EFFECT OF MARKET CONCENTRATION

IN VIRTUAL ECONOMIES

by

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Abstract

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Virtual worlds are attracting lots of academic interest nowadays both because of the detailed data they offer for analysis and because they present a controlled environment and thus are better suited to test theoretical hypotheses. This thesis looks at the virtual economy of Guild Wars 2 and attempts to check whether the widely studied relationship between the degree of market concentration and producers' profits can be observed in a virtual economy. Previous research has studied either markets for highly concentrated goods or competitive markets. By making use of a novel high-detail dataset, we can study markets with different degrees of competitiveness. I find that there is at least 16% difference in profits between firms in weakly concentrated and strongly concentrated marketplaces making the behavior of a virtual economy is very much in line with its real counterpart.

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ACKNOWLEDGMENTS

First, I would like to express my gratitude to Ruben de Vries aka 'Drakie' for making gw2spidy and his gracious provision of data. Without him, this research would not be possible.

I thank creators of strategy war games and hope that one-day playing those will be the only way to experience violence.

My greatest thanks go to my advisor, prof. Tom Coupé, who guided and advised me throughout all the stages of thesis writing from the very beginning until the very end.

Finally, I thank my friends-gamers: Alisa, Andrew and Dania, who supported me and provided valuable ideas for this research.

GLOSSARY

HHI. Herfindahl-Hirschman index

DoJ. United States Department of Justice

MMO. Massively multiplayer online game

VRI. Very Rare Item

C h a p t e r 1

INTRODUCTION

Unlike the real, physical world upon which things like the LME metal price index are based, "EVE" is an imaginary place set 20,000 years into the future in a galaxy known as New Eden. There, imaginary citizens of five different imaginary empires fight imaginary wars in a bid for imaginary domination over each other. And yet it is a world controlled and influenced by the interactions of real people: the 350,000 real world subscribers to EVE Online — its "capsuleers," as the spaceship-piloting gamers are known in their virtual existence.

Michael J. Casey
Wall Street Journal

Synthetic (or more commonly called virtual) economies are growing more and more important nowadays. Most of the online-games currently played by over 19 million[1] people worldwide (and this number only accounts for active subscribers[2] of pay-to-play games and does not account for games free for everyone) have some kind of economic system built into them by the game designer, and these systems in many aspects resemble real world economic systems. Activities within many of these massively multiplayer online (MMO) games at the very least include production, consumption and trade.

Such virtual systems are very appealing to economic researchers because they can conduct experiments, which are impossible to make on real

[1] http://mmodata.blogspot.com/
[2] Subscriber is a person who pays a monthly fee to take part in the virtual world.

countries, Castronova, (2008) is a particular evidence to this approach. Also the amount and details of data available are very high. Virtual economies allow phenomena such as homogeneous product, perfectly closed economy, perfect information to be clearly observed and not assumed, as it is frequently done in mainstream economics. In addition, the behavior of agents can be observed in real time. Altogether, this allows to test microeconomic and macroeconomic models and concepts without the influence of disturbances and shocks that are present in the real world. Concepts cannot be studied nearly as accurate in the 'classroom laboratory experiment' as they can be studied on virtual 'soil' – games are much less abstract in a virtual economy and there is much more at stake than in a typical classroom experiment.

Consequently, observations from studying virtual worlds (which, in fact, are populated by real people) can be used to produce insights into key concepts of the core economic theory.

Another interesting issue is the connection between real and virtual worlds, which manifests through real money trade of virtual items and currency for real world money. Thus, companies operating virtual worlds took the matter of managing their economies quite serious and started hiring professional economists to manage their virtual economies. This tendency began with Eyjolfur Gudmundsson, who joined CCP[3] in 2006.

The study of virtual economies is young with the first works published at the beginning of the third millennium. EverQuest, a game by Sony Online Entertainment, which is the first multiplayer online game to ever have over 100,000 concurrent users and the first game to have in-game items sold for real money was released just in 1999. Its virtual economy was thus the first to draw substantial academic interest that resulted in the foundational work by Castronova (2001).

[3] An Iceland based video game studio, developer and publisher of EVE Online – a MMO game set in a science fiction setting.

Since 2001, scholars have studied virtual worlds and economies within them from perspectives of social science, currency & relationships between real and virtual worlds, ways of monetization, macroeconomics and microeconomic science, studying the world economies as they are and running experiments to make inferences about agents' behavior.

Noteworthy, there was a single study on oligopoly markets in virtual economies (Tuan, 2012), which is of a particular interest. In this study market behavior for a single representative "very rare item" (VRI) from the virtual world is discussed and compared on several realms[4], which can be treated as closed economies. Tuan finds that in the highly concentrated market for this VRI producers profit is significantly sensitive to the degree of market concentration and exhibited oligopolistic behavior.

In this thesis the author extends this particular field of research by studying market concentration in a different virtual world, Guild Wars 2[5], which is of interest because there's a single marketplace over realms, so it can be compared to the open economy from real world. In Guild Wars 2 there's some difference between realms in terms of the number of people participating as well as production opportunities, but the marketplace is common. We will be able to see whether the market concentration effect is persistent over different goods, and the results found previously were not spurious. In addition, this thesis makes use of more detailed data. Due to specifics of trade mechanics, in Tuan's study the exact sell price of items was not retrievable, and the market shares of producers had to be assumed equal. As a market with two suppliers (huge decision power of individual supplier), placing a dozen of items on the market would have been misleadingly interpreted as a market with a dozen suppliers (with substantially smaller decision power of each individual supplier). Thus, these factors decreased the quality of the data used by Tuan and thus made his

[4] Identical copies (in terms of mechanics) of a virtual world that only differ by players participating in them.
[5] MMO game developed and operated by ArenaNet, released in 2012.

results unreliable. In this thesis, both of abovementioned issues are addressed.

