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Rigorózní práce

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RIGORÓZNÍ PRÁCE

Inflation of Virtual Currencies

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Prohlášení

Prohlašuji, že jsem diplomovou práci vypracoval samostatně a použil pouze uvedené prameny a literaturu

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Abstract

This papers examines formation of prices in virtual economy World of Warcraft, and its interconnection with real economy through Real Money Trade - exchange of in-game currency for real cash. Paper finds, that WoW economy is heavily leveraged through this channel, namely that it determines price level within the game. It empirically shows that causes of long-run inflation of currency are EUR/CNY FX rate and patches issued by game operator. Later on author builds general microeconomic model of artificial scarcity, to explain motivation of game operator to inflate own currency. Last chapter is devoted to potential of virtual currencies, argumenting with thoughts of Karl Menger, that these currencies may be able to compete with real ones. Paper heavily relies on unique data, collected using software developed by author.

Abstract

Tato práce studuje mechanismy formování cen uvnitř ekonomiky virtuálního světa World of Warcraft, a jeho propojení s ekonomikou reálnou, skrze obchod herních peněz za skutečné. Hlavním zjištěním je fakt, že ekonomika WoW je významně ovlivňována tímto obchodem, především její cenová hladina. Pomocí empirické studie autor ukazuje že dlouhodobá inflace herní měny je způsobena změnami směnného kurzu EUR/CNY, a aktualizacemi hry ze strany jejích autorů. Následuje mikroekonomický model studující motivaci autorů k znehodnocování vlastní měny. Závěrečná teoretická kapitola, vycházející z odkazu Karla Mengera, studuje konkurenceschopnost virtuálních měn oproti těm reálným. Celá práce významně spočívá na jedinečných datech, získaných pomocí softwaru vytovřeného autorem.

Keywords : Virtual currencies, Quantitative theory of money, Relative utility, World of Warcraft, Artificial scarcity, Karl Menger

JEL Classification : E31,E41,F14,L16,P40

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Disclaimer: This work is in many respects simplifying and inaccurate. The topic which it examines has till now been subject to only few rigorous works, so there are not many shoulders of giants to stand on. Also it is not supposed that reader has any knowledge of Virtual economies. Consequently a broad field of subjects has to be covered in the work, in order to provide understandable picture of core topic. Hence some auxiliary conclusions and thoughts are backed by only modest data or reasoning, in order to keep this work informative and compact.

Credits: Thanks to all, who have up till now (22.5.2009) read this paper.

Contents

The mere fact that the goods and spaces are digital, and are part of something that has been given the label "game," is irrelevant. Willingness to pay, to sacrifice time and effort, is the ultimate arbiter of significance when it comes to assessments of economic value.[3]

1 Introduction

There are two serious reasons, why rigorous science should pay attention to emerging phenomenon of virtual economies (VE). Firstly they may be viewed as most interesting large scale experiments.[4] They are indeed what every experimental economist needs - living systems where millions of real users economically interact with each other, constrained by well-defined yet changeable rules, in an computer-simulated world, where various measurement is possible. Second reason, which is perhaps of much more serious interest, is that VE's have already become a significant part of *real* economy. [1]

Virtual economies are phenomenon so far nearly unnoticed by economic science. Reason for that might be twofold - either the relatively short time for which VE's exist in a large scale (roughly 8 years), or because their label of *game* which makes them somewhat suspicious subject of study. It is in fact underlying aim of this paper, to challenge such scientific prejudice, and show that VE's may be examined in quite rigorous way. The motivation for such trial lies in authors belief, that VE's are most interesting subject for economic research. This is not only because of the above mentioned desirable properties for economic experiments, but also because their operation poses new insight into many crucial subjects of economic science including concepts of utility, rationality of agents, or question of free currencies. This work will in detail examine mainly the last one, in particular it will focus on analysis of basic macroeconomic characteristics of one chosen virtual currency.

We will first quickly introduce reader into relevant basic characteristics of VE's. Although their mechanics do in many ways resemble real economies, in some respects they are different, and will need special theoretical treatment. Regrettably, in this young field there are not many giants on whose shoulders to stand. Though in order to build a reasonable monetary theory we will need in some sense to start from the scratch, and create few very crude auxiliary theories to set basic framework. First we will examine markets with virtual goods, and their prices formation. Then we will model behavior of agents in economy - players, farmers and creators of game themselves. Emphasis will be put on Real Money Trade (RMT) phenomenon - the trade of virtual assets for real cash. [2]

[1] In contrast to majority of works in the field, this paper does not stress great potential of VE's and focuses on their present state. Although the author is deeply convinced of coming major growth in importance of VE's, he does not (with exception of chapter 5) regard this very uncertain subject.

[2] That means mostly for USD or EUR. As we will see later, these markets already operate in quite significant volumes. It is perhaps their very existence, which gives us reason to treat VE's not as a game or economic experiment, but as space where real business takes place.

After those basics will be laid, will start with studying core of our interest - the macroeconomic working of World of Warcraft (WoW) economy. We will start by measuring the effect of real exchange rates such as EUR/CNY on RMT prices, and consequently on in-game price levels. Further on we will try to justify and apply quantitative theory of money, which is (according to the core hypothesis) more appropriate to be used in virtual, than in real economy. Econometric examination of those topic will be made possible because of dataset obtained directly from WoW and from RMT sellers (for details see Appendix).

Then we will move on to examining monetary phenomena - mainly inflation of Gold (WoW currency. To avoid confusion with precious metal we will spell it with capital G), its causes and consequences. Afterwards we will propose a microeconomic model to explain behavior of Gold issuer, and of agents facing similar positions. Then in final chapter we will propose few new notes to theory of free currencies (issued by private institution), justified by findings regarding virtual currencies. Based mainly on original thoughts of Karl Menger, we shall analyze options for evolution of new payment methods, and oppose them to current mainstream theory.

1.1 What are virtual economies?

Virtual economies may be very different from Earth economies, in certain well-defined ways.[3]

Phenomenon of large scale virtual economies emerged in late 90's. It is connected with rise of Internet, which enabled creation of massive gaming networks, where tens millions of users regularly enter the game to entertain themselves, interact with others, or even (as popularly labeled) to live their virtual lives. So far, this seems to be of little interest from an economists point of view - some new entertainment good (game) has been developed, and is now widely consumed. However, recent development suggests, that these networks are becoming something more, than an ordinary product of entertainment industry. It is not hard to observe, that player interaction within virtual worlds starts to resemble economic activity, rather than "just a game". It is not only rational profit-maximizing behavior of players (which after all occurs in ordinary games like of Monopoly as well), but intensive division of labor and developed internal markets, which make us use the term *virtual economy*.

There is however one key property, which is much more interesting on VE's, than their resemblance to real economy. It is their *interconnection* with real economy. To be more specific, it is the fact, that trade of virtual goods and currencies for their real counterparts occurs, and it occurs at considerable volumes. To provide some rough picture, estimates of annual exchange volume of RMT move between 100 million and 2.7 billion USD.[6]

It is perhaps the existence of RMT itself, that makes virtual worlds really behave like real economies. Because once such link is established, the real-world agents and firms can engage in activities in virtual world, resulting in real profit. This is what empirics strongly confirm - [6] estimates, that there is 400.000

workers employed in "industry" producing virtual goods and currencies.[3]

In this paper I will try to argue, that such link makes virtual economies part of global economic system, and consequently their game monies should be treated as real currencies, which is quite important step from monetary economics point of view. This is because virtual currencies are not issued and operated by any government agency, but by private (hence profit seeking) companies, and they in some sense reincarnate liberal idea of free currencies. Of course, they do not (yet?[4]) compete against real currencies or even against each other, but they already provide a nice experimental setting about incentives of private issuer able to inflate own money - which today stands as main argument against free currencies.

1.2 World of Warcraft basics

According to [18], in 2008 there were 6 MMOG's (massive multiplayer online games), with population above 500.000 users. This work however focuses on only one, but by far the largest of them - World of Warcraft(WoW), which in 12/2008 had over 11 million of regular users.[**?**] The reason for this is, that many economic mechanisms differ across various games. Even though their basic principles are more or less the same (therefore we can generally speak of virtual economies), author believes it is more appropriate to focus on one game in more detailed manner, to give reader some real flavour of what a MMOG is, since this is today not a part of general knowledge. In the rest of this chapter, some basic mechanisms (or rules of game) will be described. Reader should be aware that game is very complex, and only few relevant basic principles will be mentioned. For much more comprehensive details see [**?**].

Characters WoW is not a single world, but is divided into separate *realms* (servers). Those are stand-alone economies, between which no transactions are possible (or at prohibitive real money fees). There is about 150 EU and 250 US realms, where game takes place. A player enters realm as a *character* - virtual representation of himself which moves through virtual world, meets interacts with other characters present in same realm, and performs various other actions. A character is bound to one realm, however player is not - he may have multiple characters across one or many realms. Though he may use only one character at once, so he can be present only in one realm at a time.

Characters are the only means through which users interact with virtual world. While active, they basically either engage in economic activity, improve their abilities or just entertain themselves (=players). Mostly their activity

[3] It is quite challenging question, whether we should speak of production, when there is no real output. Deeper examination of this issue poses some questions about concepts of goods and utility. Answering those is however out of scope of this text.

[4] Recently, there has been some evidence, that Chinese QQ coin, or Second Life Linden dollar are currently used as means of payment for some real goods and services. However reasons for using "game money" in transactions was rather tax and law evasion, than questions of efficiency. We will deal with this topic in special chapter.

is some combination of those above. As economic activity we may imagine obtaining items or Gold, which happens primarily through killing and looting monsters or gathering resources. Such obtained items and Gold can then be traded with other players.

Characters differ in many specifics such as race, class, faction - which are of minor importance for our purpose, their key properties are level (rank from 1-80) and professions (such as fishing, blacksmithing or mining). All characters are born as level 1 characters, with no professions. By killing monsters and performing various quests they can obtain higher levels, up to maximum of 80. Level is key determinant of their combat ability, and also prerequisite for perfecting professions. It also influences many other important game aspects - particularly ability to kill and loot certain monsters, and to survive in certain regions, hence gather (mine,fish..) some items present in there.

Economy Character can learn up to 5 of 12 professions, in which he may then build up skill - generally just by using them repetitively. Professions can serve for items time-costly gathering (fishing, mining), or for their inputs-costly crafting (cooking, blacksmithing) from other items. It is important to note, that some professions require inputs which can only be obtained using other professions (mining $\rightarrow$ blacksmithing), or which are obtainable only by character with sufficient level. Trade of professions inputs and products is the main engine of WoW economy, and further on will be in center of our interest.

When two characters meet, they may barter any items or trade for Gold, however vast majority of trades in WoW occurs through Auction House (AH). AH interconnects all cities across one realm, and works pretty much like ebay.com - that means, any player can offer own items for auction, while he sets auction duration, and base prices for buyout and bid. Until end of duration item is listed on auction free for bid or buyout. If any player decides to pay buyout price, he instantly gets the item. If until end of duration there is no buyout, then player who payed highest bid gets the item (and lower bidding players are refunded). If no player put a bid, item is returned to seller. AH collects small fee for item listing (dependent on item price and duration), and also 5 % tax in case of successfull auction. Most of empirical data used in this work has been collected through AH, as described in Appendix.

The most valued items in WoW are weapons and armor. These are obtained either from monster loot, or as a final product of some crafting profession. They (along with level, and player ability) determine characters chances of being successful in combat with either monsters and other players. Hence weapons and armor are both goals and means of production. For regular players, obtaining better equipment is the far most important use of currency - and reason for engaging in economic activities.

Arguably the most efficient and reliable way of making money in WoW is so called farming. It consists of simultaneous gathering resources and killing monsters while repetitively running across certain game areas. Previous paragraph implies, that efficiency of such farming is practically given by character level,

equipment (weapons and armor), and player's skill. Some decent income is thus available only for high-level characters, who however do not always engage in this rather boring activity. Instead they (together with some low-levels) obtain gold through RMT, buying it from Chineese workers - who thus engage in farming instead of them. This activity is called Gold farming, which is no different from regular farming, but it's goal is to sell the Gold for real cash.

1.3 Player's motivation

In a sociological study MMO players themselves report, that *primary motives for playing are getting sense of achievment and social fulfillment.*[13]

Now we have some notion of game mechanics, but in order to examine driving forces of economy, we need to know the goal, which are characters (and their players) following. WoW is not a game, which can be won, or even finished. A player may reach level 80, perfect all professions, gain huge amount of money and equipment .. but this is usually the main reason why players keep playing, where their utility is really hidden. It is the social interaction (usually with hundreds of other players) that makes MMOG's special among all other computer games.

Aside of mostly economic activities discussed above, there are parts of the game which are much more social in nature. These are raids, battlegrounds and arenas, where groups of 2-25 players engage in one-off combats. In raids, the group fights against computer-driven environment (large locations with monsters). Although there can be some profit made, it's usually marginal in comparison to farming. The only possible material gain is in form of rare weapons from monster looting. Arguably the main reason of players engaging in typically 1-6 hours long raids is the subjective feel of achievment, and sense of common work. The case is even better seen in arenas and battlegrounds, where no profit can be made, not even the levels for killing monsters are gained. Their only purpose is the combat against other groups of players. There is hardly any economic reason behind it, in our analysis we will see successful engaging in these combats as ultimate utility which the game is player for, and more importantly - as the reason why players need to obtain costly equipment.

Players typically go to arenas or raids with stable partners, from their guild (more or less stable social group). The corner problem is, that the activities are mostly enjoyable only for characters with roughly similar combat abilities. This narrows down to fact, that in order to enjoy the game, a character should keep up with his surrounding - in terms of level and equipment. Once he starts lagging behind his guild, he is no longer useful member of team, which decreases his subjective utility.

This is where RMT services enter the equation - they basically offer players a opportunity to replace (time costly) obtaining of equipment, by spending some sums in real world currency. RMT companies specialize in obtaining Gold (mostly by using cheap low-skilled labor), and exchange it for cash with players whose time is more costly, and who want to keep up with their game mates. [5]

[5] Aside of selling Gold, RMT companies typically also offer second type of service, called

Since the game authors repetitively extend it over time, such race with others never ends. But it is the very notion of changes, which keeps competition changing and enables players to enjoy the game for longer period of time.

1.4 Blizzard and WoW

Blizzard, is a company, which owns and runs all WoW realms. It issues new versions of WoW client software, provides technical support etc. It has two major sources of income - license sales, and subscription fees. Each player, who wants to play WoW needs first to make one-off purchase of software license. Additionally, since WoW release in 2004, Blizzard has released two expansions of WoW, which introduced new game features, and increased the maximum level (from initial 60 to 70, and finally to 80). In order to benefit from these, users had to purchase additional software license. As suggested in previous sections, further expansions can be expected in order to keep game content enjoyable.

However, more significant income, than from the license sales, raises Blizzard from subscription fees. These are payed monthly by all players, at fixed level (13 EUR per month), no matter what time they play or how many characters they possess. As we will see later on, this income may play important role in formation of prices within WoW economy.

Blizzard also issues and tries to enforce EULA (End User License Agreement), which legally bans any RMT. This is a immensely important point, reader should be well aware of, that RMT as main subject of this whole work is in fact illegal activity. By engaging in such trade, both Gold seller and buyer violate EULA, and if nothing else, they risk loosing their software license, which is what Blizzard occasionally does, when it succeeds to detect some RMT. Hence the trade occurs on secret, decentralized basis, to minimize trader's risk of getting caught. This fact in particular makes our research quite difficult, since it limits us to use of secondary data.

Blizzard's motivation for enforcing the RMT ban is questionable, we may sum it into four following hypotheses:

1. RMT distorts gameplay experience, so in the long run decreases number of players. This is an official position of Blizzard[21], and will be addressed in chapter regarding artificial scarcity.

2. RMT also potentially decreases Blizzard's profits in more direct fashion. As some activities are outsourced to professional players (*Chinese workers play the boring parts of online games that Westerners don't want to bother with).* [39] Desired game achievements are thus obtainable in shorter time, and player is likely to cease paying subscription fees earlier. We will expand the argument further later on.

power-leveling. Simply they are payed, for getting player's character to higher level. Anecdotical as it may seem, players really do pay considerable sums to *someone else for playing instead of them.* This most fascinating issue is however out of our scope. Only important point here is, that the need to keep-up with surrounding is really the driving force of player's utility.

3. Since in practice the EULA enforcement manifests by banning some fraction of RMT seller accounts (canceling their software license), some theories exist, that by such behavior Blizzard in fact collects RMT tax, in form of forcing banned sellers to re-purchase software license [19].

4. Legal issues. Allowing for RMT gives trades within the game flavor of real business, and opens space for discussions regarding regulation, and more importantly government taxation.

