

Charles University in Prague

Faculty of Social Sciences
Institute of Economic Studies



BACHELOR'S THESIS

Oligopoly Markets in Virtual Economy

Author: **Tran Quang Tuan**

Supervisor: **PhDr. Ing. Jiří Skuhrovec**

Academic Year: **2011/2012**

Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature.

The author grants to Charles University permission to reproduce and to distribute copies of this thesis document in whole or in part.

Prague, July 29, 2012

Signature

Acknowledgments

I am deeply indebted to my academic supervisor Phdr. Ing. Jiří Skuhrovec who helped me with valuable suggestions and encouraged me in my research and writing. Moreover, I am grateful to my friends Nguyen Cong Thang and Václav Šindl for technical help during writing this thesis.

Abstract

This work will focus on the virtual World of Warcraft market where mainly I am going to focus my research on the behavior of monopolists and Oligopolists in this market and then trying to verify their pricing policy with known microeconomic models. This thesis finds that the behavior of monopolistic and oligopolistic markets in a virtual economy matches the prediction of standard microeconomic and that this harmony between theory and observation is, to some extent, even more clear than in the case of most real markets. Thanks to econometric analysis the empirical verification of the correctness of the economic game theory and possibly promoting the theory of regulation is another contribution of this work.

JEL Classification D12, D22, D43, D42, D44, D41

Keywords virtual markets, oligopoly, virtual economy

Author's e-mail T.Tuan@seznam.cz

Supervisor's e-mail jskuhrovec@gmail.com

Abstrakt

Práce bude zaměřena na Virtuální trh světa WoW, zejména se zaměřím na chování Monopolistů a Oligopolistů na tomto trhu a pokusím se ověřit jejich cenovou politiku se známými mikroekonomickými modely. Tato práce ukáže, že chování monopolních a oligopolních trhů na tomto trhu značně odpovídá standardní mikroekonomické teorii a navíc se v mnohých případech tyto trhy chovají líp než většina reálných trhů. Díky ekonometrické analýze je dalším přínosem této práce i empirické ověření správnosti ekonomické teorie her a případně podpoření teorie regulace.

Klasifikace JEL

D12, D22, D43, D42, D44, D41

Klíčová slova

virtuální trh, oligopoly, virtuální ekonomika

E-mail autora

T.Tuan@seznam.cz

E-mail vedoucího práce

jskuhrovec@gmail.com

Contents

List of Tables	viii
List of Figures	ix
Acronyms	x
Thesis Proposal	1
1 Introduction	1
1.1 Introduction to Virtual Economies	3
1.2 Definition of Virtual Economy	4
1.3 Introduction to World of Warcraft	4
2 World of Warcraft basics	5
2.1 Basic game system	5
2.2 What is the game about?	6
2.3 Are all characters same?	7
2.4 Profession	7
2.5 Auction house	8
2.6 Blizzard as a God in WoW?	9
2.7 Property in WoW	10
3 Market structure	11
3.1 Goods	11
3.2 Producers concentration	12
3.3 Cost structure	14
3.4 Barriers to entry	15
4 Effect of market concentration - empirical study	16
4.1 Oligopoly markets in World of Warcraft	16

4.2	Panel data - a short overview	17
4.2.1	Data	18
4.2.2	Panel data application	19
4.2.3	Method of Fixed effects	22
4.3	Price and Size of market	24
4.4	Herfindahl index and price	24
4.5	Size of market and producer's margin (profit)	26
4.6	Econometric model	26
4.7	Margin advanced	28
4.8	Margin and non-aligned producers	28
4.9	Econometrics models - conclusion	30
5	Conclusion	31
	Bibliography	35
A	Appendix	I

List of Tables

4.1	Available data	18
4.2	Panel data	19
4.3	Producers	25

List of Figures

4.1	Market equilibrium	28
A.1	Q-Q plot for model 1	III

Acronyms

WoW World of Warcraft

MMORPG Massive Multiplayer Online Role-Playing Games

NPC Non-Player-Character

VE Virtual Economy

VRI Very Rare Item

AH Auction House

Chapter 1

Introduction

To some extent, virtual reality may be viewed as an extension of existing technology, the telephone, television, and the video game. That is, virtual reality will replace the telephone, the television, and will fulfill those social roles. Yet, virtual reality is more than just the next-generation telephone, television, and video game; it is a world unto its own. And within this world, we will see the development of a virtual economy, new business models, new social groups, and new interaction styles. Welcome to the “Virtual World.” [14]

Virtual (or, as they are sometimes called, synthetic) *economies* are growing in importance. Online games which are currently played by tens of millions of people worldwide often have economic systems built into their virtual worlds which in many aspects resemble the market structures known from the real economy.

For economic researchers, this carries a significant appeal in that it allows the execution of large-scale experiments which would be only very difficult to undertake in the real economy. In these virtual economies, the behaviour of millions of people, operating under clearly defined but changeable rules, can be observed virtually real-time, creating a unique opportunity for economic measurements and for testing of a variety of microeconomic and macroeconomic laws and models without many disturbances presented in real world. Another reason for interest in virtual economies is that there is a connection between the real economy and virtual economies - which are, after all, populated by people from the real world [26] (this was e.g. argued by Jiri Skuhrovec [26],

where he shows there really is a relationship between real world inflation and WOW inflation). Finally, virtual economies, populated by millions of real economic agents, often allow us to observe economic phenomena like *homogeneous products, perfect information or perfectly closed economies* which are normally all but impossible to observe in the real world. In this respect, observations from the study of virtual economies might yield valuable insights into many key concepts of economic theory, including such central concepts like models of *monopolistic and oligopolistic markets*.

Despite all of the above, *virtual economies* have so far attracted only little serious economic research. To some extent this might perhaps be caused by a certain suspicion raised in serious academic circles by the fact that virtual economies are mainly present in online games, especially in so-called MMORPGs (Massive Multiplayer Online Role-Playing Games). Another important author's motivation of this thesis is therefore to negate these prejudices and to present an argument for virtual economies as a legitimate and highly relevant topic for economic investigation.

The content of this thesis will be focused on the *monopolistic behaviour* of producers in a *virtual economy*. In particular, this thesis will analyse oligopoly competition in virtual markets and its impacts on product prices.

In the initial parts, the reader will be familiarized with basic information about virtual economies in general and those of their aspects that are of particular relevance for further analysis in particular. Although a virtual economy is in many ways similar to the real one, a number of significant differences needs to be taken into account in order to correctly process the data and to ensure that the relevant assumptions for testing oligopoly competition are met.

After this, I will introduce the specific *virtual economy* that will be examined during further analyses. Subsequently, the reader will be presented with a clear delimitation of the scope of the analysis as well as a description of the microeconomic models used, the particular research questions posed and the analytical techniques employed.

The final and core section will describe the results of the analysis performed and will derive conclusions regarding the microeconomic behaviour of producers in a virtual economy.

Specifically, this thesis will focus on a representative virtual world - *World*

of *Warcraft (WoW)*. With more than 10 million¹ subscribers² worldwide, WoW is the most popular MMORPG currently on the market.

1.1 Introduction to Virtual Economies

Most of today's virtual worlds have their own economic system. Most of these systems are developed so as to emulate the real-world economy in as realistic a way as possible - the users generally own *virtual property*, purchase or exchange it in a virtual market using a virtual currency and can very often also get involved in the production of these items itself.

