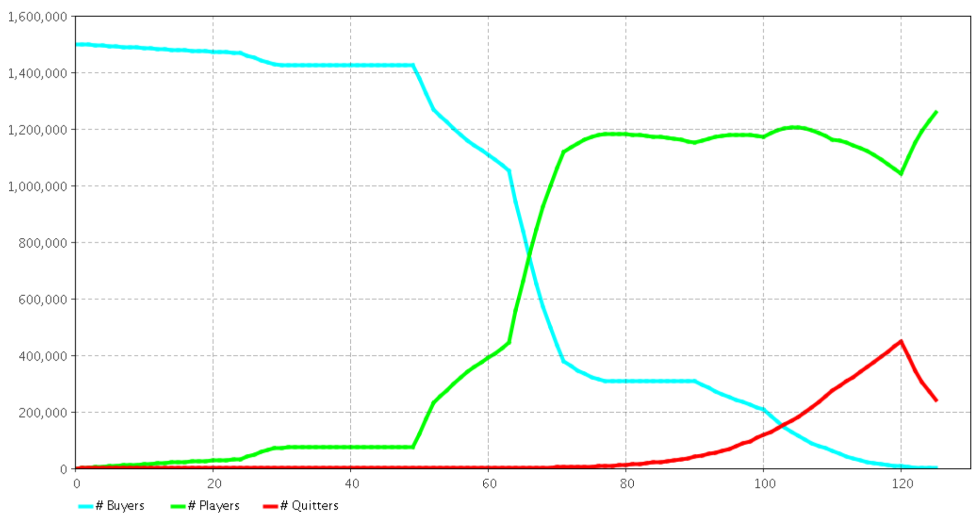

Figure 7.30: RuneScape simulation without constant updates.

As mentioned in Section 4.4, *RuneScape* is the most frequently updated MMOG in the world. Scenario three explores the evolution when frequent updates are neglected, and is illustrated in Figure 7.30. In this simulation, the game reaches critical mass late in its evolution. It is assumed that other updates still have the same impact as in scenario one. In real life, however, this would probably not be the case. With a small player base, the costs of developing big updates would probably be too high, resulting in smaller updates with reduced impact. Also, because the game reaches critical mass late, the game might die before it ever reaches critical mass.

7.2.3.4 Scenario 4

The fourth simulation explores market evolution when all update variables are equal. This simulation proves how game updates need to improve to continue growth or temporarily stop a decline.

Parameter	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
$a1$	0.001	0.001	0.001	0.001	0.001
$a2$	0.000000073	0.000000073	0.000000073	0.000000073	0.000000073
$a3$	0.000009	0.000009	0.000009	0.000009	0.000009
$l1$	0.00008	0.00008	0.00008	0.00008	0.00008
$l2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
cm	100 000	100 000	100 000	100 000	100 000
$updateFactor$	0.003	0	0	0.003	0.003
$rs2Factor$	0.005	0	0.005	0.005	0.005
$update06Factor$	0.03	0	0.03	0.005	0.03
$germanFactor$	0.003	0	0.003	0.005	0.003
$update07Factor$	0.09	0	0.09	0.005	0.09
$update09Factor$	0.039	0	0.039	0.005	0.039
$update10Factor$	0.12	0	0.12	0.005	0.12
$update11Factor$	0.21	0	0.21	0.005	0.21
$rs3Factor$	0.8	0	0.8	0.005	0.8
$reaction06Factor$	0.001	0	0.001	0.001	0.001
$Buyers$	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000

Table 7.25: RuneScape simulation parameter values.

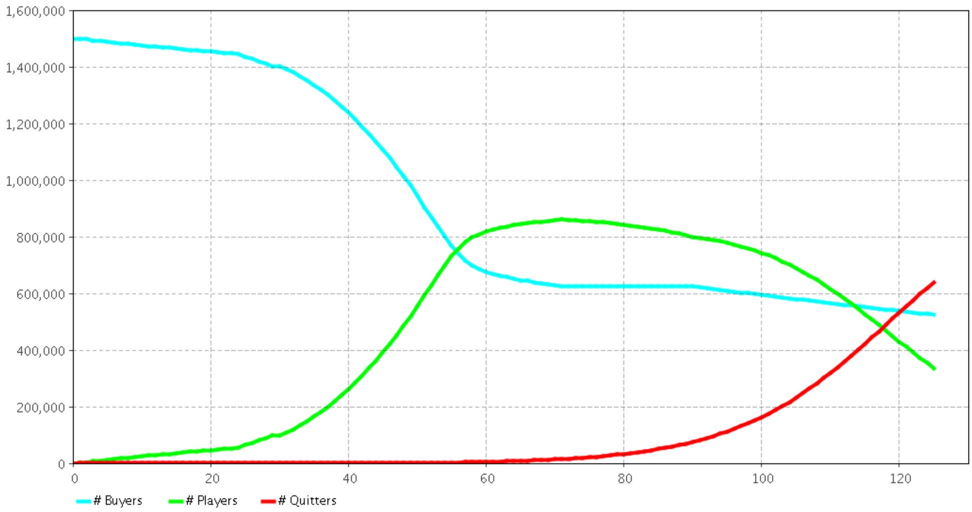

Figure 7.31: RuneScape simulation with equal update variables.

Scenario four illustrates market evolution when all updates have the same impact. As Figure 7.31 shows, the game reaches critical mass and experiences quick adoption. Compared with scenario one, the value of updates is clear. Simulation four does not reach the same player peak and has a smaller player base at $t = 120$ compared with scenario one.

7.2.3.5 Scenario 5

Simulation five illustrates a possible future market evolution – the evolution after the documented empirical data from *MMOData* [86]. The simulation is based on scenario one. It is assumed that the release of *RuneScape3* had a major impact on the population size and that updates during the following years did not affect the population significantly. Consequently, no additional update variables are added in this scenario.

Parameter	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
$a1$	0.001	0.001	0.001	0.001	0.001
$a2$	0.000000073	0.000000073	0.000000073	0.000000073	0.000000073
$a3$	0.000009	0.000009	0.000009	0.000009	0.000009
$l1$	0.00008	0.00008	0.00008	0.00008	0.00008
$l2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
cm	100 000	100 000	100 000	100 000	100 000
$updateFactor$	0.003	0	0	0.003	0.003
$rs2Factor$	0.005	0	0.005	0.005	0.005
$update06Factor$	0.03	0	0.03	0.005	0.03
$germanFactor$	0.003	0	0.003	0.005	0.003
$update07Factor$	0.09	0	0.09	0.005	0.09
$update09Factor$	0.039	0	0.039	0.005	0.039
$update10Factor$	0.12	0	0.12	0.005	0.12
$update11Factor$	0.21	0	0.21	0.005	0.21
$rs3Factor$	0.8	0	0.8	0.005	0.8
$reaction06Factor$	0.001	0	0.001	0.001	0.001
$Buyers$	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000

Table 7.26: RuneScape simulation parameter values.

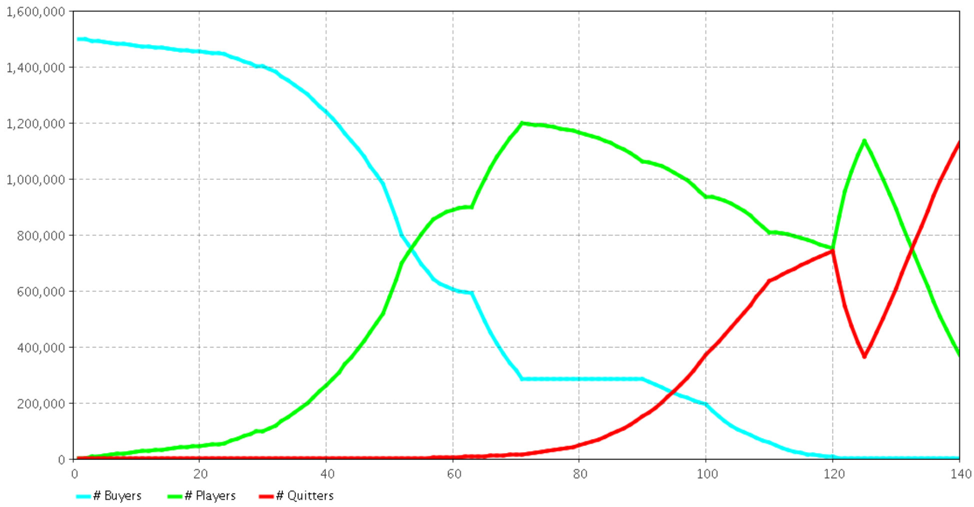

Figure 7.32: Possible future market evolution in RuneScape.