The data used in this study consists of a panel of prices on sell offers of all items that can be created by players and traded from the Trading Post (in-game platform to mediate trade between players, which is very much alike a real world exchange), prices for those items' constituents (raw materials) along with transaction costs. Data on prices are provided by gw2spidy, a fan-made Guild Wars 2 site, covering January 15, 2014 and April 9, 2014. The information about transaction costs is available on the Trading Post itself.

The empirical test regarding the hypotheses about the effect of market concentration is made by using regression analysis with merchant's margin (derived from sale price, cost of constituents less transaction fees) as a dependent variable whereas Herfindahl-Hirschman index (HHI) of market concentration, measured for each particular good, is used as a key determinant.

The profit-concentration relationship has been researched by 'real-world' economists for a long time. General findings are well known: market concentration and firms' margins are usually positively correlated, though the strength of the relationship (correlation) is low. Recent research is dedicated towards studying more in-depth relationships, but on a narrow data: a single good or aggregated industry. Commonly results in manufacturing show substantial effect for industrialized activities whereas services spheres like banking, finance or audit have insignificant relationship. Though this line of research is subject to data and methodology drawbacks which I attempt to address by studying the relationship on a virtual 'soil'.

Researching hypotheses regarding market concentration is much more reliable on the virtual world data. Firstly, it better fits hypotheses'

assumptions. It is frequently assumed in theory that products are homogeneous, whereas in fact even those that are very alike still have some specifics. In case of the virtual world, we have the case of perfectly-identical goods. Also it is important that all participants would have the same information when making their decisions and that is very rarely the case in reality. On virtual soil, all players have the same means of accessing information about markets and they have an access to exactly identical portions of this information. Secondly, the data quality is superb. In real world studies, researchers are usually limited to studying only final products' prices, because they do not usually have an access to prices of constituents used by producers – only the final price can be observed. In our case every manufacturer uses the same identical components, with a known price, thus we can look at profits, not just final prices. Moreover, while most studies deal with a limited number of goods within a single industry or category, due to scarce data, we are able to look into the economy and all the goods produced within it. Finally, for real life studies it is impossible to produce an extremely precise measure of market concentration degree, as the information is limited: even e-commerce aggregating sites do not have any information on the quantity of items available for sale in each individual store.

I find significant positive effect of increased market concentration on the producers' profit margins. In addition, I conclude that the production with higher barriers to entry correspond to higher profits. Production opportunities that require special unlocks yield almost double profits compared to those that don't; profits are sensitive to finals product scarcity and are four times higher, on average, for the most unique items compared to the most common as well as technology complexity. Results are robust to the choice of concentration measure.

This thesis has the following structure. The second chapter gives the literature review, regarding the young field of virtual economies in general,

also some particular macroeconomic and microeconomic issues of their behavior is discussed. The third chapter is dedicated to the description of the virtual world of Guild Wars 2 and production & economic systems within it. In the fourth chapter, the data used in this work are described. The fifth chapter is devoted to the discussion of methodology used for the purposes of this study. In the sixth chapter, empirical results are discussed. Lastly, the seventh chapter contains the conclusion for this thesis.

C h a p t e r 2

LITERATURE REVIEW

The young field of virtual economies (with early works dated 2001) in general is definitely appealing and tempting for economists and social scientists. Previously mentioned Eyjolfur Gudmundsson works for CCP as a lead economist, managing a team of analysts doing in-depth study of interesting events in the game economy and supplying players with economy indicators. Yanis Varoufakis works for Valve Corporation[6], where he researches digital economies that spontaneously take shape within the borderless communities of video game players and possible introduction of a shared currency (which is very much comparable to his work on the difficulties that Germany and Greece faced after adopting Euro[7]). Most recently[8], ArenaNet hired John Smith to work on their new title Guild Wars 2 (released in 2012) as the resident economist.

As for the starting point in formally defining what virtual world is, it is a paper by Bell, (2008), in which the author defines a Virtual World as a *synchronous*, *persistent network of people*, *represented as avatars*, *facilitated by networked computers*. Within the variety of virtual worlds, we should distinguish among them the group of massively multiplayer online games (MMO games). MMO games are of a particular interest, as they are known for emergence of virtual economies.

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[6] An American video game development and digital distribution company known for Half-Life and Portal series, for its social distribution network Steam and the Source engine.
[7] http://yanisvaroufakis.eu/euro-crisis/
[8] https://www.guildwars2.com/en/news/john-smith-on-the-guild-wars-2-virtual-economy/

A virtual economy is an emergent property of interaction between participants in the virtual world. These MMO games involve activities that resemble real world activities including production, trade, consumption & labor. While game designers have a lot of control over the economy by defining mechanics of trade, players' actions define economic conditions within the virtual world. Then the economy arises as a result of choices made by players under the scarcity of resources, both real and virtual like time or currency.

Expectedly, objects in the virtual economy are assigned a value, which is usually linked to the usefulness of these objects and difficulty in obtaining them. The investment of real world resources (time, membership fees, subscription, etc.) in acquisition of wealth in the virtual economy may contribute to the value of virtual items expressed in means of real world. This real-world value clearly exists, as virtual items are traded for real money (for example, 1000 of virtual Guild Wars 2 gold is traded for €91.99[9]) on a variety of online market platforms of general-purpose like eBay or specifically created for sale of virtual items like PvPBank.

Behavioral economics

To be able to consider these virtual worlds as valid means for economic experimentation and research we should start with the first group of papers – those studying virtual worlds from the social viewpoint, to confirm that agents, while being represented as avatars in virtual worlds, still behave like real people.

