2011-09-22

Analysis of the Relationship between Virtual Goods Trading and Performance of Virtual Worlds

Gwangjae Jung*, Byungtae Lee*, Byungjoon Yoo**, Erik Brynjolffson***

*Graduate School of Management, KAIST, 207-42 Cheongryangri2-dong, Dongdaemun-gu,

Seoul Korea 130-722 *{Gwangjae, btlee}@business.kaist.ac.kr*

** College of Business, Administration, Seoul National Univeristy, Seoul Korea,

byoo@snu.ac.kr

*** The Sloan School of Management, MIT, *erikb@mit.edu*

Acknowledgements. The authors wish to thank the Korea Game Industry Agency and IBM Korea for their partial support of this research project and the Management Research Center at Seoul National University College of Business Administration for grant funding. All errors of fact and interpretation are the authors' sole responsibility.

Abstract

The success of online games such as "Second Life" and "World of Warcraft" shows the popularity of virtual worlds and reveals the economic systems embedded in them. A large number of players interact with each other in cyberspace, giving rise to an interesting phenomenon where players voluntarily create their own economies that involve trading virtual items or game money for real money. This real-for-virtual-money trading itself has become a several billion-dollar business. In this study, located in Korea, we analyze the economic impacts of the trading of virtual properties and the management strategies of the virtual economy (game) operators by using a two-period game theoretic model between the game players and game operators. In this model, players endogenously switch between seller and buyer roles. We find that real-money trading benefits game operators, and there exists an optimal amount in the supply of game items that maximizes their profits. We also find that the income disparity in the real world can be reduced when real-money trading is allowed. An empirical analysis with data from popular virtual worlds also confirms our findings that real-money trading benefits the game operators. Moreover, we find that playtime and the trading price of game items have a positive relationship. Our findings, from both the analytical and empirical analysis, strongly imply the importance of the embedded economic systems in virtual worlds.

Keywords: Virtual economy, virtual worlds, real-money trading, online game

1. Introduction

With advances in information technology, the concept of virtual worlds[1] has swiftly attracted attention and broadened its applicability to many areas. A virtual world is a form of network-based simulated environment, which enables multiple users to interact through an online interface. Such virtual worlds have been utilized as online community platforms with many people gathering together at one place. The expansion of the network bandwidth lets millions of people socialize with each other in a shared space at the same time and in real-time. In the case of Facebook, the most well-known online community platform in the world, there are more than 700 million users with unique profiles sending messages to each other. Advances in graphic technology also make the appearance of virtual worlds more realistic. As a result, nowadays, virtual worlds are used not only for gaming or social networking, but also for education or even military training[2].

Of the various applications, online games, especially massive multi-players in online role playing games (MMORPGs), are the most prosperous business models that utilize the many features of the virtual worlds. The worldwide online game market recorded a revenue of $ 5.1 billion in 2006 and $ 8.6 billion by 2008 (KGIA, 2007). “World of Warcraft (WOW),” the most successful MMORPG worldwide, earned nearly $1 billion a year at the height of its popularity (Dibbell, 2007). This new genre of gaming provides platforms where people are able to massively interact with others all around the world. According to one study, 30 million people are participating in over 80 online games that provide a virtual world experience to customers (Dibbell, 2007). These online fantasy games have a staggering number of subscribers, such as over 10 million users in the case of WOW and 2.1 million players in the case of Lineage[3] in January 2008 (Reeve et al., 2008).

---

[1] In our study, we define “virtual world” as a world where players’ cyber avatars interact with other players’ avatars.

[2] http://www.virtualworldsreview.com/info/whatis.shtml

[3] Lineage was the most popular online game in Korea at that time.

The huge growth in online gaming has brought significant attention to business paradigms. Real-time managers need to be prepared for Generation Y, which is growing up in the fantasy worlds provided by online games (Erickson, 2008). Along with this, it is recommended that real-world employers embrace the new and highly positive traits of the “gamer disposition” into their workforce to thrive in the twenty-first-century workplace (Brown and Thomas, 2008). Alternate reality is also identified as a place where breakthroughs can be found (McGonigal, 2008), and in such a situation, it was predicted that business interfaces would shift toward avatar-based interactions. Hence, “remote controlled” avatars (Donath, 2008) could move freely from one world to another one, allowing consumers to live in the “metaverse” (Sarvary, 2008).

In terms of user activities in 3D virtual environments, economic interactions that consist of virtual economies in online games are the emerging and remarkable features in online games. From the inception of such worlds, people started trading in virtual items, such as virtual clothes and weapons. These virtual items are made of digital codes, creating in-game economies. Although these realistic economic zones enable users to exchange virtual objects that are exclusively effective within virtual environments (Mennecke et. al. 2007), these virtual economies do not exist in isolation. People trade virtual items including virtual currencies for real money. This phenomenon is called “real-money trading (RMT)” facilitated by either the *primary market* inside a virtual economy created by the operator or the *secondary markets* outside the immediate cyber environment, such as eBay. The popular virtual universe of Second Life internally manages its RMT market, called the “LindeX market,” and the transaction volume of this primary market exceeded $ 8 million in 2008, up from $ 2 billion in 2006[4].

RMT of virtual goods made it possible to evaluate virtual items in a real-world terms thereby linking the real and cyber economies. The value of virtual properties priced by the RMT provides the “gross domestic products” (GDP) of the virtual worlds and it was estimated that a virtual world GDP was

---

[4] http://virtual-economy.org/blog/how_big_is_the_rmt_market_anyw

already comparable to that of Bulgaria in 2002 (Castronova, 2002). Internet gaming entertainment (IGE), one of the largest MMORPG service companies, acquired Korea's second largest RMT market, *ItemMania*[5]. Because of the possible wealth transfers via RMT, some savvy online game players have taken to the activity not just for leisure but also to avail of its wealth creation opportunities. In China, there exist businesses that collect virtual items by hiring skilled players and selling their skills for real money (Dibbell, 2007). Some netizens consider the virtual world as their real place of residence; they just commute to the real world and back. To a large and growing number of people, the virtual world presents an important source of material and emotional wellbeing (Castronova, 2001). Real wealth creation in virtual spaces has been well documented in the media (Hof, 2006; Wong, 2006).

The incentive of RMT has mainly been in the traditional perspective of "leisure-work" allocation regarding an individual's personal decisions (Yamaguchi, 2004; Kelly, 2004; Castronova, 2002). Earlier studies have mostly focused on the demand side of the virtual item exchanges. That is, they tried to explain why such trading takes place among players but failed to link the operator's strategy. On the other hand, there have been anecdotal and empirical evidences that managing the embedded economic systems was critical to the success of the virtual world operators. The EverQuest economy was threatened by hyperinflation by influx of cyber cash (Basu, 2003) and Raph Koster, chief creative officer of Star Wars Galaxies recognizes that "if the economy is too dysfunctional, then the players won't have fun" (Terdiman, 2004). Huhh (2008) empirically asserts that the decline of players of Lineage II can be attributed more to the RMT market systems than other factors such as competition or price schemes etc.