In Scenario five, a possible future market evolution is simulated. As Figure 7.32 shows, *RuneScape* experiences rapid decline in the extended period. As mentioned in Chapter 4, game content takes a lot of time to develop. Consequently, in this simulation, it is assumed that the effect of the last update was so big that future updates would not be able to affect the evolution.

The scenarios above once again illustrate the importance of game updates. *RuneScape* is a game that is dependent on constant updates to attract players, and in this instance, the game would never reach critical mass without the constant updates.

Chapter 8
Analysis

To create a successful MMOG, awareness of market factors is important. First of all, it is important to reach critical mass to initiate network effects and WOM and make adoption of the game self-sustaining. MMOGs are costly to run. The games need servers to operate and require constant maintenance. Consequently, if a game fails to meet its critical mass within a given time, it will probably be shut down. To reach critical mass, the game must attract innovators/influential multipliers. At this stage, advertising, story development, and good game attributes are essential. Innovators/influential multipliers are more experienced users that are affected by the quality of the product rather than the opinion of others.

Once critical mass is reached, network effect and WOM ensure rapid adoption. MMOGs are centred around peer-to-peer interaction, hence reaching critical mass ensures that the game offers network effects. Also, once network effects are initiated, the games full potential is released, giving a better playing experience. When player experience increases, adoption through WOM begins. To further increase adoption, updates and expansions have a significant impact. Updates and expansions introduce new game content and objectives, giving the game more diversity and helps it reach a wider audience. Potential buyers get increased incentives to start playing the game, and former players get new content to explore. Also, problems in the game are fixed, contributing to an even better player experience. Finally, game updates and expansions contribute to reaching a bigger audience because new content might satisfy them.

Due to the long lifetimes and lucrative business models of MMOGs, they are great sources of income for game studios. Consequently, the market experiences considerably competition. As the simulations in Chapter 7 illustrates, people tend to play the largest game because it offers best network effects. Because MMOGs are social games, players are more likely to play the games their friends play. However, if a game recognises its market position, and takes actions to differentiate itself, it might be able to catch up with the market leader. In this paper, changing the business model from paid subscription to FTP represents this effect. Historically, this measure is widely used today [87, 88, 89].

Another way of generating additional adoption in a game is by cooperating with others. Games are usually expensive, and by including additional games, trial periods, in-game goods, etc. adoption might increase.

Looking at actual MMOGs like WoW and *RuneScape*, updates and/or expansions are essential in their evolution. WoW represents a game that generated huge initial adoption through Blizzard's good reputation and advertising. Looking at the simulations conducted in 7.2, expansions and updates have contributed to increased growth. The simulations show that these effects are greatest at late stages in the simulation. Expansions have made the lifetime of the game longer and contributed in reaching more people.

Looking at *RuneScape*, updates are much more essential in the early adoption of the game. Without any updates, the game would never reach critical mass. *RuneScape* depends heavily on its frequent updates, which is one of the big selling points of the game. Simulations prove that without this effect, the game would probably not reach critical mass early enough, and would probably be shut down. Also, updates have contributed to making the decline in population slower.

A common denominator in both games is that the impact of updates/expansions needs to be greater at later stages of the simulation to counteract a population decline. New content needs to attract many players who have already quitted the game. As potential buyers become saturated, the only way to stop a decline is by engaging former players. To attract former players, evolution and new content are important. Another similarity is that once a big expansion is released, it is quickly followed by a steep decline. This is natural because old players might want to try out the new content, and if it does not meet their expectations, quit as soon as possible. Also, as the game grows old, and players become familiar with the game mechanics, they complete new content fast, making it harder for the game studios to keep up. Once there is no more unexplored content, the player will leave the game.

Chapter 9
Future Work

In this chapter, ideas for future work will be presented. First, some ideas concerning the evolution of the BPQ model will be discussed, then, thoughts about market analysis are presented, and finally, thoughts about the future game market are discussed.

9.1 Expanding the BPQ model

MMOG markets are very complex and consist of many different factors. The BPQ model presented in this paper contains some central factors, but it can be expanded further. In this paper, the models only consist of one, two, or three games. However, in real life, the market consists of hundreds of games. Expanding the model to include more games is possible; however, it will require detailed knowledge about relations in the market.

MMOGs are games with relatively long lifetimes. During the lifetime of a MMOG, several updates and/or expansions are usually introduced. When new content is provided, more functionality is implemented. The new technology might result in increased interest in the game. To capture this effect, it is possible to introduce dynamic behaviour in potential adopters, allowing this amount to increase during the simulation. It is also possible to alter the leaving rate following expansions, to reflect increased incentives to stay in the game or leave the game.

Other possible changes may include altering network effects and WOM in greater detail, for instance decreasing the effect once competing games are released. Also, it is possible to introduce more advanced churning and cooperation variables.

9.2 Market Analysis

To identify essential market factors, and to be able to recreate correct empirical data, comprehensive market analysis is important. Understanding what makes people start to play or quit a particular game helps to construct more accurate simulation models and getting more reliable results. Studying user feedback, user ratings, and statistics might help to create a more detailed picture of factors that affect player behaviour. Utilising focus groups can provide other perspectives, and highlight new factors. Studying game specific empirical data in detail, like update notes, subscriber numbers, and external market factors. might also highlight other factors that contribute to the success or failure of a game. It may also be interesting to compare more games and prove similarities and differences.

9.3 New Technology

Today's technology innovates quickly, and the future game market might look very different than it does today. Predicting future changes might be the key to success. Virtual Reality (VR) is one of the technologies that is growing fast. The introduction of VR might change the game market completely, introducing games to a whole new audience, much like smartphones have already done [90]. Other new technologies like augmented realities, dual screen utilisation, smart glasses, and cross-platform gaming, all involves generating a bigger potential audience [91].

It is also possible that future technology will extend the lifetime of games. If the development of games requires less effort, and upgrading game mechanics and graphics becomes easier, it is possible that players choose to play a particular game for a longer period of time. By studying possible market changes, it is possible to expand the BPQ model to include new possible outcomes.

Chapter 10

Conclusion

Interactive online games are increasingly popular in today's society, and the industry is growing fast. Game studios are investing millions of dollars, and to create a successful game, knowledge about market factors is important.

This study explores factors that shape the evolution of MMOGs. To study these factors, a SD model based on the bass diffusion model is developed. The model explores temporal dynamic behaviour in a game market and includes known effects like network effects and WOM.

One important feature of the BPQ model is the support for gradual evolution to include more complex market scenarios. The gradual evolution makes it easy to start with a simple scenario, exploring basic features, before adding more complex relations. Consequently, each stage can be studied and analysed, making it more convenient to identify essential market factors and the extent of their impact.

The BPQ model is very modifiable, allowing different scenarios to be studied by altering a few components. Depending on the market being analysed, different complexity levels can be initialised to simulate the desired verbosity. The result is a model that clearly proves market factors, and that can be used for different purposes.

Common to all simulations is the importance of reaching critical mass to initiate network effects and WOM. Network effects and WOM ensure that the game obtains self-sustaining growth, allowing developers to focus on improving game content. If a game fails to meet this criteria, it faces a quick death. To reach critical mass, generating buzz around the game is important. Developing beta games, engage in advertising, and focus on creating quality game material are examples of measures to generate initial adoption. These tools contribute to recruite innovators/influential multipliers. Reaching critical mass is the most crucial event in MMOG markets, and to meet this goal, awareness of the game's market position is important.

MMOG markets consist of many games competing for the same customers. To get a dominant market position, differentiation is important. It is essential that the developers identify the market and make their product different. Differentiation might include a different business model, cooperation with other games, or making the game mechanics stand out. In today's market, the FTP business model is often used, allowing players to play the game for free, and explore the game attributes. To earn money, additional content, in-game goods, etc. can be purchased; however, this is not a requirement. FTP introduces a low threshold in game adoption and contributes to promoting the games strengths to a broader audience.