All *virtual economies* are created by private companies. In the most cases these VEs are represented in virtual games that bring some kind of benefits for their players in exchange for monthly fees the players have to pay. The revenues of the game developers running these virtual worlds mostly derive from charging the players a fixed monthly fee. Given that the players can stop paying these fees whenever they want, game developers' revenues are largely contingent on maintaining steady and high levels of user satisfaction - which almost entirely depends on the ability of the game world to entertain the users for extended periods of time [25]. In this context, the in-game *virtual economy* largely serves an auxiliary purpose through enhancing the entertainment value of the MMORPG - as has been reported, users generally find the in-game economic activities intriguing and generally enhancing the immersiveness of the game through increasing the similarity of between the virtual and the real world [7]. Specifically, in-game *virtual economies* have 5 main objectives [25]: First, the economy rations power by limiting access to goods. Second, it supports specialization by allowing trade. Third, it encourages interaction via cooperation and trade. Fourth, it provides goals, as any other goal is generally easier to reach by acquiring more wealth. Fifth, it supports economic role-playing. Many of these five roles are obviously intertwined, so that fulfilling one is essential in fulfilling the other. The term "*virtual economy*" has been used rather intuitively in literature to mean the internal economic system of a virtual world (e.g. Castronova 2002; Bartle 2003; Burke 2002; Nash & Schneyer 2004). However, design of economy-like activities and giving them the label "economy" is not sufficient to justify calling these transaction systems economies - at least

¹Taken from Blizzard's official report <http://us.blizzard.com>

²Subscriber is a person who pays a monthly fee to take part in the virtual World of Warcraft

in the sense that the term is used in the context of economics. Economies of virtual worlds, whatever they may turn out to be, are bound to differ from the economies in the real world.

1.2 Definition of Virtual Economy

A *virtual economy* is an emerging³ economy existing in a persistent virtual world where it is possible to exchange *virtual goods*. People generally do not become participants of such *virtual economies* out of necessity but rather for their own entertainment. *Virtual economies* usually lack those features of a real economy that are not perceived as entertaining. Each *virtual economy* is different and its form is created by designer with the aim to maximize the entertainment potential of the game for its target group. However, nearly all VEs are characterized by the (virtual) presence of three key phenomena - a market, a currency and some form of production.

1.3 Introduction to World of Warcraft

The particular virtual economy examined in this thesis is the in-game economy of *World of Warcraft (WoW)*. World of Warcraft is a fantasy MMORPG originally published in 2004 by Blizzard Entertainment. Over time, the original game was supplemented by a total of 3 expansion packs⁴ : The Burning Crusade (2007), Wrath of the Lich King (2008) and Cataclysm (2010). A fourth expansion pack, Mists of Pandaria, is expected to come out in 2012. As the analysis in this thesis will show, the release of expansion packs has always had a significant economic impact on the virtual economy of WoW. More than 10 million players worldwide make *World of Warcraft* the most widely played MMORPG worldwide and, as measured purely by the number of participants, its economy larger than that of e.g. the Czech Republic.

³As defined by its key properties- Such economies have very complicated system and structure that is difficult to explain

⁴An expansion pack is an addition to an existing role-playing game. These add-ons usually add new game areas, weapons, objects, or an extended storyline to a complete and already released game.(see www.wowiki.com)

Chapter 2

World of Warcraft basics

This part is dedicated to explaining the basic concepts of the WoW MMORPG which are necessary for understanding core of this thesis.

2.1 Basic game system

- The WoW world consists of several hundred *realms*¹ - *realms* are economically identical unrelated worlds with identical systems, infrastructure or material resources. Only the population differs which implies a different number of sellers and buyers in the market for individual commodities. These properties are crucial for this thesis since we will use this information for panel data analysis in section 4
- Every player has one account at his disposal through which he/she can connect to any *realm* she chooses. In any *realm*, the player can have one or more characters but she can never control more than one character from one account. The fact that one account can control multiple characters is negligible for our purposes since the number of players who acquire more than one character who will then become producers of a single given product is very unlikely to be significant. The author considers the fact that it is very disadvantageous for a player to acquire two characters both of whom are specialized in producing one specific good for trading. This is due to the fact that such a player can earn roughly the same amount of money on the market with one character as with two of them. Given that the player can send items and money among his characters free of

¹these realms are placed on servers, where we distinguish whether realm is the EU or US., depending on where the servers are located.

charge and given that it takes a certain amount of time for a character to reach an “experience level” sufficient for producing a certain good, the benefit of such a strategy is very likely to be negative.

- Every *realm* consists of identic “worlds” where the player can have the same characters but under different races..These characters are the only tool through which the player can communicate with the WoW virtual world and can trade, earn gold (the virtual money in WoW), slaying beasts and loot their possessions or simply trade in the auction hall (the concept of which will be explained shortly). Of course, there are players who only play the game sporadically and usually do not focus much on the economic side of this virtual world. However, the game is set up in such a way that the actions of every single participant have an impact on the WoW economy - even the killing of a relatively unimportant Non-Player-Character (the concept of NPCs is explained later on in this thesis) might have a tangible impact on the WoW economy.

2.2 What is the game about?

Throughout the game, the players gain so-called experience points for the completion of specific tasks which, after adding up to a certain fixed amount bring them to a higher “experience level”. Every player starts at experience level 1 and can eventually reach up to level 85 - with the number of experience points needed to “level-up” increasing with the player’s experience levels (from a few thousand points for the lower levels to a few million points needed to upgrade in the highest levels). The most common way to increase one’s experience level is to successfully complete quests assigned by computer-controlled Non-Player Characters (NPC’s) which are programmed to adapt the difficulty of the quests to the given player’s experience level so as to treat players of all experience levels fairly. Levelling-up is, apart from the acquisition of gold and valuable items, the main motivation of WoW players. Economically, the player’s experience level also has significance in that it increases the player’s productivity in economic activities - each player can choose a (combination of professions) such as herbalism or tailoring through which she can produce items for sale or exchange and getting to higher experience levels enables her to produce increasingly valuable items.

2.3 Are all characters same?

The characters differ by race, fraction, class (mage, warrior etc.), physical appearance or profession. Of these, it is the differentiation by profession that is of key importance to this analysis since it is one of the determinants of the player's involvement in the WoW economy.

2.4 Profession

Every character can choose two (of a total of 11) *primary professions* and 4 secondary professions. *Primary professions* can be separated into two main categories - gathering, i.e. the collection of commodities that can later be used by other *primary professions* for production, or crafting - i.e. the production of the items itself. Mostly gathering profession is interconnected with some production profession - e.g. to produce a weapon, a blacksmith needs ores which he needs to acquire from a miner or - if he has mining as his second *primary profession* - mine himself. As mentioned earlier, the value of the items produced (or materials gathered) increases with the player's experience level. However, for producing some goods, levelling-up is not the only pre-requisite - sometimes it is necessary to acquire (purchase, loot) a *recipe* for the production of the given item. *Recipes* play a key role in the latter parts of this theses.

Most items in WoW can be learnt from an NPC trainer, but there are also items that cannot be learnt from them. To produce these items characters usually need so-called *recipes*. Such a *recipe* can be bought from other players, from NPC merchants or it may be obtained by killing monsters. Crucial characteristics of a *recipe* are that it can only be used once by one character only and that the skill obtained through the *recipe* lasts indefinitely (cannot be "forgotten")

It is important to note that because a character can engage in a maximum of two professions, no player can single-handedly produce all items available in the *World of Warcraft* and that it is therefore necessary for characters to trade with each other. The terms under which the characters trade with each other are entirely subject to mutual agreement and it can therefore be said that the prices paid are the market prices, fully dictated by supply and demand for the given item. For our analysis of *oligopolies*, it will be important to focus on very precious items the acquisition of which is extremely difficult (due to the properties described in section 4). Often, such items are produced from

recipes looted from very rare beasts (so-called bosses²). Only small numbers of such *recipes* is acquired throughout the world (mostly 1 or 2 *recipes* within one week). It is therefore not uncommon that for some of these items, only one or a few producers are active on the market - as the reader has surely noticed, if only one scroll containing the *recipe* for an item becomes available throughout a week, its owner effectively becomes a *monopoly producer* of the given precious items, if several are made available, an effective *oligopoly* is created in the market. If an *oligopoly* environment arises, it is also important to note that the few suppliers offer an identical product. Over time, of course, the number of *recipes* and with it the number of producers capable producing a particular precious item increases. This has a significant effect on the price of these precious items - as we will see from the analyses later on.

