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The determinants of monetary value of virtual goods: An empirical study for a cross-section of MMORPGs

Qiu-Hong Wang · Viktor Mayer-Schönberger · Xue Yang

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Abstract This study investigates the monetary value of virtual goods in the context of 24 most popular massively multiplayer online role-playing games (MMORPGs). Building on classic economic theory, we approach this issue through a combination of experimentation and cross-sectional time series data analysis. Our findings suggest that more intensive social networking and flatter social hierarchical structures are associated with lower monetary value of virtual goods across various MMORPGs. Instead, a larger base of active users increases the potential demand and thus the monetary value of virtual goods in the short run. A steeper social hierarchical structure further strengthens the effect. The implication is that social networking and hierarchical structure can be two effective angles for game developers or policy makers to address the issue of real-money trading of virtual goods.

Q.-H. Wang (✉)
School of Management,
Huazhong University of Science & Technology,
Luoyu Road 1037,
Wuhan, China 430074
e-mail: qhwang@mail.hust.edu.cn

V. Mayer-Schönberger
Oxford Internet Institute, University of Oxford,
1 St Giles,
Oxford OX1 3JS, United Kingdom
e-mail: Viktor.MS@oii.ox.ac.uk

X. Yang
School of Management(Business), Nanjing University,
Hankou Road 22,
Nanjing, China 210093
e-mail: yangxue@nju.edu.cn

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1 Introduction

The Internet has become an integral part of our lives. According to a survey conducted by Forrester Research Inc. of 30,064 US individuals in January and February 2010, for the first time ever, the average US household spends as much time online as it does watching TV offline, a growth of 121% since 2005.

More and more people are making a living by producing virtual goods on the Internet.[1] Intangible, virtual goods exist in digital forms only, produced through people's online activities, e.g., through the generation of digital traffic or the provision of digital content. The production of virtual goods has risen further through the emergence and rapid evolution of virtual worlds—online and persistent virtual environments generated by computers, in which players interact through avatars, a textual or visual representation of themselves (Bell 2008). Typical examples of virtual worlds are online games. In this context, researchers even narrow down virtual goods to only characters, items, currencies and tokens that exist inside various online games and hangouts (Fairfield 2005; Lehdonvirta 2009). In July 2007, comScore reported 217 million people playing online games including all sites that provide online or downloadable games but excluded gambling sites.[2] A more conservative report of 16 million

[1] As reported in a recent Wall Street Journal, 452,000 people in America are making a living as bloggers, a scale close to the number of lawyers in the country.
[2] http://www.comscore.com/Press_Events/Press_Releases/2007/07/Worldwide_Online_Gaming_Grows.

people was provided by mmogchart.com including only players who maintained active subscriptions to the 45 most popular online games. Players in these worlds spend considerable time to acquire virtual coins or equipments for their in-game avatars. They trade those virtual goods via in-game marketplaces and auction platforms, and utilize or consume them for adventure, social networking, entertainment or any other forms of self-fulfillment.

Real-money trading (RMT) for virtual goods first emerged in 1999 on eBay where users listed their hard-earned game possessions (e.g., items or coins generated in Ultima Online and EverQuest) on auction (Hamari and Lehdonvirta 2010). As it takes significant time commitment for players to acquire or make virtual goods, players with proportionally more money than time in the real world have an incentive to shortcut parts of the experience in virtual worlds (Ondrejka 2004). As a result, the real-money trading (RMT) markets have grown rapidly and evolved from player-to-player transactions into commercial markets. The first driving force in RMT markets is game operators selling goods directly to their users, such as MapleStory and Habbo. Players are exempted from monthly subscription but expected to spend money on virtual goods (Nojima 2007). The other driving force is gold farmers who are specialized sellers dedicated to make in-game items to earn real money (Huhh 2008). As the Internet enables global exchanges between virtual goods and real money, cheap workers from developing regions have become the main force of gold farming. The global volume of virtual goods transaction was estimated at 2.1 billion USD per year in 2006 (Lehtiniemi and Lehdonvirta 2007).