One of the first scholars, if not the first, to study virtual worlds and economies emerging with them, Edward Castronova produced a number of works on the subject. An early work of his (Castronova, 2001) makes a

[9] As listed on PvPBank, http://www.pvpbank.com/gw2-gold-eu/blacktide.html, retrieved Dec 15th, 2013

firsthand study of the market and society on the virtual frontier – emergence of a virtual world of "Norrath" with GNP comparable to real-world countries. Though his original GNP estimates were criticized later on (for example, Lehdonvirta (2005), in this seminal paper Castronova makes an important observation that people perceive virtual assets as possessing real value. It is also noteworthy that he observed the 'foreign' exchange (market for virtual currency) that allowed him to put a dollar value on virtual assets from that virtual world. In his later paper he discussed the little to absent social tension around the income inequality in virtual worlds (Castronova, 2005a) and provided more evidence that virtual economies acted like real ones with more examples of real money trade in Castronova, (2005b).

Macroeconomics

A lot of papers produce convincing evidence that virtual economies behave like real ones on the core level, though exhibiting some unique features at the same time.

For instance, in the recent paper by Castronova et al., (2009) authors found empirical evidence that aggregate economic behavior in EverQuest 2[10] followed what one would expect to see in the real world, but GNP volatility in that world was disproportionately higher than the one there was in real countries. They suggest that virtual economies should be a more precise analog for not post-industrial, but rather frontier, developing or black market economies. Tuukka Lehtiniemi (Lehtiniemi, 2008) examined macroeconomic indicators of inflation and aggregate production, Gross User Product (named similarly to mainstream economics) in the virtual realm of EVE Online.

[10] MMO role-playing game developed by Sony Online Entertainment, released in 2004.

Currency

Nowadays virtual currencies are actually seen all over the internet, not only in MMO game worlds. The most high-profile of them include Microsoft Points by Microsoft for their Xbox platform and Facebook credits. The basic study of virtual currency from "Norrath" is made in the abovementioned Castronova, (2001).

Hiroshi Yamaguchi made a more thorough analysis of currencies from virtual worlds in Yamaguchi, (2004). Clearly, in the real world money is defined via having three basic properties: medium of exchange, measure of value and a store of value. Yamaguchi found that inside the virtual world, virtual currency possessed all three of those characteristics. He made an analogy with the currency usable inside the issuing country. As virtual currencies were also exchangeable for real-world currency (by means of real money trade mentioned above), it made virtual currencies as 'real' as real ones. Another noteworthy paper on issues of virtual currencies is the work by Jiri Skuhrovec, who studied the inflation phenomenon in World of Warcraft[11] (Skuhrovec, 2009). There he found that its virtual economy was interconnected with a real one through the exchange of in-game currency for real cash and produced some empirical evidence that in-game inflation was caused majorly by EUR/CNY exchange rate, meaning that it behaved like a real world currency leveraged on another country's currency. A discussion of virtual money being equivalent to real world currency is given in Castronova, (2009).

Microeconomics

A noteworthy study of microeconomic experimentation on the basis of virtual worlds (Castronova, 2008) produced an empirical test of basic laws

[11] MMO role-playing game by Blizzard Entertainment, released also in 2004 with over 7.5 million active subscribers as of December 2013.

of demand in a synthesized virtual world. Researchers created two realms of otherwise identical worlds with the only difference in price of one particular item and randomly assigned players to them. They found that lower demand was observed in the realm with higher price, which is in line with the theory.

Eli Kosminsky in his paper (Kosminsky, 2010) studied whether World of Warcraft was a viable instrument for modeling perfectly-competitive behavior and he concluded that the virtual economy of World of Warcraft in most respects behaved like a highly competitive real world market (for select virtual goods) and in fact approached the ideal of perfect competition. Contrary to Kosminsky, who looked into goods that were abundantly supplied to the market, Tran Quang Tuan in his work (Tuan, 2012) studied applicability of oligopoly market models in the virtual economy of World of Warcraft for a different set of goods than Kosminsky – those that were insufficiently provided to the marketplace (which Tuan calls VRIs – Very Rare Items). Tuan concluded after the empirical analysis that there was conformity between oligopoly theory and behavior of virtual markets, which is even clearer than one observed in most of the real markets. However, as already mentioned, the data used by Tuan had some drawbacks. Due to specifics of trade mechanics, the exact sell price of items was not retrievable. Auction house in World of Warcraft is a classical English action, and at the moment of data retrieval only the current bid (or minimum bid set by the seller) was available, thus not only the exact sale price was used, but also was it proxied with a current bid for the item. In the Guild Wars 2 Trading Post is an Open Book with exact listing of bid & sell offers. Secondly, it was impossible to determine the amount of goods sold by a particular producer, because listings were a single item each, so corresponding market shares had to be assumed equal. This assumption would misleadingly treat a market with two producers supplying a dozen units of good to the market (and thus having big individual power over the good's price) as a market with a dozen of suppliers, meaning that each of them would have a much lower influence on the market price and this would put downward-bias onto respective HHI

estimates. These two factors decreased the quality of data used by Tuan and are both addressed in this thesis.

"Real-world" industrial economists have been studying the relationship between profitability and concentration for many years now. The general result is that there is significant correlation between profitability and degree of market concentration, though the correlation is weak. Conyon and Machin, (1991) study profit margins in UK manufacturing on industry-aggregated data and find that 1% increase concentration corresponds to 0.1pp increase in industry players' profit margins. Smirlock, (1985) concludes that correlation between concentration and profits is insignificant for the banking industry in the US. Papers that use highly aggregated data (particularly, Jacquemin et al., (1980) and Clarke, (1984)) tend to conclude that there is no relationship between profits and market concentration, but note that failure to detect the relation is possibly due to over-aggregation.

In addition, papers had common drawbacks and the main issues with the research in the field are outlined in a paper by Clarke et al., (1984). Firstly, it is hard to measure firms' profits per se, as change in margins may come both from change in costs or from change in price, not directly observable, though with data quality in the virtual world, this is not the issue. Secondly, the concentration could be driven by firms having competitive technological advantages above its peers, but luckily, this effect is ruled out since in the virtual world all the firms have identical technology. In addition, there is issue with distinguishing between concentration effect itself and barriers to entry, since concentration variables would absorb effect of entry barriers, though the general interpretation is single.