While the virtual inside economy resembles a real world economy in many ways, in other ways, it remains alien, especially in the sense that everything, including the virtual items and the rules governing their supply and demand, can be created and manipulated by the game operators (Simpson, 1999). Altough it has been strongly advocated that the health of economic systems embedded in the virtual world

---

[5] IGE, ready to sweep Korean RMT market? http://virtual-economy.org, 2006

and their derivative markets facilitating RMT are critical to the success of the operators, we find little formal studies on such linkages. At the 28th International Conference on Information Systems (ICIS), researchers highlighted the potential of virtual world research (Mennecke et. al. 2007), but historical research has largely been focused on just technological issues such as user interfaces or user perceptions (Knoll, 2007). Nowadays, due to the advances in technology, the number of inhabitants has been dramatically increased. There is a lot scope for research in the economic and social interactions among cyber citizens. However, the lack of ground theories and existing data meant that the research on economics interactions in the virtual world was limited to mere speculation.

The main objective of our research is to provide an analytical framework that captures the more realistic characteristics of the virtual world. The utilities provided by fantasy worlds are basically governed by the concept of “puzzle of puzzles” (Castronova, 2001). That is, the game should be fun for players by virtue of its novelty factor and appropriate levels of challenges. Often, the virtual world manages to prolong the life expectancy of online games by providing multiple levels of challenges. Hence, players’ avatars grow up and lead their lives through the level system. We specifically model the player’s life-long decision-making patterns against a skill-level system by using a dynamic game. This model predicts the RMT equilibrium price and the quantities of virtual items being traded. At the same time, it indicates population changes in the game, which is the main concern of the game operators since the users’ playtime is their major source of revenue.

Based on this framework, it is possible to link the performance of the derivative markets of RMT to the operator’s performance. This permits the operator to optimize their created virtual worlds and provides them with an evaluation framework for selecting the optimal game design and embedded economic systems. In terms of the link between the virtual and real economy, this study analyzes the impact of RMT on wealth distribution in real world. The growth of virtual economies and markets transferring wealth between them and the real world means that, sooner or later, it will be of concern to economic planners in the real world. We provide partial answers to the critical questions on the different relationship between the two worlds.

The results of the analytical model are also empirically validated using detailed data on game playtime and outcomes of RMT markets. Our results show that performance of RMT market clearly dictates the incentive of subscribers to play games. In other words, RMT facilitates the migration from real world to the virtual economy. However, the flow between two worlds is not unidirectional. Under certain assumptions regarding the productivity of population in the two worlds, we show that an ever-increasing number of people who earn wealth in the virtual economy and transfer it to the real world, certainly have an impact on the economy of real world as well.

The increasing number of people playing online games (especially gambling) has been a sensitive topic of debate for policy makers and parents alike. Addiction to online games is a well-known social issue (Reuters, 2005). Becoming rich from online games through RMT, a possibility that attracts youngsters who otherwise are deprived of such economic opportunities in the real world has become a critical social agenda. Reacting to demands from groups advocating pro-game regulations, the government enacted laws concerning the various game-related issues (Camp, 2007). Such action is sufficient evidence of the significance and relevance of these issues to policy makers.

This paper is organized as follows. In the following section, we review theories related to our study. The third section introduces the analytical model and presents the results of the analysis. In the fourth section, data from online games are empirically tested to validate the results from our analytical analysis. Concluding remarks and limitations of the study are discussed in the last section.

2. Literature Review

The virtual worlds that we analyze are essentially cyber communities where gamers' avatars live. MMORPG is a typical example of such a world. Avatars can be either representatives of players (characters) or non-player characters created by the operator, such as monsters, in the virtual universes.

These worlds are “highly planned by the designers” including everything from the tradable items to the rules that govern their supply and demand (Simpson, 1999) but it cannot control its player population. As mentioned, these worlds mainly attract users with their elements of fantasy and fun. Operators compete for players’ time in their worlds. To that end, the operators introduced a character development system in games that consisted of levels and experience points (Bartle, 2003). Thus, if a player fulfills a certain mission such as hunting a monster (a non-player character or NPC), they receive a certain amount of experience points as a reward. When the player’s experience points reach a certain threshold, she/he moves to the next level. The utility of a game has rather unique characteristics with respect to the challenge level (Castronova, 2002). This is known as “the puzzle of puzzles”—the appropriate challenge level that maximizes the utility in virtual worlds. Too easy or too difficult challenge levels reduce the utility such that an inappropriate level of difficulty may create a negative marginal utility.

Game items are also given to players as rewards for staying longer in the virtual world or as an initial incentive to do so. Many such items are traded in these worlds and for different reasons. For example, players with different roles in an MMORPG game may act in groups so that items are shared. This is similar to the economic history of the real world where economic institutions have been introduced to facilitate the trading of items, starting from bartering in the Stone Age to market mechanisms inside and outside modern virtual worlds (Yamaguchi, 2004). Fiat money was also introduced as a means of reducing transaction costs in the virtual trade, for example, gold in WOW and the Linden Dollar in Second Life. Now, virtual assets include currency, personal property, real estate, accounts, and even securities (Lehdonvirta, 2005). Simpson (1999) documented the difficulties and failure of such closed economies by using the online game, *Ultima Online* as a case study.

A great deal of attention has been paid to the concept of the virtual “foreign trade,” that is, the trading of virtual items for real money through out-of-game markets. In this, virtual economies interact with those in the real world so that they turn into open economies themselves. Since virtual assets are exchanged (valued) with real money and virtual economies also often have their own currencies, it stands to reason that the exchange rates between the two currencies (real and virtual) exist as well. Studies have attempted to provide the economic reasoning for RMT (Yamaguchi, 2004; Kelly, 2004). Users allocate their time between the virtual and real worlds, involving, typically, decisions between leisure and work. There is a trade-off in the impact of income on game time allocation. As explained earlier, the individual wants to play at the challenge level appropriate to him/her. One of roles of the virtual items is to make a game (task) easier. Even in Second Life, people easily develop and decorate their real estate with "materials." Hence, the optimal challenge level can be individually fine-tuned with virtual items. Such items can either be "bought" or "made" as any goods/service in the real economy. In other words, a player can purchase an item with RMT (buy) or get it by playing more (make)[6]. Hence, RMT can be interpreted as a process of optimizing the procurement of game items by players whose opportunity costs of producing them are higher.

We already introduced the fact that virtual "foreign trading," especially by a savvy player, creates opportunities for generating wealth. Managing the open economies is even more difficult. For example, a deflation in a virtual economy can jeopardize the business operating the virtual world. The values of the virtual assets will evaporate under a deflation due to their over-supply as the game matures. Then, players will get bored with too easy games that have abundant game items and players with higher skills may migrate to an alternative world where the value of their virtual assets might be better off. Then, both novices and experts leave the game and the immediate virtual economy collapses. So does the business of the game operators. We can easily speculate on the failure of virtual economy under the opposite condition, that is, inflation. Inflation makes it difficult for players to buy virtual items so that they cannot optimize their challenge level. The linkage between such derivative markets and game performance is

---

[6] Certain items can be purchased only directly from the operator. Owing to the networking effects of an online game, many games allow players to join the game for free but later charge money for selling them game items. Operators seem to have abandoned the subscription fee-based business models.

alluded to by an empirical study done by Huhh (2005). Park (2004) also suggested that the “PK system[7]” in MMORPG might induce RMT.