The growing size of this virtual economy (and the resulting business opportunities), its Internet-enabled global markets, and the simultaneity of production and consumption in virtual worlds have attracted sustained attention from business and academia. In particular, virtual goods harvested by gold farmers flood into the RMT markets and pose significant challenges to game providers desiring to maintain the health of their virtual economy (Jung et al. 2009) and to regulators seeking to measure the impact of virtual economies on the real world (Castronova 2001). The fundamental economic question underlying these controversies is what factors drive the demand for virtual goods and finally determine their monetary value in the RMT markets? We address this issue in the context of a large subset of virtual worlds, namely Massively Multiplayer Online Role-Playing Games (MMORPGs).

Researchers have identified users' incentives on virtual goods sales, such as advancement in a status hierarchy, advantage in competitive settings, keeping up with co-players, experiencing new content, customization and self-expression (Martin 2008; Lehdonvirta 2009, Hamari and Lehdonvirta 2010). While existing studies focus on the intrinsic motivation for the demand of virtual goods from an individualistic perspective, we complement their work by investigating the economic factors which are general to most MMORPGs and shape the demand and supply of real-money trading of virtual goods at a market level. To minimize disturbances induced by an MMORPG's specific storyline in evaluating any particular virtual item, [3] we instead compare an avatar's in-game productivity measured in real dollars across MMORPGs and at the stage when the least game-specific context is involved in virtual item production.

We approach the above research question based on the theory of demand and supply in classic economics and through a combination of theoretical modeling, experimentation, and cross-sectional time series data analysis. Twenty four MMORPGs are incorporated in our study based on their popularity and the availability of information. Table 1 lists the 24 MMORPGs and their profile information regarding developer, theme, age and pricing schemes.

We further analyze the driving forces of demand and supply of virtual goods in RMT markets. Based on the panel data from experimentation and secondary sources, we regress the monetary value of an avatar's in-game productivity on factors that define the demand and supply curves in a clearing RMT market for an MMORPG with control for player-specific effects.

Our findings show that the monetary value of an avatar's in-game productivity is relatively higher in MMORPGs with a larger active user base, with less time spent on collaboration or social-networking related activities, and a steeper social hierarchical structure consisting relatively of more low-end avatars. The social hierarchical structure has a further moderating effect on the other two factors. The rationale behind the findings may be that (i) user engagement that requires collaboration and social networking weakens the transferability of in-game production through RMT markets and accordingly reduces the incentive to trade in RMT markets; and (ii) the social equality in a flat virtual society reduces scarcity and hence discourages buyers' valuation on virtual goods.

These findings have important business implications. First, it questions the effect of interoperability efforts, such as a joint project between IBM and Linden Lab to integrate virtual worlds and minimize users' migration cost. As our results point to the persistent importance of social capital in virtual worlds, it may not be enough to lower migration costs for users to switch from one world to another. Providers will also have to look at switching cost associated with social capital.

Second, game developers are striving to retain players. One of their core strategies is to add levels for avatars and

[3] For example, a virtual item in game World of Warcraft is not comparable with the same kind of title in Ever Quest.

Table 1 List of the 24 MMORPGs (as of Dec. 2007)

MMORPG name	No. of months from the first launch	Monthly subscription fee (US $)	Micro transactions	In-game auction	Developer	Theme
Anarchy Online	78	0	√	–	Funcom	Futuristic
Archlord	14	0	√	√	NHN Games	Fantastic
City of Heroes	44	14.99	–	√	Cryptic Studios	Super-Hero
Dark Age of Camelot	74	12.95	–	–	Mythic	Fantastic
Dofus (EU)	27	6.9	–	√	Ankama Studio	Fantastic
Dungeon and Dragons Online	22	14.99	–	√	Turbine	Fantastic
EVE Online	57	14.95	–	√	CCP	Futuristic
Everquest	104	12.99	–	–	SOE	Fantastic
Everquest2	37	14.99	–	–	SOE	Fantastic
FFXI	45	12.95	–	√	Square	Fantastic
Granado Espada	5	0	√	–	IMC Games	Fantastic
Guild Wars	32	0	–	–	ArenaNet	Fantastic
Hellgate London	2	9.95	–	√	Flagship Studios	Futuristic
Hero Online	17	0	√	–	MGame Corporation	Fantastic
Knight Online	37	0	√	–	MGame Corporation	Fantastic
Lineage 2	44	14.99	–	–	NCSoft	Fantastic
Lord of the Rings Online	8	14.99	–	√	Turbine	Fantastic
Maple Story (Global)	56	0	√	–	Wizet	Fantastic
RF Online	22	0	√	√	CCR	Futuristic
Scions of Fate	13	0	√	–	MGame Corporation	Fantastic
Star Wars Galaxies Online	53	14.99	–	√	SOE	Futuristic
Tabula Rasa	1	14.99	–	√	NCsoft	Futuristic
Vanguard Saga of Heroes (US)	11	14.99	–	√	SOE	Fantastic
World of Warcraft	37	14.95	–	√	Blizzard	Fantastic