Overall, there has been very little research in the young field of "virtual economies" since its onset in 2001. Except the basic field overview papers there are empirical studies that can be divided into three groups: 'behavioral economics', where authors study how people attach value to things, which

are in fact not real; 'macroeconomics', in which the evidence of the fact that virtual economies behave like real ones on the core level is provided and 'microeconomics', where researchers test economic basic concepts like law of demand, market structure and pricing issues. This thesis adds to the 'microeconomics' group of virtual economies research by improving upon the previous research of the impact of market concentration on price.

C h a p t e r 3

WORLD OF GUILD WARS 2

"People say the real world in a casual way, where it sounds like something fundamental. But people tend to forget that the world we live in is just a game designed by our governments. Our economic systems are just a game."

Hilmar Petursson
CCP CEO

Every Guild Wars 2 player has a personal account, under which several virtual characters (avatars) are stored. Though at the same time only one character can be present in the world and via that character an human player is represented. Each player account is tied to a 'home world' an instance of the Guild Wars realm, Tyria, in which a particular stratum of players participates. Players usually choose realm by time-zone preference (particularly, eastern and western US time) and by language (for example some realms are dominated by French speaking players, some – by Polish speaking and so on). Players representing these realms compete in an in-game activity called World versus World, dominance in which grants all citizens of the winning realm performance bonuses, like experience boost or high-quality items production rate boost or improved chance of gathering better (rarer) materials.

Characters differ by race, gender, class, physical appearance and crafting profession. Out of these characteristics of importance for this analysis is differentiation by crafting profession, as it's a determinant of player's involvement in the Guild Wars 2 economy. Players gain valuable items in-game by investing their time into slaying monsters (killing Non-Player

Characters) and looting gold and valuables from their corpses; by gathering raw materials in three categories: mining (collecting a variety of ores used in steel-working and jewelry professions), logging (timber for crafting woodworks) and plants gathering (for cooking, creating consumable potions and sewing cloth armor); and lastly – by crafting items in craftsmanships. There are eight total crafting professions in Guild Wars 2 and each character can master two of them. They include three (armorsmithing, leatherworking and tailoring) designed for creating armor and bags, two for creating arms (weaponsmithing and huntsmanship), artificing for creating magical weapons and potions, jeweling and, lastly, cooking.

For producing some of the most valuable (rare class) items, not only gathered materials and experience in a select crating profession are required. A payment in non-tradable 'karma'-currency price has to be paid, which in its turn corresponds to time mandatory invested by the producing player and thus – fixed unobservable costs of production. It is unnecessary to consider several characters 'owned' by a single player as items' producers because the fixed costs associated with an achieving ability to produce a certain kind of item makes it unreasonable to procure such an ability for more than one character for any given item.

When a new item is introduced to the game, the first player to meet the requirements for production (obtaining the recipe and crafting materials) effectively becomes a monopolist in the market for this good. As soon as a new producer comes to this market – the structure changes to oligopoly, and it is characterized by homogeneity of the product (rarely observed in real life, but frequently assumed in theoretical economics). Now market participants need to account for other vendors' likely responses when setting up prices for their items. Later on, when the item becomes widely spread, the market is likely to turn into a competitive one.

When it comes to exchange, players can exchange with each other directly, either by trading items (barter) or through buying (selling) items for gold.

Most exchanges take place in the Trading Post – an in-game instrument for trade that resembles a real-world exchange for commodities. When a player wants to purchase (or sell) an item, she brings up the trading post window, looks up the desired item and can either list a sell(buy) offer with her desired price for the item or, contrary, buy(sell) an item in response to the already listed trade offer. When such a transaction is completed, gold (item) is withdrawn from player's account and the purchased item (sales gold) is delivered to player's inventory. Trading post is your way to go whether you want to trade raw materials, crafting components or final products.

Every character in Guild Wars 2 can have an access to the Trading Post and monitor prices for all the goods offered. Any player could find out how many items of any good are supplied or demanded and at what price.

As characters can only be engaged in two professions, no player can himself produce all items available, so she has to trade with others. Exchange terms are subject to mutual agreement only (mediated via Trading Post), so it can be concluded that prices paid are market prices driven by supply and demand of that particular item. Also formally there is a bottom restriction on the price for most goods, known as 'vendor price' meaning the price you get for selling the item to a NPC vendor, though it is very rarely binding.

Raw empirical data used in this work were gathered from the Trading Post by gw2spidy project by Ruben de Vries.

Chapter 4

DATA DESCRIPTION

The empirical data used in this thesis is a collection of sell offers for monetary exchange on nearly all items traded on the Guild Wars 2 Trading Post listed on the exchange, with prices retrieved twice: January 2014 and March 2014. Software developed and used by gw2spidy[12] accesses the Trading Post at frequent intervals (which varies from hours to days depending on items' relevance) and retrieves price listings for all the items, doing so more frequently for highly-demanded items (with larger market volume), which exhibit higher price volatility. In this work, two snapshots of prices are used. The first one: January 15, 2014 and the second one as of April 9, 2014. Data processing was very intense in terms of computing time. Calculation of prices of constituents for recipes at a given point in time took hours of computing time, and that is the reason why data was restricted to only two periods.

These raw data are then refined. In order to get an item's *HHI index* at time *t*, we aggregate all listings of a particular item retrieved at time *t* and weight them by *count*. The lowest of the listed prices becomes the items market *price*. Given that production recipes are known, we can aggregate production cost of an item, by summing up market prices for corresponding constituents. This way we get the item's *cost*. The difference between *price* and *cost* then defines the *profit*. As some recipes allow the creation of items in bulk, we get profit per unit, *uprofit* by dividing profit by the quantity produced from a single crafting attempt. Further, dummy variables for categorical variables *rarity*, *type* and *discipline_id* are made. Finally, in order to make robustness

[12] http://gw2spidy.com Guild Wars 2 Trading Post Graphs

check three- and four-firm market concentration ratios are calculated to be used as an alternative for HHI, as well as dummies for weakly, moderately and highly concentrated marketplaces, with accordance to DOJ[13] classification. The dataset covering two points in time has 16666 observations. Earlier period has 8282 observations and 8384 correspond to the second one. The difference is due to the introduction of new items later on in the game. The balanced portion of the panel data has 16564 observations (8282 observations each period). Table 1 shows description of the variables and summary statistics are presented in appendix, table 7.