This research focuses on the linkage between the derivative markets of virtual items and the performance of the virtual businesses. To the best of our knowledge, no research has explicitly addressed this. Since the seminal works by Castronova (2002, 2004), models based on optimal allocation time between leisure and work have been used to explain why players indulge in virtual trade. However, little attention was given to players who live in the virtual world to build their real wealth from there. In addition, literature on the aspect of gaming population dynamics through a skill and experience level system in virtual games and its consequences on the virtual business were not found either. In addition, Castronova (2002) theorizes that virtual economies might be merged into real economies. He speculates that with a more pervasive RMT, there will be more migration to the virtual worlds. Brain drain has always been an important topic of debate but no formal model has been offered to study them in a more direct manner. The model we present in the following section fills these research voids.

3. Analytical Model

3.1. Model Setup

We analyze the market of game items by using a two-period game theoretical model for both game players and operators. In this model, the operator releases a brand new online game, which includes an experience system and one type of game item that gives an advantage to the player who owns the item. The online game in this model uses an experience point system, a scheme used for a character’s advancement in role-playing games (Bartle, 2003). Experience points are awarded for some actions and they reflect the players’ experience in playing the game. This is cumulative so that the experience points

---

[7] PK (Player Killing) means players kill other players, not monsters. Because of the possibility of complete annihilation of a player’s identity and all their assets, players may try to find better game items to survive. However, RMT is pervasive even for games that allow PK. Hence, it cannot be a major reason for RMT.

increase by the total time of play within two periods (Bartle, 2004). Hence, it is assumed that experience points in Equation (2) are increasing in playtime (h_t) at period t, the previous experience points (θ_{t-1}), and use of the game item (ϕ) since it substitutes playing time. There exists the maximum ($\bar{\theta}$), beyond which players exit the game since the game becomes too easy for them[8]. Since the online game is brand new at the beginning of the first period, starting experience points of all players are assumed to be zero without the endowment of game items but with heterogeneous skill levels.

(1) $u(w,h_t,\varphi,\theta_{t-1}) = I(w,h_t) + \alpha v(h_t,\varphi,\theta_{t-1})$

(2) $\theta_t = \theta(h_t,\varphi,\theta_{t-1})$

Players decide the amount of time they spend in the online game by its opportunity cost and, as a result, their record of playing time will boost their experience points. The opportunity cost is incurred by abandoning other things, such as work or other leisure activities, to play online games. In this sense, we assume that players are heterogeneous in their wages of real work and the wages are uniformly distributed ($w \sim U[0,W]$)[9]. The utility function of players is defined by Equation (1). We define the utility function based on users' time allocation between work and gaming. This allocation has been adopted in previous research (Kelly, 2004; Yamaguchi, 2004). Castronova (2002) further assumed the allocation to be between work, gaming, and other leisure activities. However, when focusing on the gain and loss of wealth in moving between work and online games, it is assumed that the utility from other leisure

---

[8] In the case of the infinite game theoretical model, a skilled player may remain in the game to earn virtual assets that can be sold later. However, in such a case, most of players will produce only game items that tip the balance between demand and supply. This might cause the market of game items to collapse. For this reason, Lineage release Lineage 2 and WOW developed extension games such as "Burning Crusade" and "Wrath of Lich King" to refresh their experience point systems. Hence, we limit the model to a finite game and focus on the market equilibrium of game items under this assumption.

[9] It can be easily generalized with any income distribution.

activities in real world is the same for all players. The first term in Equation (1) represents the utility from the income from real work ($I(w,h_t)$) and the second term denotes the value from playing the online game ($v(h_t,\phi,\theta_{t-1})$). The marginal wage rate is assumed to be constant (w) during the game playing period and so that income is linear in work hours ($H-h_t$) where H is the upper limit of a player's hours[10]. The second term is assumed to be concave in playtime (h_t) and proportional to both, the previous experience points (θ_{t-1}) and the use of the game item. If a player uses the game item, then $\varphi = 1$; otherwise, $\varphi = 0$. Since the unit of value of playing the online game is not expressed normally in monetary terms, we assumed the coefficient α that transforms this value to a monetary unit.

At the beginning of the first period, the operator releases a new online game. In this model, the game consists of an item and experience point system. The game operator controls the quantity of game items by setting the productivity of players in earning time allowances. This is set by the threshold of an experience point (θ_b). If a player exceeds this point, one game item is awarded, called "drop rate" in the virtual games. By adjusting this drop rate, the operator controls the quantity of game items. In this model, we assume that there exists only one type of item in the game and each player uses only one item in one period[11]. Players may not be aware the exact threshold point. The game gives the same amount of value and rewards experience points per unit of time to all players. Players choose their duration of participation in the game on the basis of their marginal wage rate. At the end of the first period, experience points of players are increased by their playtime and the total sum of playtime represents the profit of the game operator. Even though there exist diverse revenue models in online games, such as subscription, advertising, selling a certain set of virtual items etc., we use the total amount of playtime as a proxy for

---

[10] There might be a chance that the marginal wage rate can be altered as players spend time on online games. This could be generally insignificant from the short-term perspective.

[11] In reality, the ability of an acquired game item can vary by the player's experience points. However, for simplicity of analysis, we assume one item, which represents the aggregated item values in terms of substitution of the skill levels of players.

the game operator's profit since eventually the profit depends on total eye-balls and their time in the virtual world regardless of the revenue models

$$(3)\quad T = \int_0^W (h_1 + h_2) dw$$

In the second period, players can be divided into two groups depending on their possession of game items. Now, the groups take on differing strategies. Any player with the item decides whether he/she sells or uses it. If a player sells the game item, he/she can earn real money and increase his/her income or he/she can get more value (utility) from playing the game with the item. A player without the item makes a buying decision. Like on the selling side, the trade-off between the income and value function exists on the buying side as well. Like in the first period, the total sum of playtime in the second period is also the profit of the game operator. Thus, players decide the amount of playtime and choose whether to buy or sell game items. The game operator's objective is to maximize the total amount of playtime of all players, as given in Equation (3), by deciding the quantity of game items through the drop rate as explained earlier. By backward induction, the equilibrium price of game item and the profit of game operators are derived in the next section.