2.5 Auction house

As has already been mentioned, 2 characters can trade with each other directly - either through exchanging items or through buying/selling items for gold. However, the vast majority of trade in the *World of Warcraft* is performed through an *Auction House* (AH) which connects all cities within a given *realm* and works in a way very similar to eBay.

When putting an item up for auction, it is necessary to pay a deposit for the organization of the auction. The deposit is then paid back once the item is successfully sold. However, for all successfully sold items, the auction house gets 5% of the final sales price. If no bids appear for a certain item (usually because another producer appears who sells it for a lower price), it is returned to the player who submitted it.

The auction house serves to simplify trading for the players. For the purpose of this thesis we are going to explain only the relevant options. When a seller puts an item up for auction, she sets 2 prices and the auction's duration. The first price is called the "start price", i.e. the lowest price for which the seller is willing to sell her item. The second price is called "buyout price" i.e. the price for which the buyer can immediately buy the item without waiting for the auction to end. The last term to explain is the duration of an auction. Sellers can choose 3 types of duration - 12h, 24h and 36h. The winner of the auction

²Boss is a special monster who has a unique name and appear only once in game

is the buyer who buys the item for the buyout price or bids the highest price in the auction.

With no exception every character in WoW can use the Auction house and monitor all goods offered. This character could find out for example how many producers offer some kind of products in AH moreover she could see the name of seller as well. For every item offered in AH all characters can check a start price, buyout price and the highest current bid for an item.³ In thesis buyout will be a key information since we don't have any data about for how much the item was sold.

Most of the empirical data used in this thesis was gathered from the Auction House in a unique way using software from Jiri Skuhrovec [26] (see appendix)

2.6 Blizzard as a God in WoW?

Blizzard Entertainment is the California-based game developer that has created WoW and runs all its *realms*. The main sources of the firm's revenue are one-time license fees enabling players to install the game and the monthly fees paid by users for continuing to play. Blizzard entertainment runs the WoW *virtual world*, fixes technical issues in the game, can permanently delete accounts (if this is considered appropriate etc.). Of particular relevance among the firm's activities is the regular release of so-called patches which, according to [23] have highly significant impacts on the WoW economy. The release of new patches has so far always meant a significant change in the WoW markets in the form of new items, precious *recipes*, new weapons, armours etc. being made available. New patches also change the maximum experience levels achievable - e.g. the Wrath of the Lich King patch released in 2009 increased the maximum experience level from 80 to 85. The primary consequence of this has been that some of the items from the previous versions became less difficult to obtain and therefore less expensive.⁴

³in provided data for this thesis there are no information about the price at which the given item was actually sold

⁴the author derives this observation mainly from statistics from www.wowwiki.com

2.7 Property in WoW

A citation by Jiri Skuhrovec [26] is appropriate here:

“Legally, all items in WoW belong to Blizzard. However from player’s perspective, until used for crafting or sold, an item is in his possession. Even death of character does not lead to losing any item. Furthermore, items are transferable at no costs, perfectly storable, durable, there is no asymmetric information regarding quality- so the economy should work quite well. WoW however completely misses one key desirable property - enforcement of contracts. Apart from simultaneous barter or AH trade, there is no legal enforcement of trade terms. Consequently, some basic aspects of economy can probably never fully develop here - such as loans. It would be hugely beneficial to level 1 character (incapable of Gold) to borrow Gold. But since there is none existent way of forcing him to repay debt, loans exists only on Guild or other social group level, where legal enforcement is replaced by some form of mutual trust. which might work thanks to their existing real world relationships.”

This means that if a player produces or buys an item, he can own it indefinitely⁵. The matter in which the item is used depends entirely on the player’s choice - the player can use it for her own purposes, give it to another player for free or sell it for gold. In most cases, players behave rationally and use the items to either increase their virtual wealth (i.e selling items in AH or just own items) or to further improve their character. Instances when a player sells an item only for a minimal price that AH allow are very rare and insignificant for our analysis - especially if the main focus is on precious and therefore highly valuable items.⁶

⁵Sometimes, e.g. in cases where a player acquired an item in a forbidden manner, Blizzard can intervene

⁶Based on Jiri Skuhrovec’s research [26] which has not observed a single instance where rare items would be sold for a minimal price.

Chapter 3

Market structure

3.1 Goods

As has already been mentioned, the character is the only channel through which a player can get involved in the WoW *virtual world*. The key motivations of a player are to increase the experience level and the income of her character. Over time, however, all players can achieve the highest possible level (level 85) and that's why player's motivation to increase character's level disappeared. After this point, most players focus on increasing their wealth. The amount of gold currently present in the player's inventory alone does not provide precise information about the player's wealth. The virtual income is also influenced by other factors than trading (e.g. killing beasts, gathering or production using commodities purchased e.g. in the Auction house). The goods can be sold to an NPC trader for a certain basic amount of gold or to another player for an agreed-upon sum. That means that goods also represent a part of a player's wealth in the World of Warcraft.

As opposed to the real world, every player has perfect information about the goods that can be acquired - i.e. the player does not need to worry about acquiring low-quality or damaged goods etc¹. This only benefits this thesis since it is not necessary to take into account any externalities arising through the influence of *asymmetric information*. Similarly to the real world, the WoW economy also involves very rare goods which will be the key topic for further investigation. These rare goods cannot be produced by every character. Usually, a character must meet a number of criteria to be able to acquire or produce the

¹The www.wowwiki.com website offers all information about all items in the WoW world.

item. In order to produce e.g. the very rare “*Leggings of Nature’s Champion*”², a character must have reached the maximum level in the leatherworking profession, her overall experience level must have reached 85 and, most important of all, must acquire the recipe for the item’s production . which is by no mean a simple matter since such recipes only very rarely become available after slaying the main *bosses*³. However, once a player learns to produce this item, she never forgets it. This property of the recipes will be used in a further chapter.

3.2 Producers concentration

Every character in the *World of Warcraft* can become a producer of some type of good. Even characters at the lowest experience levels can kill the weakest monsters and loot certain types of goods to sell in the *auction house*. Repeated killing of the monsters with the purpose of selling the goods might therefore make the character an effective producer of the goods. In the market for *very rare items* (VRI), however, the number of producers is, at least initially⁴, limited. In the first weeks after a VRI becomes available, only 1-3 producers usually appear on the market (see section 4). The degree of producer concentration in this market is therefore usually somewhere between a *monopoly* and an *oligopoly*.

The *Hirschmann-Herfindahl Index* (*HHI*)⁵ is an effective tool to measure the size of a firm in relation to the industry and how market is concentrated. The formula is:

$$HHI = \sum_{i=1}^n S_i^2 \quad (3.1)$$

where S_i is a market share of i – th firm, $i = 1, 2, 3, \dots, n$

²<http://www.wowhead.com/item=71986>

³Main bosses are the strongest monsters in the game. To slay such a creature, a player must team-up with a group of other players. Such raids can be performed only once a week.

⁴ During the patch-period Blizzard often adds new items to diversified the game for players

⁵conclusion comes from United States Department of Justice (see <http://www.justice.gov/>)

1. A *HHI* index below 0.01 indicates a highly competitive index
2. A *HHI* index below 0.15 indicates an unconcentrated index.
3. A *HHI* index between 0.15 to 0.25 indicates moderate concentration.
4. A *HHI* index above 0.25 indicates high concentration

In this thesis, we will assume that every producer of a particular *VRI* will have an equal share in the market for the item. This is based on the assumption that every producer of a particular *VRI* has the same opportunities in the market and that perfect information about the product is available - *VRI* market is a market with homogenous product.