Table 1. Description of variables.

Variable	**Type**	**Description**
item_id		Item identifier
t		Time of retrieval
price		Specified item market price (cheapest sell price)
count		Number of items
rarity	*categorical*	Rarity of the item
discipline_id	*categorical*	Profession (one of eight) that allows to produce the item
type	*categorical*	Item type: weapon, armor, consumable, durable
discipline_rating		Crafting profession level requirement
constitutents	*vector*	List of item id's needed to make the item
karma_cost		Quantity of karma necessary to make the item
requires_unlock	*dummy*	Whether performing a specific in-game activity is necessary to start producing such an item

Now let us discuss some basic summary statistics, restricting the sample to items that have a positive *uprofit*, as clearly no producer will make items if they expect to receive a loss. Such situations of a negative expected profit

[13] United States Department of Justice

can occur if a good has been put up for sale, but afterwards – the price of its constituents increased and new entrants will not have incentive to enter production now, given the current market price of the final good. Or, for some raw material goods, when they are used in basic production players are engaged in only to master a crafting profession (when the good is only valuable while in its raw form, not in refined). First of all, different professions differ in number of unique items produced, varying from only 573 in the 'Cook' profession to as much as 1559 for the 'Weaponsmith' (table 2).

Table 2. Breakdown of recipes by profession.

Profession	*Recipes*
Huntsman	1221
Artificer	871
Weaponsmith	1559
Armorsmith	1136
Leatherworker	1135
Tailor	1290
Jeweler	540
Cook	573

Also, the advancement in a discipline is designed to match the player's progression through the game, allowing players to create items useful for their current level. Creating items useful in later game the content requires more time investment and it thus should be more rewarding. Moreover, as we can see from the graphs below, as the profession skills become harder, producer's profits increase (figure 1).

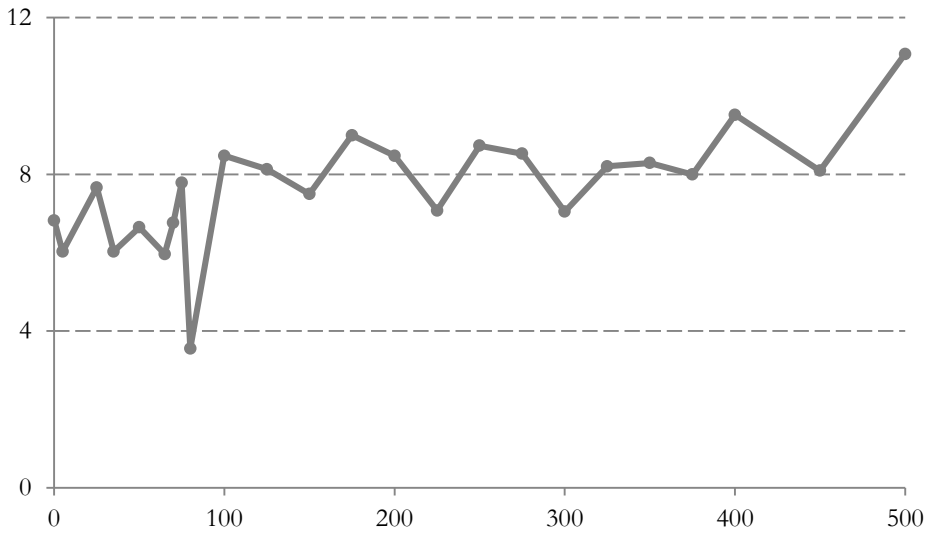

Figure 1. Log of average(uprofit) by profession skill.

The same is true about rarer items: when we consider items from basic to rare, the *log(average(uprofit))* is roughly the same, but markets for items of higher rarity yield substantially higher returns for producers (figure 2).

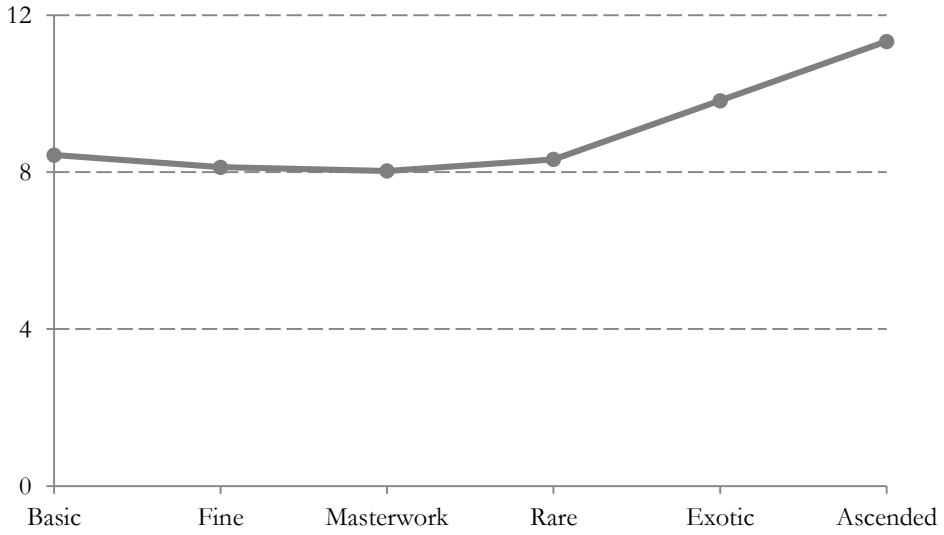

Figure 2. Log of average(uprofit) by item rarity.