3.2 Market Equilibrium

3.2.1. Supply of Game Items

Equations (4) and (5) show the optimal playtimes of players in the first and second periods, respectively. After the first period, players whose optimal playtime in the first period exceeds h_q will receive game items. At the same time, players whose experience point in the first period exceeds the maximum experience point ($\bar{\theta}$) cannot play the online game at the second period. Moreover, if the optimal playtime is lower than 0, players do not participate in the game. Therefore, after the first period, players are divided into four groups. That is, player i (1) exits the game if his/her wage rate is $w_i \in [0, w_a]$ since his/her experience points exceed the maximum, (2) plays the game with the item if $w_i \in [w_a, w_b]$, (3) plays the game in second period without possession of the item if $w_i \in [w_b, w_c]$, and (4) did not enter the game in the first period if $w_i \in [w_c, W]$.

$$(4)\quad h_2^* = \left[h_2 \left| \frac{\partial I(w,h_2)}{\partial h_2} + \alpha \frac{\partial v(h_2,\varphi,\theta(0,h_1^*))}{\partial h_2} = 0 \right. \right]$$

$$(5)\quad h_1^* = \left[h_1 \left| \frac{\partial I(w,h_1)}{\partial h_1} + \alpha \frac{\partial v(h_1,0,0)}{\partial h_1} + \frac{\partial u_2^*(w,\varphi,h_1)}{\partial h_1} = 0 \right. \right]$$

According to this, players' optimal playtime is inversely correlated to their wage rate. Therefore, players with the lower wage spend more time playing the game and get more chances to earn game items. Let w_b be the wage rates of players who spend h_q amount of time playing the game. That means players in $[0, w_b]$ have game items, so they can be on the supply side in the second period. Whether players sell their items or not will be decided by comparing their utility in each case. After maximizing the utility of the playtime, the utility can be written as a function of wage (w) and the use of item (φ). If a player in $[w_a, w_b]$ decides to use an item, then the maximum utility of selling item is given by Equation (6) where p is the price of the item. A player in $[0, w_a]$ does not play the game in the second period. Therefore, his/her only option is to earn money by selling the item and then, the total utility is $wH + p$. Let w_d be the wage rate, which satisfies equation (6). Figure 1 shows the utility of selling or using items according to the price. Players in $[0, w_a]$ choose to sell items, regardless of the price. Players in $[w_a, w_b]$ will change their decision according to the price. At w_d, the player in $[w_a, w_b]$ is indifferent between selling and using the item. If the price of the item increases, the utility of selling moves upward. That pushes w_d to the right on the x-axis. A price drop causes the opposite movement.

$$(6)\quad u^*(w,1) = u^*(w,0) + p \qquad w_a < w < w_b$$

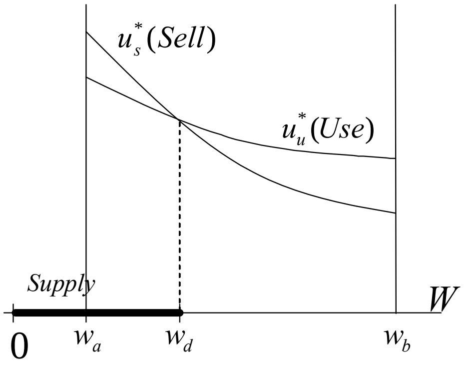


Figure 1. Supply of Game Items

3.2.2. Demand for Game Items

Players in $[w_b, W]$ do not receive items after the first period. Players in $[w_b, w_c]$ decide whether to purchase the item by comparing the left-hand (buying) and the right-hand side (playing without the item) of Equation (7). However, players in $[w_c, W]$ did not play the game in first period, so they will not play the game if they do not buy an item. Therefore they compare the left-hand (buying and playing) and the right-hand side (not playing) of Equation (8). Let w_e and w_f be the indifferent wage rates in Equations (7) and (8) respectively. Figure 2 shows the utilities of the two cases mentioned above. If the price of an item increases, the utility of buying drops so that indifferent points w_e and w_f move leftward. Players in $[w_c, w_f]$ are more price-sensitive than ones in $[w_b, w_e]$. Therefore, players in $[w_c, w_f]$ will not buy the item if the price of item exceeds some level,

(7) $u^*(w,1) - p = u^*(w,0) \quad w_b < w < w_c$

(8) $u^*(w,1) - p = wH \quad w_c < w < W$

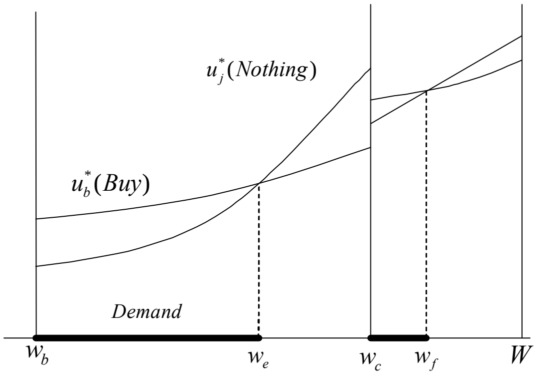
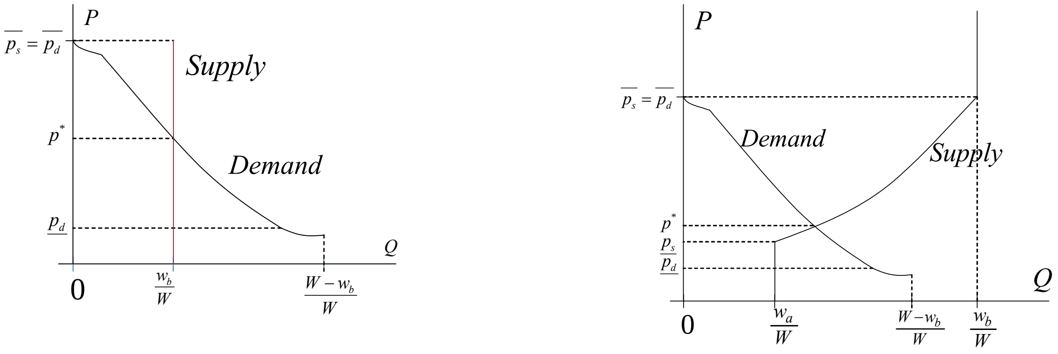


Figure 2. Demand for Game Items

3.2.3. The Equilibrium Price

Using the assumption of one item per user who plays beyond the threshold, the total number of game items becomes w_b/W. Note that the maximum number of items earned by players is w_b and the number of players whose experience points are beyond the maximum is w_a. Therefore, if $w_b < w_a$, all items possessed by players will be on the market regardless of price. In that case, the supply would be a vertical line (Figure 3). Otherwise, the maximum supply of the item is limited to w_d/W as explained above. The demand derived above remains as $(w_c - w_b + w_f - w_c)/W$.

Figure 3 shows the equilibrium price of a game item for both the cases. However, if the minimum supply is higher than the maximum demand, the price will be zero. Therefore, the equilibrium price exists only when the number of retired players (w_a) is smaller than the number of players who do not receive any items ($W - w_b$), i.e., $w_a \leq W - w_b$. In addition, if the maximum experience points increases, implying a decrease in the number of retired players (w_a), the supply will be more price-sensitive (Figure 3). To summarize, the following Proposition 1 explains the equilibrium. Detailed proofs of all the following propositions are included in the Appendix.