The fact we are dealing with homogenous product results from the truth about perfect information for all items in WoW thus the market with such an item is clearly defined. There is no chance to differentiate product without player haven't noticed and that's why we can with calm heart say that *VRI* market is the market with homogenous product. Therefore each producer produces identical item, has the same information and even occasion to entry and trade in AH are the same therefore we can claim that each producer will have the same opportunities and market share - Surely with changing number of producers the producer's share in the market is changing as well.

The *HHI* index for the *VRI* market will therefore have the form

$$HHI = V_1^2 + V_2^2 + \dots + V_n^2 \quad (3.2)$$

Where n is the number of producers of the *VRI* and V_i is the share of each producer in the market, $i = 1, 2, 3, \dots, n$

Since once we have an assumptions that every producer of a particular *VRI* will have an equal share in the market for the item. We can rewrite the formula for *HHI* index for the *VRI* market to following form

$$HHI = \frac{1}{n} \quad (3.3)$$

Where n is the number of producers of the *VRI*.

In the section on measures of market performance we will verify that the price can indicate the size of market which leads *HHI* to change depends on whether price is increasing or decreasing.

3.3 Cost structure

The producer in WoW is mostly confronted with some type of costs. Most items need specific commodities as inputs for their production. Some of these commodities can be gathered directly by the player but for others, this is often not possible (e.g. for reasons of location, the player's profession etc.). Such items are therefore often acquired through the *auction house*. It is quite obvious that players aiming to maximize their wealth will not produce an item if the costs of its production input are lower than its market value. Of course, transaction costs such as time, also play a role here - certain items might still be profitable but the amount of time necessary to acquire the necessary input discourages the player from producing them. To a great extent, these transaction costs can be minimized by using the *auction house* (which, as mentioned previously, acts as an intermediary in the vast majority of the trades) since we know that in compared to *VRI* market, commodity markets is strongly competitive thus price are close to the marginal cost of production [26]. And one can therefore, without significant loss of accuracy⁶, express the costs of producing a particular *VRI* purely as the sum of the costs of the required commodity inputs:

$$C_{ri} = P(S_1) + P(S_2) + \dots + P(S_n) \quad (3.4)$$

Where C_{Ri} is the production cost of the *VRI*, $P(S_i), i = 1, 2, \dots, n; n \in N$ is the price of the i -th commodity required for producing the item.

In the section 4 we will verify that the costs are a key factor for determining the price of a given *VRI*

Using the costs, we can also easily calculate the producer's margin expressed by the formula:

$$Mar_{ri} = P_{ri} - C_{ri} \quad (3.5)$$

Where Mar_{ri} is the margin from selling *VRI*, P_{ri} is the price of *VRI*, C_{ri} is the cost of the *VRI*

⁶Author takes into account that for player the production itself doesn't cost any time, money and even much physical effort.

3.4 Barriers to entry

It is usually not overly complicated for a player to enter a specific market in the WoW world. To produce⁷ a specific standard item, one must normally reach a certain experience level or it is possible to acquire the recipe from NPC traders for a relative low price. However, in the market for VRIs, the barriers for entry are relatively high (as discussed earlier). As will be demonstrated later, these high entry barriers mean that only relatively few producers manage to entry into this market and the profits for those producers who were first-to-market are significantly higher .

⁷Production is meant to include the gathering of specific herbs or killing monsters with the purpose of acquiring required products.

Chapter 4

Effect of market concentration - empirical study

4.1 Oligopoly markets in World of Warcraft

This section is focused on the analysis of panel data in the *World of Warcraft*. The aim of this analysis is to determine how price and margin of *VRI* influence the market in the WoW virtual economy. The *VRI* market was chosen mainly due to its unique properties:

1. High barriers for entry in the form of difficulties of acquiring the *recipe* for production. (this barrier, however, is not insurmountable)
2. Small number of producers in the period following the introduction of a particular *VRI* (usually 1-2 suppliers per realm in the first month)¹
3. The *VRI market* is a market with a homogeneous product. Thanks to perfect information about each product in the WoW, there is no need to worry about characters selling counterfeit or damaged goods (which would certainly influence the analysis considering that the quantities of the *VRI* available on the market are usually very low)
4. The producer can set the price for which she wants to sell the *VRI* (he is clearly the price maker). The buyers are price takers and can only decide whether or not to purchase the particular item.

¹Based on data from Jiri Skuhrovec [26]

5. In case of a number of producers higher than 1, there is a high degree of codependence in the decision-making process. The price set by a producer of a *VRI* is influenced by the prices set by other producers of the item.

All 5 of these properties are valid during the first month after the *VRI* is introduced on the market. A careful reader will surely notice that these properties characterize an *oligopoly* [27] as well as a *monopoly* (in cases when there is only one producer active in the market). In the following section, we will examine this market more closely paying special attention to how this market changes over time and in response to changes in the number of producers (which implies the degree of market concentration.)

4.2 Panel data - a short overview

Analysis of *panel data* can be defined as the study of individual subjects (*VRIs*, firms, states, *realms*) and their mutual relationships which involves a periodic investigation of characteristic properties and their deeper investigation. *Panel data* can be described using the following definition: *panel data*, sometimes also called longitudinal data are data whose characteristics are examined over two or more time periods. Compared to simple cross-sectional data (i.e. data acquired only at one given point of time or one particular time interval) or time-series data, panel data offer a number of clear advantages. First of all, panel data allow us to use large numbers of observations which are normally not available in conventional time-series. Unlike typical time-series data, panel data are usually not overly aggregated and therefore allow for the testing of more complex hypotheses regarding the dynamics of the relationships between the variables examined. This is a feature that is normally not available from simple cross-sectional examinations performed at a single point of time [4]. Through *panel data*, we understand a set of units that are very similar or related through a specific characteristic (persons, *VRI*, firms, *realms* etc.) which are repeatedly measured over time. Such a set can consist of the entire population as well as a randomly generated representative sample. A necessary condition for defining a panel and subsequently analysing *panel data* is that the dataset does not change over time (i.e. units that “fell out” over time are not replaced with new ones).

Investigation of panel data uses solution models which contain elements of time-series analysis as well as regression analysis. In a way, panel data

therefore represents a further degree of modelling that enhances the value of often painstakingly gathered information.

4.2.1 Data

This thesis uses a huge amount of data from a software application that uses a unique method for gathering data about every item that appears in an auction in a given time.² For the purpose of our analysis, I have filtered out several *VRI* products which were released in December 2011 (*VRI* 2011). Also, I have filtered-out several *VRIs* released prior to December 2011. With respect to these products, however, I have often encountered the problem of missing observations which would make the *panel unbalanced* and significantly complicate the analysis.³ In comparison, the dataset of *VRI2011* products has satisfied all the necessary requirements for a *balanced panel*.

I have chosen a specific *VRI* - *Leggings of Nature's Champion*⁴ as a representative item for the analysis of the market. This *VRI* was chosen because its dataset was the most robust of the chosen *VRI* 2011 products and I have therefore assumed this would be the best dataset for testing. Furthermore, this item exhibits all 5 characteristics from the section 4.1. The auctioneer software has been collecting data from the Auction house on a weekly basis. In our case, we care about the Leggings of Nature's Champion product and the data made available by the software application are the following:

Table 4.1: Available data for this thesis

Id	scan Time	realmId
faction	Duplicates	fileId
itemId	seller Name	sellerId
stack Size	realm Country	realm Name
buyout Price	items Quality	min Bid
curBid	gears core	item Name
time Left	item Class	

For our analysis, we need to know which *realm* the product is sold in (realm Name), the *buyout price* for the product (buyout price) at the time of data collection (scan time) from the *Auction house* as well as the name of the seller

²Auctioneer software adapted by Jiri Skuhrovec [26] for data collection

³if there are missing values in data set, the data set is referred to as an unbalanced panel.