Nonetheless, occasional RMT sellers banning perhaps distorts, but certainly not destroys RMT market. What it does, is that it moves whole range RMT activities into illegal sector - increasing RMT transaction costs, and more importantly for us - it renders most of data about RMT market unavailable.

Property in WoW Legally, all items in WoW belong to Blizzard - this is why RMT ban may be enforced. However from player's perspective, until used for crafting or sold, an item is in his possession. Even death of character [6] 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 raising 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. Later on we will suggest, that there might exist some Gold financial market between the RMT companies, which might work thanks to their existing real world relationships, however such phenomenon is of little interest to us. Furthermore, many desirable transactions (such as RMT) are against EULA, hence they can not be enforced legally even if contract regarding some virtual trade was made in real world. The fact of such legal vacuum puts WoW among traditional VE's, whose authors try to detach them from real world, which is supposed to make gameplay more authentic. The underlying intention is, that VE's should *not* resemble real economies. In chapter 5 we will shortly examine other VE's where in contrast with WoW, the link with real world businesses is allowed, and widely supported by authors. However here we conclude this chapter by stating, that economic processes in WoW are heavily affected by non-existent enforcement of contracts, and legal ban of RMT. These undermine potential emergence of many businesses (which can be observed in other VE's), and makes operation harder for those which already exist. However, this might be one of reasons why WoW is so successful - as a game, not as Virtual Economy, which emerges merely as a unwanted side-effect.

[6] which is nothing irreversible in WoW. Characters are infinitely lived and may be easily resurrected after death

2 Price of virtual goods

This section analyzes working of internal WoW goods market, and proposes a model of internal prices formation. First relative prices are derived using simple micro model, then with help of quantity theory of money a hypothesis about determining absolute price level is formed. Finally, by introducing RMT into model we analyze how Gold farmers might affect the economy. In next chapter our theoretical predictions will be confronted with empirical observations.

2.1 Goods price determination

We will start by proposing that markets with all goods in WoW are competitive. Namely, that there are many producers and that equilibrium price of goods is determined as each competitive price - by unit production costs. Let's look closer at mechanics of production to see why.

Goods in WoW are produced either by killing and looting monsters (which requires certain level), or by gathering & crafting (which requires certain profession). Obtaining both level and profession is very time consuming - hence costly in terms of opportunity costs. These can be considered as one-off market entry costs, which hypothetically could distort competitiveness of market. This however does not happen in practice, since these one-off entry costs grant a *permanent* ability to produce certain good (because level cannot be lost and profession forgotten). Consequently the number of potential producers is generally quite high - even the most requiring goods can be produced by roughly 10 % of realm population. This estimate has been obtained by following line of thought: according to [16] the 15.9 % of total WoW population is in maximum level (71-80) category, hence capable of all level-determined goods production. The census for skill-determined goods producers does not exist, however game mechanics imply, that each character above level 65 can perfect up to 5 of 12 available professions. Hence the fraction of producers of such goods should move in one-digit numbers. Since production capability for most of goods is level determined, we may consider 10 % of population as reasonably low approximation of producers count. Given the typical realm population (> 10.000), we may conclude, that markets with virtual goods are generally competitive, because the number of potential producers (capable of entering market in nearly zero time and zero cost) exceeds 1000.

Now, for vast majority of goods in WoW, the number of producers is high enough, so we can assume their respective markets are competitive. Hence their prices are formed primarily by unit production costs. Now we will briefly analyse, how these costs (therefore prices) are structured.

All WoW goods are in some sense freely available in unlimited amount, however it takes some time to obtain (or perhaps to "produce") them. That means, their producer bears no other costs, than those determined by production time, which denoted as opportunity costs C_o. The time of production is either given by specific game mechanisms - in particular by probability of getting some item

in result of given action (such as killing a monster, mining a copper vein)[7], and by distribution of resources (monsters, veins..) across gaming area. For crafting professions, there exists also important cost of inputs (other virtual goods, which need to be consumed during production), however price of those inputs is likewise determined by *their* production costs. In the end, we can decompose production cost of every good into sum of times required for production alone, and for production of all inputs. [8] So we can formalise first core hypothesis of this paper as follows:

$$P(G) = \frac{1}{0.95} \sum_{i \in I} t_i C_o + \epsilon \tag{1}$$

where $P(G)$ is price of good G, I is set containing good itself and all inputs, t_i is mean time required for production of good i. The absolute coefficient $\frac{1}{0.95}$ follows from 5 % fee, collected at AH. ϵ is random white noise, caused by short-time market fluctuations

However, equation (1) is perhaps too simplifying. While subscription costs C_s are same for all players, opportunity costs C_o are not - as it follows from their different productivity, and it denotes the revenue from their most profitable opportunity available. We will generally assume, there is some distribution of C_o among population. While analyzing a market, for given current price P we may distinguish three groups of players, according to their specific production costs $P(G, C_o)$:

- $P(G, C_o) > P$ these are buyers of good, since their specific production costs are above current market price
- $P(G, C_o) \leq P$ and $P(G, C_o) > 0.95P$ These produce good for own use, however they don't sell it to others, since AH fee makes such sale unprofitable.
- $P(G, C_o) \leq 0.95P$ Are both producers and sellers of good.

We may easily see, that such market is self-equilibrating. If P becomes too high, players will shift in direction from group 1 to group 3 - hence the supply will rise and demand fall, pushing the price down until production of group 3 exactly covers demand of group 1. At this point, price is equal to production cost of marginal buyer (the person with lowest C_o within group 1), or equivalently

[7] Even though these are stochastic variables, we must realize that thousands of such goods are produced. Hence using law of large numbers we will further simplify our work by using mean values, considering them as deterministic.

[8] Not accidentally this resembles Ricardian labour theory of value. Given that thanks to near-perfect competition, the price is given by supply side, and apart of some exceptional cases there is no capital (other than character itself) included in production, it follows that in WoW is labour theory of value (=price) reasonable assumption.

to 1.05. production cost of marginal seller (the person with highest C_o within group 3).

We see, that through mechanism described above, relative prices in WoW are determined. The price ratio of any two chosen items should move around mean value of their production times (plus production time of all inputs, if the good is product of crafting profession). Of course, there are many sources of fluctuations in WoW - farming results are mostly stochastic, the supply and demand continuously move (for instance demand for most goods typically peaks at weekends and in evening hours), some players speculate on various markets etc. However only permanent change of relative prices might happen, when Blizzard issues patches which alter production times - and it takes some time till market adjusts etc. In 2008 there have been four such major patches, in first five months of 2009 we have seen three. These patches generally change more than production times, and will later get into core of our interest - as a profit-seeking tool of Blizzard, now we just need to know, that they are only event able to permanently shift relative prices.

As an example, we may use some third party data from various goods markets. First look at price development of item Silk Cloth 9, which shows price stability of good which is subject to no changes. Regardless of temporary fluctuations, price tends to return to single price level - which clearly is determined by something, arguably by production costs. Then compare with Pygmy Suckerfish 10 and Eternal Air 11 - where equilibrium price has obviously changed at certain time point - which was the date of new patch. Although Blizzard does not publish such data, we may find further evidence that patch changed production conditions of Pygmy Suckerfish here [23].

Now we will move on to much more complicated issue - determination of absolute prices. This topic is tightly bound to our main subject - the RMT. As I will first argue and later on prove empirically, its existence can distort inner functioning of WoW economy, especially its price level. In following two sections we will first examine how price level is determined ideally - without RMT, and how it might be, according to my hypothesis, determined in practice.

2.2 Prices without RMT

Suppose there is no RMT. All players play for their own pleasure and not for real life income. If they engage in farming, they do so to obtain Gold, which they again intend to spend within WoW economy. The economy is perfectly closed with both items and Gold appearing only according to game mechanisms defined by Blizzard. We already have rough idea that items appear out of nowhere during farming, gathering or are crafted from other items. How do items leave game? Some are plainly consumed (for game purposes of no relevance for us - other than that they provide some utility), used equipment is bound to character so that it cannot be traded anymore. More importantly - some goods are consumed during production, so that their value does not disappear from economy. Finally all goods can be sold to 'vendors' - for very small but positive amounts of Gold (for useful goods such as crafting ingredients, this price moves

around 1/100 of their AH price).

Gold sources and sinks This moves us to second, more important topic - the Gold appears and disappears through so called sources and sinks. There are many of these in WoW economy, we will mention just the most important, starting with sources. Primarily, Gold enters economy during farming - while looting monsters, character gets random items and Gold. These come at strictly (Blizzard) defined probabilities [9]. Other major sources of Gold are quests - where character performs some difficult action, again for some Gold and items. The message here is, that *Gold and items appear in economy in fixed ratio.*

First and most stable Gold sinks to mention are equipment repair costs and public transport costs, which are small but almost inevitable needs for each player. Other typical Gold sinks are fixed costs, which each player needs to pay for leveling and gaining profession skills. Although these can be seen as one-off costs, reader should be aware that there is always relevant fraction of realm population leveling up[10]. For leveling purposes, also some equipment is needed - which mostly can be bought from other players at AH, or there is always some available from vendors - at lower quality, and fixed price (which typically is much lower than at AH). But, possibly largest amounts of Gold disappears from economy through AH trade. For each listing there is some fee, and more importantly 5% tax is cut on each sucessfull trade. Contrary to previous cases, these costs increase with price level - which will later on play important role for price equilibration. Last but not least, there is consumption which we will call *spontaneous*. There are some items sold by vendors at fixed costs, which cannot be used during production - yet their consumption brings some utility.[11]

Monetary equilibrium Above described mechanisms would economist perhaps call endogenous money. Apart from Blizzard occasionally changing game mechanics, there is no monetary authority. We may view such setting as a Friedman rule of monetary growth tied to product. Gold appears and disappears from economy only through player activity, but according to well-defined rules of game. Further on we will defend following proposition:

Proposition 2.1 (Gold-goods equilibrium) *With given player preference and game mechanics, there is a stable equilibrium ratio of Gold and goods in WoW economy, which is fixed in the long run.*[12]

Why it should be so? The intuition follows from paragraphs above - since channels through which items and Gold enter the economy are tightly bound

[9] These probabilities are not published, however some third parties make serious profit by maintaining databases with very exact estimates. For getting the flavor, see for example http://thottbot.com/c5992 section Drops.

[10] As we can see in [16].

[11] Nice example can be snowballs or fireworks - characters purchase some of those, with no other purpose than to impress others and possibly gain some social utility.

[12] Game is now running for four years, while the game mechanics have changed 7 times just in last two years. Contrary to standard economic slang, when speaking of long run, we generally mean several months, short run means weeks or even days.

together, the ratio of sources is more or less given. Sinks are a little more problematic - although practically any player activity generally requires consumption of both items and Gold, this ratio needs not to be stable. For instance, if players decided to use more public transport, engage more in spontaneous consumption or sell less items to vendors - all these decisions would imply and increase in goods/Gold ratio. In short - it *is* a matter of player preference (hence play style), whether he brings into economy more Gold or goods. Consequently, global shift in preference would result into change of G/g.

This is however unlikely - with more than 10.000 players per realm, the law of large numbers practically denies possibility of preference shift within months - at least in case when there are no changes in game rules, which might possibly be the only objective event that might have such consequences. Note that even though increasing level or profession skill does enhance character's productivity, it does not change his net G/g output - which is more subject of player's preference.

But such conclusion is not enough to call the equilibrium stable. Absence of structural shocks does not explain why economy tends to given equilibrium, or (as we will argue later on) that the g/G ratio is roughly same on various realms. In short - there needs to be some equilibrating mechanism. Before we will propose how does it look like, we need one more thing - idea how G/g translates into absolute prices, because these prices will be the key mechanism of economy self-regulation.

Quantity theory of money Now we will simply argue, that QTM works in WoW. First we need address question, why such theoretical leap should be valid - why theory traceable back to David Hume's thoughts about *real* economy should have anything to say about virtual worlds? As argued in introduction - because basic mechanisms in VE's are very similar to real ones, perhaps by intention of authors to create environment in many respects imitating real world. Nonetheless - as we will see (and later on empirically validate), QTM is quite valid for WoW economy. Perhaps, thanks to lack of market imperfections, it is more valid than it is today for real economy.

So, we state classic QTM as follows:

$$P = \frac{M.V}{Q} \tag{2}$$

Where in our terms P denotes price level, M amount of Gold in economy,Q is the volume of items in economy, and V is speed of transactions. Now, we state, that V stays constant over time, following the same logic regarding stable preferences of player population, which is same for production, transport .. and trade. We may omit this constant because price level P is a measure whose scale is arbitrary. Then we realize, that our equation degenerates to what we already know:

$$P = \frac{G}{g} \tag{3}$$

Where fraction on right side of equation is nothing else than G/g ratio of Gold and goods, known from previous paragraphs. We built the theory in order to obtain this mechanism, which we will be able to use as rule for determination of absolute prices. But prior to that we first need to show that it holds in time frame short enough for our purposes.

So, why should quantity theory of money work *in the short run*? Or more concretely - why should be Gold neutral? Common reasoning for short term non-neutrality of money, follows from price stickiness. The shock from increase in M first affects the aggregate demand, raising product. Then in longer horizon prices adjust returning the product to potential, at higher level of P. In WoW this should not work for three reasons:

1. The prices are not sticky. Maximum time, an item stays in AH is 48 hours. If it is not sold by then, it is returned to seller who needs to manually re-list it on AH. Since majority of sellers use tools detecting price level, they naturally re-list items at adjusted price. So we can say, that prices adjust almost smoothly (in terms of hours or days).

2. There is no interest rate in transition mechanism from M to P, pretty much like in original 19th century QTM. The channel working in WoW is much quicker - from the moment of M increase, it is only a matter of hours, before the Gold gets to commodity market. And through increased demand pushes prices up.

3. More generally, there are also no financial innovations, or other structural changes in working of WoW economy (aside of Blizzard patches).[13] This denies common argument why QTM does not work in *real* economy, at least since 70's.

4. No interest[14] also implies no speculative motive for holding money. This naturally gives larger importance to transaction motive, which is ground of QTM.

Advantage of virtual economies is, that they are both compact and very interconnected inside. In WoW, AH works in manner not far from neoclassical ideal of Walrassian auctioneer. It is a central trading system, through which great majority of trade occurs at negligible transaction costs (other than explicit tax). Price levels of all goods adjust smoothly according to spot supply and demand, resulting (in case of most traded goods) almost into perfect competition with all producers selling at single price, given by costs of production. Furthermore, trades occur in zero time. Using those facts, it seems reasonable to assume, that prices may well adjust to amount of money in economy in short time. This means, that quantity theory of money does not hold in just long

[13]Such as 1 hour delay for getting money after successful AH sale, which was introduced in patch 2.2.0. See http://www.wowwiki.com/Auction_House

[14]There is nothing like interest in WoW at - least for players themselves. Since there exists quite complicated supply chain of RTM companies, we may not deny possibility, that they do engage in mutual short term lending, but this is out of this chapter's scope.

run (as we know it from real economy), but P should equilibrate according to changes in M within horizon of days or weeks.

Absolute price level More serious argument against our use of QTM might be endogenity of money. Earlier we argued that G is endogenous in economy - which contradicts standard QTM assumption, that money supply is fully exogenous. But, we have in fact even stronger assumption - proposition 2.1, stating that whole G/g term is exogenous. So, even though money supply spontaneously changes over time, volume of goods in economy do so in same proportion, offsetting any backwards effect which P might have on M. But, more importantly, the proposition states, that G/g ratio is stable. This statement together with QTM has one quite serious implication:

Proposition 2.2 (Price stability) *With given player preference and game mechanics, the price level of realm moves around stable mean value.*

Earlier we intentionally skipped question, why proposition 2.1 states that G/g ratio should be *stable*. By showing that 2.2 is true, we will thus also verify this earlier point, because when assuming QTM works, propositions 2.1 and 2.2 are equivalent.