$w_b < w_a$ $\qquad$ $w_b \geq w_a$

Figure 3. Equilibrium of the Virtual Item

Proposition 1. *The equilibrium price of game items* p^* *exists under the following conditions:*

$$\exists p^* \ \ s.t. \ \ w_e(p^*) = w_e(p^*) - w_b + w_f(p^*) - w_c \qquad when \ \ w_a + w_b \leq W \ \ \& \ \ w_b \geq w_a$$

$$\exists p^* \ \ s.t. \ \ 2w_b = w_e(p^*) + w_f(p^*) - w_c \qquad when \ \ w_a + w_b \leq W \ \ \& \ \ w_b < w_a$$

Recall that the operator can manipulate two variables in this setting. The first is the productivity of players in earning an item. This dictates the total size of the possible supply in the virtual world. This must be distinguished from the supply of the item in the RMT market since not all items are sold. The other variable is the maximum experience points for retirement (levels). The maximum point represents the difficulty level of the game. Therefore its increase retains the players for a longer period and decreases both the supply ($[0, w_a]$) and the equilibrium price. Moreover, if the number of players who have received an item (w_b) increases, the supply will be more elastic and demand less elastic. In this model, the number of players with an item is inversely proportional to the threshold experience point of obtaining items (θ_b). This means that if the effort to acquire a game item increases, the equilibrium price decreases. Hence, the following propositions characterize the market equilibrium with respect to the parameters set by the operator or the real world economy.

Proposition 2-1. *The equilibrium price is reversely correlated with the effort to obtain a game item.*

Proposition 2-2. *The equilibrium price increases with the level of the game (the inverse of* w_a*).*

Proposition 3-1. *The supply of game items becomes more elastic when the maximum wage rates (*W*) decreases or when the maximum experience points (*$\overline{\theta}$*) increases.*

Proposition 3-2. *The demand for game items becomes more elastic when total quantity of game items (*$w_b(h_q)$*) decreases or when the maximum wage rates (*W*) increases.*

3.3 Strategies for the Game Operator

Given the objective of maximizing the total playtime of the game, Equation (3) can be re-written as in Equation (9) where RMT is permitted or as in Equation (10) where the total sum of playtime it is prohibited. T_1 is the sum of total playtime in first period and it is constant. w_d, w_e, and w_f are dependent on the price of items (p) and the price is a function of the total quantity of items (w_b). Then we can find the optimal supply of game items.

$$(9)\quad T = \int_0^{w_c} h_1^*(w)dw + \int_{w_a}^{w_f} h_2^*(w,\varphi)dw = T_1 + \int_{w_a}^{w_d} h_2^*(w,0)dw + \int_{w_d}^{w_e} h_2^*(w,1)dw + \int_{w_e}^{w_c} h_2^*(w,0)dw + \int_{w_e}^{w_f} h_2^*(w,1)dw$$

$$(10)\quad T = \int_0^{w_c} h_1^*(w)dw + \int_{w_a}^{w_b} h_2^*(w,1)dw + \int_{w_b}^{w_c} h_2^*(w,0)dw$$

Proposition 4. *There exists the unique optimal supply of game items (the item productivity level) to maximize the total sum of each player's playtime.*

Clearly, RMT increases the number of total participants in online games. It gives an incentive for people with low marginal value of gaming to participate in the online games. At the same time, it does not mean that the total sum of playtime increases. We can compare the Equations (9) and (10) according to the item productivity set by the operator. Figure 4 shows the difference made by RMT.

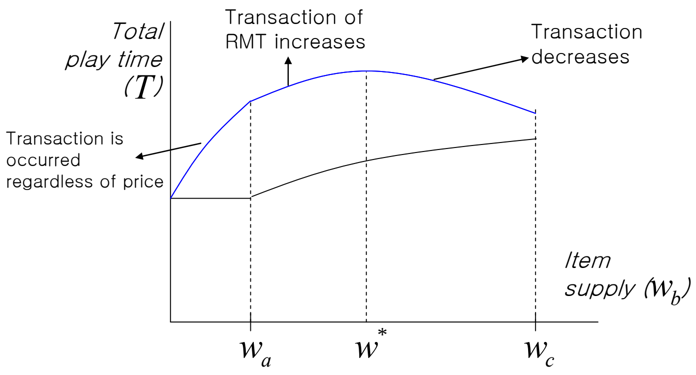


Figure 4. The Total Playtime

Proposition 5. *When RMT is allowed, the game operator becomes better off.*

3.3.1. Sustainability of Virtual World

The life expectancy of the virtual world is critical to game operators assuming a continuous income flow from the game as long as the players' avatars exist. The sustainability of the virtual world in this model can be defined by the population, which is further defined by the ratio of number of possible entrants to retired players. Therefore, game operators should control these two numbers to increase their respective durations in the virtual world. In this model, the number of retired players can be expressed by w_a while the number of possible entrants can be represented by $W - w_c$. In this sense, the sustainability of the virtual population is given by $\frac{W - w_c}{w_a}$. If we assume that the total population is fixed at K ($w_c - w_a = K$), then the measure becomes Equation (11). The equation tells that if the number of retired players increases, the durability decreases. In Proposition 2-2, the equilibrium price decreases when the number of retired players increases (w_a). Therefore, the relationship between sustainability and the price of game items can be derived as follows.

$$(11)\quad Sustainability(S) = \frac{W - K - w_a}{w_a}$$

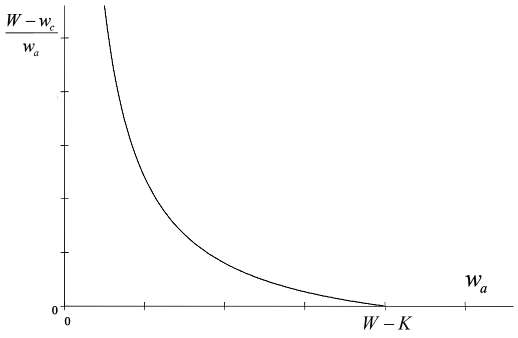


Figure 5. Sustainability of The Virtual World Population

Proposition 6. *If the operator does not develop higher levels of games, the virtual world is more likely to collapse.*

3.4. Impacts of RMT on the Real World Economy

Since the virtual economy provides an opportunity of creating real wealth through RMT, we are going to analyze the income distribution in the real world for three cases: no game, no RMT, and RMT allowed. Without the virtual economy, each player's income is linearly proportional to his or her wage rates. In that case, players with a lower wage rate spend more time on playing the online game than do players with a higher wage rate owing to the opportunity costs of their real income.[12] Moreover, there is no incentive for users who did not play the online game previously to participate now. As a result, the income disparity increases when the players with a lower wage rate play a game since they lose income relatively more than those with a higher wage rate do. On the other hand, when RMT is introduced, players with lower wage rates can make money by selling game items and players with higher wage rates spend more time for the game by buying game goods. Hence, skilled players will live the virtual world and occasionally visit to the real world. In that sense, the gap between these two groups will be narrowed.