Another finding is that expansions and updates are important to extend the lifetime of a game. Providing new content increases adoption from potential adopters and create initiatives for re-adoption, making former players start playing again. Also, new content might help the game reach a bigger audience. When the game grows older, improvements and new releases become increasingly important because players push through the content faster. Basic dynamic behaviour suggests growth followed by stagnation and decline, and to counter this evolution, measures must be taken. Releasing new versions of the game initialises small instances of dynamic behaviour in sections of the evolution. If this effect is big enough, and the content is good enough, the lifetime of the game is extended.

In conclusion, people join a particular game as a consequence of many different factors. Initial adopters are adopting a game as a result of good game specifications, advertising, game content, and betas. Once enough initial adopters have adopted the game, network effects are initialised, improving the game experience for each player. Network effects are important due to the social aspects of MMOGs. When the gaming experience increases, people start recommending the game to their friends, initialising adoption through WOM. How big the game becomes depends on competitors, collaborators, the impact of network effects and WOM, and the quality of the game.

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Appendix A
Models

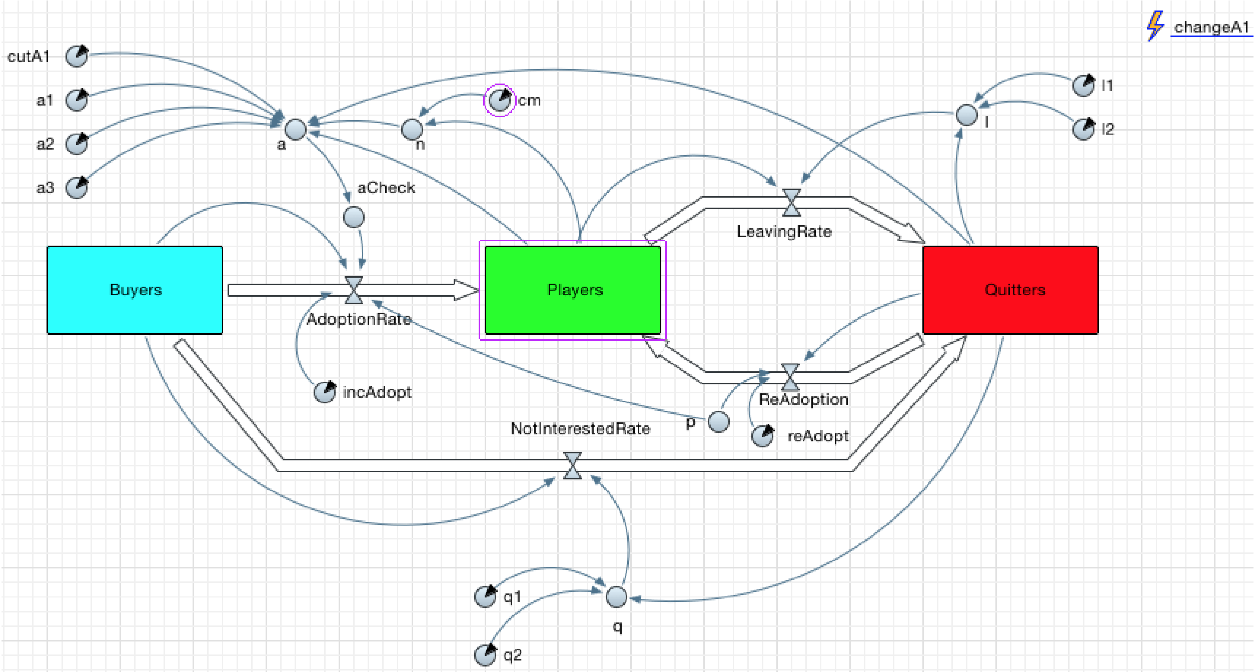

Figure A.1: AnyLogic BPQ model with re-adoption.

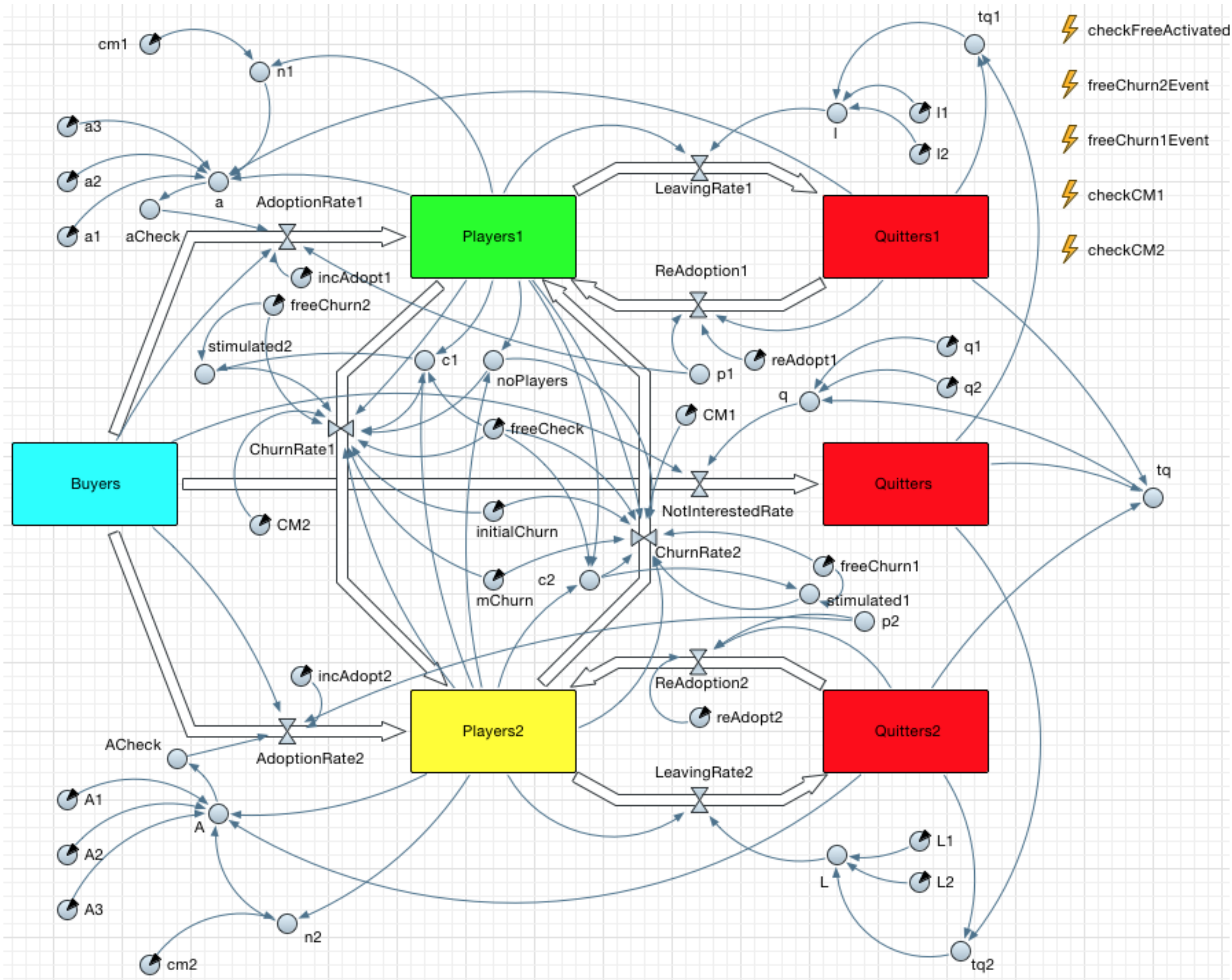

Figure A.2: AnyLogic BPQ model with churning.