Monetary basis equilibrating mechanism Why should realm economy converge to fixed price level? It is given by nature of some Gold sources and sinks, which tend to behave like corrective mechanisms. Assume that P got above equilibrium level P^*. Then following processes start:

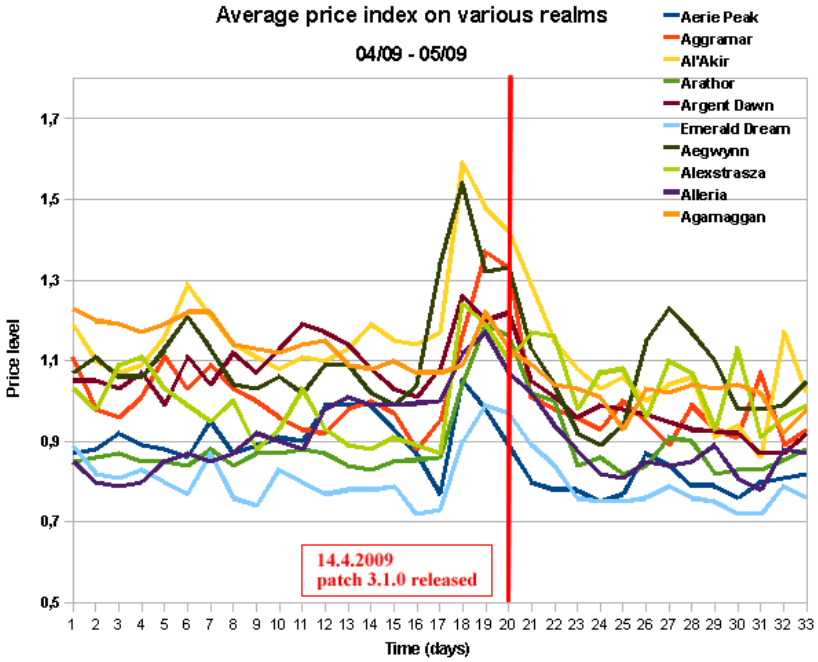
1. Players sell less goods to vendors (G source, g sink), as the AH offers relatively better prices than usual.
2. Players substitute for consumption of goods with fixed costs - vendor goods, spontaneous consumption goods, public transport (all G sinks), instead of buying relatively more expensive goods at AH.
3. AH 5% tax linearly grows with larger prices. Supposing that same volume Q of goods is traded, $= 0.05Q(P - P^*)$ more Gold disappears from economy through AH tax than in equilibrium.

Likewise in case that $P^* > P$ analogical effects behave in opposite direction, creating again equilibrating pressure.

Note that points 1 and 2 to some degree neglect point 3. By stating that AH supply rises and AH demand falls, we cannot be really sure how Q will behave outside equilibrium - which makes equation in 3 slightly inexact, but still relevant argument. More importantly, rising AH supply and falling demand imply what we are trying to show - that AH prices go down, possibly back to P^*.

Now we see importance of fixed prices in equilibrating process. They do serve as nominal anchor to variable ones, present at AH. Players substitute

Figure 1: Average Gold price index across various Realms



between both according to current AH price level, making the economy return to equilibrium. Now we more clearly see relevance of our assumptions - preference stability, and game mechanics. Stable game mechanics imply unchanging fixed prices (transport,vendor goods...), serving as anchor of economy. Unchanging preferences then guarantee stable substitution rates between goods with fixed and goods with variable price.

Empirical observation We can hardly perform some straightforward test for propositions above. Since we cannot obtain data regarding player preferences, our evidence will be only indirect. We will study development and distribution of price levels on various realms, using data collected from 17 realms - from which we have computed panel of two price level indicators - Average price index and Minimum price index(API, MPI)[15].

First have a look at API development on 10 European realms over 33 days at figure 1. Later on, these data will play key role in our computations, but now we are only interested in one thing - price level stability. On the first glance at figure, our hypothesis seems valid. With exception of single spike each of realms seems to fluctuate around stable mean.

The spike is obviously formed around date of 3.1.0 patch release, which occurred in middle of our measurement. This was rather unlucky event, as it

[15]For details see Appendix

caused sharp fluctuation and created serious leverage points in data, possibly worsening our further results. Nonetheless here it is useful for showing serious effect of game patches. Even though both the figure, and our further computations reliably show only mild change in equilibrium price level, we see that the spike starts *before* the patch. This specific patch did possibly not introduce much serious changes to game economy, but such thing is never known prior to announced patch date. Consequently, players with experience from recent patches form some expectations and adjust their behavior. In later chapter we will provide hypothesis explaining why the spike heads upwards. Now we are satisfied with observation that population of players is broadly aware of serious changes, which patches may do to economy - which supports importance of our stable game mechanics assumption.

Moreover, we should notice speed of price adjustment after spike - to new and relatively stable price level. From that we see, that our earlier remarks about QTM working in short run could be justified. Even though we cannot assume, that it is a general pattern and that all patches deliver their result so quickly (some deeper structural changes might take more time to manifest), we get at least the rough idea about smoothness of adjustment, pushed by competitive markets. Likewise we should remember earlier figures 10 and 11 showing basis of such adjustment by zooming to single market.

Now, to analyze monetary equilibrium more rigorously, we will run a simple regression to estimate effects of time, realm-specifics and 3.1.0 patch on price level. Dataset consists of 33 daily price observations on 10 European realms. The estimated equation follows:

$$MPI_{T,R} = \alpha + \alpha_R + \beta_1 T + \beta_2 Patch \tag{4}$$

Where α_R is specific dummy variable for each realm R, T is time in days, and $Patch$ is dummy which equals 0 prior, and 1 after patch. We leave only one $Patch$ dummy because the patch effect should arguably be same or very similar at all realms. Results are following:

Parameter	α_R	T	$Patch$
Coefficient	-0.09 to 0.12	0.003	-0.16
P-value	all significant	0.002	0
N	330		
Adjusted R^2	0.62		

First important result to notice is solid adjusted R^2 value. We explained 60 percent of price level variance using only linear trend and 10 dummy variables. Without spike, for which we did not treat at all, explained variance would be probably even more. This leads us to conclusion, that (at least on our short data) we observe strong equilibrating tendency on each realm.

Secondly, the -0.16 parameter at $Patch$ variable is strongly significant. This is also consistent with our theory, implying that 3.1.0 patch reduced equilibrium price level by 16%. Notice, that players did possibly anticipate rather inflationary patch. Their consequent short-term decision to decrease money holdings

buy goods is perfectly legitimate explanation for temporary price level increase - which we observed prior to patch.

The only disturbing result is the significant parameter T. Although we may argue that our small sample implies inexact results when regarding long-run equilibrium, especially thanks to patch adjustment, the significance is high and estimated effect of 9% change over 30 days is not negligible. In next chapter we will offer some explanation, but now we are about to adress different result.

Distribution of realms All WoW realms are divided into three basic groups according to their location - USA, Europe and Asia. Across European realms there is further language division to English, German, Spanish, French and Russian. It is important to be aware that there is no further geographical division - my research took place mainly on English and German realms. We will assume that their populations consist primarily of English and German speaking countries citizens, plus portion of minority language groups from Netherlands, Italy, Poland, Romania etc. With exception of dominantly Czech Drak'Thul realm, author is not aware that population of any other realm is seriously biased from suggested mean, so we will suppose that other servers populations consist of random mixture of above mentioned nations.

Why this is important? When we will discuss differences across realms, the natural question will raise, that different nationality may imply different preferences - even when they regard uniform virtual worlds[16]. Such point is perfectly valid, but hard to prove - as we cannot observe population structure. Further on we shall naturally suppose and treat for differences among servers. This follows from simplifying view, that realm populations are randomly drawn from European countries. To show the reader that such view is not so unreasonable, we offer at least modest evidence using our price data:

If realm populations (which are mostly greater than 10.000) were drawn randomly, law of large numbers suggests, that their distribution should be somewhat normal. If we according to out earlier hypotheses assume that their aggregate distribution manifests through their preference into price levels, we should observe equilibrium price levels to be normally distributed as well. So we computed all time average price indices and tested them. The Lilliefors test for normality of sample did not deny zero hypothesis, that average price levels on sample of 17 (both US and EU) realms are normally distributed, with p-values 0.37 and 0.5 for API and MPI respectively. Message which this result tells us is, that although there is some heterogeneity among servers there are no clear outliers, or separate groups of realms (such as US or German), which significantly differ from rest of population.

Time trend In regression (4) we saw significant time trend T, which raised legitimate doubts about our long term price equilibrium hypothesis. Ongoing movement of price level would suggest permanent changes in economy's Gold

[16] Especially when considering RMT where differences in real wealth might cause different demand.

stock, which would not be offset by change in goods volume. In fact,it is quite popular view that each realm economy does spontaneously evolve according to some general time pattern. This theory states, that the age of realm matters - after it is online for longer time, some items or Gold accumulate within economy, more players reach level 80 and perfect their professions etc., which should lead to serious in-game price movements - as the server becomes more mature, both supply and demand on various markets would shift in some manner, reflecting changing needs of economy.

Using our data we can raise serious doubts about such theory - whereas it may be possible that conditions on certain items markets do change, economy as a whole is more or less stable. At least from perspective, which interests us - that there seems to be no development in aggregate price level over time. To show this, I made a snapshot[17] measurement of price level on 16 European realms. I also obtained comparable data for one US based realm, which is also included in following table:

Realm	Realm age	API price index	MPI price index	Average(MPI)
Eonar(US)	53	0.71	1.06	
Aggamagan	52	1.04	0.98	
Emerald Dream	52	0.8	0.73	
Al'Akir	52	0.92	0.94	
Alexstrasza (DE)	52	0.8	1.08	1.019
Aegwynn (DE)	52	1.09	1.04	
Alleria (DE)	52	0.76	1.1	
Argent Dawn	52	0.86	1.09	
Aggramar	52	0.75	1.14	
Arathor	52	0.89	1.03	
Drak'Thul	41	1.02	1.04	
Eonar	38	0.72	1	
Aerie Peak	36	0.71	1.11	
Alonsus	33	0.8	1.2	1.04
Anachronos	28	0.97	1.1	
Terokkar	7	1	0.96	
Colinas Pardas	2	1.73	0.87	

Realm are sorted by their age - time from their launch date in months. The snapshot price levels move around mean value 1 with standard deviation of 0.12, caused by short term fluctuations and differences in realm population preferences. Important finding here is, that average price level of old (52 to 53 months), and young (2 to 41 months) realms are *not* significantly different. As they are 1.019 and 1.04 respectively, passing two-sided t-test with p-value 0.71,

[17] By snapshot is meant an measurement of average price level over single week. Since WoW economy typically moves in weekly cycles, such time frame is long enough to provide robust measure, but also short enough not to be biased by any longer time trend.

which does not deny hypothesis that populations are not same at any thinkable level of significance.

This result means, that observed trend T has not long-term effect. We may therefore conclude, that its significance was caused rather by small dataset, and patch adjustment process, than by some ongoing development of price level. But we will not. Since framework sketched in this chapter has clearly no valid explanation for medium run price shift (which we observed), we shall propose alternative explanation that allows for such event.

2.3 Prices with RMT

There is perhaps one thing a bit puzzling on data we saw in previous section. Why are the equilibrium prices so similar. Why do closed economies, which are not interconnected at all, differ only in such small degree - after all standard deviation of 12% is not much, and speed of adjustment is way too quick even for nearly perfect markets. In the spirit of our recent propositions we could argue that it is the similar preference of player populations, and self-regulating mechanisms of economy in form of nominal anchors, that keep realm economies within tight boundaries. Such argument is perfectly valid and hard to falsify. Instead of trying to do so, we will offer an alternative theory of price formation, which will hopefully provide even better explanation and also an answer to our problem with significant time trend.

When we look at figure 1 again, we see that price indices are obviously correlated. Some of this correlation might be explained by weekly play cycles, but not all of it. Starting with time trend and following with non-linear mutual movements, there needs to be some factor that affect *all* realms. Since we know, that realm economies are not interconnected, we will need to look outside - for some objective condition, other than Blizzard patches, that might affect realm economies. In next two chapters I will argue, that it is the development of real-world foreign exchange market, that affects price level *within* the game - through RMT channel. That time trend we saw earlier was not really a time trend, but an adjustment to changing exchange rates between euro and yuan. But before we get to that we need to analyze carefully RMT market to see what is happening there.

Gold farming business How does a Gold farming company look like? For production of Gold you don't really need much - just computers with Internet connection, valid WoW subscription ... and a lot of workforce. By workforce we generally mean some qualified staff taking care of distribution channels, website, research[18] etc., but most importantly players - who even need not to be literate, just have to be able to play the game. When it comes to farming, the job is

[18] Yes, research. With constantly changing game environment, development of new play techniques is needed to maximize worker productivity. Although there is plenty of literature advising regular players how to make Gold most efficiently, professional players might have most serious interest in further developing those techniques - in order to gain some competitive advantage.

easy to learn - purely mechanical, repetitive and boring. And what we do with such type of work in EU and USA? Right, we outsource it to China[19].

This is also how it works it reality. Companies engaging in RMT are mostly US or EU based, however great deal of their workers - especially low-skilled ones live in China. It is quite straightforward, since online games such as WoW might be played wherever is Internet access. In some sense, RMT is ideal industry for outsourcing - it is labor intensive, there are no transport costs, no information asymmetry related problems, almost no intellectual property to steal, and small needs for capital investment. Headquarters in developed state takes care of sale channels, Chinese workforce does the rest. Also there are reports about purely Asian RMT companies - which manage to engage in end sales too. Possibly this is not the typical case - since RMT contracts are illegal, hence not enforceable reputation of US or EU located seller is some competitive advantage. In response, purely Asian companies typically offer Gold at slightly cheaper prices.

RMT market structure is rather even more complicated, and full vertical integration is not common. *Most gold farms cannot reach foreign customers directly, so they rely on international brokers to distribute their commodities.*[12] In other words, there exist longer supplier chains, not only to reduce costs and increase flexibility, but also to deceive. Blizzard constantly hunts for Gold farmers, and repetitive transfers within company would perhaps be quickly traced. Frequent switching intermediary suppliers reduces the risk of getting caught, and loosing account together with all accumulated Gold. To further reduce the risk, RMT companies try to hold as little Gold as possible. They can afford so, because through flexible adjustment of workforce or some of great number of suppliers, they are able to replenish Gold stock on any realm within hours, or days at most. A last point regarding we need to make, is to recall that farmers make they money (not surprisingly) through farming. They repetitively kill monsters, and gather resources - which is both very time consuming - to obtain items and Gold. Then they sell collected items - some of them to vendors, but most income comes from AH sales.

However here we will not deeply examine market structure. Important hypotheses following from above are these:

1. RMT markets are competitive, hence their prices are mainly driven by Gold production costs.
2. Gold production costs consist mainly of farmer's labor costs.
3. Farmers do not accumulate high Gold stocks.
4. Farmers obtain most of their Gold through AH, which has two following consequences:

[19] Why China, and not for example India? Farming industry is mostly in China - in 2008 BBC used estimate of 80% [25]. Without further evidence this work supposes that majority of Gold farmers is located there. For possible explanations (regarding Chineese absent language skills and preference for gaming) see [24]

5. With RMT, AH markets become even more competitive

6. Farmers hourly revenue is dependent on AH price level

Absolute price determination II. Now, we can revisit our earlier equation, used for determining relative prices within WoW, which is now about to get quite new meaning.

$$P(G) = \frac{1}{0.95} \sum_{i \in I} t_i (C_s + C_o) + \epsilon \tag{5}$$

Only new term in equation is C_s, which stands for monthly subscription fee, payed to Blizzard. Provided that one month means limited amount of playtime, it is valid to assume, that its (say hourly) fraction translated into price .. which brings us to much more important point. Although rest of equation has not changed, the accounting unit did. *In this chapter, we will now denominate in-game prices in yuan(CNY), and not in Gold.*

How should that be useful? First, look closer at the C_o parameter. We know that it is given by production capabilities of given economic agent - but is this agent a game character, or is it the real player? Up till now, we assumed it was a character. Without RMT link to real world there clearly is no sense in using other units than Gold. Things change, when there is *significant* proportion of professional players, who see their gaming as economic activity leading to real income. They will naturally recalculate in-game prices into yuan, or whatever currency they wish to earn. In this chapter, I am going to defend following proposition:

Proposition 2.3 (Price level determination with RMT) *Given stable game mechanics and player preferences, if activity of Gold farmers on one realm is above certain threshold, then AH price of each good denominated in yuan moves around stable mean.*

Up till now, each player engaged in production of virtual good, in which he was most efficient. Prices were determined by productivity of various characters. This is about to change, when we allow players to trade Gold for USD/EUR. Underlying hypothesis of this chapter is, that once this happens, some players begin to optimize their virtual world behavior with respect to the real world costs. For our model it means, they start substituting between in-game and real life production.

Once this happens, the fraction of players which is more productive in real world stops engaging in production of virtual goods at all.[20] Analogically, those

[20]The objection, that some players may consider virtual goods production itself entertaining and will not cease, even if they are much more productive in real world, is perfectly valid. Here we argue, that after introducing RMT only *part* of players changes pattern of behavior. After all, WoW is primarily a game and is supposed to be entertaining most of the playtime. Although many players consider farming and increasing in skill or level unpleasant (after all, these activities are called *grinding* in player's slang), we may not deny a hypothesis, that

players whose productivity in WoW is relatively higher than in real world, will shift whole their productive activity into virtual world. Reader should note that this model outcome might be quite close to observed reality. Recent (2008) estimates speak of 400.000 farmers [6], grinding full time in virtual worlds, mainly WoW, and selling their virtual currencies and other items to players from Europe and USA - who possibly do not farm at all. While there were roughly 4.5 million of WoW players in those continents at the time [28], it is not unrealistic to assume, that relevant part of them did buy Gold through RMT.