We can see that looking at preliminary eyeball tests supports the hypothesis that high rarity and entry barriers, crafting allows producers to receive higher profits. However, these conclusions do not take into account such important factors as market concentration, profession and item types, other factors and interactions between them. These are considered further, in empirical analysis.

Chapter 5

METHODOLOGY

Every Guild Wars 2 character can become a producer of this or that good by taking a crafting profession or simply being engaged in one of the three basic gathering activities, or repeatedly kill monsters with the purpose of selling loots on the Trading Post for gold. In the markets for more rare items the number of suppliers is relatively low and the degree of producer concentration in the market is expected to be somewhere between oligopolistic and monopolistic. The Hirschman-Herfindahl Index (HHI) is an instrument for measuring the market concentration:

$$HHI_t = \sum_{i=1}^{n} s_{i,t}^2 \quad (1)$$

here s_i is a corresponding market share of a firm i (which in our case is represented by quantity of items supplied), and n is the number of firms.

On the cost side of production there are specific commodities needed as inputs for producing this or that item. Some of these can be gathered, while others need to be crafted by artisans of different professions and therefore acquired via the Trading Post. We will thus assume direct cost of this items' production as the sum of costs of its required inputs:

$$C_{i,t} = P_{1,t}^{input_i} + P_{2,t}^{input_i} + .. + P_{n_i}^{input_i} \quad (2)$$

Given the costs formula, we can then calculate the margin as:

$$Mar_i = P_i - C_i \quad (3)$$

where Mar_i is the margin for selling a particular item, P_i is the sell price and C_i is the corresponding cost.

In the oligopolistic and monopolistic markets, producers set prices, which is definitely the case here. In addition, the number of firms is low and each producer's actions affect market conditions. The ability to maintain long-run profits in this market is driven by a small number of firms competing. As more and more firms surmount the entry-barriers, market concentration will fall and each particular firm's ability to affect market will deteriorate. The market will move towards perfect competition and reaching zero profit levels, meaning the decrease of producer's margin with new firms' entry.

To see whether market concentration is related to producer's margin in this particular market, the model will be considered:

$$ln(Mar_{i,t}) = \beta_1 \cdot HHI_{i,t} + \beta_2 \cdot t_i + \alpha_i + u_{i,t} \quad (4)$$

Here i stands for within-group index (item) and t is the time index. β_1 is the coefficient of primary interest, α_i would control for unobserved time-constant factor not included in direct costs, β_2 would control for market saturation with time, as while time passes by the item, which was rare before, becomes more and more accessible. This equation is estimated with fixed effects method.

In addition, to see effect of some observable fixed over time factors, we also estimate a pooled OLS regression of the following specification:

$$ln(Mar_{i,t}) = \beta \cdot HHI_{i,t} + \gamma \cdot karma_i + \delta \cdot other + \alpha + u_{i,t} \quad (5)$$

As there is explicit cost in a non-transferable 'karma' currency for some goods, γ would control for its effect. Other controls would include entry barriers, profession and item type effects. Particularly, we could expect that consumables (even rare ones) will have lower margins, as producing these requires more accessible and cheaper inputs, which is consistent with the

real world situation. Also there's a possibility that different crafting professions could be more or less profitable (in our sense of profitability margin) than others because of implicit costs associated with acquisition of experience in the select crafting profession (analogue of fixed entry costs), as it is higher for some professions and lower for others[14].

[14] For example, as shown on http://gw2crafts.net (retrieved Feb, 28th 2014), complete mastery of Tailoring is 12% more expensive than of Leatherworking.

Chapter 6

EMPIRICAL RESULTS

Our base specification is the pooled regression of producer's margin (expressed in terms of *log(uprofit)*) on our variable of interest – degree of market concentration *hhi* and observable cost characteristics: *karma_cost*, which is the expense of a non-tradable currency and whether it is necessary to perform some particular activity in the game in order to start producing a given item (dummy, whether it *requires_unlock*). These two factors directly affect the cost of production, but they are not included in explicit *cost* of inputs.

Table 3. Base specification regression.

	ln(uprofit)
HHI	2.356***
	(0.112)
Karma cost	0.000044°
	(0.00023)
Requires unlock	0.775***
	(0.075)
constant	6.932***
	(0.031)
N	4807
R^2	0.089

Robust standard errors in parentheses,

° $p < 0.10$, *** $p < 0.001$

We can see a significant positive effect of increased market concentration on the producers' profit margins. Given this specification, the increase in HHI by 0.01 (100 points[15]) corresponds to almost 2.36% increase in profits. In addition, we can also see that the production with higher barriers to entry (expressed in special unlock requirements) correspond to 77% higher profits, ceteris paribus.

Before extending our base model, we must test if pooling data are appropriate (whether the effect of these factors is stable over time). We test this explicitly by interacting covariates with time. Table 4 has the estimation results.

Interaction coefficients are all insignificant and a corresponding F-test for $t \cdot hhi = t \cdot karma\_cost = t \cdot requires\_unlock = 0$ has p-value of 0.42. Thus, it is appropriate to use the pooled estimation.

Now we study several extensions to this base specification, particularly to control for other characteristics (constant over time) of the production process: complexity of production technology, expressed in terms of crafting discipline advancement level (*discipline_rating*), *rarity* of the produced item and the type of craftsman discipline itself. Table 8 in the appendix has the summary of these extended models.

We see that net effect of market concentration decreases while we add new covariates. Particularly because these new factors correlate with market concentration: for example, production components for more rare items are more scarce and thus it is harder to enter the market, so the effect of the final product rarity was absorbed by the effect of market concentration in the underspecified model.

[15] It is common to measure HHI in 'points' from 0 to 10000, or in shares (purely from 0 to 1, as it is in our data). Here and further, we give interpretation in term of points.