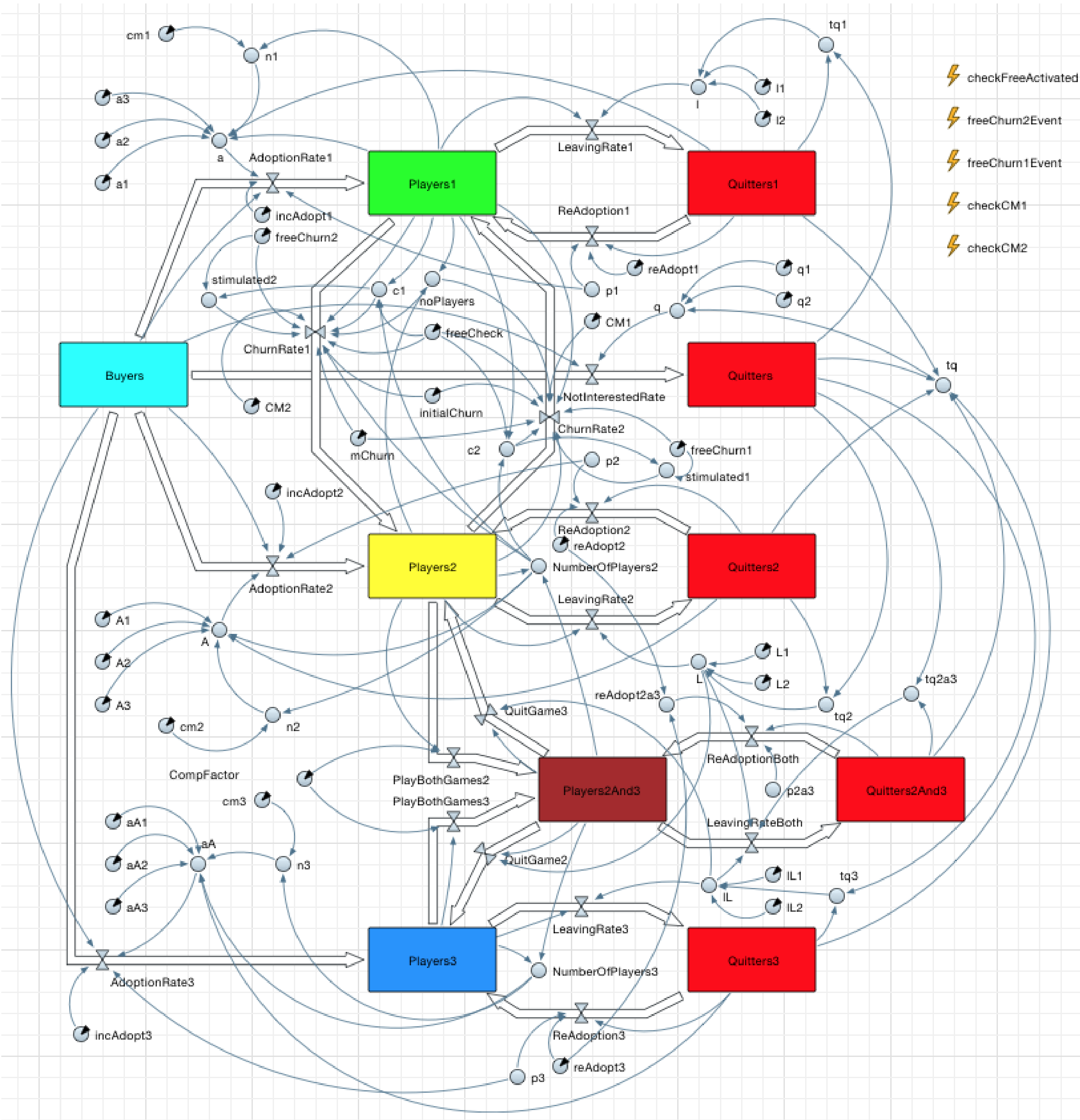

Figure A.3: AnyLogic BPQ model with churning and cooperation.

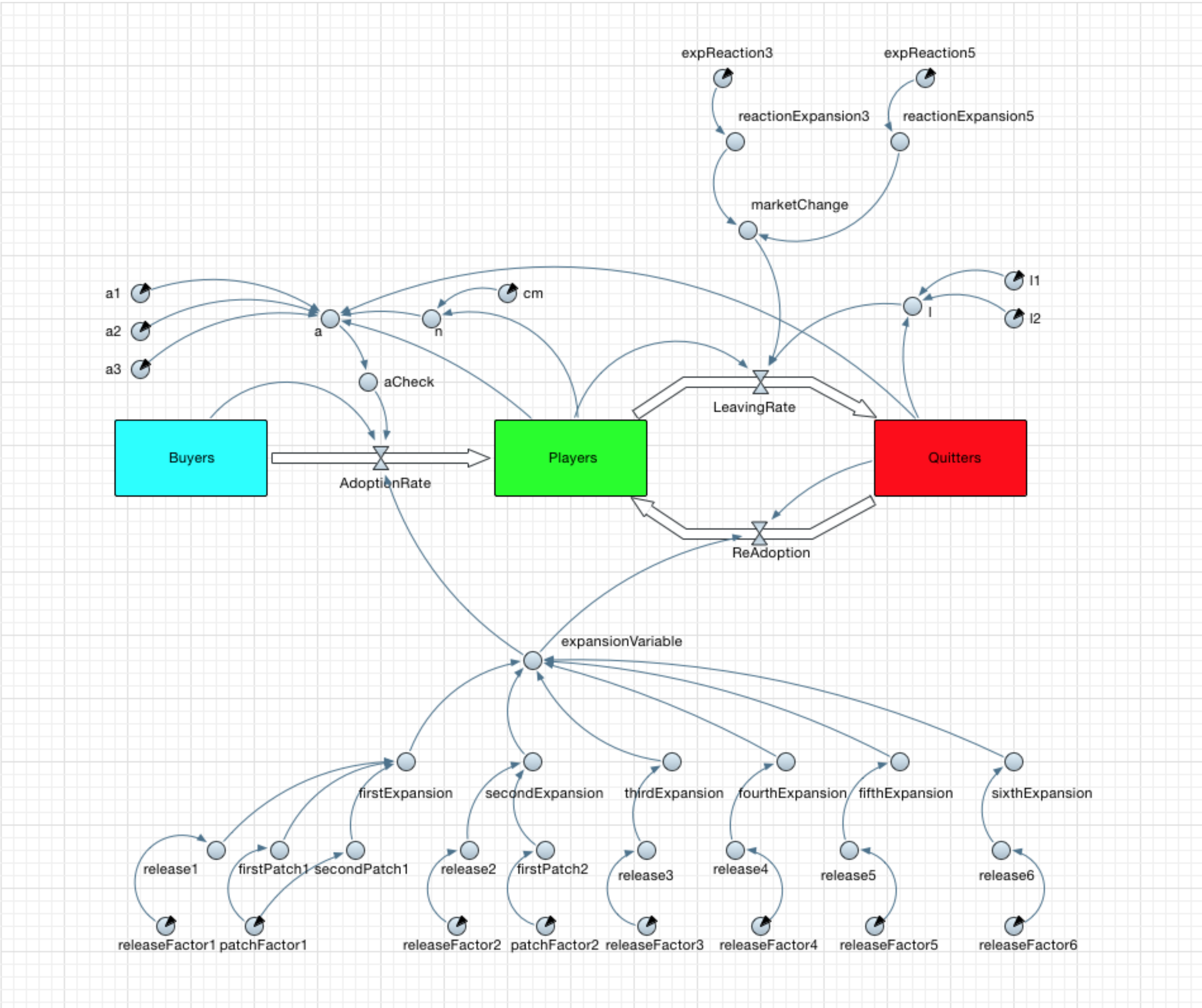

Figure A.4: World of Warcraft simulation model.