To compare the income distributions in each case, we use the Lorenz Curve as a graphical representation of the cumulative income distribution function. The Lorenz Curve is used as a graphical

---

[12] This is true when the participation cost is minimal as is the case in most virtual worlds.

device to represent the size distribution of income and wealth (Kakwani, 1977). In Figure 6, a horizontal axis means the percentage of players and a vertical axis shows the percentage of total income (real money) in this model. A diagonal line in the middle of Figure 6 describes a perfectly equal income distribution, that is, every player has the same income. The higher the concavity of the curve, the more unequal the income distribution. Comparing the Lorenz Curve of three cases, we maintain that RMT may result an income redistribution effect on the real economy. As proven in Proposition 7, the figure also shows that allowing RMT may narrow the gap of income among players.

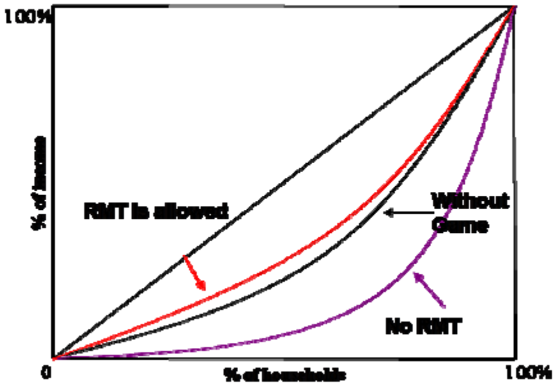


Figure 6. Lorenz Curves of Three Cases

Proposition 7-1. *The Lorenz Curve when RMT is allowed is less convex than that when it is not.*

Proposition 7-2. *The Lorenz Curve when RMT is allowed is less convex than that when there is no game.*

From an economics perspective, this result shows that RMT has a positive impact on the real economy by inducing the income distribution to be more balanced. In terms of the amount of money, the risk of losing one’s income by playing online games (instead of spending time for work) obviously exists. However, social welfare increases by allowing RMT. Previous studies on the impacts of RMT usually focused on its negative impacts such as game addiction or criminal results from the perspective of social behavior (Yoon, 2004; Lindstrom, 2004). However, the results of this study show the possibility of a positive impact of RMT.

4. Empirical Analysis of RMT

The analytical results highlighted the impact of RMT on the online game business. The results covered the market equilibrium in RMT, management of item quantities for operators, and the impact of RMT in the real economy. Extending the analytical model further, several findings or assumptions are empirically tested by using data from the RMT market. The empirical analysis mainly examines three parts. First, we test if the total amount of playtime can be a proxy for a game operator's profit, which is a basic assumption in our model. The, we test the two results in our model. We first test the relationship between the price of a game item and its quantity in the market equilibrium. We also test the influence of RMT on an operator's profit by examining the relationship between the aggregated playtime and the transaction volume of RMT.

4.1. Data Set

To supplement our analytical results, an empirical analysis is conducted with RMT data. Due to difficulty in accessing online game companies, we collected the data sets from three different sources. Gametrics[13], the Korean online game information company, collected weekly playtime data on the seven most popular online games from all the Internet cafes (called PC bangs[14]) in the country. The data was collected for the period between January 1, 2005, and December 31, 2006 (104 weeks). While online games can be played from various locations, "PC bangs" appear to be the places where the majority of online game consumption takes place. We obtained the total playtime for one online game collected from the operator directly and found that it is highly correlated with that playtime data obtained from the PC bangs. The second data are the transaction data from Itembay[15]. Itembay is one of duopoly RMT market makers whose market share is more than 40% of total trading market in Korea (GITISS 2007). This data set includes the transaction volumes of RMT, the prices of game items (the exchange rate of game items to real money), and the revenue of major online gaming companies. Transaction volumes are the amount

---

[13] http://www.gametrics.com

[14] http://en.wikipedia.org/wiki/PC_bang, bang approximately means "room" in Korean. PC bang can be translated as an Internet café or a LAN gaming center.

[15] http://www.itembay.com

of money that players trade in one day. The third data set is from one popular MMORPG gaming company that sells virtual items to players. Our data is limited to Korea as the country has the lion's share of the global online gaming industry. In 2007, Korea represented $ 1.78 out of 5.1 billion of the global market, a close second to China's market share of $1.8 billion in the same year[16]. We collected the direct revenue of this company for the period between May 3, 2006, and February 6, 2007. Because revenue data is especially sensitive information for firms to release, revenue data and its analysis for only one game was possible.

From these various sources, the six most popular online games were identified. According to Gametrics, one of them (Game 1) has had the highest number of users of all Korean MMORPGs since 1998, and three games (Game 1, 2, 3) have ranked among the top 5 in market shares in online gaming industry during the data period. Except for Games 2 and 3, all the other games were published by different companies. All six games basically have playtime and transaction volume data. These two data sets were used for the first part of our empirical analysis. Additionally, Games 1 and 2 have transaction volume data while Game 6 has its revenue data.

4.2. Empirical Model

This paper uses the autoregressive distributed lag model (ARDL) to test the effect of RMT. ARDL models are usually applied to the test of the short- and long-run relationship between the two variables (Narayan, 2005). Online games differ from each other in their history and maturity. At an exploratory stage of research in this area, we do not have an extensive list of control variables yet. Hence, we adopt autoregressive distributed lag (ARDL) model and use lag terms of dependent variable as control variables for each analysis. ADL models are also applied to examine long-term relationships between dependent and independent variables (Kiviet and Dufour, 1997). The empirical analysis tries to verify three relationships: between playtime and transaction volumes, price and transaction volumes, and revenue and

---

[16] http://english.cri.cn/3130/2008/03/02/65@329059.htm

playtime. All three models consist of a dependent variable (the first term in the three relationships) and autoregressive terms of the dependent variables, and lag terms of the independent variables (the latter term).

Transaction volumes of an online game are defined as the amount of money (in this case, Korean Won) that players have spent for RMT per week. In the empirical analysis, objects of RMT include game items and the virtual currencies of the online games. Playtime in an online game means the total sum of hours that an individual player has logged in a game server for a week. Price in RMT is defined as the average exchange rate of real money to the virtual currency of an online game. Note that playtime is the proxy of profit in our analytical model. Hence, we can test that assumption empirically. Revenue of an online game is the amount that a game company has earned by micropayments[17] and subscription fees of an online game for a week.

To develop the model for our empirical analysis, we conduct several tests and diagnostics, and specify the three regression models based on Pesaran (1999). First, we perform a unit root test for each variable to find out whether the variables are stationary. Then, we analyze the correlation and causality between the dependent and independent variables in each equation, and further verify the autocorrelation. We use the pairwise Granger causality test for the causality test. For the specification of the lag terms in each model, we first observe the correlogram of each variable and nominate several models that include lag terms of dependent and independent variables. From among the several candidates, we select the one with the lowest Akaike Information Criterion (AIC) by diagnostic checking. The following Equations (12), (13), and (14) are the models finalized for our empirical analysis.

$$(12)\quad \ln T_{i,t} = \alpha_0 + \alpha_1 \ln V_{i,t} + \ldots + \alpha_p \ln V_{i,t-p} + \alpha_{p+1} \ln T_{i,t-1} + \ldots + \alpha_{p+q+1} \ln T_{i,t-q} + e_{i,t}$$

---

[17] http://en.wikipedia.org/wiki/Micropayment, Micropayments are a method of selling virtual items or money in online games. This is usually used in games that are free to play, i.e. with no monthly fee. Items traded with micropayments are more powerful in helping a player to perform better in the game than those that can be obtained for “free.”