Now, although the pricing model remains almost unchanged, by choosing different unit we get quite different picture. It is indeed again a Walrassian equilibrium players produce and sell virtual goods, but the other part engages purely in real world production and buys virtual goods. Here we must note that trade between those two occur indirectly. Virtual goods is not sold for real assets, but for Gold at AH. Gold (and only Gold) is then traded for real currencies. This follows not from the logic of the model (nor it is against it), but is simply the institutional arrangement, which has apparently evolved as most efficient.[21]

Again, we may divide players into three groups according to their individual opportunity costs C_o (which are this time denominated in yuan). By C_{IN} we denote opportunity costs in game (their Gold productivity times RMT exchange rate), and by C_{OUT} their real world productivity in yuan . Additionally we introduce RMT transaction costs TC, which in fact aggregate many factors - transaction costs of RMT in strict sense, risk of getting banned by Blizzard for RMT, and possible subjective disutility from performing action which gaming society disapproves. So, after introducing RMT into our model, our original three groups will transform into following:

- $C_{OUT} < C_{IN} + TC$ Gold farmers. By playing WoW they attain best real income they can get.
- $C_{IN} + TC > C_{OUT} > C_{IN}$ Regular players. They work in real world, but also farm in game to cover own Gold expenses.
- $C_{OUT} > C_{IN} + TC$ Gold buyers. They are very productive in real world, so they are willing to sacrifice TC, and buy Gold for real money, instead of spending their precious time by farming.

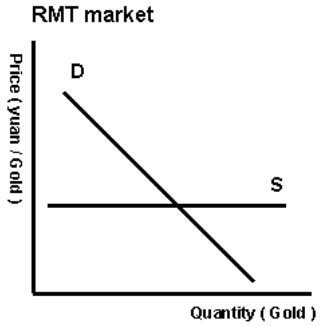
There is no reliable source for comparing numbers of RMT versus non-RMT players. Since RMT itself is illegal, unethical one-off transaction unobservable by third party, there is probably no way for getting the data directly. [22] Arguably the prohibitive TC term might make group 2 very large, at some point

there still is some positive utility connected with them. This however is equally true for real world jobs. For simplicity we shall leave this issue out, much like many classical aggregate labor market analyses do, and focus on substitution driven by financial stimulus.

[21] Not a minor reason for this outcome was perhaps ban of virtual items trade at ebay.com [22]. However, apart from really high-cost trades, low transaction costs (5%tax & fee) of AH trade practically elliminates economical feasibility of trading goods outside WoW.

[22] In early sociological study[14], 22 % of 1923 respondents reported, they at least once

Figure 2: Perfect competition on RMT market



it might even eliminate Gold farming (which would move economy to non-RMT equilibrium described earlier), by reducing size of group 3 to zero. This is because size of group 1 is determined by group 3. Like we pointed out earlier - there is perfect competition among Gold farmers [23], so once their price is given (as hourly productivity C_{IN}), *it is the demand for Gold, that determines actual RMT volume.* Intuitively - there are plenty of farmers in China, ready to deliver as much Gold as group 3 demands (at fixed RMT price). Hence from now, further on we will use simple perfect competition model 2.

To show, that such approach is reasonable, we run following regression:

$$log(RMT^{Q}_{R,S}) = \alpha + \alpha_R + \beta_1 log(RMT^{P}_{R,S}) + \beta_2 T + \beta_3 Patch \tag{6}$$

Where $RMT^{Q}_{R,S}, RMT^{P}_{R,S}$ are daily prices and trade volumes reported by Swagvault RMT company for each realm. α_R is again realm-specific dummy variable, T is time in days, and $Patch$ is dummy which equals 0 prior, and 1 after patch. Results are following:

Parameter	α_R	log(RMT^P)	T	$Patch$
Coefficient	-0.12 to 0.32	0.24	-0.0015	0.05
P-value	11 of 15 significant	0.07	0	0
N	1097			
Adjusted R^2	0.66			

Here we see that on RMT market, price is *not*[24] significant factor for explaining volume sold - which confirms our hypothesis of flat supply curve. To

bought virtual currency. Although this result is doubtfull both in terms of sample size, and answer reliability, it can at least provide a picture, how developed was RMT market as early as in 2005.

[23] *With the increasing number of gold diggers entering into the profitable industry since 2006 and strict policies from game operators against gold farming, the profit has fallen sharply. Many workshops went bankrupt as a result of the frequent bans from game operators. The RMT market has changed from a high-profit industry into a relatively stable business. The competition in the RMT market in China is very fierce.*[30]

[24] Note that analogical regression without logarithmic transformation got very similar re-

get such result, we needed to control for realm specifics - intuition here is, that on each realm there is different equilibrium RMT price (later on we will explain this fact through differences in in-game equilibrium price levels). Now we (on reasonably large sample from 15 realms) that *yuan denominated* RMT price and volume are unrelated.

Note, that now committed a statistical sin, by extrapolating from one observation (one seller), to whole population. But in this case, it probably does not distort reliability of our findings. This is because we found, that one large seller has flat supply curve [25]. We might have seen upwards sloping curve, and still argue, that many of these will aggregate into nearly flat supply (like it is common in Keynesian AS framework). Since we saw flat curve even in case of one seller, we thus can even more strongly argue, that many flat curves will join into flat aggregate.

Last result to mention is again significant time trend, which we can only explain by shift in demand. How come, that such movement apparently occurs jointly on 15 realms? It is quite unlikely, that it is result of shift in preferences. Again we point to next chapter, which tries to explain such trend (of yuan denominated demand) through trend in EUR/CNY exchange rates.

Yuan denominated costs Later on we will broadly rely on one simplifying assumption, regarding RMT market: that whereas European Gold buyers earn money in euro (which is quite reasonable assumption), Gold Sellers bear their costs in yuan. To show, that this is the case (that for example price margin of US or EU based sellers does not account for major part of the RMT cost) we should at least roughly estimate what might the cost of Gold production be. Note, that our estimate will tend to undershoot the proportion of costs in yuan, since also other parts of Gold-farming might be (and most likely are) outsourced to China[26].

The crucial figure of farmer's wage is quite hard to answer - the sources widely differ and/or are possibly outdated. We can find statements as: *The salary for farmers ranges from 40 USD to 200 USD per month.*[12] or *Chinese worker earns 56 [USD] cents per hour* [15]. We will try to elaborate rough estimate, by supposing that work farmer needs to be about as qualified as low-end manufacturing worker.

The hourly manufacturing wages of worker in China are roughly 0.81 USD [27] Further on we suppose, that farmer's wage should be slighly lower. This

sults, and showed RMT^P even less significant (p-value 0.16). We rather chose to examine logarithmic one, whose parameter size is easier to interpret.

[25] In fact we did not. Our finding of unrelated P and Q might be as well interpreted using flat demand - which is unreasonable because since there are no increasing marginal costs of Gold production, such market would have degenerated into some monopoly or oligopoly structure. Other explanation could be supply and demand jointly shifting in either horizontal or vertical direction - which seems really complicated. Therefore we conclude, that from these options, flat supply seems most plausible.

[26] Including customer support and in-game Gold delivery

[27] It is difficult to obtain reliable data regarding labor market in China. This figure has been estimated as follows: [1] records the year 2002 average hourly wage in China's manufacturing

is because of better nature of job - it intuitively fits that farmers themselves view gold farming as very pleasant job. For example [2, 154] even considers pleasure from the game to be in fact part of farmers reward as follows: Total Compensation = wage + fun. From theory of compensating wage differentials it follows, that farming should be paid below average manufacturing wage, say 0.7 USD.

Further on we assume that productivity of worker fully devoted to farming might be about 100 Gold per hour - which is my conservative estimate based on various gold making guides such as [**?**], and own experience. Now, we get that costs of farming for 1000 Gold are $0.7 * 10 = 7$ USD. Currently Gold sells for 13 USD in average, so we see that farmer wage may account for roughly half of total Gold costs. Since we argued, that this estimate should tend to undershoot total fraction of production costs in yuan - we may view our simplifying assumption as plausible.

Gold price level After small roundabout, we can return to main question of this section - determination of in-game prices. We already saw, how yuan denominated price of item is determined by its production costs. If for example one worker is able to produce 5 Iron ore per hour, and his hourly wage is 10 yuan, then price of Iron ore should be roughly equal to 2 yuan. Its price on AH will be as stable, as competitive is Iron ore market. If Iron ore is one of many items, that Gold farmers typically produce for profit, then variance of its price will be very small. The stability of prices is again achieved through mechanism - if Iron ore is undervalued, farmers start looking for more profitable production, and reduce supply till price returns back to equilibrium.

So far, we have made no clear assertion regarding Gold denominated prices with RMT, but the reasoning is quite straightforward. In this chapter we assume stable Gold - yuan exchange rate RMT^P. So the Gold denominated prices can easily be computed from yuan prices. Before we will release this simplifying assumption (under which we are able to explain cross-realm differences, but not time trends in equilibrium in-game price level.), we will provide an empirical proof of proposition 2.3 in form of slightly altered regression we already used in (4):

$$MPI_{T,R} * RMT^P_{T,R} = \alpha + \alpha_R + \beta_1 T + \beta_2 Patch \tag{7}$$

Only term which changes is the response variable - which is multiplied by (cross-seller)average yuan spot RMT price at given realm.

sector as 0.57 USD, while averages in various subsectors vary from 0.41 to 1.47 USD / hour. From [20] we know, that from 2002 to 2006, Chinese average (yuan-denominated) manufacturing wages rose by 75%, while yuan appreciated against USD from 8.3 to 6.8 CNY/USD. Altogether, this gives us very crude estimate of $0.57.1.75.\frac{6.8}{8.3} = 0.81$ USD per hour.

Parameter	α_R	T	$Patch$
Coefficient	-20 to 9	-0.02	-12.95
P-value	6 of 10 significant	0.74	0
N	330		
Adjusted R^2	0.71		

Here we finally see that time trend is not significant, as proposition 2.3 predicts. Even though we saw time trend in original price index data, it was probably offset by opposite development of RMT price. Further we should notice, that even without significant time trend, we explained 9% more variance of response variable than in earlier regression (just by server and patch dummies!). This leads us to surprising conclusion, that by multiplying in game price index(MPI) by RMT exchange rate we *reduced* its realm-specific variance, leaving larger proportion of cross server variance, that is explained by dummies. In other words we came to most interesting finding, that price level on each realm is more stable when denominated in yuan, than in Gold. Question of factors determining Gold prices are addressed next chapter.

3 Inflation in World of Warcraft

In previous chapter we have closely examined, what mechanisms keep WoW economy in given equilibrium. We have barely touched the question how such equilibrium is determined, by broadly stating that is is a matter of player preference. In this chapter we are about to address this topic much more deeply - we shall try to show, that equilibrium price level is heavily affected by degree at which RMT occurs on given realm[28]. In particular we will show, that EUR/CNY exchange rate affects in-game price level through RMT demand. In the end we will deny popular opinion that Gold farming itself causes ongoing inflation in WoW.

RMT supply determination For our analysis we will use one crucial proposition, which is a consequence of our previous argumentation regarding perfect competition on RMT market. We already know, that farmers mainly obtain their Gold through selling goods at AH. Then, the mean hourly Gold production of average farmer is determined *only* by game mechanics and price level[29]. Finally on perfect RMT market, price is driven by unit production costs. Which has one very useful implication:

Proposition 3.1 (RMT price determination) *Supply-determined yuan/Gold price on RMT market is a function of game mechanics, in-game price level and (yuan) farmer wage. In long run it increases with wage and falls with price level.*

[28] Which is no deviation from earlier proposition of equilibrium determined by player preference. Recall that intensity of RMT is determined by transaction costs TC, given by objective conditions *and* player preference.

[29] We no longer account for differences in player abilities, which do not matter in aggregate.

Note that this proposition can go both ways - once we confirm idea regarding relation between price level and RMT price, we can backwards approximate price level from RMT price. Though we cannot suppose that there is some one-way causality between those; for sure the link $P \Rightarrow RMT^P$ is given by farmer productivity. However, if (as we argue) RMT has significant effect on WoW economy of yet unknown direction, then it could backwards affect its price level. In short - these two variables are tightly linked together. Although they might be both endogenous and mutually affect each other, it is their close co-dependence which will be most useful in further analysis.

3.1 Quantity theory of money revisited

So, what should be overall effect of RMT on WoW economy? Before we start with empirics, we should check what theory implies. Again, our price formation predictions will be based on quantity theory of money, for the same reasons like in previous chapter. The fact itself, that some of players are farmers, and that they collect fees *outside* of the game does not collide with any of our earlier arguments. Transfers of Gold alone do not tap any sources nor sinks - so why should they affect G/g and equilibrium price? But this is not whole picture. We need to be aware, that Gold farming can induce behavioral changes at significant number of players, so it can can seriously affect whole economy. To formulate it in our earlier terms: RMT causes change of population distribution. Consequently player preference regarding G/g production ratio gets somehow skewed. For long run equilibrium price level this implies nothing else, that it might change (in both directions) when RMT activity increases.

So, how does population with farmers differ in play style from one without them? This question obviously does not regard only Gold sellers, but also its buyers [30] - who might also behave differently than average player (group 2 = not-buyer,not-seller). Now we will examine activity of both, and try to argue in what direction and time frame they might affect G/g ratio of Gold and goods in economy - which according to QTM determines price level.

Gold farmers typically do not tap wide variety of Gold sources nor sinks. Their production regime consists mainly of looting and gathering - which, as we know, brings into economy both Gold and goods at ratio defined by Blizzard. Such ratio can slightly differ, by concrete type of activity, however no serious deviation from other population G/g can be expected here. More important is what the farmers don't do - they probably do not do much quests ($\Rightarrow G \searrow$), they do not excessively consume goods to gain advantage against other players ($\Rightarrow g \nearrow$), they do not level - since they are already on level 80 ($\Rightarrow G \searrow$) and for sure they do not spontaneously consume ($\Rightarrow G \nearrow$), or engage in PvP (player vs. player) combat - which brings only repair costs ($\Rightarrow G \nearrow$). Possibly most significant effect might have their AH activity. They sell largest deal of their production on AH and possibly also speculate a lot, throwing much Gold into

[30] These are groups 1 and 3 from previous chapter. Most probably the population of buyers (group 3) will be larger than one of sellers (group 1), but inversely farmers will be more economically active. Hence we should suspect that both groups behavior changes are relevant.

5% tax sink($\Rightarrow G \searrow$). So, the overall effect of Gold farmers activity on G/g is rather inconclusive.

The intuition regarding **Gold buyers** is a little more straightforward. They don't farm, but rather play PvP and spend Gold. From previous chapter we know, they are possibly those with high opportunity costs, so they should try to save time on behalf of Gold spendings - buying expensive items at AH (instead of waiting for better price $\Rightarrow G \searrow$) and using public transport ($\Rightarrow G \searrow$). Generally they will most probably choose more Gold consuming play style, since they can afford it once they have open RMT channel of income. These players will most probably shift G/g ratio towards goods, hence cause deflation.

To sum it up, Gold production may theoretically affect G/g ratio in both directions, as argued for example here [27]. We might rather support hypothesis of deflationary long run effect of RMT, but such conclusion would be too weakly justified. We would need quantitatively analyze usage of sinks and sources to give better prediction, but data for that are not available. Instead of analyzing its parts, in following section we will try to directly measure overall effect using data we have - from RMT market. Before we do that, we should also give reader few ideas about adjustment process whose speed shall play important role in further analysis, as we need to know how seriously lagged variables to introduce in our regressions.

Adjustment process Short run analysis of RMT effects is perhaps even more complex than long run, we present only a simple suggestion how it might go. Supposing that farmers have some Gold reserves (which are for security reasons not large, as we argued earlier), we will consider those as outside of economy - because they don't circulate, hence they don't affect prices through QTM. When some positive RMT demand shock occurs, these reserves diminish - they are sold to players, released into economy ($G \nearrow$). Within following hours or days farmers increase their activity temporarily to replenish stock, or permanently - if the demand shock is permanent. What does this imply for price level? In short run after an inflow of G we should observe increase in P. But this effect is reversed in medium run - as farmers again move similar amount of G from economy to their stock. Before that happens, high price level causes more Gold to be washed in sinks (see self-regulatory mechanisms in previous chapter), so when farmers get to original reserve stock of Gold, G is already below original level - which implies deflation. With deflated prices, Gold farmers find it harder to produce further gold and RMT^P moves up. So does the RMT demand for deflated (hence more valuable) Gold - so direction of change in RMT^Q is inconclusive - and so is the second shift in price level. Changed price level again through same channels affects both RMT supply and demand, and vice versa. Because we did not observe RMT^P seriously oscillating, we suppose that finally equilibrating mechanisms start to work, RMT^P and P move back to old equilibrium (or to new one, if original demand shock was permanent).