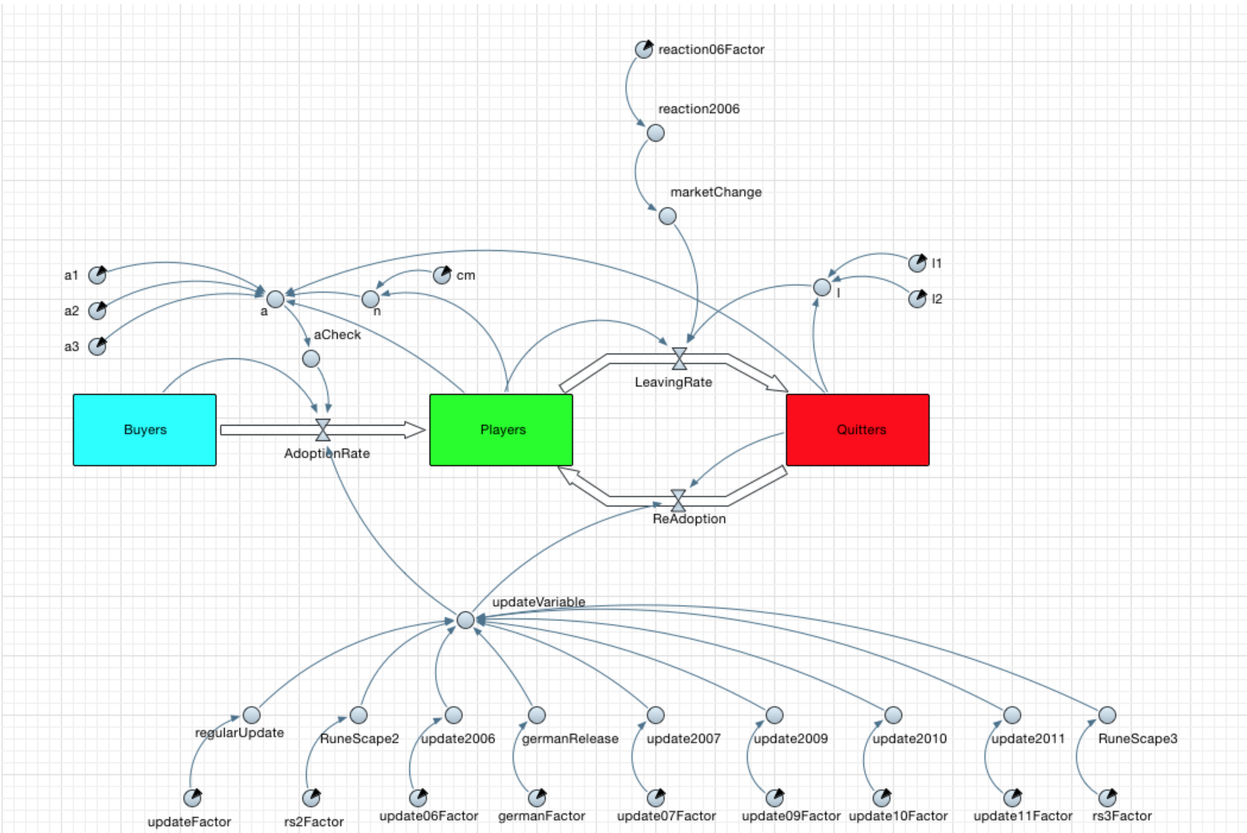

Figure A.5: RuneScape simulation model.

Appendix B

Additional Simulations

B.1 Complete BPQ model

Parameter	Simulation 1	Simulation 2	Simulation 3	Simulation 4	Simulation 5
$a1$	0.005	0.007	0.005	0.005	0.007
$a2$	0.000005	0.000002	0.000002	0.000002	0.000002
$a3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$A1$	0.005	0.005	0.005	0.005	0.005
$A2$	0.000002	0.000002	0.000002	0.000002	0.000002
$A3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$aA1$	0.005	0.005	0.005	0.005	0.005
$aA2$	0.000002	0.000002	0.000002	0.000001	0.000002
$aA3$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
$l1$	0.005	0.005	0.005	0.005	0.005
$l2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$L1$	0.005	0.005	0.005	0.005	0.005
$L2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$lL1$	0.005	0.005	0.005	0.005	0.005
$lL2$	0.0000003	0.0000003	0.0000003	0.0000003	0.0000003
$q1$	0.001	0.001	0.001	0.001	0.001
$q2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001

Parameter	**Simulation 1**	**Simulation 2**	**Simulation 3**	**Simulation 4**	**Simulation 5**
$reAdopt1$	0.03	0.03	0.03	0.03	0.03
$incAdopt1$	0.003	0.003	0.003	0.003	0.003
$reAdopt2$	0.03	0.03	0.03	0.03	0.03
$incAdopt2$	0.003	0.003	0.003	0.003	0.003
$reAdopt3$	0.03	0.03	0.03	0.03	0.03
$incAdopt3$	0.003	0.003	0.003	0.003	0.003
$mChurn$	0.0008	0.0008	0.0008	0.0008	0.0008
$compFactor$	0.005	0.05	0.008	0.005	0.05
$initialChurn$	0.02	0.02	0.02	0.02	0.05
$cm1$	10 000	10 000	10 000	10 000	10 000
$cm2$	10 000	10 000	10 000	10 000	10 000
$cm3$	10 000	10 000	10 000	10 000	10 000
$Buyers$	100 000	100 000	100 000	100 000	100 000

Table B.1: Case 3 parameter values.

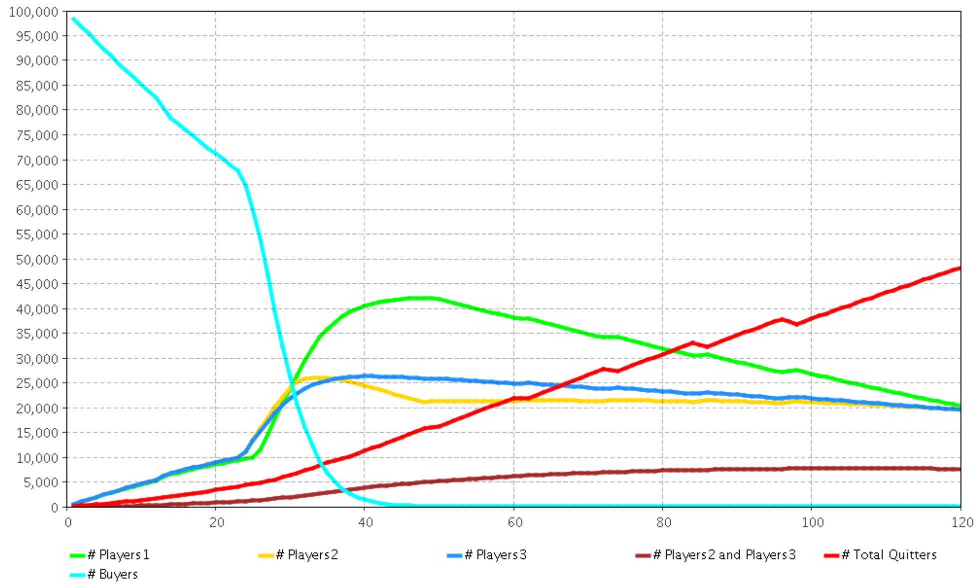

Figure B.1: Simulation 1 graph.

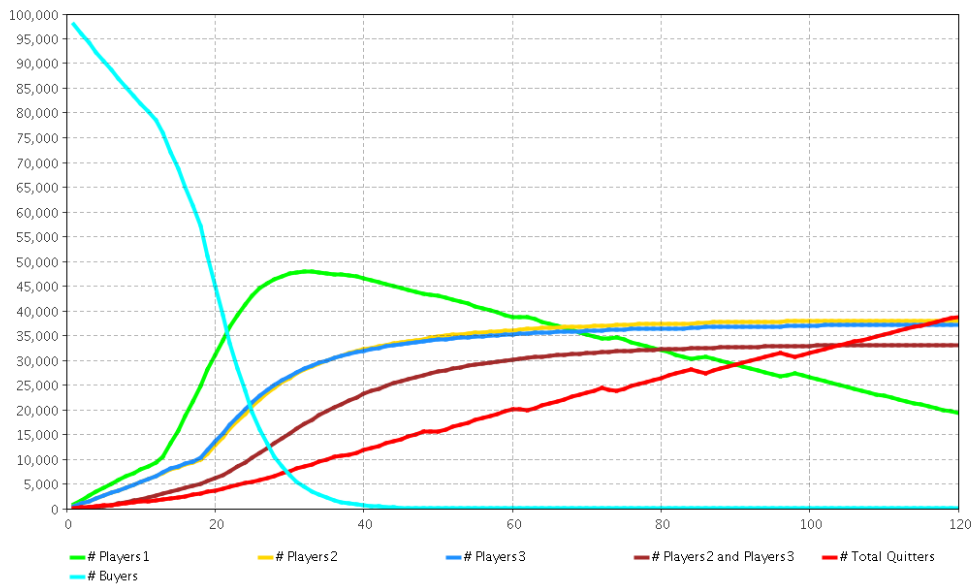

Figure B.2: Simulation 2 graph.