(13) $\ln P_{i,t} = \beta_0 + \beta_1 \ln V_{i,t} + \ldots + \beta_p \ln V_{i,t-p} + \beta_{p+1} \ln P_{i,t-1} + \ldots + \beta_{p+q+1} \ln P_{i,t-q} + e_{i,t}$

(14) $\ln R_{i,t} = \gamma_0 + \gamma_1 \ln T_{i,t} + \ldots + \gamma_p \ln T_{i,t-p} + \gamma_{p+1} \ln R_{i,t-1} + \ldots + \gamma_{p+q+1} \ln R_{i,t-q} + e_{i,t}$

The Eviews 6.0 program is used for the regression analysis. Equation (12) tests Proposition 5 in the analytical model. Equation (13) tests the relationship between the equilibrium price and the volume of RMT. The assumption that playtime is the proxy of profit is tested by Equation (14). We use panel data analysis for Equation (12) to test the relationship between the transaction volume and playtime.

4.3. Empirical Results

For the estimation of the equations, we first test the correlation and causality between the variables in each equation. Unit root test for each variable is also conducted. Table 1 presents this data.

Table 1. Descriptive Statistics

	Playtime	Transaction Volumes	Price	Revenue
	Mean (hour)	Mean (won)	Mean (won)	Mean (won)
Game 1	423363.79	1269114.4	18947.17	-
Game 2	339913	1871450	20448.49	-
Game 3	342163.27	2215051.9	-	-
Game 4	279236.02	271593.27	-	-
Game 5	80543.144	11014783	-	-
Game 6	69983.635	1129425	-	41711033

4.3.1. Does RMT lead to more playtime?

We use six online games (Games 1~6) for panel data analysis. Games 1, 2, and 3 have considerably higher market shares than Games 4, 5, and 6, which means that the playtime of the first three games record significantly higher values than the latter three. Therefore, we test two models for the Equation (12). First, we use all six online games. After that, we limit the analysis for Games 1, 2, and 3, all of record the top three aggregated playtimes. Six games have significantly positive correlations between playtime and transaction volumes[18]. The Granger causality test implies that the transaction volumes have an interaction effect on playtime in general. However, Game 1 has interaction effects on both playtime and transaction volumes.

Table 2. Relationship between Playtime and Transaction Volumes ((): std. errors)

	Fixed Effect Model 1 (including all 6 games)	Fixed Effect Model 2 (including only 3 highest market share)
C	1.1057*** (0.28)	0.8216*** (0.27)
$\ln V_{i,t-1}$	0.0154 (0.01)	0.0188* (0.01)
$\ln V_{i,t-2}$	-0.0136 (0.01)	-0.0014 (0.01)
$\ln V_{i,t-3}$	-0.0019 (0.01)	0.0024 (0.01)
$\ln V_{i,t-4}$	0.0392*** (0.01)	0.0116 (0.01)
$\ln T_{i,t-1}$	0.8531 (0.02)	0.9008 (0.03)
Adjusted R^2	0.98	0.87

The result of pooled regression shows that the transaction volumes of MMORPGs have positive coefficients. This confirms Proposition 4 in the analytical analysis done previously. In the case of the first model (model 1), the effect of RMT is realized four weeks later. On the other hand, in the case of the second model (model 2), the effect is realized only one week later. This might be because of differences in the characteristics of the top three games and the others. The top three games require a monthly subscription fee from players, while the other three games adopt a micropayment policy. Therefore, other three games sell diverse game items, which increase the gamers' avatars' abilities in virtual worlds. It is interesting that Game 3 has the effect of RMT on playtime, because it was said that the developers of Game 3 implemented a policy to discourage RMT in game design. There is a positive relationship of RMT with longer lags. The full regression results are reported in the appendix.

4.3.2. Equilibrium Price and Quantity

---

[18] In case of games 1, 2, and 3, correlation coefficients are 0.6461, 0.6067, and 0.5848.

In the analysis between transaction volumes and price in Equation (13), we use data of Games 1 and 2 and not of the other games because their price data were not available or missing for some time periods. To summarize, it can be said that playtime and price have a positive relationship. This result partially supports Proposition 2-1 and the left side of the graph in Figure 4. Proposition 2-1 said that the increase of game item productivity (w_b) results in the decrease of the price. In Proposition 3, the increase in item supply results in the decrease in total playtime if item supply exceeds the optimal level (w^*). That is, there is an oversupply of game items. Therefore, the analytical results are supported by the results from the empirical analysis as well.

Table 3. Relationship between Price and Transaction Volumes ((): std. errors)

	Game 1	Game 2
C	13.50*** (2.98)	6.25*** (2.31)
$\ln V_{i,t-1}$	0.47* (0.26)	0.71*** (0.21)
$\ln P_{i,t-1}$	0.61*** (0.14)	0.94*** (0.04)
Adjusted R^2	0.41	0.46
Prob. (F-statistics)	0.00	0.00

In studying the relationship between price and transaction volume, it was found that positive correlations between them exist in both MMORPGs. Moreover, in both MMORPGs, the null hypotheses of the causality test—that price does not Granger-cause transaction volume (p = 0.89890 for game 1, p = 49663 for game 2)—is not rejected, but the opposite (p = 0.12521 for game 1, p = 02540 for game 2) is rejected. Therefore, it can be concluded that transaction volumes are price-determinant. From this result, it was found that both playtime and transaction volumes have an interaction effect on each other in the cases of Games 1 and 2. Therefore, it can be concluded that transaction volumes affect playtime, and at the same time, playtime causes transaction volumes.

4.3.3. Revenue and Playtime

From the data obtained from one online gaming company, we test the relationship between revenue and playtime of online games. In the causality test between revenue and playtime, the null hypotheses of the causality test—that revenue does not Granger-cause playtime (p = 0.99450)—is not rejected but the opposite (p = 0.0144) is rejected. That means that the revenue of online games is the result of playtime. The result of the AR analysis shows that a 10% increase in the playtime causes a 7% increase in revenue. This result supports the assumption that playtime can be a proxy for profit in online games in the analytical model. It is interesting that R_t is affected by R_{t-4}. That means that the revenue of online games has a monthly effect. It may be related to the players' monthly salary in real worlds. To sum up the results of these three relationships: playtime and transaction volumes, price and transaction volumes, playtime and revenue, it shows that RMT has a positive effect on the revenue from online games. Prosperity of RMT market makes players play more and increase the revenue of online game operators.