We should observe the first part of process within hours or days - we saw that internal WoW markets adjust very quickly. Yet the horizon in latter part

is more unclear - it depends on length of Gold supply chain (how long it takes before change in price level manifests in RMT supply price), and response of RMT demand (how quickly do players realize that price level changed, and adjust their Gold demand). Anyway, from above it is perhaps reasonable to suppose, that any adjustment of WoW economy should take no longer than few months, so that even in our relatively short datasets (daily, from 1 month to 1 year length) it seems legitimate to look for signs of equilibrium. In general - once we will have rough idea regarding speed of above described convergence we will abandon analyzing this complex phenomenon and focus on long run equilibrium, for which only the G/g ratio matters.

3.2 Two puzzles

Provided that increasing population of farmers shifts G/g ratio, thus also the equilibrium, we have an additional interpretation for distribution of equilibrium price levels among various realms, that we saw earlier: the price level could indicate how serious is Gold farming on given realm. Before we start to look more rigorously for scale, and more importantly even direction of such RMT effect, let me present two stylized facts, or say puzzles, which we will try to answer in this chapter:

Emerald Dream puzzle When we look again at figure 1 and table 2.2, we see that even though our data passed normality tests, there is one realm with considerably lower price level - Emerald Dream. Its deviation can of course be result of random effect, or the population preference may simply imply different G/g equilibrium. However this realm has reputation of being heavily leveraged by Gold farmers [29]. This is also confirmed by our Swagvault data, which reports second largest sales on Emerald Dream. Then also, perhaps not surprisingly, Emerald Dream has highest average RMT price reported by Swagvault - which by the way supports our Theorem 3.1.

Such observation is puzzling - especially when we compare them to Blizzard's claim [21] or other sources [12] stating that Gold farming causes inflation. Our "evidence" suggests quite the opposite. On the other hand, there is no discussion about fact, that last years saw rise of Gold farming, and many players report that prior to our relatively short observation WoW realms really experienced long ongoing inflation - which rather seems to support Blizzard's statement. So, what is the real cause of inflation in WoW?

Swagvault puzzle In one of my early RMT market examinations I tried to estimate RMT demand elasticity by following regression. Idea was simple - Gold suppliers bear almost all costs in yuan. So, when we consider increase in CNY/EUR exchange rate, in our simple *yuan denominated* RMT market model, supply should not shift as production costs in yuan still remain same. Yuan denominated demand should move upwards, because European buyers are suddenly endowed with larger purchasing power. Then the quantities sold should increase as well. However, my results were quite opposite:

$$RMT^{Q}_{T,R} = \alpha + \alpha_R + \beta_1 FX_T + \beta_2 Patch \tag{8}$$

$RMT^{Q}_{T,R}$ is quantity sold by Swagvault company at time T on realm R, FX_T is spot CNY/EUR rate and rest are usual dummies for specific servers and game patches.

Parameter	α_R	FX	$Patch$
Coefficient	-4000 to 16000	-6000	-1100
P-value	7 of 15 significant	0	0.01
N	1097		
Adjusted R^2	0.64		

We see that volume of Gold sold actually declines with strengthening euro - which is quite strange. For that we may think of two possible explanations. First, there is inferior goods hypothesis, that European consumers endowed by larger purchasing power decided to buy less Gold. However such explanation seems highly unlikely - there is no economic reason for supposing that Gold is inferior. But when sticking to our hypothesis of flat supply curve and very natural assumption of downward sloping demand that shifts right with increased endowment, we are left with only other explanation - that even though demand shifts right as we supposed, supply also shifts - upwards, to more than offset shift of demand in terms of quantity sold.

Only reasonable explanation of such movement might be found in Theorem 3.1: increase of in-game price level. But through what channel does increase in demand change price to such high degree?[31] So, neither the second of our alternative explanations seems much plausible - it would require the FX to have very strong leverage on in-game price level.

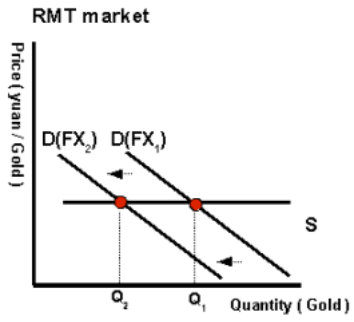


Figure 3: Gold as inferior goods

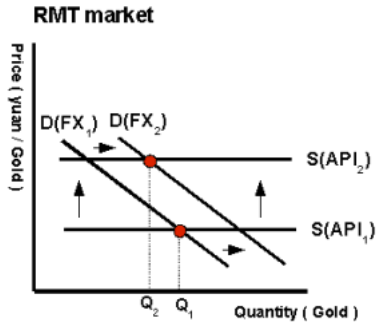


Figure 4: Price level shift

[31] -6000 parameter means, that on average server with daily 30.000 Gold sales fall of volume by 20%, in response to 10% FX shift. Because farmer's productivity is almost linear function of price level, the price level would need to shift by more than 20% supposing that RMT demand is unit elastic.

3.3 Effect of FX

The trouble with RMT market analysis is endogenity of practically all variables we can observe. Like we saw in Swagvault puzzle - we cannot deny possibility, that endogenity of supply curve completely reversed effect, we were looking for. This is the reason, why this work heavily relies on FX changes, which are clearly exogenous[32], but possibly very relevant for WoW economy. So, before we shall examine RMT market in closer detail, it might be useful to run simple regression showing how FX and in-game price level are related. Even though this will not tell us much about actual working of RMT market, we will at least get result unflawed by possible endogenity, telling us roughly what the demand shock on RMT market does to WoW economy.

$$API_{T,R} = \alpha + \alpha_R + \beta_1 FX_T + \beta_2 FX_{T-7} + \beta_3 FX_{T-30} + \beta_4 FX_{T-60} + \beta_5 Patch \quad (9)$$

$API_{T,R}$ is average price index at time T on realm R, FX_T is spot CNY/EUR rate and rest are usual dummies for specific servers and game patches.

Parameter	α_R	FX_T	FX_{T-7}	FX_{T-30}	FX_{T-60}	$Patch$
Coefficient	-0.3 to 0.08	-0.007	-0.18	0.16	-0.1	-0.23
P-value	9 of 10 significant	0.92	0.002	0	0.08	0
N	330					
Adjusted R^2	0.76					

First thing we look for here, is the long run effect of FX change (sum of all FX parameters) on price level API, that results in -0.13. This is good result - it shows us that *appreciation of EUR actually causes deflation in WoW*. When re-considering Swagvault puzzle, this indicates that price level shift explanation might be the right one. Also the numerical result is quite close - in our rough footnote computation we were suggesting that -0.2 shift would be needed, which was merely an approximation based on (unproven) unit elasticity assumption.

It is natural to suspect that parameters of highly correlated FX lagged variables might show false significance by jointly fitting on some random fluctuation, and canceling out in long run - which could seriously distort resulting image of both adjustment process directions and scale (however they should not much change the overall effect). In many slightly altered regressions, we really observed such parameter behavior, and reported one of more conservative results. But still, the scale of each single parameter should be taken just as approximation. Surprisingly reliable was the stability of signs of parameters - showing repetitively pattern of sharp decline in FX_T or FX_{T-7}, rebounce in FX_{T-14} or FX_{T-30} and small but very significant fall in FX_{T-60}. This was the case even if we omitted one or more parameters, to prevent the mentioned joint fitting.

[32] Not even author is optimistic enough to suppose, that economy of virtual worlds might affect some real exchange rate.

Result presented above is kind of median representative of many models tried - after all we used 60 days long time frame of FX to explain observations of price levels over 33 days, which is far from ideal. However during regressions it showed up, that 60 days long frame really is needed - results using shorter FX data were even less stable, with aggregate effects moving between API (and also MPI) -0.5 and 0.1. Such high variance was most likely caused by capturing different stages of adjustment process. So we can conclude, that 60 days is perhaps reasonable scope for examining adjustment of WoW economy - but we would possibly need longer price level data to confirm.

RMT market Luckily we managed to obtain such data - using two panels from own 2009 measurement and 2008 data that was kindly provided by Goldbuster - German RMT company, we managed to get long time series of daily average RMT market prices. From proposition 3.1, we know that there should be negative nearly linear link between WoW price level and RMT prices. So, using our RMT data, we can possibly cross-check above result, regarding relation between FX and API, running very similar regression:

$$RMT_T^P = \alpha+\beta_1 FX_T+\beta_2 FX_{T-7}+\beta_3 FX_{T-30}+\beta_4 FX_{T-60}+\beta_5 Patch1+\beta_6 Patch2+\beta_7 Patch3+\beta_8 Patch4 \tag{10}$$

$RMT_{T,R}^P$ is average price of Gold at time T denominated in yuan. FX_T is spot CNY/EUR rate. Then there are four dummies controlling for patches (they are zero prior to patch and one after patch). These patches are 3.0.2, Wrath of The Lich King expansion, 3.0.9 (jointly with 3.0.8 - these two came in 20 days, so their adjustment processes probably merged together), and 3.1.0.[33]

Parameter	FX_T	FX_{T-7}	FX_{T-30}	FX_{T-60}	$P1$	$P2$	$P3$	$P4$
Coefficient	-0.4	14.1	-24	23	33	-15	-39	-2
P-value	0.9	0.004	0	0	0	0	0	0.6
N	213							
Adjusted R^2	0.83							

Again - first we check long run effect of FX rate shift, which is 12.7. In late April 2009 (middle time of our Price level observations) mean yuan price of Gold was about 90, so the estimated effect of unit euro appreciation accounts for 14.1 % increase in RMT prices. Through proposition 3.1 this confirms both sign and size of our earlier estimation of long run FX effect of in-game price level (and reversedly also serves as strong support for proposition itself). When looking at both long run effects of FX (14.1% on RMT^P and -13% on API), we may further extend proposition 3.1 by setting an approximative rule of thumb that ceteris paribus (when worker wage and game mechanics dont change), there is negative *linear* relation between those two:

[33] We controlled only for patches that are claimed to be major. For all patch details and release dates see [**?**].

$$\Delta log(API) \cong -\Delta log(RMT^P) \tag{11}$$

Also the single parameters seem quite consistent with time pattern we saw in API price level index adjustment. There after hypothetic appreciation of euro we saw a short run downward spike, which was almost offset in 30 day horizon, then finally in 60 days price level moved to new, slightly lower equilibrium. Our theory implies, that RMT prices (reflecting production costs) should after initial shock caused by shift of demand move with slight lag behind API this trend in inverse direction suggested by our new rule of thumb. This is what we may actually see in data - after initial spike (caused possibly by both initial demand shock, and consequent deflation), RMT^P adjusts to new equilibrium. Here the most significant portion of adjustment takes place in last 30 days, which was not completely the case of API. The possibility of longer RMT market adjustment was already suggested in 3.1.

What our theory did not fully predict is the temporary decrease of RMT price *below* initial level (although we did not see similar behavior of price level, which our rule of thumb would require). The most apparent possible explanation is, that we have not fully captured API adjustment pattern by our sparse (0-7-30-60) set of lagged variables[34]. There could also be numerous other explanations regarding sloped short-run supply curve, buyers and sellers adjusting money reserves after deflationary spike, and notably also our short-run RMT^Q indeterminacy caused by endogenity of both RMT supply and demand. We will not examine those, as details of adjustment process are out of scope of this work.

3.4 Causes of inflation

In previous section we have shown that WoW price level is heavily leveraged through RMT market. There are four exogenous factors determining RMT market and consequently equilibrium of in-game price: player preference ($\Rightarrow$ RMT demand), CNY/EUR exchange rate ($\Rightarrow$ RMT demand), Chinese worker costs ($\Rightarrow$ RMT supply), and game mechanics ($\Rightarrow$ both supply and demand). Apparently player preference is only non-objective of those factors, so it is perhaps the determinant of different equilibrium price levels across realms.

Answer to Emerald Dream puzzle In the end our answer will only extend original very general proposition 2.1, stating that differences in long-run equilibrium price levels are caused by different player preferences. Our extension will be following: it might be useful to distinguish between preferences related to game itself (directly affecting price level through G/g ratio), and preferences related to RMT (namely transaction costs TC determining size of group 3 - number of Gold buyers). Both of these most probably affect price level, and

[34] Again this is a problem of short data, we would possibly not do any better with unreliable results of overspecified model such as (0-7-14-21-30 etc.)

can cause cross-realm differences. But which of them actually is main cause of price level dispersion we observed in chapter 2?

Intuitive step to find out what fraction of price level differences would be regressing RMT sale volumes price level API on RMT^Q while controlling for realm with dummies. Then regression parameter of volume times actual volume should indicate RMT effect, while server dummy should stand for effect of in-game preferences. This approach *would* be plausible, if RMT^Q was exogenous. But since both RMT supply and demand are functions of API, this is certainly not the case.

There is not even way to use some instruments for RMT^Q such as FX, because we earlier saw, that it affects to API and hence also to RMT supply. What we can do, is just to provide most intuitive answer on our puzzle: from studying FX shifts we know, that higher RMT demand ceteris paribus leads to lower price level and high RMT prices. Then again more as a rule of thumb than as a law we can propose that *Realm with higher average RMT price has probably higher demand for Gold on RMT market.* This says nothing else that both low price level and high RMT prices at Emerald Dream indicate, that it's economy is indeed heavily leveraged by Gold farming activity.

Long run inflation Using development of three objective causes of inflation mentioned above: Chinese worker costs, CNY/EUR exchange rate, and game mechanics, we will be much more successful in explaining long run trends jointly working on all realms. We earlier quoted Blizzard website, claiming that inflation is caused by Gold farmers - but this is far from being true. In fact quite the opposite might show reasonable - as much of our evidence suggests, Gold farming itself actually *decreases* price level.

However, over last eight months (09/2008 - 05/2009) average RMT prices for 1000 Gold have decreased from 130 yuan to 80 yuan - which by our rule of thumb implies Gold inflation of 38 % (so our theory confirms that player's complaints and Blizzard adressed issues of Gold inflation have solid reason). How might we explain that? When we look back at our estimate (11) we may actually use it for explaining such movement.

In the same period CNY/EUR rate has fallen from 10.9 to 8.9, which implies $-2 * 12.7 = -25.4$ decrease in RMT price. When we further add up all patch dummy parameters we get another -23 shift. Together this results in RMT price shift of 48.4, that is by rule of thumb Gold inflation of 37 %, which is quite close to inflation which we wanted to explain. Such result however has at least two flaws: firstly we have not accounted for worker wage, supposing that it did not change significantly over 8 months (if it did, it might have caused bias of our estimates). Secondly eight months is enough for change of population preference - or even for change of population structure. But when supposing that number of Gold buyers increased (which is much more likely than the oposite), we know that this would actually push the inflation *down*, so we would only underestimate effect of FX and patches.

We may therefore conclude that the most possible causes of observed in-

flation in World of Warcraft were Blizzard patches and yuan appreciation. Gold farming played the role in it, however only as a channel through which CNY/EUR rate changes translated into WoW economy. By itself the Gold farming actually pushed price level down. The only way how could Gold farmers drive inflation up is by stopping their activity. [35] Hence Blizzard either makes mistake in its official statement, or more likely it willingly promotes it's anti-RMT policy by accusing farmers of causing inflation (one half of which is by irony caused by patches from Blizzard itself).

4 Artificial scarcity

In previous chapters we saw, that 3 of 4 patches issued by Blizzard caused inflation of Gold. Also we saw that prior to patch, price indices spiked up - possibly because of inflationary expectations of players (caused by experience from previous patches). From these two observations we will induce conclusion that Blizzard patches generally do cause inflation. What is the motivation for such behavior - for destabilizing own economy? In this chapter we will present a microeconomic model, which tries to explain such behavior of inflating own currency - or rather of deflate costs of all its other products - virtual goods).

Before we get to the model, there is one more thing to be made clear - what does really happen during these inflationary patches? Importantly, the G/g production ratio does not change much, and if it does it is not major source of inflation - we will assume it does not. What patches basically do is, that they extend the high boundaries of productivity. This happens for instance by introducing new, stronger items, or even more fundamentally by increasing the level cap. With that new equipment or higher level, characters naturally become more productive - in one hour, they are able to gather more resources and loot more monsters - so that both more goods *and* Gold enter the economy. So far we see no inflation, only the economy "grows".