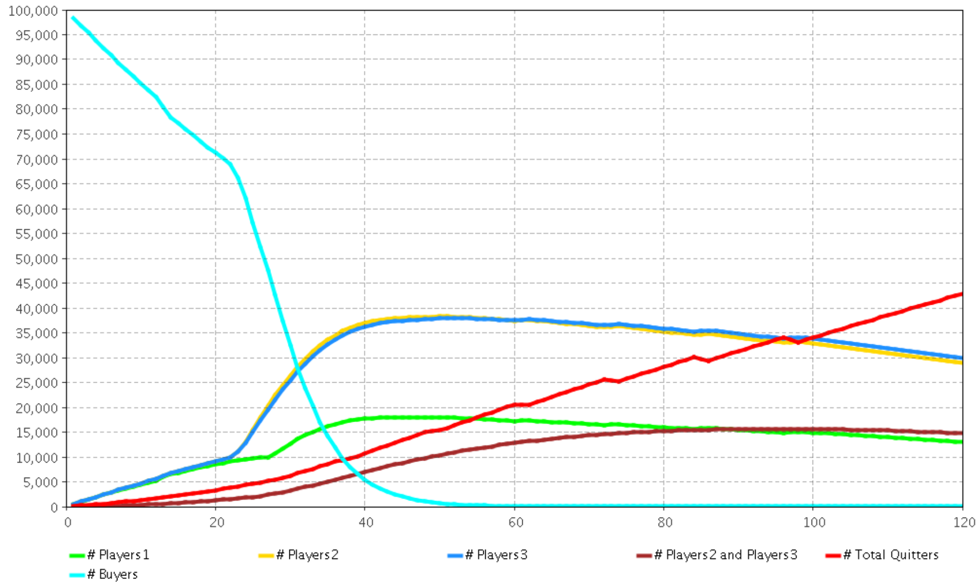

Figure B.3: Simulation 3 graph.

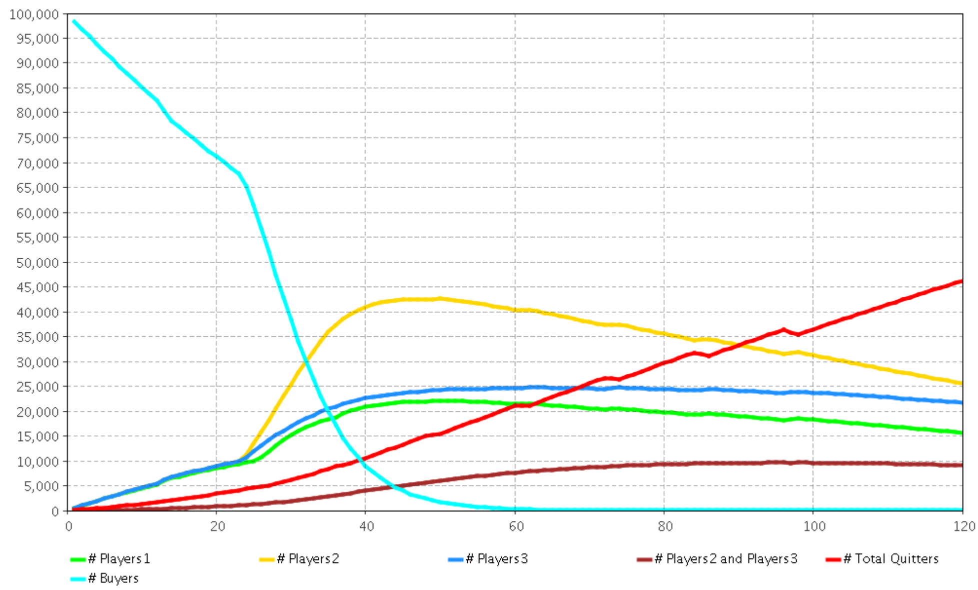

Figure B.4: Simulation 4 graph.

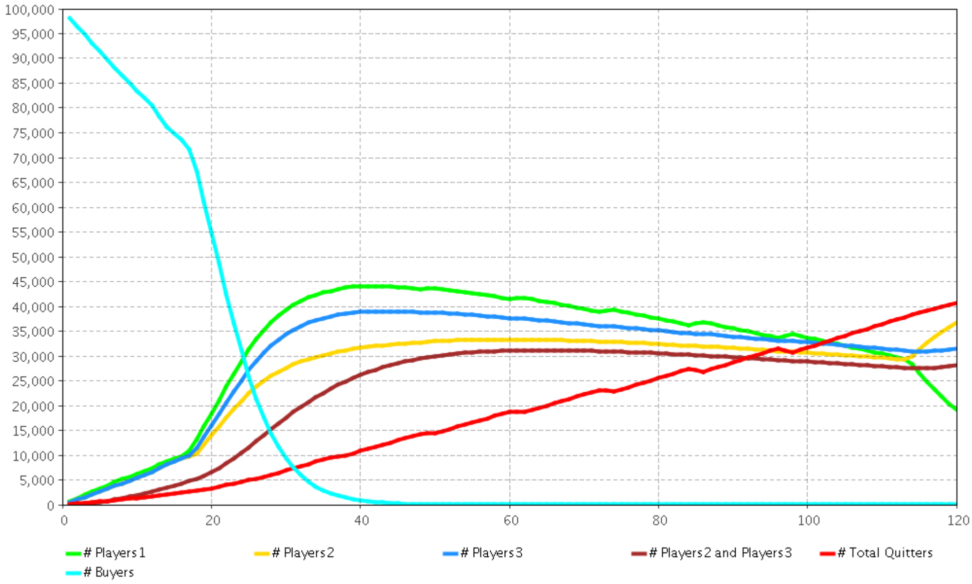

Figure B.5: Simulation 5 graph.

B.2 World of Warcraft

Parameter	**Simulation 1**	**Simulation 2**	**Simulation 3**	**Simulation 4**	**Simulation 5**
$a1$	0.027	0.01	0.027	0.01	0.027
$a2$	0.0000000053	0.0000000053	0.000000001	0.0000000053	0.000000001
$a3$	0.000002	0.000002	0.000002	0.000002	0.000002
$l1$	0.00008	0.00008	0.00008	0.00008	0.00008
$l2$	0.000000008	0.000000008	0.000000008	0.000000008	0.000000008
cm	2 000 000	2 000 000	2 000 000	2 000 000	2 000 000
$releaseFactor1$	0.055	0.055	0.055	0	0
$patchFactor1$	0.055	0.55	0.055	0	0
$releaseFactor2$	0.1	0.1	0.1	0	0
$patchFactor2$	0.18	0.18	0.18	0	0
$releaseFactor3$	0.08	0.08	0.08	0	0
$releaseFactor4$	0.7	0.7	0.7	0	0
$patchFactor4$	0.18	0.18	0.18	0	0
$releaseFactor5$	0.6	0.6	0.6	0	0
$releaseFactor6$	0.8	0.8	0.8	0	0
$expReaction3$	0	0.05	0.05	0	0
$expReaction5$	0	0.06	0.06	0	0
$Buyers$	12 000 000	12 000 000	12 000 000	12 000 000	12 000 000

Table B.2: World of Warcraft simulation parameter values.

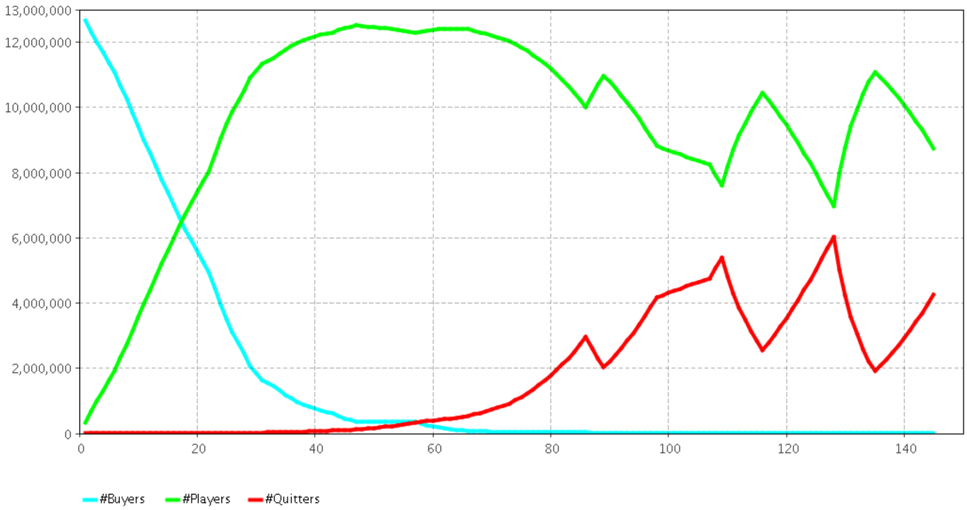

Figure B.6: World of Warcraft simulation 1.