thus attract existing players to continue playing the game. By adding to the in-game social hierarchy as defined by different power levels associated with each player, this strategy stimulates some players to shortcut gameplay through real money trading, thus creating the demand for gold farming. This in turn exacerbates the inflation in virtual worlds and reduces a game's market lifecycle (Castronova 2006). Hence, adding hierarchy levels may not be an effective way to retain players and maintain a healthy virtual economy in the long run. Instead, we suggest game developers may be better off by enriching virtual content and facilitating players' in-game collaboration and social networking.

The remainder of this paper is organized as follows. Section 2 summarizes the relevant literature on virtual communities, virtual economies and particularly on real money trading for virtual goods. Section 3 presents the theoretical foundation and hypotheses; Section 4 introduces the experiment and reports the estimation results with robust tests; Section 5 summarizes the paper and discusses possible future research.

2 Literature review

As argued by Meredith et al. (2009), there has been very little published academic research concerning online gaming. Most of extant studies in online games adopt qualitative or analytical approaches with few empirical studies and even less on the different types of online games. Given the lack of data, Meredith et al. conducted a scoping study to examine the extent, range and nature of the 20 most popular MMORPGs. Our study goes further by incorporating both the primary and secondary data from 24 most popular online games (14 of them overlap with those in Meredith et al.'s paper). It is among the first to empirically identify the economic factors which are general to most MMORPGs and shape the demand and supply of real-money trading of virtual goods at a market level. We approach this issue based on the extant literature of virtual communities in information systems, as well as basic microeconomics.

According to Balasubramanian and Mahajan definition (2001), virtual worlds are virtual communities, resting on one of the four purposes: transaction, interest, fantasy and

relationship as identified by Hagel and Armstrong (1997). Most generally, virtual worlds are extensions of the physical world. To businesses, they are burgeoning channels/media of marketing and distribution, and offer new business models; to individuals, they are substitutes of the real world activities; to regulators, they create new domains of intellectual property ownership, taxation and related legislation (Papagiannidis et al. 2008).

Unlike their counterparts in the real world, virtual goods generated in virtual worlds have no material or physical presence. Hence time spent is considered the only scarce resource associated with the production of virtual goods (Huhh 2008). Real-money trading for virtual goods directly results from players' valuation of virtual goods and their heterogeneous opportunity costs of the time spent in virtual worlds (Ondrejka 2004; Huhh 2005). The scholarly publications address real-money trading of virtual goods from three perspectives. As argued by Lehdonvirta (2009), the majority deals with the legal and philosophical issues associated with virtual worlds and virtual goods (e.g., Lastowka and Hunter 2004; Fairfield 2005). Another group adopts a sociological perspective on consumption. Although virtual goods cannot fulfill material needs, researchers highlight their role as symbols of status, individuality and belongings in avatars' social interaction (Martin 2008). Functional, hedonic and social attributes are identified as important factors that drive decisions of virtual-item purchase (Lehdonvirta 2009).

The economic perspective on real-money trading of virtual goods focuses on the pricing of online game services and the strategic interaction of demand and supply in RMT markets. Huhh (2008) defines four pricing regimes of online game service: flat fee[4] without RMT, flat fee with player-to-player RMT, flat fee with gold farming, and two-part tariff with firms' direct selling. In their study on MMORPGs, Huhh and Park (2005) further identify that incentives of low-level players constitute the demand side of the trading market while high-level players are capable of supplying the trading market due to their superior ability in collecting or producing valuable items.