What happens next is crucial to us - one character needs one weapon, one shield, one pair of boots etc. When new and better items appear on market, value of old ones diminishes. Suddenly mote goods is rendered useless, and is sold to vendors. Notice, that this is not a one-off shock but a permanent trend, since old items types, which are no more valued at AH, keep appearing during standard farming. Many similar mechanisms which we won't mention work in this direction - core information is that after patch, mean production time of items decreases, but also more Gold starts appearing in economy. Some items are sold, Gold stays in circulation - and price level in Gold increases.

How is it with price level in *yuan*? For convenience we recall our earlier pricing equation determining absolute price of goods in yuan:

$$P(G) = \frac{1}{0.95} \sum_{i \in I} t_i (C_s + C_o) + \epsilon \tag{12}$$

[35] This is further supported by known fact, that when Blizzard bans larger number of Gold farmer accounts at once (because of anti-RMT policy), prices most typically spike up.

We know that t_i decreased, other factors did not change - after patch, yuan denominated costs actually decrease (offsetting inflation, as we know from our rule of thumb). So even though we earlier saw and discussed inflationary patches, we actually see they are inflationary only in terms of increased Gold availability, but through decrease in t_i they actually increase availability of items (through both own farming or RMT purchase) too.

4.1 Blizzard's profit

We can simplify our view on WoW economy to a market, where virtual goods are sold to players for real cash. To realize this we should examine the C_s term from our pricing equation. The time spent in game is in some sense costly. With given monthly playtime, player pays for each hour appropriate part of it - to Blizzard. Since part of the playtime players spend by obtaining needed items or Gold, we may say that they in fact purchase them from Blizzard for costs of $t_i * C_s$ (plus they bear the opportunity costs, which are now out of our interest). The fact that players pay *fixed* monthly subscription and not for actual playtime only obscures fact, that for producing an item each player pays some small fee to Blizzard. That fee is of course variable - if the production time of item is for simplicity an hour, and player plays WoW T hours a month, then fee he pays for producing each item is C_s/T.

Now, what happens, when RMT farmers come into game? Their playtime T_F is supposedly very high, so that fees which Blizzard receives from them C_s/T_F per produced item are lower - which should not matter, as they produce more items. However, they do not consume those items, they cheaply sell them through AH to other players - who otherwise would have produced them themselves. So how does actually Blizzard lose money through this channel? Thanks to farmers, players can faster level-up, get more easily to some desired game achievements etc., so in the end they actually cease playing (and paying subscriptions) after shorter period of time. However elaborate and synthetic our model may seem, it well reflects at least this dimension of gaming, and actually justifies why Blizzard should struggle to reduce Gold farming - in order to sustain own profits. We will return to this later.

More importantly this approach of Blizzard "selling" virtual goods will help us to explain its motivation for issuing inflationary patches, using an microeconomic model. Before we do that, we need to realize one key fact about virtual goods - the relative nature of its utility.

..but the satisfaction of that [gaming] experience can be significantly lessened if one observes that other players, who ought to be poor like oneself, are instead very well arrayed in expensive equipment that they bought for hundreds of dollars outside the game[3]

The game of WoW (and many other virtual worlds) is in fact a sort of red queen race. The purpose of most important items which player needs, is to outperform other players. Intuitively - if all players get better swords, no one

of them is better of when they start fighting against each other.[36] To put it in more economic terms, each good creates a negative network externality. The utility from a sword heavily relies on what other swords are out there.

A reader who is not familiar with virtual economies should rather imagine markets with fashion products, or high-tech consumer electronics, or perhaps even money. Great deal of their utility lays in fact that they are scarce. Even though marginal production costs of those goods is close to zero, the demand for them is largely driven by *the fact itself, that they are scarce.* This is typically caused by decision of their manufacturer, who maximizes profit by somehow adjusting price of his product to keep network effect low. Further on we will call such behavior an inducing artificial scarcity - which means, that monopoly producer of a good willingly keeps it price high perhaps even above standard monopoly price, in order to maximize long-run profit while taking into account the negative network effect.

4.2 Defining the problem

It is not unique to virtual economies, that some producers can create goods with positive value [37] at zero marginal costs. After covering initial investment, they could possibly flood the economy with their products at price close to zero, however they don't do so. Since their markets are always in some sense monopolies, they maximize revenues by keeping price high, like in classical microeconomic examples.

Under certain circumstances, a monopolistic producer of good may find optimal to create what we call Artificial scarcity of goods, that is to deliberately reduce amount of goods sold way below presumable short run competitive or even monopoly optimum. Such behavior may seem irrational, but as we will see later, it only just follows from little bit more sophisticated approach.

Now we will propose simple microeconomic model, to illustrate motivation for such behavior. As I believe, it may provide some insight in analysis of other markets, however there seems to be no clearer example of such market setting, than virtual goods markets.

There are two very distinctive assumptions in the model – we already mentioned zero marginal costs of production, but the second one is slightly more complicated. First we will denote stock of goods present in economy as S_t. That is goods, which has already been sold and is being consumed in period t.

$$S_t = \sum_{j=0}^{t-1} Q_j.d^{t-j} \text{ where } 0 < d \leq 1$$

[36] Similar, but slightly more complicated is the need of equipment for activities where players fight together against game environment. It is because their utility here still derives from how well do they do compared to other teammates.

[37] That means there exists at least someone willing to pay for the goods.

Here Q_j stands for amount of goods sold in period j, and d for durability of goods. Each period, fraction $1 - d$ of goods is destroyed. Apparently for $d = 0$ all goods are destroyed immediately after consumption, conversely for $d = 1$ the good is perfectly durable, and each piece of it can be used indefinitely. As we will see further on, latter is not as academic case as it may seem, and will have some implications for our subject of study.

We further on assume that market with our good emerged just in period 0, and is running till presence – that is till period t and further on. There was no initial stock of goods, that is $S_0 = 0$. For quickly emerging (and deteriorating) markets which we study this assumption of given starting point is quite realistic.

Now we can move on to our second core assumption, which states that demand shifts over time based on quantities sold in previous periods, and also autonomously deteriorates.

$$D_t = A - Bp - Et - S_t$$

The somewhat strange S_t component has its roots in theory of relative utility. Consumers do perceive their utility relatively to other agents, and the amounts of good they consume. The more widespread is consumption of certain good the less individual utility it provides. It follows that consumers adjust their demand according to stock of goods present in economy.

It is a very natural property of network effect, that transfer of information across network is subject to some friction. Here the demand reacts to stock changes with one period lag. This follows from concept of bounded rationality – the individual makes his demand decisions on the spot, but amount bought (and consumed) by others is seen with delay. This delay is caused by decentralized nature of such information, preventing consumer from fully assessing own utility obtained from potential purchase.

With given demand and production functions [38] we may move on to producer profit maximization problem. Now we will specify the model again more precisely and try to obtain some form of solution.

4.3 Algebraical solution

First, we may define demand (hence quantity sold) as

$$D_t = A - Bp_t - Et - S_t,$$

[38] Production costs we simplify to zero no matter what quantity is produced. In our model we neglect initial costs as sunk, which means that they mattered in question of entering market, but not in price decision making, which is our main interest.

where

$$S_t = \sum_{j=0}^{t-1} Q_j d^{t-j},$$

and

$$A, B, E > 0,\ S_0 = 0,\ 1 \geq d > 0,\ Q_t = \max\{0, D_t\}\ \forall t.$$

Now we can define the producer optimization problem as maximizing total profit Π over all periods (assuming zero interest rate for simplicity).

$$\Pi = \sum_{t=0}^{\infty} Q_t p_t = \sum_{t=0}^{\infty} Q_t . \frac{-Q_t + A - Et - S_t}{B}$$

Here $p(Q_t)$ was easily derived from demand equation. Now we differentiate to obtain first order conditions, which we will use for examining properties of solution (which is some sequence $\{Q_t\}_0^\infty$ maximizing producers profit).

$$\frac{\partial \Pi}{\partial Q_t} = \frac{1}{B}[-2Q_t + A - Et - S_t - \sum_{j=t+1}^{\infty} Q_j d^{j-t}] = 0 \quad \forall t \in N_0,$$

which can be further simplified as

$$Q_t = A - Et - \sum_{j=0}^{\infty} Q_j d^{|j-t|}\ \forall t \in N_0.$$

Now, using assumption $E > 0$, it can be easily shown from demand equation, that for each optimal solution $\exists k \in N_0\ \forall t > k\ : Q_t = 0$. Furthermore we may choose such k that $\forall t,\ 0 \leq t \leq k,\ Q_t > 0$

By assumption used above, we in fact only eliminate (for us yet not so interesting) possibility of $E = 0$, that would bring us closest to standard monopoly model. It results in some infinite horizon optimization which would be complicated and completely unrelated to dynamic (and short-lived) markets, we are trying to analyze.

Now our model degenerates into set of k linear equations with k unknowns, which is still difficult to solve[39], but algorithmical solution exists. We however

[39]Main difficulty lays in fact, that although we know that k exists, it is still unknown. After it is found, the easy linear algebra results in unique solution $\{Q_t\}_0^k$. In special cases it may also result in no solution, or infinite set of solutions. Possibly it can be shown that under our conditions this may never happen, however this is beyond authors mathematical skills - and beyond scope of our interest, as such case would probably have no economic relevance.

don't need to obtain exact solution, in order to derive some economic implications.

The first important finding is the existence of such solution itself. Optimal behavior of producer is a *finite* number of steps in which he sells *finite* stock of goods. Then he exits the market since demand becomes zero or negative. By plugging our results into demand equation we can derive our desired conclusion about producers price setting behavior.

We will now plug our result

$$Q_t = A - Et - \sum_{j=0}^{k} Q_j d^{|j-t|} \ \forall t \leq k,$$

into demand equation for D_t, since we know that $Q_t > 0$ hence $Q_t = D_t$.

Now from

$$A - Et - \sum_{j=0}^{k} Q_j d^{|j-t|} = A - Bp_t - Et - S_t,$$

we derive surprisingly simple equation

$$p_t = \frac{\sum_{j=t}^{k} Q_j d^{j-t}}{B}.$$

In case that we employ our optional $d = 1$ assumption, we get

$$p_t = \frac{\sum_{j=t}^{k} Q_j}{B}.$$

We can now compare our result for p_0 with plain monopoly price, which the same producer would have chosen, if he did not regard future demand development. This is standard microeconomic outcome, computed as follows:

$$\Pi = (A - Bp)p$$
$$\frac{\partial \Pi}{\partial p} = A - 2Bp = 0$$
$$p_{plain} = \frac{A}{2B}, Q_{plain} = \frac{A}{2}$$

Now we shall compare this outcome with our results. From the first order conditions we know, that

$$Q_0 = A - \sum_{t=0}^{k} Q_t,$$

from which it follows that if $k > 0$, then

$$Q_0 < Q_{plain} \text{ and consequently } p_0 > p_{plain}.$$

4.4 Model implications

Our result is in fact quite intuitive. Producer takes into account, that by supplying product to market he undercuts his own future demand. Hence he tends to reduce sold quantities (= to overshoot prices), compared to classical monopoly benchmark. The main message of this example is, that such behavior follows from relative utility driven demand. Even though a good has zero marginal cost of production, seller releases it deliberately at very low quantities, in order to make this costless good artificially scarce. Scarce good is from consumers point of view very valuable and he is willing to pay high prices for it.

From final equation for p_t with $d = 1$ we see, how producer gradually reduces prices. The stock of goods in economy builds up, and the good looses its value from consumers point of view. This would in fact happen even in case when we released our assumption and set $E = 0$, however it follows from the first order conditions, that producer would reduce price at infinitely small steps. [40] Such outcome would possibly be eliminated by introducing interest rate, and discounting of future incomes into model. The possible outcomes can be seen from figures Figure 7 and Figure 8, where behavior of producer under different time horizons E is demonstrated.

Artificial scarcity and WoW Now we will examine the link between Artificial scarcity model and our main topic - WoW. Not to be misunderstood - purpose of this quite general model was *not* to sufficiently describe actual working of virtual goods market in WoW. Goal here was only to point out a pattern according to which profit maximizing monopoly producer of good with negative network effect should behave. Introduction of this chapter should then be rather viewed as defense of my position, that Blizzard actually is such producer, than a good model for describing its actual market. The artificial scarcity model is perhaps general enough to give us idea also about behavior of other companies running virtual worlds - which may differ in many details, however key fact of monopoly producer selling virtual goods is perhaps common to all of them. Before we will move on to more general implications of our model, we should first examine more closely what does the model say about WoW.

The empirics are in accordance with model - since launching WoW in 2004, Blizzard released two major expansions, which both increased maximum level

[40] In fact, in such case our discrete model proposed above would collapse, and such solution would not be easily obtainable. However the economic intuition is clear - once the seller does not have to bother with autonomously diminishing demand, he slowly exploits maximal profit. Graphically represented, such profit would cover all the surface under initial demand curve just like in microeconomic model of perfect discrimination. Once $E > 0$ imposes time limit, seller hurries to capture autonomously diminishing demand, so he makes smaller profit, however in finite time.

and introduced new items, and we also saw that minor patches might have similar nature. By changing the game in such manner, the price of older items went down (in yuan, or time required for obtaining, not necessarily in Gold). With characters at higher levels, those items could be obtained more easily, so they became available to poorer players[41]. Newly introduced stronger items then took their place of luxury goods available only to top 10 % of players who could afford it - regardless whether through high in-game effort or RMT.

One could argue, that demand for old items fell mainly because new and better items got introduced - that is because of the patch and not the network effect, however this is not fully true. The demand for them would slowly fall anyway - either because taste of players for new experience (leading to player outflow from game, in terms of model $E > 0$), or because of market saturation (virtual equipment gets never destroyed, hence $d = 1$). By issuing an expansion Blizzard in fact both creates new monopoly markets, and performs price reduction strategy on old ones, in accordance with our model.

Evidently, game owners are dictators whose benevolence depends only on the constraint that they must remain profitable. This power structure has predictable effects. In every game currently on the market, the owners consider it their right to introduce changes to game mechanics at any time, without prior consultation with the players. As a result, avatars [=players] can have their real market value destroyed overnight, without warning.[3]

Up till now, we have considered producers of virtual goods to be monopolists. Although such view is valid (since no one else has control over production of WoW Gold), it might perhaps be useful to broaden our view for a while. We have already touched the issue above, when discussing parameter $E > 0$. There are more virtual worlds out there, and they should be seen as imperfect substitutes. Even though "migration" from one virtual world to other has serious costs in form of losing all virtual assets (which often needs not to be that painful, as previous paragraph suggests), achievements of given character and sometimes also need to purchase software license of other virtual world's client, such migration of players between various games is quite common phenomenon (and also most fertile ground for sociological studies).

In our model, producer sees the threat of losing players (hence consumers of virtual goods), which manifests in value E that corresponds to his subjective estimate regarding how long will it take, before all players will spontaneously migrate elsewhere. If this subjective perspective changes, producer consequently adjusts his pricing policy. Most typically operators of virtual world, which start losing population, tend to accelerate inflation (increase availability of virtual goods) - to maximize profit over shorter time frame than previously expected.

In contrast with that, we may study opposite case - that some producer of goods with negative network effect may see that there is potential for sustaining demand for it in long run. In my further research I plan to make further use of artificial the model by showing that when $E = 0$ and $d < 1$, the producer's

[41] By *poorer* we mean poverty in terms of Gold. However reader can easily realize RMT link to player's real world wealth.

optimization gets an infinite horizon, he actually might end up in *not* inflating own product. That means to keep the stock of goods in economy constant by selling $Q_t = S_t(1-d)$ each period. To put it in words: if an operator of virtual economy got more confidence that he is going to sustain demand for his virtual goods and/or virtual currency, he might have an economic incentive to keep its price constant.

4.5 From goods to currencies

In next chapter we shall try to expand one of most interesting consequences of possible sustainability of virtual economy. It lays in fact that currency of such economy may have potential to become real currency - in a sense that it could be used as storage of value, unit of account and means of payment - possibly even for real goods or services. From this starting point reader should be aware, that such discussion might not be that academic as it looks. Later on we will lay some evidence, that even today we already observe some small signs of such use of some virtual currencies (other than WoW Gold).

Although it may not seem so, this is no serious deviation from our topic. We deliberately studied in details markets for virtual goods and inflation of Gold, to get a solid ground for inducing more general theory about its value and sustainability. We shall use much of above, since it is not possible to study potential of virtual currency without having some knowledge of markets where it is primarily used - virtual economies.

We have already mentioned, that artificial scarcity model in some sense describes not only position of producer of virtual goods, but also of private currency issuer who is in surprisingly similar situation; the exchange value of his currency is very sensitive to its amount previously released into circulation, and more importantly - the his motivation to inflate is very much given by his expectations regarding future demand for his goods (currency).