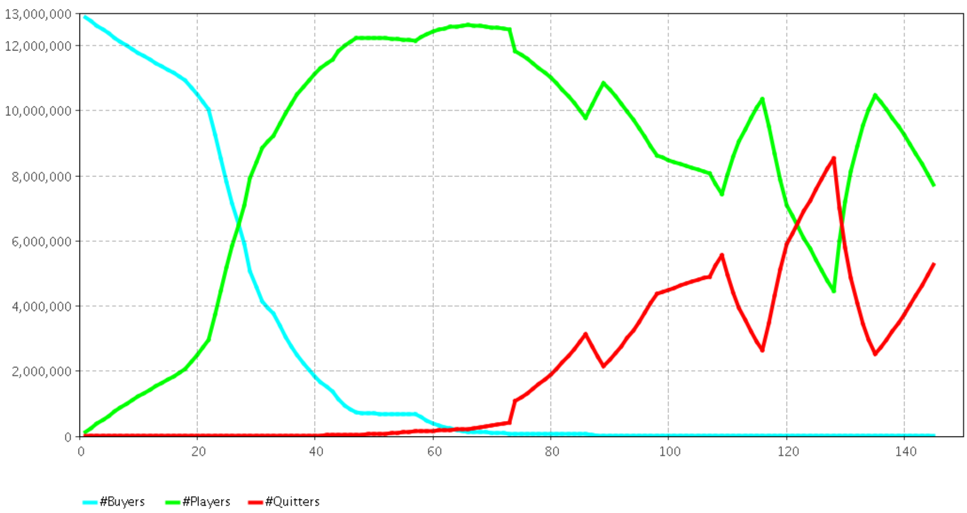

Figure B.7: World of Warcraft simulation 2.

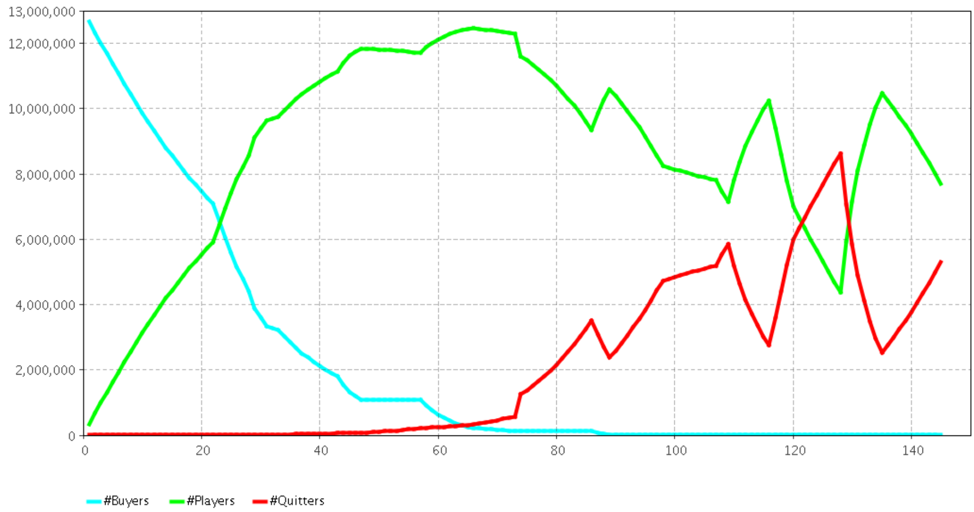

Figure B.8: World of Warcraft simulation 3.

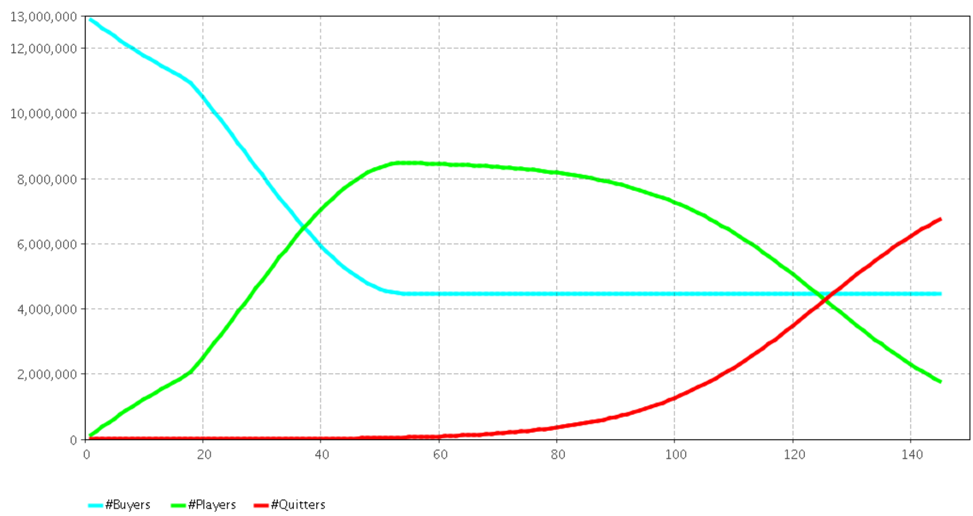

Figure B.9: World of Warcraft simulation 4.

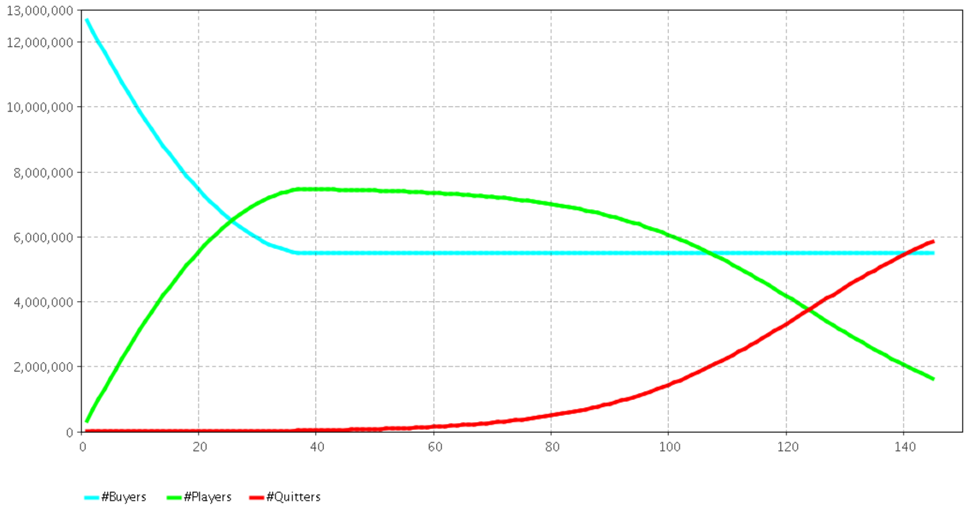

Figure B.10: World of Warcraft simulation 5.

B.3 RuneScape

Parameter	**Simulation 1**	**Simulation 2**	**Simulation 3**	**Simulation 4**	**Simulation 5**
$a1$	0.0027	0.001	0.001	0.001	0.0027
$a2$	0.000000073	0.00000005	0.000000073	0.000000073	0.000000073
$a3$	0.000009	0.000009	0.000009	0.000009	0.000009
$l1$	0.00008	0.00008	0.00008	0.00008	0.00008
$l2$	0.0000001	0.0000001	0.0000001	0.0000001	0.0000001
cm	100 000	100 000	100 000	0	100 000
$updateFactor$	0.003	0.003	0.01	0.003	0
$rs2Factor$	0.005	0.005	0.005	0.005	0
$update06Factor$	0.03	0.03	0.03	0.03	0
$germanFactor$	0.003	0.003	0.003	0.003	0
$update07Factor$	0.09	0.09	0.09	0.09	0
$update09Factor$	0.039	0.039	0.039	0.039	0
$update10Factor$	0.12	0.12	0.12	0.12	0
$update11Factor$	0.21	0.21	0.21	0.21	0
$rs3Factor$	0.8	0.8	0.8	0.8	0
$reaction06Factor$	0.001	0	0.001	0.001	0.001
$Buyers$	1 500 000	1 500 000	1 500 000	1 500 000	1 500 000