Table 4. Pooling test regression.

	ln(uprofit)
HHI	2.382***
	(0.355)
Karma cost	0.00014*
	(0.00007)
Requires unlock	0.595*
	(0.235)
t	-0.141*
	(0.062)
t · HHI	-0.019
	(0.224)
t · (karma cost)	-0.00007
	(0.00005)
t · (requires unlock)	0.122
	(0.150)
constant	7.141***
	(0.100)
N	4807
R^2	0.09

Robust standard errors in parentheses,

° p < 0.10, * p < 0.05, *** p < 0.001

Under our final specification, ceteris paribus, market concentration effect is that move of 100 points in HHI corresponds to 1.86% change in producer's profits; production opportunities that require special unlocks yield almost double profits compared to those that don't; profits are sensitive to finals product scarcity and are four times higher, on average, for the most unique items compared to the most common as well as technology complexity. Thus, our conclusion is in line with real-world findings, though we cannot compare the exact figures, as the dependent variable used is different.

To see whether market concentration effect is different between professions (industries) we also consider interactions (estimates for this regression are

given in the appendix, table 9). We conclude that producers' profits in different craftsmanships are to a different extent sensitive to market concentration. Weapons & armor producing professions, including huntsman, weaponsmith, armorsmith, leatherworking and tailoring have statistically the same effect of concentration (2.39% increase in profits for each 100 points increase in HHI, ceteris paribus), though the other cohort are much more sensitive to HHI. Particularly, artificer profession has 14.5% move in profits per 100 points HHI and cooking has 12.6%: these two mainly produce consumables and are alike. Finally, jewelers have 132% increases in profits with 100 points increase in HHI. Such different sensitiveness to concentration might be caused by different nature of the demand for jeweling products in the game. Overall, these findings are in line with literature results, comparable to different concentration effects in different industries. Particularly – Clarke et al., (1984) also find such heterogeneity of concentration effect between industries.

To conclude our discussion of OLS estimates, we perform the robustness check with respect to specification of market concentration. Alternative measures of the degree of market concentration, which are used in the literature, are k-firm market concentration ratio[16] (where k in 3-5 is the most common). We use 3-firm market concentration ratio (the market share controlled by 3 largest firms), 4-firm market concentration ratio and consider a new categorical variable weakly/moderately/strongly concentrated market as an alternative to Herfindahl-Hirsman index. Extempt of the results are presented in table 5 below (see table 5A in the appendix for entire output).

[16] Market share controlled by k largest firms.

Table 5. Regressions for the robustness check (exempt)

	HHI	3-Firm	4-Firm	Categorical
HHI	1.869***			
3-Firm		2.529***		
4-Firm			2.521***	
Concentration				
[Weak]				(omitted)
Moderate				1.063***
High				1.497***
Karma cost	0.0002***	0.0002***	0.0002***	0.0002***
Requires unlock	0.986***	0.569***	0.547***	0.917***
Discipline rating	0.0028***	0.0024***	0.0024***	0.0027***
N	4632	4632	4632	4632
R^2	0.4873	0.4755	0.4758	0.4902

Legend: *** $p < 0.001$

As can be seen, our results produce substantial and significant relationship between producers' profit and degree of market concentration and they are robust to the choice of the measure of market concentration.

Though we included many factors that could theoretically affect producers' profit, there definitely are unobserved factors left. We use further the fixed effects method to eliminate the effect of unobserved constant over time factors. Since *hhi* and *t* are the only covariates that vary over time in our data sample, we include only these in the fixed effects estimation (table 6).

Table 6. Fixed effects regression.

fixed effects	ln(uprofit)
HHI	1.083***
	(0.259)
t	-0.064*
	(0.028)
constant	7.217***
	(0.047)
N	4800
R^2 overall	0.144

Clustered robust standard errors in parentheses, * $p < 0.05$, *** $p < 0.001$

After controlling for all time-invariant heterogeneity, we see that the change in HHI of 100 points corresponds to about 1.1% change in producer's profit in the corresponding market. Under DoJ classification, this means at least 16.25% difference in profits between weakly concentrated (fairly competitive market) and strongly concentrated (tight oligopoly-monopoly). In addition, we can see a negative effect of passage of time. A possible explanation for this is that with passing of time all consumers finally gain desired goods and thus overall demand decreases, pushing profits down. These results are consistent with those found previously by Tuan and extend to a much wider range of goods.

The results obtained by researching the virtual economy of Guild Wars 2 are consistent with findings in the studies of real markets. Producers' profits are dependent on the degree of market concentration: markets with oligopolistic and monopolistic structure yield significantly higher returns for their participants. Also we find that indirect costs associated in production (that could correspond to real-world analogues of implicit costs & technology costs) are also accounted for when it comes to pricing goods by the market in a virtual economy. We as well find that in terms of goods'

rarity luxurious goods have on average much higher profitability than consumer goods. In addition, different crafting professions in Guild Wars 2 have different sensitivity to the degree of market concentration. This is in line with real-world analogy of different industries and results found by Clarke, (1984). Finally, our results are robust to the choice of measure: HHI index, market concentration index or categorical groups of market concentration all have similar and significant estimates.

Chapter 7

CONCLUSIONS

The main aim of this thesis is to study the presence of market concentration effect in a virtual world of Guild Wars 2 and demonstrate that inspecting an economy of a virtual world may yield new results for real economic issues or allow to test elements of economic theory. With so many players participating in the economy, those players attaching value to possessions gained or lost in a virtual world and the fact that all their activity is being recorded provides a vast amount of observations for economic and statistical research.

Being the first to make use of these data, we produce our empirical results that are consistent with findings in the studies of real markets. Producers' profits are strongly dependent on the degree of market concentration: markets that are more concentrated yield significantly higher returns for their participants. Moreover, producers profit is measured a lot more reliable way, as every market participant knows the production process and the prices of goods' constituents. In real world studies, researchers are usually limited to studying only final products' prices.