⁴All information about product items can be found at <http://www.wowhead.com/item=71986>

(seller name). The seller name variable deserves particular attention since one must realize that the seller is most likely to be the person able to manufacture the item.⁵

4.2.2 Panel data application

After filtering-out all irrelevant variables from the software, I obtained the data necessary for this analysis which are in this shape:

Table 4.2: Applied panel data by Tran Quang Tuan

t	Realm	BoP	P_K	P_M	HHI	cost	mar
Dec-11	1	BoP_{11}	$P_{K_{11}}$	$P_{M_{11}}$	HHI_{11}	$cost_{11}$	mar_{11}
Jan-12	1	BoP_{12}	$P_{K_{12}}$	$P_{M_{12}}$	HHI_{12}	$cost_{12}$	mar_{12}
Feb-12	1	BoP_{13}	$P_{K_{13}}$	$P_{M_{13}}$	HHI_{13}	$cost_{13}$	mar_{13}
Mar-12	1	BoP_{14}	$P_{K_{14}}$	$P_{M_{14}}$	HHI_{14}	$cost_{14}$	mar_{14}
Apr-12	1	BoP_{15}	$P_{K_{15}}$	$P_{M_{15}}$	HHI_{15}	$cost_{15}$	mar_{15}
May-12	1	BoP_{16}	$P_{K_{16}}$	$P_{M_{16}}$	HHI_{16}	$cost_{16}$	mar_{16}
Jun-12	1	BoP_{17}	$P_{K_{17}}$	$P_{M_{17}}$	HHI_{17}	$cost_{17}$	mar_{17}
Jul-12	1	BoP_{18}	$P_{K_{18}}$	$P_{M_{18}}$	HHI_{18}	$cost_{18}$	mar_{18}
Dec-11	2	BoP_{21}	$P_{K_{21}}$	$P_{M_{21}}$	HHI_{21}	$cost_{21}$	mar_{21}
Jan-12	2	BoP_{22}	$P_{K_{22}}$	$P_{M_{22}}$	HHI_{22}	$cost_{22}$	mar_{22}
Feb-12	2	BoP_{23}	$P_{K_{23}}$	$P_{M_{23}}$	HHI_{23}	$cost_{23}$	mar_{23}
Mar-12	2	BoP_{24}	$P_{K_{24}}$	$P_{M_{24}}$	HHI_{24}	$cost_{24}$	mar_{24}
Apr-12	2	BoP_{25}	$P_{K_{25}}$	$P_{M_{25}}$	HHI_{25}	$cost_{25}$	mar_{25}
May-12	2	BoP_{26}	$P_{K_{26}}$	$P_{M_{26}}$	HHI_{26}	$cost_{26}$	mar_{26}
Jun-12	2	BoP_{27}	$P_{K_{27}}$	$P_{M_{27}}$	HHI_{27}	$cost_{27}$	mar_{27}
Jul-12	2	BoP_{28}	$P_{K_{28}}$	$P_{M_{28}}$	HHI_{28}	$cost_{28}$	mar_{28}
. .							
Jun-12	21	BoP_{217}	$P_{K_{217}}$	$P_{M_{217}}$	HHI_{217}	$cost_{217}$	mar_{217}
Jul-12	21	BoP_{218}	$P_{K_{218}}$	$P_{M_{218}}$	HHI_{218}	$cost_{218}$	mar_{218}

This table shows a 2 – dimensional panel structure. The individual characteristics (BoP , P_K , P_M , HHI , $cost$, mar) are collected for the different *realms* in different time periods.

⁵there exists so-called brokers, who are buying products on the market at a lower price and then sell for a higher price. For this thesis we include these brokers in data. However thanks to a short lifespan of one supply it just help real producers to create the price that is formed from basic fundamentals - cost and margin.

BoP BoP or Buyout is the price for which the product (*Leggings of Nature's Champion*) can be bought in the *Auction house* immediately. When buy out price was not be realized it's important to note that any characters cannot see for how much item was sold. Therefore the buy out price is one of a key determinant of price. The buyout price is set by the producer directly after entering the product in the *Auction house*⁶. Initially, however, the dataset analysed contained a major problem in that the buyout price can be set by the seller arbitrarily and was, in fact, often set at levels several times higher than the market price (the sellers thought they were the only players in the market or they were just trying their luck). Using such data could significantly distort the results from the econometric model. To bypass this problem, I chose to define the buyout price as the lowest buyout price that has occurred in the given realm during the given time period- assuming that the lowest buyout price would approach the market price. This bypass is all right since we are in a Market with homogenous product and perfect information.

P_M P_M stands for the number of producers actively selling the product in the Auction house in the given month⁷. In case that no producer actively sells the product in the given month, P_M may therefore be equal to zero. Compared to P_K , P_M does not necessarily need to be a non-decreasing function over time. Furthermore, compared to P_K , P_M also captures the moment when the producer decides to stop the production of the item.

P_K P_K characterizes the cumulative number of producers on the market. Here, it is important to note who is the actual producer. For a character to produce the Leggings of Nature's Champion, she has to fulfil several criteria. The character needs to have achieved the maximum possible level in the Leather-working profession and to have achieved the maximum overall experience level of 85. Most importantly she must acquire the recipe for the production of the Leggings. It is important that once the player learns to produce the item, she cannot lose this ability and must therefore be considered a producer in all subsequent time periods. P_K must therefore be a non-decreasing function of time.

⁶Producers can set any price her wants

⁷The fact that the producer is actively involved in the market captures that her name will be captured in a given month as a salesman Leggings of Nature's champion.

HHI HHI stands for the Herfindahl-Hirschman index for the market in Leggings of Nature's Champion. In our data, it is calculated by the following formula.:

$$HHI_{it} = [(V_1)^2]_{it} + [(V_2)^2]_{it} + \dots + [(V_n)^2]_{it} \quad (4.1)$$

Where HHI_{it} is the HHI index for the i – th realm at time t , n is the number of producers who are capable to produce leggings (HHI is a function of P_K) in the i – th realm at time t and $(V_j)^2_{it}$ is the share of the j – th producer in the market of the i – th realm at time t , $t = 1, 2, 3, \dots, n; j = 1, 2, \dots, k$.

We assume here that each producer of the item has the same market share. We consider that each producer has the same market opportunities and that perfect information about the product is available.

Cost Cost represents the costs of producing a single piece of *Leggings of Nature's Champion*. The production of a single piece of the leggings requires the following commodity inputs: 8x Pristine Hide (PH), 40x Volatile life (VL), 4x Chaos Orbu(CO), 8x Essence of destruction(ED). These commodities can be purchased through the auction house and their price was determined from the buyout prices in a similar fashion as *BoP* that is defining the buyout price as the lowest buyout price that has occurred in the given realm during the given time period. We define the cost as following formula:

$$Cost_{it} = 8PH_{it} + 40VL_{it} + 4CO_{it} + 8ED_{it} \quad (4.2)$$

Where $Cost_{it}$ is the cost of producing the single piece of Leggings of Nature's Champion in the i – th realm at time t , PH_{it} is the price of the Pristine Hide in the i – th realm in at time t , VL_{it} is the price of the Volatile Life commodity in the i – th realm at time t , CO_{it} is the price of the Chaos Orb commodity in the i – th realm at time t , ED_{it} is the price of the Essence of Destruction in the i – th realm at time t .