Users can directly purchase virtual items in RMT markets or via an in-game auction house using the virtual currency that they have acquired in RMT markets. Ondrejka (2004) suggests that virtual currency performs all three functions of real money: a medium of exchange; a measure of value and a store of value. At the same token, virtual currency is subject to more serious inflation. As a virtual world goes through stages towards maturity, the relative number of new players is declining and the production capability exceeds the pace of consumption. Thus we witness the accumulation of excessive virtual goods (Huhh 2005).

Instead of studying players and their transactions in RMT markets, Lehdonvirta (2005) addresses virtual world providers' economic integration strategy intervening in RMT. He considers a virtual asset market as the interface between a virtual economy and the real economy. Providers influence their economies by adjusting this interface. A provider's economic integration strategy is defined by two variables. First, does the provider enter the RMT market, and if so, as a buyer, seller or both? By allowing trade to go on unabated, they can promote interaction and integration. By enforcing a trade embargo, they can promote isolation. By asserting a monopoly, they can exercise control over the interactions. Second, does the provider control the marketplace? If yes, it is likely centralized and easily regulated. If not, it may be distributed and less susceptible to provider regulation.

While the aforementioned studies mainly adopt qualitative or analytical approaches, the online game industry in Korea provides some data for empirically addressing the impact of RMT markets on virtual worlds. Based on the practices in the Korean game industry, Huhh (2006) proposes a strong positive correlation between RMT and the commercial success of a virtual world. He empirically tests that the declining usage of Linage II—a popular Korean MMORPG—was affected by a drop in RMT returns (Huhh 2005). This finding resonates with Yoo et al.'s study about the relationship between embedded economic systems and performance of virtual worlds (Jung et al. 2009). Other researchers are less positive on RMT. Some consider RMT a disruption of game immersion (Castronova 2006), or accelerating inflation (Ondrejka 2004).

Similar to Lehdonvirta (2005), in this study we are also interested in the RMT market as the linkage between the virtual economy and real economy. The difference is that we focus on the economic implication exposed by this interface—the driving forces which are independent of an online game's storyline but drive the different monetary value of virtual goods generated in various online games. With a wide coverage of MMORPGs with different themes, pricing schemes and date of the first launch, we are able to take a more holistic view of the relationship between online games and their RMT markets.

3 Theoretical foundation and hypotheses

MMORPGs provide a feasible context for the cross-sectional study of the monetary value of virtual goods. First, prior research has found experimental evidence that the law of demand holds in MMORPGs (Hagel and Armstrong 1996). Second, MMORPGs are based on provider-generated content

[4] Huhh (2008) defines flat fee as "applying a fixed price unilaterally without regard to each player's usage level for a fixed period". Two-part-tariff means that game service providers charge a small entry fee (normally free) and at the same time conduct RMT by selling virtual items to players—the so called micro-payment.

and a predefined hierarchical framework in which each avatar is associated with different power levels. Unlike those virtual worlds with user-generated content, e.g. Second Life, Maple Story, etc., players in MMORPGs must follow and are constrained by the game's telos and the underlying storyline, regardless of how different they are in personality, brain power, or experience (Mayer-Schönberger and Crowley 2006). This enables a controlled experiment at the individual level and minimizes the effects due to players' intrinsic difference. Third, the existence of online RMT markets for virtual goods provides an economic linkage between the real and virtual worlds, and enables us to observe the time series of listed prices for virtual goods across MMORPGs.

The challenge for a cross-sectional study lies in the lack of a unified platform across virtual worlds. Due to business and technology constraints, virtual worlds with different developers are isolated from each other. Thus virtual goods acquired from different virtual worlds, including gold, artifacts or even complete avatars, cannot be directly transferred or compared with each other. However, MMORPGs have imposed scarcity of virtual goods in the sense that acquiring, making, or developing things of value demands significant amounts of time for regular players (Malaby 2006). Hence rather than virtual goods, a comparable virtual product across MMORPGs could be the real monetary value of an avatar's in-game productivity.