In economic research, we test theories, a virtual world economy is much closer to the theoretical model, and this makes virtual soil a more appropriate and reliable platform for testing economic theories. In addition, the quality and detail of the data we have are optimal. Researches almost never work with homogeneous products: the products are very alike, at most, whereas in our case goods *are* indeed homogeneous. Also access to the information is identical. Everyone has the same means of accessing the

market information as well as has access to the same, complete amount of information. Moreover, while most studies deal with a limited number of goods within a single industry or category, due to the scarce data, we have been able to look at all the economy as a whole.

It is a drawback that we do not discuss causality in this thesis. We only conclude that there is a strong relationship between producers' profit margins and degree of market concentration in the corresponding market. Causality study was not the object of the research and was limited given data restriction in terms of time periods. This matter is not yet rigorously researched with real-world data and could be a possible direction for further research.

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APPENDIX

Table 7. Descriptive statistics of the dataset.

Variable	Mean	Std.Dev.	Min	Max
Discipline	4.07	2.08	1	8
Discipline level requirement	258.46	142.25	0	500
Cost, 000	66.14	327.02	0	22021.48
Karma cost	15.41	284.00	0	18900
Profit, 000	-51.46	320.97	-22021.48	338.20
Requires unlock	0.19	0.39	0	1
Item rarity	3.28	1.41	1	7
Item type	8.94	8.07	0	18
HHI[17]	0.0143	0.1032	0.[18]	1
MCR 3-firm	11.28	31.48	0.	100
MCR 4-firm	11.31	31.47	0.	100
Discipline (Categories)	**Mean**			
Huntsman	0.148			
Artificer	0.105			
Weaponsmith	0.188			
Armorsmith	0.137			
Leatherworker	0.136			
Tailor	0.155			
Jeweler	0.065			
Cook	0.067			
Rarity (Categories)	**Mean**			
Basic	0.081			
Fine	0.265			
Masterwork	0.247			
Rare	0.196			
Exotic	0.125			
Ascended	0.083			
Legendary	0.003			
			Observations	**16565**

[17] We code HHI as a share from 0 to 1. Sometimes in the literature, it is also expressed in points, where 10000 points corresponds to share value of 1.

[18] 0. is used to indicate small positive but indistinguishable from zero values.

Table 8. OLS estimates with ln(profit) dependent variable.

	ln(uprofit)		
HHI	2.356***	2.661***	1.869***
Karma cost	0.000044	0.000011	.000183***
Requires unlock	0.775***	.705***	.986***
Discipline rating	-	.0017***	.0028***
Rarity			
[Common]	-		
Fine	-	0.794***	0.942***
Masterwork	-	0.861***	1.042***
Rare	-	2.178***	2.051***
Exotic	-	3.120***	2.894***
Ascended	-	4.544***	4.011***
constant	6.932***	4.913***	4.949***
Discipline dummies	No	No	Yes
N	4807	4807	4807
Adj. R^2	0.089	0.396	0.487

Legend: *** p<0.001

Table 9. Regression with interactions.

ln(uprofit)	Coef.	Robust s.e.
HHI	2.394***	0.790
Karma cost	0.00018***	0.00004
Discipline rating	0.0027***	0.0002
Requires unlock	0.992***	0.066
Rarity dummy		
[Common]		
Fine	0.940***	0.100
Masterwork	1.031***	0.094
Rare	2.042***	0.0888
Exotic	2.842***	0.128
Ascended	3.985***	0.206
Discipline dummy		
[Huntsman]		
Artificer	-0.272**	0.092
Weaponsmith	-0.426***	0.073
Armorsmith	0.283***	0.080
Leatherworker	0.0325	0.079
Tailor	0.022	0.082
Jeweler	-1.139***	0.091
Cook	-1.987***	0.101
(interactions)		
[hhi x huntsman]		
hhi x artificer	12.070***	2.569
hhi x weaponsmith	2.289	1.885
hhi x armorsmith	-0.423	0.812
hhi x leatherworker	-0.540	0.812
hhi x tailor	-0.776	0.810
hhi x jeweler	130.585***	26.141
hhi x cook	10.199**	3.559
constant	4.959***	0.092
N	4807	
R^2	0.482	

Legend: ** $p < 0.01$, *** $p < 0.001$

Table 5A. Regressions for the robustness check (complete).

	HHI	3-Firm	4-Firm	Categorical
HHI	1.869***			
3-Firm		2.529***		
4-Firm			2.521***	
Concentration				
[Weak]				(omitted)
Moderate				1.063***
High				1.497***
Karma cost	0.0002***	0.0002***	0.0002***	0.0002***
Requires unlock	0.986***	0.569***	0.547***	0.917***
Discipline rating	0.0028***	0.0024***	0.0024***	0.0027***
Rarity				
[Common]				
Fine	0.942***	0.727***	0.672***	0.934***
Masterwork	1.04***	0.953***	0.924***	1.054***
Rare	2.051***	1.779***	1.696***	2.044***
Exotic	2.894***	2.570***	2.468***	2.873***
Ascended	4.011***	3.978***	3.868***	4.067***
Discipline				
[Huntsman]				
Artificer	-0.224*	-0.089	-0.059	-0.215*
Weaponsmith	-0.416***	-0.279***	-0.249***	-0.406***
Armorsmith	0.289***	0.288***	0.308***	0.272***
Leatherworker	0.031	0.002	0.022	0.014
Tailor	0.000	0.013	0.032	-0.001
Jeweler	-1.094***	-0.701***	-0.598***	-1.075***
Cook	-1.968***	-1.516***	-1.434***	-1.940***
constant	4.949***	4.881***	4.847***	4.954***
N	4632	4632	4632	4632
R^2	0.4873	0.4755	0.4758	0.4902

Legend: * $p < 0.05$, *** $p < 0.001$