Mar Mar represents the margin from the sale of one piece of the Leggings. This margin is defined through the sales price and cost of the product as

$$Mar_{it} = BoP_{it} - Cost_{it} \quad (4.3)$$

Where Mar_{it} is the margin from one piece of the Leggings sold in the i -th realm at time t , BoP_{it} is the buy out price for one piece of the Leggings in the i -th realm at time t , $Cost_{it}$ is the cost of producing a piece of the Leggings in the i -th realm at time t .

t Represents time

Realm Realm stands for the economically not interconnected worlds observed over time. As seen in the table below, a total of 21 *realms* is examined.

4.2.3 Method of Fixed effects

One of the problems in regression analysis is the occurrence of unobserved factors which influence the variable under consideration. Let us consider a simple regression equation with one independent variable and include these factors into its expression:

$$y_{it} = \beta_i x_{it} + a_i + u_{it} \quad (4.4)$$

Where the lower index i represents the realm observed and the lower index t the given month. In equation 4.4 the unobserved factors are separated into two types of errors. The expression u_{it} represents the idiosyncratic error which embodies the factors that influence y_{it} and which differ over time. The expression a_i encompasses omitted factors that are constant over time (this is why the t -index is missing) and is called the fixed effect. As a result of these errors, the estimates of the β -coefficients in panel data are biased and inconsistent. “The method of fixed effects therefore aims to eliminate the a_i expression from the regression equation”⁸

⁸GREENE, William H. *Econometric Analysis*. 5th ed. New Jersey : Pearson Education, 2003. 802 s. ISBN 0-13-066189-9.

If we average equation 4.4) over time into the form

$$\bar{y}_{it} = \beta_i \bar{x}_{it} + a_i + \bar{u}_{it} \quad (4.5)$$

And subsequently subtract the two equations, we get the following expression for each time period

$$\dot{y}_{it} = \beta_i \dot{x}_{it} + a_i + \dot{u}_{it}, t = 1, 2, \dots T \quad (4.6)$$

The highlighted expressions are adjusted for heterogeneity in because the above adjustment has subtracted the average of each cross-sectional unit over time from each observation of the cross-sectional unit. This way, a_i is eliminated from the equation and a regression analysis can be undertaken. After executing the regression analysis, one must make sure that our fixed effects model meets all prerequisites necessary for its application [4]. These prerequisites are listed in the *Appendix*.

4.3 Price and Size of market

Now let us more closely examine the behaviour of the *VRI market*. We are interested in how the price will develop in relation to market concentration. Because the *VRI market* has an *oligopolistic* nature at the time when the given *VRI* is released, we assume that the price of the *VRI* would be significantly higher than in a perfectly competitive market.

Let us recall some differences between a *monopoly* and *perfect competition*. The *monopoly* is the antithesis of *perfect competition*. The supply of a whole industry in which the *monopoly* exists is generated by a single company (pure *monopoly*). There is no competition and because the average costs of the *monopolist* are minimized at an output level higher than that which is demanded by the market and the price is higher than average cost, enabling the company to turn a profit. In contrast, producers operating in *perfect competition* achieve zero profit in the optimum and the optimum price under *perfect competition* is lower than in a *monopolistic* environment [27]. Compared to firms operating in a perfectly competitive environment, *monopolies* tend to constrain production while achieving higher prices and profits.

In practice, these two extreme states occur only very rarely and the most common market structure is somewhere between the two abovementioned extremes. In these cases, *oligopoly* (a few firms on the market) and *monopolistic competition* (for markets with more firms present) are more relevant.

Our hypothesis (H1) is that as more producers enter the market, the price of the good will decline. I assume that once a producer of a given *VRI* comes to the market, she will be able to realize *monopolistic* profits for some time because no other player was yet able to start production (see 4.6). These profits are, however, the reason why it is highly lucrative for other players to follow. As competition arrives at the market, monopoly profits disappear until the market settles in the “equilibrium state” of *perfect competition*. (In this thesis we will focus mainly on those states when the market is still *oligopolistic*)

4.4 Herfindahl index and price

As we already mentioned HHI is an effective tool to measure the size of a firm in relation to the industry and how market is concentrated. We know that as the index approaches zero, the market becomes increasingly competitive while as the index approaches 1 it becomes more and more concentrated. The degree of

Table 4.3: Cumulative producers in each realms at a given time

Realm	P_K in December 2011	P_K in July 2012
Aegwynn(K)	8	65
Aerie Peak(K)	1	16
Agamaggan	3	7
Aggramar	1	31
Alexstrasza	2	30
Alleria	3	32
Alonsus	6	29
Anachronos	4	33
Arathor	4	39
Archimonde	3	26
Argent Dawn	1	30
Baelgun	5	20
Blackhand	1	21
Bloodhoof	2	19
Boulderfist	1	10
Bronzebeard	2	11
Colinas Pardas	3	33
Drak'thul	6	47
Emerald Dream	1	18
Eonar	1	27
Terokkar	1	30

concentration in the *VRI* market is high in the period shortly after a product's release but tends to decline over time as more suppliers enter the market - see the table of the 21 *realms* examined where P_K is the cumulative number of producers in each of the *realms* in December 2011 and July 2012.

Monopolist set higher price to maximize its profit while the firm in *perfect competition* market is just a price taker. Thus in equilibrium *monopolist* has higher price than producer in a *perfect competition* market [27]. In practice, these two extreme states occur only very rarely and the most common market structure is somewhere between the two abovementioned extremes.

We therefore expect that higher prices of a *VRI* in a particular realm indicate that the market exhibits lower degrees of concentration and vice versa. Our hypothesis (H2) is therefore that higher *VRI* prices indicate a lower degree of competition and will therefore positively influence the HHI.(see 4.6)

4.5 Size of market and producer's margin (profit)

"Profit is the ignition system of our economic engine."[23]

Profit is one of the fundamental terms in economics and one of the key variables determining a producer's behaviour on the market. Profits can motivate increases in labour productivity or the entry of firms into new markets and decide about the further existence of a firm. However, profits can also demotivate producers, drive companies out of a market or even end their existence.

In the case of our *VRI market*, we define profits by subtracting the price of the commodities required for production from the selling price of the product. Basic economic models of *monopolies* demonstrate that *monopolies* can command higher profits than companies in a perfectly competitive market[27]. In most cases, however, the actual profit will be somewhere between these 2 extremes. Those we expect that higher numbers of producers will push producer margins downwards due increased competition. I.e our hypothesis (H3) is that margins will decline with increasing numbers of producers (see 4.6).

4.6 Econometric model

Let us consider the model 1:

$$Mar_{it} = \beta_1 HHI_{it} + \beta_2 t_i + a_i + u_{it} \quad (4.7)$$

Where Mar_{it} , HHI_{it} and t_i are data from section 4.2, a_i stands for time-constant omitted factors and u_{it} is the idiosyncratic error.⁹

Initially I tried to apply a model without a time component, but statistical tests of our assumptions have shown that not all of the key assumptions have been met. It has been observed and computed by the Stata correlation test that the explanatory variable $HHI(t)$ is not exogeneous and that u_i correlate with the dependent variable in the fixed-effects model. Moreover, a graphical test for normality of the residual has demonstrated that u_i is not an *i.i.d.* normal random variable and that one can therefore not correctly apply F-statistics and t-statistics for testing the significance of the model's coefficients (see apendix).

⁹The error u_{it} is often called the idiosyncratic error or time-varying error, because it represents unobserved factors that change over time and affect dependent variable.

Why we insert time component is explained mainly by the fact that in the market for *VRIs* a state often occurs where the product stays on the market for a longer time because not everyone can afford it due to its high price and the market is eventually saturated. This saturation may be released only in time till buyers can be found.

We will use fixed effects estimation for panel data which we have described above in section 4.2.3 and get following output:

	parametr β_1	parametr β_2
Coefficients	7.17+e07	-3147268
t	5.86	-2.71
p-value	0.000	0.008
overall	R^2	0,33
number of groups	21	
number of observation	168	

This model satisfies all the necessary pre-requisites e.g. graphical test for normality of residuals show us that u_{it} are independent and identically distributed (see Q-Q plot in appendix) as Normal (σ_u^2). So fixed effects estimator is normally distributed and t and F statistics have exact t and F distributions.