For any MMORPG i, to measure the monetary value of an avatar's productivity, we must know the total items that it is able to earn within a fixed period of playtime. Since virtual currency (e.g. gold) is the exchange media within an MMORPG, the total items can be further transferred into the amount of virtual currency. Given the amount of virtual currency, ω_i that a player can earn within a fixed period of playtime and the exchange rate between the virtual currency and the real dollar, p_i, the monetary value v_i of an avatar's productivity can be derived as

$$v_i = \omega_i \times p_i \tag{1}$$

For example, we may consider an avatar in the World of Warcraft who has played the game for 1 h and thus acquired a certain amount of virtual items including weapons, treasures, etc. within the playtime. This avatar's productivity, ω_i, is measured by the total amount of virtual currency that it can earn by trading those virtual items with a non-player controlled trader in the game.[5] If p_i is the average price in U. S. dollars for a unit of the virtual currency in a RMT market, the monetary value v_i of this avatar's productivity can be calculated by Eq. (1).

Equation (1) implies that the monetary value v_i of an avatar's productivity is determined by two groups of factors. One is related to the RMT market structure and the other is related to a specific avatar. We first consider the factors that affect the demand and supply of virtual goods in an RMT market. The laws of demand and supply state that in a clearing market, the price is determined by the intersection between the downward-sloping demand curve and upward-sloping supply curve (Png and Lehman 2007). MMORPGs are owned by different providers and are digitally isolated in the sense that players cannot directly move their virtual belongings across virtual worlds. Hence we expect an independent RMT market for each MMORPG and the equilibrium price is the one at which the quantity of demand equals the quantity of supply.

For an MMORPG, i, the demand curve of ω_i in the RMT market is shaped by the market potential and the demand elasticity. Given others held equal, the real money value of ω_i as denoted by v_i increases with market potential and decreases with demand elasticity.

Factors that may affect price elasticity of demand include e.g., the necessity of a good or the price of the good as a proportion of income (Png and Lehman 2007). As these factors measure the importance of virtual goods relative to real world substitutes or income, we assume they are similar across MMORPGs.

Next, only by playing in the game can buyers utilize the virtual items that they have acquired on RMT markets. Thus price elasticity of demand is also affected by the cost to play a game, i.e., a recurring subscription fee, C_i^f. We expect a negative effect from it on the price elasticity of demand. Ceteris paribus, we hypothesize that

H1: the monetary value v_i is higher in MMORPGs with a higher subscription fee C_i^f.

The RMT market potential for virtual goods is affected by the potential buyers in an RMT market, its in-game value to players and the value relative to its substitutes in the primary market, e.g., virtual goods that are directly acquired from game service providers or through in-game transactions.

The active user base of an MMORPG determines the upper bound of potential buyers in an RMT market, while the MMORPG's social hierarchical structure affects the actual ratio of such buyers relative to the active user base. An MMORPG's social hierarchical structure is composed of avatars from the lowest to highest levels. The social hierarchical structure becomes steeper if there are more lower-level avatars relative to the higher-level avatars. Following the discussion in Section 2, as an MMORPG gets older,

[5] Some of these virtual items may be listed in an RMT market and thus can be directly valued in real-world currency. However we cannot ensure a real-money value available for each item in the same RMT market and at the same time. Thus using the price in virtual currency offered by a non-player controlled trader in the game can avoid the noise introduced by the variance in RMT markets.

more and more players advance to the highest level while the number of new players shrinks. Then its hierarchical structure tends to become flatter or even an upside-down triangle. As avatars advance to higher levels, they become more productive in earning virtual items, which reduces the relative benefit that they can derive from real-money trading of virtual items. As a result the demand for virtual goods in an RMT market shrinks. We suspect a moderating effect of an MMORPG's social hierarchical structure, β_i, between its active user base, N_i and the monetary value of an avatar's productivity, v_i. Given others are equal, we hypothesize that

H2.1: The monetary value v_i is higher in MMORPGs with a larger active use base N_i;

H2.2: The positive effect from an active user base is stronger in an MMORPG with steeper social hierarchical structure β_i.