Whether keeping the commitment [of price stability] in later periods is profit maximizing depends on the relation between the expected costs and revenue of inflating in each period. (...) It depends on his [issuer's] subjective discount rate, the real demand for the currency in each period, as well as the time issuer plans to stay in business.[9]

In this chapter I have perhaps been using a bit confusing terminology - first we saw "inflationary" patches, which actually caused decrease of some virtual items costs. We also spoke of inflating producer, who in fact only gradually reduced price[42] of produced good over time - which is hardly an inflation from any conventional point of view. Now is hopefully a little more clear what was meant - that by increasing volume of such good in economy, producer decreased its utility - through negative network effect. This then caused what inflation actually is - that exchange value of that particular good (or money) went down.

Now, when we will focus our view on currencies, the inflationary terminology will become more natural. For simplicity we shall further on assume that (unlike

[42] In WoW this price reduction wend through reducing farmer's mean production time of an item.

in WoW, where the inflationary process is of more hidden nature), the inflating behavior of virtual goods producer has purely monetary form. This means, that he maintains game mechanics, and fixed nominal costs in game, but he makes currency more easily available, which manifests in better affordability of other virtual goods he sells. Note that this also is the kind of behavior which we described by Artificial scarcity model, and that in real consequences it does not much differ from WoW patches we examined. [43]

[43] Cause of such inflation would be perhaps only be more apparent to players and might cause their unwanted migration.

5 Virtual currencies

In this theoretical chapter we will almost completely abandon case of WoW virtual economy, and will try to discuss general issue of virtual currencies - and their capability of overlapping into real economy. The argumentation is mainly based on Karl Menger's article Money[10], so let me first briefly sketch the parts which will be of our interest, namely those which regard the emergence of money. His analysis begins with movement from barter to money economy, further continues by describing competition between various forms of payment, and ends with usage of precious metal coins. The money is depicted as social institution; although physical characteristics of currencies (slaves,cattle,metals,tobacco) change over time, their one property is crucial: to accept them, individual needs to expect that they will be further accepted by others. That is, what makes money a social phenomenon, and that is why it's evolution is so complex.

As Menger stresses, *specific goods may function as money only in certain strata of country's population and even for certain transactions only [conjunctions removed].* In his view, on the very beginning of evolution of new currency there is just few individuals who find it convenient(or directly profitable) to use some commodity as means of payment. Only if the benefits of new payment method are strong enough to overpower Nash equilibrium of old currency, the social institution of new currency may arise. Consequently, only if advantages of this new currency are able to attract increasing mass of population, then it becomes money in sense of generally accepted means of payment. [44] For a commodity to become a currency, the most solid starting point is a large and stable market for its non-monetary use. Then, if it's other properties are convenient [45], it might *gradually* get accepted as means of payment in wider and wider parts of society, becoming generally used currency in the end.

Case of currency which has no inherent value (such as paper money) Menger treats only marginally, with general notion that such money must be either be redeemable for valuable commodity, or legally enforced. Thus we may think, his theory is of no major value, for today's reality. However, even though there are no direct implications, it is Menger's method and general view on evolution of money, which leaves his work unsurpassed for our purposes till today. [46] *Neo-*

[44] Reader needs not to confuse himself with definitions of money. The question of when some good becomes money is of little interest to us. Menger briefly answers it as follows: *Commodities that have become generally used intermediaries of exchange, if only within certain geographical boundaries, and possibly even within certain segments of population or territory, are called money in scientific usage.* In further text we will stick to this broad definition, which is suitable for evolutionary view on money, and which probably causes least confusion. Just note, that the term 'territory' is not to be taken literally, namely it may stand for real as well for virtual areas of economic activity.

[45] In ideal case, it is durable, divisible, transportable etc. However, as we know from classical Yap stones example, at least two of three mentioned properties are not really necessary. It is its general acceptance in trade, which causes good to become money.

[46] ..and perhaps also the fact, that 20th century was century of national currencies (as emphasized for example in [8].), which made the monetary theory swing into different direction. Although it might seem odd to base analysis of virtual economies on works from 19th century,

classical concepts focus on steady state equilibria, and fixed institutional setting. Thus they can hardly be employed for analysis of institutional evolution - which we see today in electronic payment systems.[10] Of course, there are difficulties to capture evolution of institutions in any model. In particular, Schmitz sees the most disturbing simplification of present theories in the perfect rationality of agents. Although Menger's analysis is frequently quoted in neoclassical papers [47], his key point is missing - that the acceptability of money stands on how agents form their expectations. The assumption that agents are endowed with some form of perfect rationality is simply misleading, certainly when institutional evolution is in question. Only a currency which is individually rational to accept (without prior knowledge of all other agents preferences) for some fraction of agents, might be successful. *Only a small fraction of population initially learns about different degrees of marketability [=to use money].* This comes from realistic thought, that under conditions of institutional evolution, the agents are generally not rational, and their information is not symmetric. *[Menger's] theory is grounded in the behavior of decentralized, self-interested, and modestly informed individuals.*[8] Advantage of Menger's 'model' is, that it does not require any Nash equilibria or collective action, for money to emerge. Notice that, in Kyotaki and Wright's model, money can never emerge from barter economy. [10] Apparently we should stick to Menger's notion of acceptance, because it is more useful for explaining actual evolution of money, in realistic world of decentralized information. Most typical example of such information needed to accept some commodity based money is a good knowledge of underlying commodity market. We are now going to argue, that such commodity might be virtual goods.

5.1 Virtual commodity money

Each money is in some sense fiat - one accepts it only because own expectation about future demand of other agents. In case of money type which is traditionally understood as fiat, the statement is obviously true, as the belief that others will in future accept the money is crucial for its acceptance. However, it is not so clear that the same holds for commodity redeemable money, where we need to go just one step further. Because it's acceptance has one additional cornerstone - the belief, that even if money will not be demanded by other agents in future, the underlying commodity will be.[48] There is common understanding that commodity backed money is of more solid and reliable nature. Apparently this is true only as much as solid and reliable is the demand for underlying commodity. To put this in other words, when deciding about acceptance of money, agent considers his chances to get some value back in future. When we set aside transaction costs, he is indifferent between getting it back through direct exchange

there is probably none more insightful theory available.

[47] For example the most of well known Kyotaki and Wright's model[7] is just formalization of Menger's ideas.

[48] We intentionally omit the marginal case, when agent accepts money and intends to consume underlying commodity, which is equivalent to directly buying commodity itself.

of money, or through redeeming money and selling the underlying commodity. Hence, although there are two forms of demand for commodity money (for its pecuniary and non-pecuniary use), only thing that matters to him in the end is an aggregate of both. When, in contrary, he considers whether to accept pure fiat money, there is only pecuniary type of demand to consider. Once we realize this, we know that we have no clue for a priori saying which type of money is better i.e. demand for which should be more stable. This is most possibly the reason why currently established currencies (which are fiat) should generally outperform any privately issued currency - even if it was redeemable for a commodity. The demand for pecuniary use of established fiat money is more reliable, than aggregate of both demand types for any newly issued commodity redeemable money. At least here Kyotaki and Wright do make a very relevant point. In most countries, current situation with one national currency in use is kind of Nash equilibrium. One would need to have serious incentive (such as hyperinflation) to start using other means of payment *for real transactions*, than official currency. Let me stress, that global occurrence of such incentive is quite unlikely in modern economies (especially today when there is rather a fear of deflation imminent). So, even if hyperinflation of some currency occurs, its users should much more likely switch in favor of other national currency, than of some new privately issued coin - simply because of higher reliability of its future demand.

Selgin and White argue that this is the case: *The forces of convergence that drove that evolution [of commodity money] strongly favor an established money over any would-be alternative.*[8] This conclusion follows from thought, that advantages of already established currencies maintained by agents who are not profit driven are so prohibitive, that they don't allow for any new entrants to the currency market. Establishing new means of payment would according to them need a *co-ordinated public decision, much like a decision to switch the side of the road on which we will all drive.*

Such statements about future direction of evolution are allays a bit tricky. They generally rely on author's experience and intuition, and are hard to dispute until proven wrong. I am certainly not entitled to challenge ideas following from experience of two renowned scholars on theoretical field. But, later on I will pose two recent examples, suggesting that no collective action is needed for establishing new means of payment - at least on some local markets. This in fact shows, that the hardest point of currency evolution in Mengerian sense - breaking of Nash equilibria, is not an unbearable obstacle for evolution of currency, as Selgin and White suggest. In other words, even under todays conditions of state monetary monopoly, some groups may find using new means of payment individually rational.

It is perhaps clear to which point we are heading - that virtual economies might serve as needed starting point for emergent currency. We may view their currencies as commodity based money, redeemable for *virtual* goods. By maintaining VE (without inflationary patches), operator guarantees availability of non-pecuniary use of currency, but much more importantly - by sustaining VE player base he also creates reliable demand of currency and enables its

"redeemability" through RMT.[49]

The problem here clearly is the reliability of demand for such money. We already discussed that nature of demand for virtual goods is unstable. We even proposed model that supposes only finite frame, for which such demand may be sustained and furthermore shown, that operator of virtual currency has serious incentive to inflate it. This implies that no agent should be willing accept such money, if he had possibility to use some real currency.

Only way out of here is possibility of long-term sustainability of VE (in model it is the $E = 0$ case), which would break issuers inflationary incentives. Yet this *is* an academic case. VE phenomenon is now too young and too quickly evolving, so that no operator may foresee future of his virtual economy in longer horizon than a year or two, which practically neglects possibility of non-inflationary incentives. In contrast with this fact, we will now present some cases of virtual currencies being used as means of payment in *real* transactions.

5.2 Real use of Virtual currencies

Above we doubted motivation of agent to accept virtual currency, because of inflationary incentives of issuer, and instability of demand for it. This certainly rules out the case of using virtual currency for longer ongoing transactions or as storage of value. However the horizon at which demand for virtual currency might significantly evolve is (arguably) say a week. Then there is plenty of possible transactions which do have shorter span - which do not need a long-run demand stability, since agent plans to redeem earned virtual currency for real cash within few hours from transaction. Now, if payment in such transaction using a virtual currency is more convenient, it might easily become favored means of payment in some community.

Tencent QQ coin Two years ago, Wall Street Journal published article[31] about emerging virtual currency in China. The QQ coin issued by Tencent company, whose original purpose was to serve as exchange medium for its instant messenger users, but something else happened. *Online game sites beyond Tencent started accepting QQ coins as payment. The coins appeal as a safer, more practical way to conduct small online purchases, because credit cards aren't yet commonplace in China. (...) Dozens of third-party trading posts sprouted up to ease transactions, turning the QQ coin into a kind of parallel currency.* It is immaterial now, that it was possibly lack of credit cards on market, which enabled such evolution. The point here is, that once some virtual currency has solid ground of regular users (in case of QQ it was 233 million of regular registered users of instant messenger), it might be able to fill in a hole on market - to get accepted beyond borders of its original purpose.

However there is also a black side of liberal dream about free currency. *State-run media reported that some online shoppers began using QQ coins to buy real-*

[49] Now we are getting out of scope of WoW - where there is no guarantee of redeemability at all. We speak of VE's where RMT is completely legal and transparent - like in Entropia universe, or in Second Life which will be discussed later

world items such as CD's and makeup. So-called QQ Girls started accepting the coins as payment for intimate private chats online. Gamblers caught wind, too, and started using the currency to get around China's anti-gambling laws, converting wins in online mahjong and card games back into cash.

During following year *People's Bank of China issued an edict tacitly aimed at Tencent and its coin*[32], effectively shutting down whole QQ business. Without mentioning QQ coins specifically, the [PBC] statement said that the government will bar users from trading virtual currency for real money, and ordered sites to make a distinction between online credits (like QQ coins) and real money used for e-commerce. The reasons for such steps were probably mixed - liberal would argue, that it was the central bank fear of competing currency, common sense rather suggests that prevention of money laundering, and other activities mentioned above was the case.

Second Life and Linden dollar *Second Life was created in 2003 by Linden Lab, a San Francisco-based technology company. The number of users has soared from 700,000 last autumn [=2006] to 6.2 million. (...) [it's currency] Linden dollars can be freely exchanged for real American dollars. On an average day, about 750,000 pounds changes hands.*[33]

The case of Linden dollar itself would make a topic for a book. It is actually a virtual currency, that is by far closest to be called real money. The most apparent reason for that is Lindex, a working market where Linden dollars are traded for USD at daily volumes mentioned above. The stable exchange value of Linden dollar, strongly encourages entrepreneur activity in virtual world. The stability, which can be seen in Figure 6, can largely be explained by regime under which Linen dollar operates, which up till now it might be seen as managed float. Operator of SL - Linden Lab has been deliberately maintaining stable exchange rate by issuing additional dollars, and selling them at Lindex whenever its market price went up.

But a real test of devotion of Linden Lab to keep its currency stable has not yet come - we have up till now not seen the case of Linden dollar significantly depreciating below target exchange rate. As soon as demand for it stops exceeding supply, Linden Labs will be supposed to intervene *in favor* of own currency - which will be costly in terms of USD. Up till now they had an easy job, to manage floating currency and make profit by selling it at the same time. Now, currency seems to be almost at fixed rate, but Linden Labs does *not* have any obligation to sustain it so - which they probably won't do, if it should not be profitable in long run. After such hypothetical release of Linden dollar into free floating regime, its value will also be determined solely by demand for goods sold in virtual world. It might perhaps keep some of its value and become a really competitive currency.

However not even Second Life is free of trouble: *It is a land of six million citizens with no police force, no courts and no taxes. The fast-growing economy is lightly controlled, and banks and the stock exchange lack even basic regulation.*[33] However this gradually stops being the case, in 2008 Linden Labs

Figure 5: Lindex historical development - volume[34]

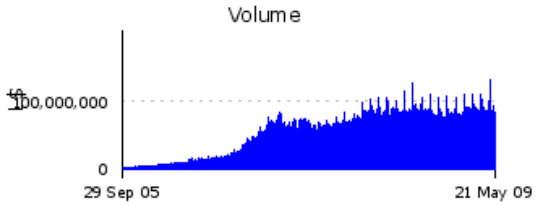
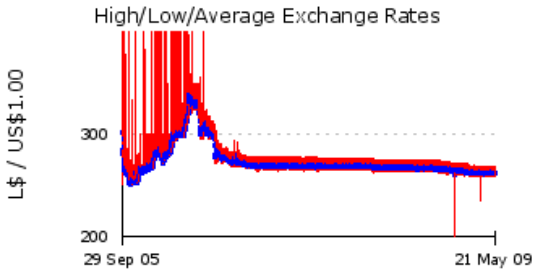


Figure 6: Lindex historical - price[34]



introduced strict policy of bank licensing[35] to prevent further banking frauds, which was an important next step of strengthening the virtual currency - that now actually may bring positive and reliable interest, like real currencies do.

Last thing to mention is, that even though I found no record of Linden dollar being persistently used in real-world transactions, other most interesting events are reported - that whole real world businesses relocate their activity to Second-life. Fields like education[37][36], or marketing [38], might tap serious potential in using virtual environment - and they actually do. This work is no place for assessing such trials, the point here is that by moving some part of business into virtual world, entrepreneurs help to stabilize demand for virtual currency - reinforcing its acceptability in transactions and also giving it potential to really serve as a storage of value.

5.3 Outlook for virtual currencies

Once a monetary standard has been selected, network effects make that standard difficult to dislodge without coercion, especially by an imagined money with no base of current users.[8] In this statement, Selgin and White give us a hint about how to challenge their conclusion. It is the lack of base of current users, that makes emergence of new currency impossible. How come? Let's once again return to the Menger's line of thought. Did precious metal money have base of users, when they started to compete against older, and well established currencies? No, but precious metals themselves did. And this is exactly the

point, which Selgin and White (and many others) are possibly missing: the initial base of users needs not to demand emerging currency for further monetary use. Once this currency is commodity based (just like golden standard bank notes), in early stages of evolution it may derive its exchange value primarily from the value of commodity it represents - regardless if it is gold, or virtual assets. Once *after* some individuals start using it purely as a means of payment, the demand for it further grows making the base even more solid. But this is already beyond our question of unbearability of initial Nash equilibrium - which we now consider as solved for commodity-backed currencies. But what about the second stage - can such currency today attract more users?

We got used to fiat money, and return to commodity money seems unthinkable. There has been plenty of academic discussion about this topic, and I am neither going to extend nor to summarize it. Let me just end this chapter by an open line of thought: Perhaps the most supported argument for implausibility of commodity based money is unstable behavior of market with given commodity. Evolution of economy and technology may influence both its supply and demand in unpredictable manner, which poses serious threat to the derived currency. Now consider nature of virtual goods, with monopoly producer who strictly defines rules of their production and use. Are they subject of such shocks as well? If issuer was able to sustain demand for them [50], would they be able to penetrate much more markets than presently QQ coin or Linden dollar?