One can notice that the HHI_{it} coefficient is highly significant as well as the time coefficient. Positive coefficients on HHI_{it} indicates that with increasing market concentration in the $i - th$ realm at time t the margin for one piece of leggings sold in the $i - th$ ream at time t is increasing.

Therefore we can say that the *monopoly* margin is higher than *oligopoly* margin. Since we define HHI_{it} as a function of P_K it is important to pay attention to HHI_{it} that approximates to null since P_K increases infinitely. Thus we can interpret a positive coefficient on HHI_{it} as the fact that with increasing number of producers the margin is decreasing and hypothesis H3 is verified.

The reason why we use HHI in the mode instead of P_K is due to fact that P_K is a linear function and applying it to our model could be confusing. A negative coefficients on P_K could mean that with increasing number of P_K the margin is going to minus infinity (which is of course wrong). Due to this fact HHI is better for our model since HHI is a nonlinear function with values from 0 to 1.

Similarly since we define Margin as a function of $cost_{it}$ and BoP_{it} therefore it is obvious to see a linear relationship between margin and BoP. Thus we

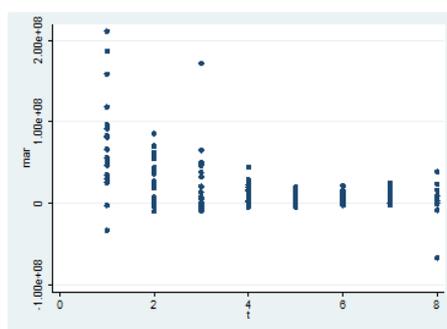
can come up with the conclusion that prices increase with increasing market concentration and hypothesis H2 is verified since this implies that higher prices indicate a lower degree of competition. In other words we can say that as more producers enter the market, the price of the good will decline and hypothesis H1 is verified as well.

To sum up the profit of the *monopoly* producer is higher than *oligopoly* as well as a specific product with a higher price can indicate that the market is a lower concentration.

4.7 Margin advanced

When talking about profits it is necessary to keep in mind that although profits do decline as the number of suppliers increases, they cannot be negative over the longer term. We therefore expect that the margin for the Leggings of nature's champion will decrease with the growing number of suppliers in the market but once it falls into negative values, several suppliers will drop out and, over the longer horizon, the margin will therefore converge to zero. Further examination for this hypothesis goes beyond the scope of this thesis but convergence towards zero can be seen quite clearly when plotting supplier margin (y-axis) against time (x-axis) (1= December 2011,2=January 2012. . . . , 8=July 2012).

Figure 4.1: Market equilibrium



Source: author's computations.

4.8 Margin and non-aligned producers

For another econometric model we consider a contestable market [28]:

A contestable market is an economic concept that refers to a market in which there are only a few producers that, because of the threat of new entrants, behave in a competitive manner. A key factor here is no entry or exit barriers (K1), no sunk costs (K2) and access to the same level of technology (K3)¹⁰.

Potential producers can be expressed as $P_K - P_M$ and these potential producers already have learnt how to produce *VRI* product from the recipe - therefore there is no entry or exit barriers for them.

Thus our hypothesis (H4) is that with increasing numbers of potential producers Margins (and price as well since there is a linear relationship between margin and price) will decrease due to the threat of new entrants.

Let us consider the model 2:

$$Mar_{it} = \beta_1[P_{K_{it}} - P_{M_{it}}] + \beta_2 P_{M_{it}} + a_i + u_{it} \quad (4.8)$$

Where Mar_{it} , $P_{K_{it}}$ and $P_{M_{it}}$ are data from section 4.2, a_i stands for time-constant omitted factors and u_{it} is the idiosyncratic error.

We obtain the following output:

	parametr β_1	parametr β_2
Coefficients	-1496147	-4059748
t	0 -6.52	-4.93
p-value	0.000	0.000
overall	R^2	0,18
number of groups	21	
number of observation	168	

After verifying the assumptions we can observe a highly significant β_1 which means that each non-aligned producer can influence the margin. This means that with an increasing number of non-aligned producers the Margin will decrease and hypothesis H4 is verified.

Thus we can say that a *monopolist* may not prove its market power to control the price and will set a lower price due the threat of entering of the potential producers.

¹⁰K2 and K3 are obvious from analysis above

4.9 Econometrics models - conclusion

There are *monopolistic* and *oligopolistic markets* in the World of Warcraft that behave as microeconomics theory moreover these markets behave even better than many real markets. This can be explained by the fact that virtual economies are much more likely to meet the classical microeconomics assumption. In this thesis we have analyzed 2 models to test *monopoly* and *oligopoly* behaviour on the *VRI market*. Each of them has a different competitive explanation:

1. The model 1 where market saturation of time was included
2. The model 2 where potential producers were included

Since our statistical tests have concluded that key assumptions are satisfied, both models can be considered valid and well explained. But the author is still far from saying which model is better and which is worse as answering this question would require significant further research.

Chapter 5

Conclusion

The goal of this thesis was to study monopolistic and oligopolistic behaviour in the WoW economy and demonstrate, using econometric methods, that investigating an economy of a virtual world may provide economists with new perspectives on economic problems or allow them to verify elements of current economic theory. With millions of participants whose transactions are all recorded real-time, virtual markets can provide a wealth of valuable observations for all types of economic and statistical research. As has been mentioned in the introductory sections, investigating virtual markets provides additional benefits in that it allows for direct observation of certain economic phenomena like homogeneous products and perfect information that are, at best, only approximated in the real world. These features played a significant role in the econometric investigation in section 4 by allowing for more precise measurement and improving the overall data quality - in our case, the panel data collected was found to be perfectly balanced.

The author does not, however, necessarily claim that all the conclusions are correct. The main contribution of the thesis is perceived to be mainly in investigating the hitherto relatively unexplored WoW virtual world which still abounds with opportunities for economic research. The author believes, that the findings from this thesis, even if found to be invalid in the real world, could contribute to improving our understanding of virtual economies. In which case the observed differences between economic behaviour in the real and the virtual world might themselves become a very interesting topic for further research.

The introductory sections of this thesis have tried to acquaint the reader with virtual worlds, virtual economies and basics of the World of Warcraft in order to allow a better understanding of the analyses. However, despite the

efforts to make this text easy to understand, it is understood that some of the arguments might be somewhat difficult to follow. The author therefore hopes that the thesis will allow the reader to better understand the topic and offers his apologies should any part of the thesis appear somewhat confusing.

The results of the econometric investigation demonstrate that the behaviour of oligopolies in the virtual markets of the World of Warcraft matches the prediction of standard economic models. Moreover these markets behave even better than many real markets which is explained by the fact that virtual economies are much more likely to meet the classical microeconomics assumptions. The thesis has verified that monopolies generally command a higher selling price and higher profits than oligopolies. It has also been found that higher product prices are indicative of lower degrees of supplier concentration on the market. Another result of this thesis is the observation that product prices and margins decrease with the entry of new competitors into the market and that. With further increases in the number of suppliers, the product margins were observed to converge to zero. This confirms existing theory regarding the profits of suppliers of homogeneous goods in perfectly competitive markets operating at their optimum. These conclusions might not be a great surprise for most economists but can significantly influence later analysis of virtual economies. In the end, even mathematics can be derived from only 5 axioms.