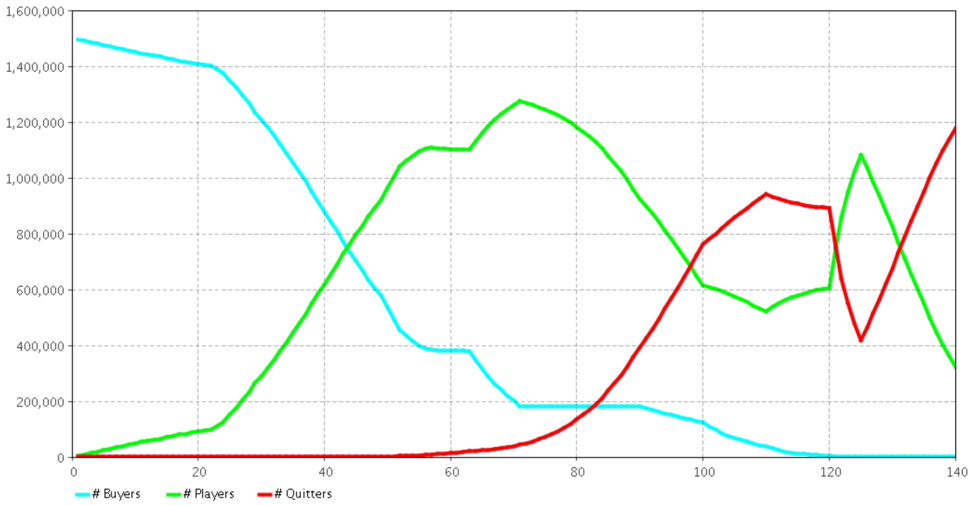

Figure B.11: RunseScape simulation 1.

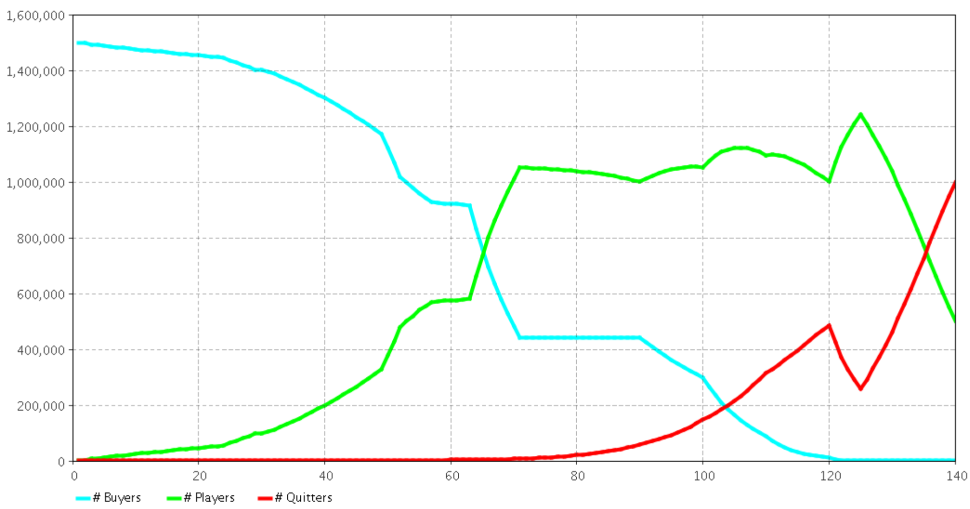

Figure B.12: RuneScape simulation 2.

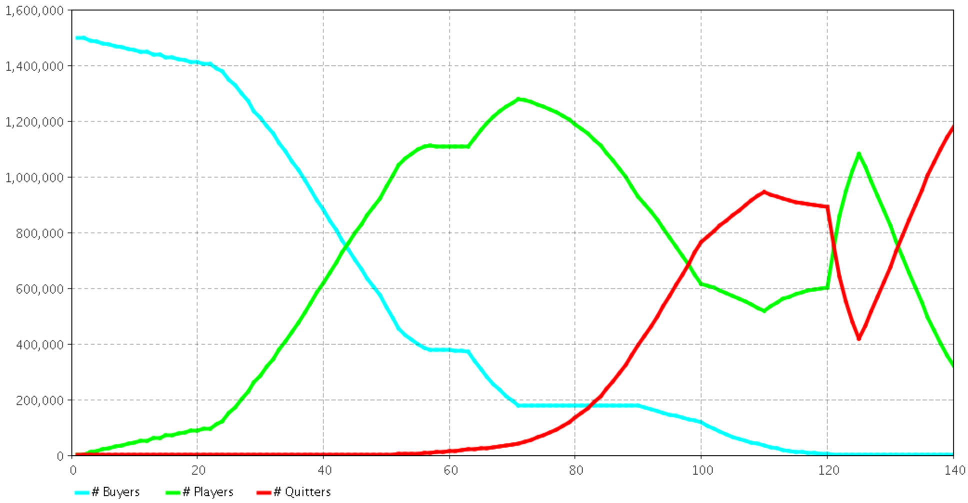

Figure B.13: RuneScape simulation 3.

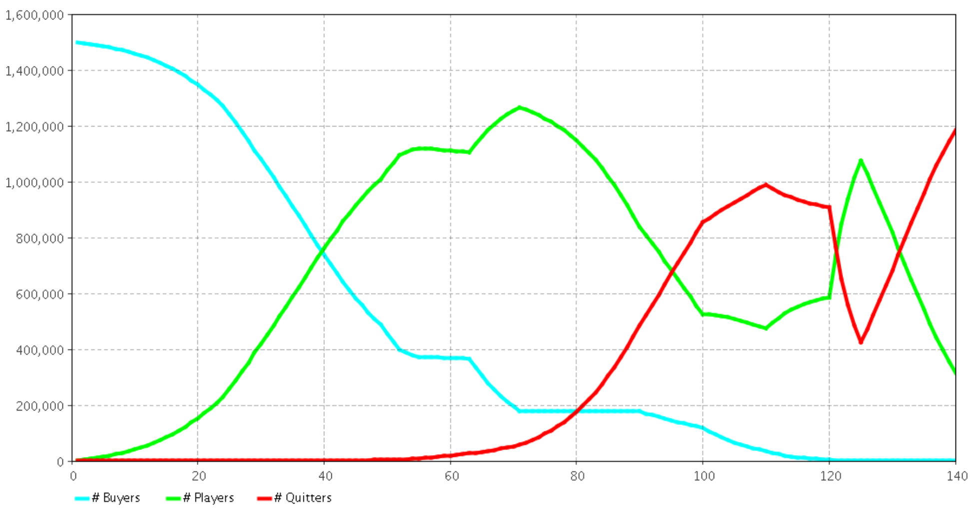

Figure B.14: RuneScape simulation 4.

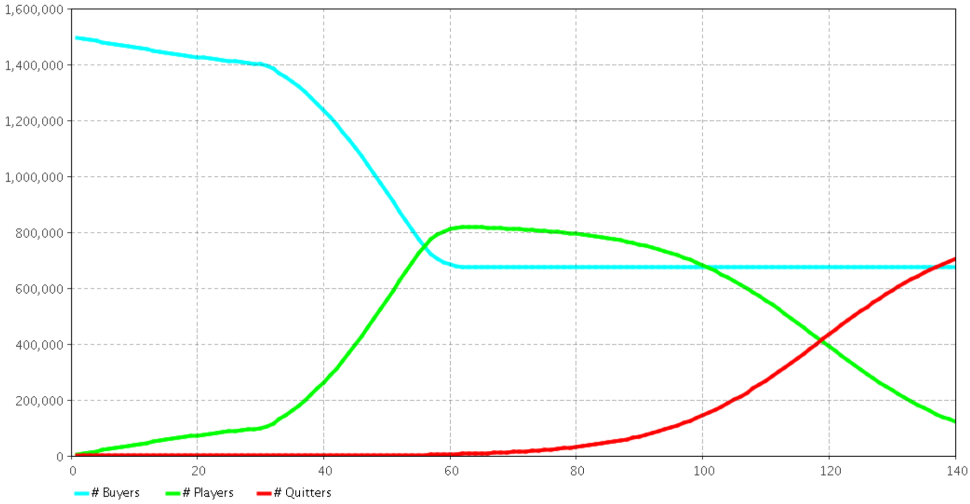

Figure B.15: RuneScape simulation 5.