The intrinsic value provided by real-money traded virtual items is also positively related to the input from the game provider, U_i. As employee salary is the most salient cost in software development, we may consider the total number of members in the game development team as a reasonable measurement on the game provider input. We hypothesize that

H3: The monetary value v_i is higher in MMORPGs with more developer input U_i.

The net value of virtual items is also negatively related to the static context-fixed cost to play a game, i.e., cost (if any) to purchase the software, C_i^s, and hardware cost. As game operators tend to minimize users' barrier to play a game, the hardware requirement is similar across MMORPGs.

Note that the above factors affect the market potential in both the primary market and the RMT market. The potential demand in an RMT market is further affected by the extent of substitution to the primary market. Specifically, how many players that the RMT market can attract away from the primary market depends on how much of in-game time spent can be transformed into virtual goods listed on an RMT market. Although virtual goods bear a strong relationship with the amount of time required to make them (Malaby 2006), the time spent on social networking cannot be fully digitalized, nor is it transferrable between players due to its interdependence with other players. [6] Social networking in MMORPGs may include (1) the temporary associations that take place in groups, (2) the more permanent connections found via family/friendship networks, and (3) guilds, the officially sanctioned organizations of players with a basic hierarchical leadership structure (Jakobsson and Taylor 2003). Hence for those MMORPGs where social networking is essential for in-game achievement (e.g. a task can only be completed by a guild rather than individual), an avatar's in-game production becomes less substitutable by those virtual items supplied in RMT markets. Consequently, the demand in a RMT market decreases, which in turn dampens the willingness of potential buyers to pay for the virtual items listed in the RMT market. Further, this dampening effect should be more substantial on an MMORPG with relatively more lower-level avatars as they are the main demand force in RMT markets. Hence, we suspect that RMT of virtual goods is less attractive in an MMORPG consisting of relatively more entry-level avatars than higher-level avatars.

H4.1: The monetary value v_i is higher in MMORPGs in which avatars spend less time, W_i on social networking;

H4.2: The negative effect from social networking is stronger in an MMORPG with steeper social hierarchical structure, β_i.

We next consider the supply of virtual goods in an RMT market. The supply curve is shaped by the fixed cost of production and the price elasticity of supply. Ceteris paribus, real money value of ω_i as denoted by v_i increases with the fixed cost of production and decreases with supply elasticity.

Fixed cost, similar to the demand side, is related to software cost and hardware cost. It also includes costs of operating a gold farming studio. According to Heeks (2008), the supply in RMT markets is mainly from gold farmers in developing countries whose average income in the real world is much lower than in developed countries where there is a high demand in RMT for virtual goods. Hence, in such a globalized market with cheap and almost unlimited supply of labor, the supply by gold farming is not sensitive to the income levels in any particular region. Following the law of supply, the determinants of price elasticity of supply are related to a supplier's capacity, availability of substitute markets, and factor mobility (Png and Lehman 2007).

Game providers control the in-game supply of virtual goods by setting the awards that players can receive per action, which we consider as the primary market of an MMORPG. Gold farmers' production capacity cannot exceed the supply provided in the primary market which is constrained by computing power and digital storage, D_i. We expect the price elasticity of supply to be lower in MMORPGs with smaller D_i.

H5: the monetary value v_i is higher in MMORPGs with lower computing power and smaller digital storage D_i.

Some MMORPGs may offer free subscription but charge players on some items or premier services. Such micro-payment has double-edge effects on the price elasticity of supply. On the one hand, MMORPGs with micro-payment,

[6] This is evidenced by our observation that no guild membership is traded separately or bundled with a listed avatar account in 5173.com, the largest real-money trading market in China.

O_i, have an incentive to undersupply listed items in order to maintain a high profit margin. This reduces the price elasticity of supply by constraining the supply from the primary market. On the other hand, a micro-payment scheme increases the competition between the primary and RMT markets, which increases the price elasticity of supply. As a result, the combined effect of micro-payment on the monetary value v_i is ambiguous.

To counter RMT markets run by third parties and further reap players' surplus in transaction, many game providers have established in-game auction houses to facilitate the exchange of virtual goods. Thus we consider the setting up of an in-game auction house, A_i, is the substitute of the RMT market and leads to higher price elasticity of supply.