Bibliography

- [1] Appelbaum, E. (1982), 'The estimation of the degree of oligopoly power', *Journal of Econometrics* 19(2-3), 287-299.
- [2] Armentano, D. (2005), 'A Critique of Neoclassical and Austrian Monopoly Theory', Technical report, Ludwig von Mises Institute.
- [3] Arnade, C.; Pick, D. & Gopinath, M. (1998), 'Testing oligopoly power in domestic and export markets', *Applied Economics* 30(6), 753-760.
- [4] Bainbridge, W. S. (2010), *Warcraft Civilization*, MIT Press.
- [5] Bresnahan, T. F. (1989), Empirical studies of industries with market power, in R. Schmalensee & R. Willig, ed., 'Handbook of Industrial Organization', Elsevier, , pp. 1011-1057.
- [6] Brock, W. A. (1983), 'Contestable Markets and the Theory of Industry Structure: A Review Article', *Journal of Political Economy* 91(6), 1055-1066.
- [7] Burke, T. (2002), 'Rubicite Breastplate Priced to Move, Cheap:How Virtual Economies Become Real Simulations', Technical report, Swarthmore College, available at <http://www.swarthmore.edu/SocSci/tburke1/Rubicite%20Breastplate.pdf>.
- [8] Castronova, E. (2008), *Synthetic Worlds: The Business and Culture of Online Games*, University of Chicago Press.
- [9] Castronova, E. (2006), 'On the Research Value of Large Games: Natural Experiments in Norrath and Camelot'(1621), Technical report, CESifo, Available at SSRN: <http://ssrn.com/abstract=875571>.
- [10] Castronova, E. (2006), 'A Cost-Benefit Analysis of Real-Money Trade in the Products of Synthetic Economies', *Info* 8(6).

-
- [11] Castronova, E. (2004), 'The Price of Bodies: A Hedonic Pricing Model of Avatar Attributes in a Synthetic World.', *Kyklos* 57(2), 173-196.
- [12] Castronova, E. (2002), 'On Virtual Economies', *CESifo Working Paper Series* 752(752), Technical report, CESifo, Available at SSRN: <http://ssrn.com/abstract=338500>.
- [13] Castronova, E. (2001), 'Virtual Worlds: A First-Hand Account of Market and Society on the Cyberian Frontier'(618), Technical report, CESifo, Available at SSRN: <http://ssrn.com/abstract=294828>.
- [14] Cline, M. (), *Virtual Reality: a Catalyst for the Social and Economic Change*.
- [15] Friedman, D. (1998), 'On economic applications of evolutionary game theory', *Journal of Evolutionary Economics* 8(1), 15-43.
- [16] Kirzner, I. M. (1998), *Jak fungují trhy*, Praha : Liberální institut : Centrum liberálních studií.
- [17] Lehdonvirta, V. (2005), 'ECONOMIC INTEGRATION STRATEGIES FOR VIRTUAL WORLD OPERATORS', Master's thesis, University of Helsinki.
- [18] Lehdonvirta, V. (2005), *Virtual economics: Applying economics to the study of gameworlds*.
- [19] Lehtiniemi, T. (2008), 'MACROECONOMIC INDICATORS IN A VIRTUAL ECONOMY', Master's thesis, University of Helsinki.
- [20] Mankiw, G. N. (1999), *Principles of economics*, Grada.
- [21] Meehan, M. (2006), 'Virtual Property: Protecting Bits in Context. Richmond Journal of Law and Technology', Available at SSRN: <http://ssrn.com/abstract=908924>.
- [22] Nash, J. & Schneyer, E. (), 'Virtual economics: An in-depth look at the virtual world of Final Fantasy XI', Available at <http://lgst.wharton.upenn.edu/hunterd/VirtualEconomies.pdf>.
- [23] Niels, Gunnar; Jenkins, H. K. J. (2011), *Economics for Competition Lawyers*, OXFORD HIGHER EDUCATION.

-
- [24] Oxenstierna, G. C. (1998), 'An asymmetric Oligopoly Model and a Method for Its Empirical Application', *Journal of Economics* 67(1), 39-61.
- [25] Simpson, Z. B. (2000), 'The In-game Economics of Ultima Online' Computer Game Developer's Conference'.
- [26] Skuhrovec, J. (2009), 'Inflation of Virtual Currencies', Master's thesis, Institute of Economic Studies, Faculty of Social Sciences, Charles University.
- [27] Varian, H. R. (1992), *Microeconomics Analysis*, W. W. Norton & Company.
- [28] Wooldridge, J. (2002), *Introductory Econometrics: A Modern Approach*, South-Western College Pub.
- [29] worldofwarcraft.com <http://www.worldofwarcraft.com/>
- [30] mmogchart.com <http://www.mmogchart.com/charts/>
- [31] <http://www.worldofwarcraft.com/info/basics/antigold.html>
- [32] Patches <http://www.wowwiki.com/Patches>

Appendix A

Appendix

Data collection methods

Data for this thesis were collected and modified by unique way. With using auctioneer (This program can be freely downloaded from web and help players with trading in AH) the data for all 21 realms were collected every week for 8 month. After this Jiri SKuhrovec [26] programmed a parser that could transform data stored in the Auctioneer and then implement it directly into MySQL database. The parser is intentionally written in PHP so that it could provide it as a service for other players in form of online scripts available at www.mmometrics.org/aucdb2/

Assumptions for fixed effects

In this appendix, we provide statements of the assumptions for fixed effects estimation [28]

Assumptions FE1

For each i , the model is

$$y_{it} = \beta_1 x_{it1} + \beta_2 x_{it2} + a_i + u_{it}, t = 1, \dots, T, \quad (\text{A.1})$$

where the β_j are the parameters to estimate.

Assumptions FE2

We have a random sample in the cross-sectional dimension.

Assumptions FE3

For each t , the expected value of the idiosyncratic error given the explanatory variables in all time periods and the unobserved effect is zero:

$$E(u_{it}|\mathbf{X}_i, a_i) = 0 \quad (\text{A.2})$$

Assumptions FE4

Each explanatory variable changes over time (for at least some i), and there are no perfect linear relationships among the explanatory variables.

Under FE1-FE4, FE estimation is unbiased, the key assumption is strict exogeneity FE3

Under FE1-FE4, FE estimation is consistent

Assumptions FE5

$$\text{Var}(u_{it}|\mathbf{X}_i, a_i) = \text{Var}(u_{it}) = \delta_u^2, \text{ for all } t = 1, \dots, T. \quad (\text{A.3})$$

Assumptions FE6

For all $t \neq s$, the idiosyncratic errors are uncorrelated: $\text{Cov}(u_{it}, u_{is}|\mathbf{X}_i, a_i) = 0$

Under FE1-FE6, the fixed effects estimator is BLUE

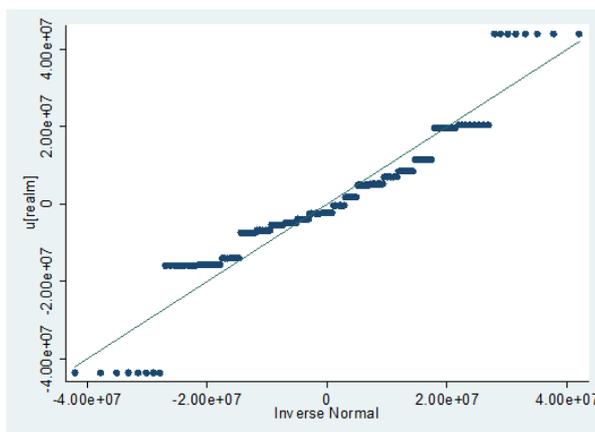
Assumptions FE7

Conditional on X_i and a_i , the u_{it} are independent and identically distributed as $Normal(0, \delta_u^2)$

Last assumptions assure us that the FE estimator is normally distributed, its t and F statistics have exact t and F distributions. Without FE7 we rely on asymptotic approximations (but it requires large N and small T)

Q-Q plot

Figure A.1: Q-Q plot for model 1



Source: author's computations.