Many economists argue that this really can't happen. Issuing of currency has the properties of natural monopoly, and once established, *the monetary authorities can "get away" with a great deal of monetary misbehavior before loss of market to competing currencies poses any significant problem*[5]. This however does not mean, that there cannot emerge new currency which will not drive traditional ones from their markets, but will be naturally dominate new ones - like those with virtual goods.

It however still remains open question, whether such markets are sustainable. The motivation for deliberate inflating of currency, implicitly depends on expectations of the issuer. In our case of commodity backed money, the relevant expectations are those about future development of that commodity's market. For our specific topic of virtual worlds, it is needed to broadly address issue, which we haven't mentioned much - the profit maximizing behavior of currency issuer, who is also the monopoly producer of its underlying commodity. Income duality of such agent poses challenge for further research - profits from inflating currency and sustaining profits maintaining artificial scarcity of produced commodity are clearly not in accordance. Further examining their trade-off might provide interesting theoretical results.

[50] Which today is certainly not - but remember that virtual economies experience the very first decade of their existence. We may well imagine an Blizzard-like issuer, sustaining demand for virtual currency by continuously updating virtual content (canceling out falling demand for underlying commodity, which is here because of negative network effect), but without inflating the currency itself. Such (very hypothetical) issuer would be able to sustain exchange value of own currency, and hence be able to compete with modern fiat currencies.

6 Conclusions

The major contribution of this work lays in fact, that it (perhaps as a first work in this field) analyses virtual economies, especially economy of World of Warcraft, using standard economic and econometric tools. This was made possible by quite elaborate retrieving of unique dataset, from Real money trade (RMT) companies and from the inside of WoW economy. Author is far from claiming that all his findings are correct. Main contribution of this work lays rather in mapping potentially very fruitful research area of WoW economy, and posing some hypotheses which - even if only by being proven wrong - should help our understanding of virtual economies.

The work finds surprisingly high effect of RMT on WoW economy, actually arguing that it is major cause of changes of in-game price level, which is even more surprising when we realize that RMT is officially banned in WoW. Author argues, that serious inflation observed in WoW over last years was primarily caused not by RMT traders (as Blizzard - the company that runs WoW - argues), but by changes in EUR-CNY exchange rates and by game patches released by Blizzard itself.

In second, more theoretical part of paper author proposes a model, which tries to explain motivation of issuer of virtual currency to inflate it. As most probable cause he sees negative network externality of all virtual goods sold, and a finite horizon of profit-maximizing issuer. Under such conditions he finds it optimal to maintain artificial scarcity of virtual goods, by selling it even above standard monopoly price benchmark. The model proposed is possibly not only relevant to producers of virtual goods, but also those of fashion goods or high-tech consumer electronics, which show similar properties.

Final part of the work lays some new arguments to theory of free currencies, grounded in ideas of Karl Menger regarding evolution of money. In particular it supports the idea, that virtual currencies are in fact commodity money backed by virtual goods, and that they might have potential to be persistently used as means of payment in real transactions, side by side with real currencies. Although many authors deny for such possibility by addressing the current state as Nash equilibrium, natural monopoly or even public good, their denial of further evolution might be seen rather as Schumpetarian lack of imagination, than a real argument.

Through whole work, author has suggested several directions where further research might go, and plans to engage in it as well. More importantly he intends to keep and further extend very original datasets used in this work, and make those available to other researchers.

What this work has not touched at all is the dimension of RMT from point of welfare economics. The fact itself, that 400.000 Chinese workers today en-

gage in production of "assets" which might be created by will of game operator and a single mouse click, is quite alarming. Such line of thought also leads to tempting idea of Blizzard company seeking extra profit by directly selling own virtual currency.

Despite of effort to make text understandable for an economist without any prior specific knowledge of virtual economies, some arguments are possibly hard to follow. Author hopes that this work has helped to improve readers understanding of this topic to reader, and in advance apologizes for any confusion caused.

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7 Appendix

7.1 Data collection methods

Price indices - API and MPI Over 33 days I created snapshot of data of all items available at acution house (AH) at the moment, on each of 12 chosen European realms. This was done using third party Auctioneer plugin, for standard WoW client software. Afterwards I programmed an parser, able to transform data saved by Auctioneer into MySQL database. The parser has been deliberately written in PHP language, so that I could provide it as a service for other players in form of online script available here http://www.mmometrics.org/aucdb2/ . Purpose of this was also to collect additional data, beyond my observed 12 realms - which was successful. This is how for example some data from US realms were obtained - however not at regular basis that would be satisfactory for use in broader statistical analysis.

Once I had broad panel of observations (8.5 millions of items), regarding mainly item type(I) and buyout price (P), I started to choose reliable basket. Problem of my observations was, that not all (of 35.000) item types are available at AH each time. Hence we can not observe all prices from each snapshot. This lead to problem of choosing right basket - it needed to be broad enough to really capture overall price level, but not too broad to contain items for which there was not enough data available. For following procedure (including choice of consumption basket) I programmed a software - potentially reusable on larger dataset.

Using a rule of thumb, that item going into consumption basket needs to be observed at least in 90 % of observations is chosen a basket of 300 most traded item types. Then an average minimum price, and average price are computed for each item type I from chosen basket an as follows:

$$AMP_I = \frac{1}{R * T} \sum_{R,T} min_{i \in I_{R,T}}(P_i)$$

$$AP_I = \frac{1}{R * T} \sum_{R,T} avg_{i \in I_{R,T}}(P_i)$$

Where sum over R and T stands for all combinations of realm and time, where was observed at least one item of type I, that is where set of items $I_{R,T}$ was not empty. That means we sum over maximum of $33 * 12 = 396$ snapshots. Now, once we have these aggregate prices we can actually compute price index for each realm / day combination, using these averages as weights:

$$MPI_{R,T} = \frac{1}{\|S_{R,T}\|} \sum_{I \in S(R,T)} \frac{min_{i \in I_{R,T}}(P_i)}{AMP_I}$$

$$API_{R,T} = \frac{1}{\|S_{R,T}\|} \sum_{I \in S(R,T)} \frac{avg_{i \in I_{R,T}}(P_i)}{AP_I}$$

Where $S_{R,T}$ is a set of item types from consumption basket, observed in time T on realm R. As a result we got two panels of indices measuring price level - while MPI is more sensitive to Gold inflows, and better reflects actual availability of goods(in terms of price), it is also more volatile. Note that we generally used more stable average price index for estimating longer trends with more variables, and more sensitive minimum price index for simpler equations with less variables, where is lesser danger of overspecified model capturing its larger random noise. However all regressions reported in this work have shown similar results for both indices (which is certainly not case of all models I tried), so their result are to be considered a little more robust, than statistical indicators report.

It might be subject of critique that I did not take into account possibility of changing consumption basket. Especially because my measurement took place in time of 3.1.0 patch, when new items have been introduced, there is good reason to suppose that consumption needs shifted - for which my fixed basket did not account. To defend my approach: the consumption basket did typically not contain any of items that might be substituted for newly introduced ones (weapons and equipment). The most traded goods at AH (which has been chosen into consumption basket) are resources for creating those items, whose supply did not change during patch, and which have been most probably consumed prior and after patch in roughly same proportions.

RMT Data Some part of data (year 2008) was achieved from Goldbuster company, in form of SQL database dump. The data from 2009 was collected directly from websites of 5 major Gold sellers (IGE, Swagvault, Bankofwow, Guy4game and MySuperSales)[51], where they report actual prices for each realm, and in case of Swagvault company also daily sale volumes. For those purposes I programmed a web crawler, which automatically collects such data. Even though in this work I used only time series of 75 own observations, the crawler keeps on collecting data, and will possibly provide reliable dataset for my further research. Also I am going to publish the datasets to be available for other researchers on my prepared mmometrics.org website.

Since RMT companies publish all of their prices in USD, the data needed to be recalculated to other currencies as needed. For these purposes I used time series from ECB modified as follows.

FX data As a source of data has been used panel from ECB available here: http://www.ecb.int/stats/exchange/eurofxref/html/index.en.html However, here the rates are reported only for workdays, and our other observations were made 7 days a week (this was perfectly reasonable - in fact the activity on WoW realms peaks on weekends and holidays - and so posibly do RMT sales). Hence for filling in missing FX data I used simple linear interpolation.

[51] For estimate of total RMT market shares (not only WoW) of those companies see http://www.mmobux.com/articles/2270/ige-thsale-and-friends-gold-seller-revenues-in-2007

Choice of observed realms For both price and RMT observation simple random sample of realms was chosen as all realms starting with A with reasonably high population. Later on Drak'Thul and Emerald Dream were added because potentially interesting properties - high Czech population, and possible high number of Gold farmers. Later on I made also one-time snapshots of several younger realms, however the age of realms in panel data used in most estimations is the original one without young realms.

7.2 Other results and figures

Figure 7: Artificial scarcity producer beaviour with small dampening effect

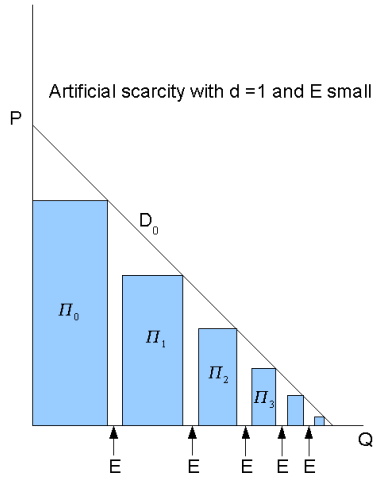

Figure 8: Artificial scarcity producer beaviour with large dampening effect

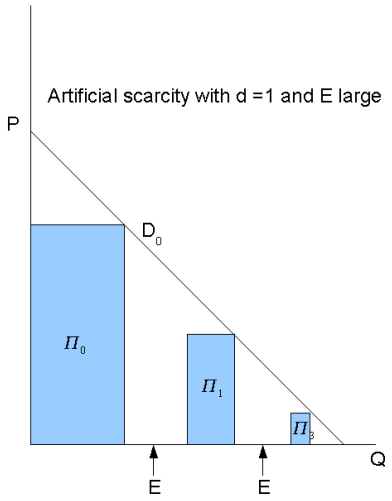

Figure 9: Price stability of good with constant production cost

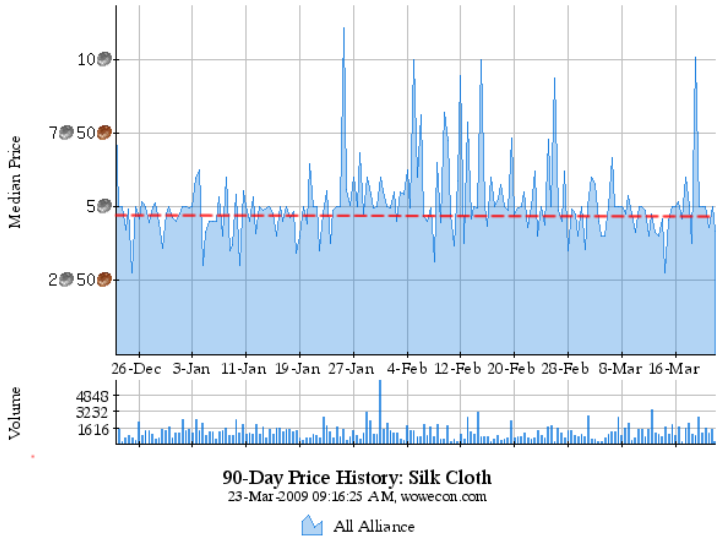

Figure 10: Price shift after production cost change - example 1

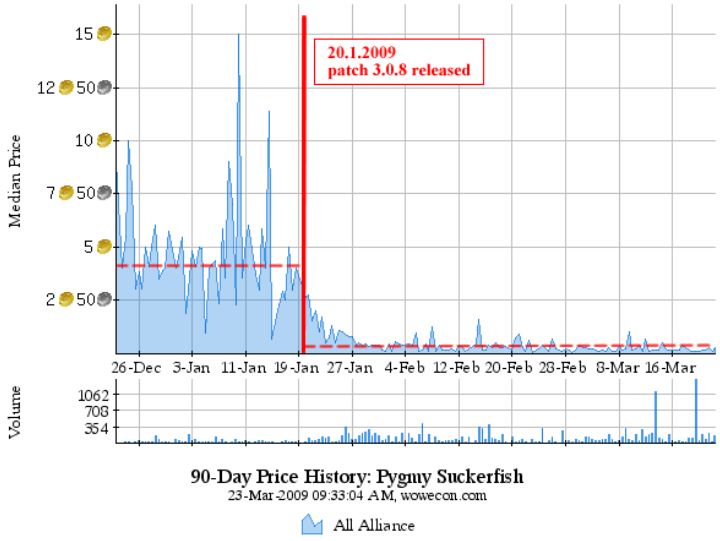

Figure 11: Price shift after production cost change - example 2

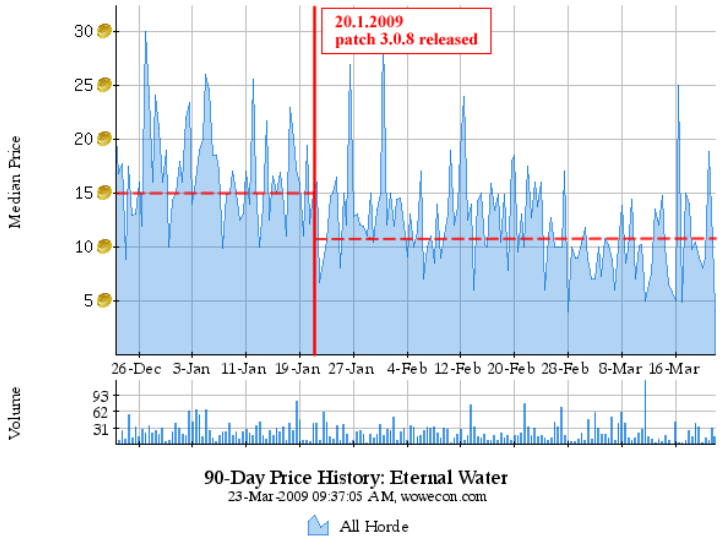

Figure 12: Average Gold prices across various Realms

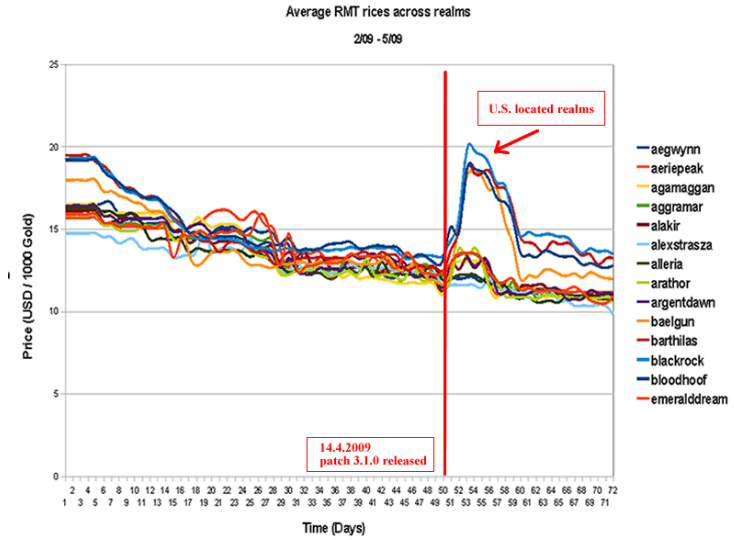

Figure 13: Gold RMT prices of various sellers in US

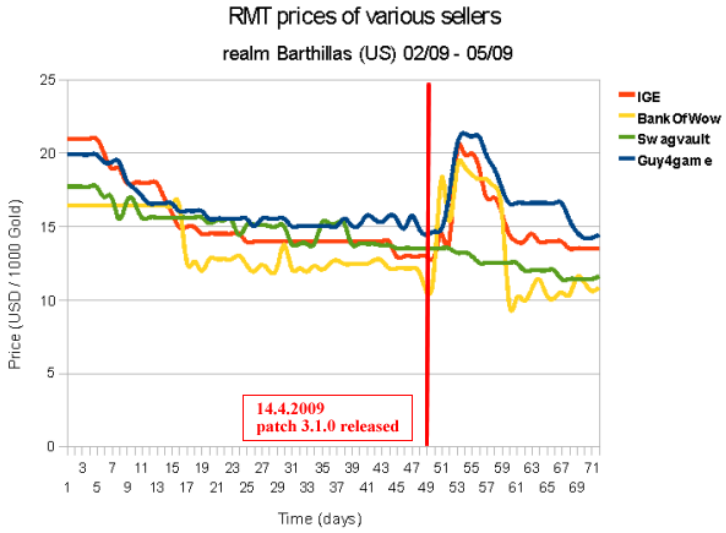

Figure 14: Gold RMT prices of various sellers in EU