Table 4. Relationship between Revenue and Playtime ((): std. errors)

	Game 6
C	8.08* (4.25)
$\ln T_{i,t-1}$	0.70** (0.32)
$\ln R_{i,t-1}$	0.50*** (0.10)
$\ln R_{i,t-4}$	0.25** (0.10)
Adjusted R^2	0.48
Prob. (F-statistics)	0.00

5. Conclusion

We presented a framework that captures the essential strategic features of virtual worlds such as the experience point system in a stylish and dynamic game theoretic model. The impact of the operators' design variables (the productivity of items and levels of the game) on the game performance was explicitly investigated. Hence, the game operator's optimal design principles of embedded economic systems and the game are derived in this paper. Our results show that markets of virtual assets enable users to play the game at their optimal challenge levels. The relevance and importance of the embedded economic systems in the virtual world's performance were also explained in previous sections. The derivative markets (RMT) of the virtual items are linked to the game performance. Hence, we believe that this analytical framework may be used by the operator as well as by policy makers.

We also empirically tested some of the propositions using detailed data. Our empirical results confirm that RMT significantly affects the choices of players. Even in the case of popular and older online games, RMT can account for a significant portion of their demand. It is very interesting that the same holds true even for games that discourages RMT. Many online operators have now begun to sell their virtual items directly to users. Allowing RMT (throughout the game market) may lead to competition among the operators and the homogeneous items market. Hence, for the optimal design of the market and business model decision, this issue must be further investigated.

Some limitations inherent in this research must be noted. First, our analytical model includes some simplifying assumptions. The sensitivity of such assumptions must be further studied and may be relaxed if necessary. Our empirical models employ a very limited number of variables. Further exploratory research is needed to improve on them. Even though Korea has the largest RMT global market share, our data sets are also limited to those only from Korea. Hence, a generalization of our findings may be compromised by this limitation.

Under the assumption of possible wealth transfer between the two worlds (virtual and real), the macro-economic impact of virtual economies on the real world is studied. Wealth re-distribution by RMT is derived for illustration. If virtual worlds and their economies continue to expand, their impacts on the real world will be wider and deeper. One frequently raised issue is the possible loss of production in the real world by mass migration to the virtual world. Given the addictive nature of online games, it may pose a serious threat to the real economy. On the other hand, as illustrated, the wealth transfer between the two worlds could change the distribution of wealth in the real economy and the velocity of money flow in it. These effects may not only be beneficial but may also alter economies. For example, RMT gives people with lower or no wages in the real world a chance to earn from the virtual world and to then consume other goods in the real world. The extended full equilibrium model between the two economies that takes these factors into account is under development.

The virtual world is a very interesting subject for IS researchers and economists because operators of virtual worlds have almost 100% perfect information of their worlds, like deities. The economic systems inside these worlds evolve at the speed of light. This provides very fertile grounds for micro- and macroeconomic research by academicians, practitioners, and policy makers. We believe this study can be an addition to this field of research as a new frontier of analysis.

References

R. Bartle. 2004. Pitfalls of virtual property. *Themis Group* 1-22.

R.A. Bartle. 2004. *Designing virtual worlds*. New Riders Pub.

D. Basu. 2003. Fear of Hyperinflation Grips Norrath. *The Visible Hand* 7.

J.S. Brown, Thomas, D. 2008. The Gamer Disposition. *Harvard Business Review*. 86(2) 17-48.

B.T. Camp. 2007. The play's the thing: a theory of taxing virtual worlds.

E. Castronova. 2001. Virtual worlds: A first-hand account of market and society on the cyberian frontier. *The Gruter Institute Working Papers on Law, Economics, and Evolutionary Biology*. 2(1) 1.

E. Castronova. 2002. On virtual economies. *CESifo Working Paper Series No. 752*.

E. Castronova. 2004. The price of bodies: A hedonic pricing model of avatar attributes in a synthetic world. *Kyklos*. 57(2) 173-196.

J. Dibbell. 2007. The life of the Chinese gold farmer. *Life*.

J. Donath. 2008. Giving Avatars Emote Control. *Harvard Business Review*. 31.

T. Erickson. 2008. Task, not time: profile of a Gen Y job. *Harvard Business Review* 19.

GITISS. 2007. Korea Game White Paper 2007. *Game Industry Total Information Service System*.

R. Hof. 2006. My virtual life. *Business Week*.

J. Huhh. 2008. Simple economics of real-money trading in online games. *SSRN eLibrary*.

J.S. Huhh. 2005. Empirical Study on the Decline of Lineage 2 in Korea.

N.C. Kakwani. 1977. Applications of Lorenz curves in economic analysis. *Econometrica: Journal of the Econometric Society* 719-727.

J.N. Kelly. 2007. Playtime: Analysis of MMORPG Play as Economic Activity. *Working Paper*.

KGIA. 2007. The Economic Analysis of the Impact of Real Money Trading of Online Game Items. *Korea Game Industry Agency*.

J.F. Kiviet, Dufour, J.M. 1997. Exact tests in single equation autoregressive distributed lag models* 1. *Journal of Econometrics*. 80(2) 325-353.

A. Knoll. 2007. Guest Editor's Introduction: Toward High-Definition Telepresence. *Presence: Teleoperators and Virtual Environments*. 16(5).

V. Lehdonvirta. 2005. *Virtual economics: applying economics to the study of game worlds*. City.

M. Lindstrom. 2004. Branding is no longer child's play! *Journal of Consumer Marketing*. 21(3) 175-182.

J. McGonigal. 2008. Making Alternate Reality the New Business Reality. *Harvard Business Review. Special Issue: Top*. 20.

B. Mennecke, Roche, E., Bray, D., Konsynski, B., Lester, J., Rowe, M., Townsend, A. 2008. Second Life and Other Virtual worlds: A Roadmap for Research. *Communications of the Association for Information Systems*. 22(20) 371-388.

S. Narayan, Narayan, P.K. 2005. An empirical analysis of Fiji's import demand function. *Journal of Economic Studies*. 32(2) 158-168.

B. News. 2002. Inflation Threatens EverQuest Economy. *BBC News World Edition*.

S. Park. 2004. The Nature of the Economic Phenomena in MMORPG. *Gamestudy.org*.

M.H. Pesaran, Shin, Y. 1999. *An autoregressive distributed lag modelling approach to cointegration analysis*. Cambridge University Press: Cambridge, City.

B. Reeves, Malone, T.W., O Driscoll, T. 2008. Leadership's online labs. *Harvard Business Review*. 86(5) 58.

M. Sarvary. 2008. Breakthrough ideas for 2008: The metaverse-TV of the future. *Harvard Business Review*. 86(2) 17-45.

Z.B. Simpson. 1999. *The in-game economics of Ultima Online*. City.

D. Terdiman. 2004. Fun in following the money. *Wired News* 63363-63360.

G. Wong. 2006. How Real Money Works in Second Life. *CNNMoney.com*.

H. Yamaguchi. 2004. An analysis of virtual currencies in online games.

U. Yoon. 2004. The Legal and Political Inquiry into the in-Game Item Ebaying of MMORPGs. *Gamestudy.org*.

D. Young. 2005. *Asia Tackles Online Game Addiction*. City.