H6: The monetary value v_i is higher in MMORPGs without in-game auction house A_i.

To test the above hypotheses for a cross-section of MMORPGs, we need to control the factors that are specific to an avatar, which include its player's characteristics and the avatar's in-game status. Note that the storyline of different MMORPGs are not comparable and game providers can manipulate an avatar's capability based on its experience and performance. Thus the comparability of v_i between MMORPGs decreases with the impact of any specific game context on an avatar's in-game productivity ω_i. As normally more manipulated factors are associated with higher level avatars in an MMORPG, to capture ω_i generated by the lowest-level avatar may minimize the disturbances imposed by each MMORPG's specific storyline. We summarize the above discussion into a linear regression model between v_i and its determinants:

$$v_i = \alpha_0 + \alpha_1\beta_i + \alpha_2 N_i + \alpha_3\beta_i \times N_i + \alpha_4 W_i + \alpha_5\beta_i \times W_i + \alpha_6 U_i + \alpha_7 C_i + \alpha_8 O_i + \alpha_9 D_i + \alpha_{10} A_i + \alpha_{11} H_i \quad (2)$$

where H_i denotes the theme of a game (e.g., futuristic, fantastic or super-hero as shown in Table 1). The necessity of the virtual goods, its price as a proportion of income, the operation costs for gold farming studios and hardware cost to play a game are assumed the same across MMORPGs, and thus absorbed into the constant term. Figure 1 illustrates the hypothesized effects from each factor.

Table 2 lists the measurement for each factor. Among them, we measure the status of an MMORPG's social hierarchical structure by the number of months since the first launch date. According to Huhh and Park (2005), as an MMORPG goes through stages to maturity, more and more avatars have advanced from the entry level to higher levels as predefined in its hierarchical framework by the game developer, while the number of new players is declining. Hence, the online virtual society consists of relatively more higher-level players and forms a flatter social hierarchical structure as time goes on.

Note that information about the number of active players for each game is not directly available. Fortunately, XFire, a provider of a widely-used game plug-in, offers daily reports of the number of active players for each game and the total number of minutes that the players have connected with XFire. By end of 2011, The XFire users are composed of more than 20 million registered players across over 2477 online games—probably a stratified sampling of the population of players in the world. Using World of Warcraft (WoW), the most popular MMORPG as an example, in a monthly basis, its active user base reported by mmogchart.com[7] and the number of active XFire subscribers are correlated at 0.88. Thus, numbers gleaned from XFire enable us to compare the *relative* user base across MMORPGs.

Furthermore, as one of the most active gaming communities in the world, XFire serves as "a free tool that automatically keeps track of when and where gamers are playing PC games online and lets their friends join them easily".[8] Thus XFire samples actually have a bias towards players with more needs of in-game social networking. This is a desired feature for our study. First, usage of XFire naturally filters gold farmers—the main suppliers in RMT markets.[9] XFire's user base mainly consists of players for fun—the potential buyers in RMT markets. Second, players connect to XFire for the purpose of in-game communication. Thus the average connecting minutes with XFire spent by users playing a certain game provide a reasonable measurement on their engagement that requires collaboration and social networking in the game. While Jakobsson and Taylor (2003) were able to observe social networking activities between players in the online game EverQuest via their chat logs, observations obtained from an open-platform communication tool, such as XFire, is probably among the few approaches that can be employed to understand the *relative* social networking time across different types of online games.

[7] To the best of our knowledge mmogchart.com is the only available public source which provides the number of active subscriptions for 45 massive-multiple player online games till the end of 2008.

[8] http://www.xfire.com/cms/xf_aboutus/.

[9] In June 2009, we conducted face-to-face interviews with three gold-farming entrepreneurs in mainland China. All of them disclosed that instead of asking their employees to play online games 12 h shift as described by Jin in 2006, the gold farming industry in China as of in 2009 has evolved into a stage of "add-on", software program that can communicate with game servers to automate gold-farming process. Thus an employee in their studio can be simultaneously in charge of four computers to harvest online game items. Consequently XFire does not look like an efficient or even necessary channel for the communication between gold farmers.

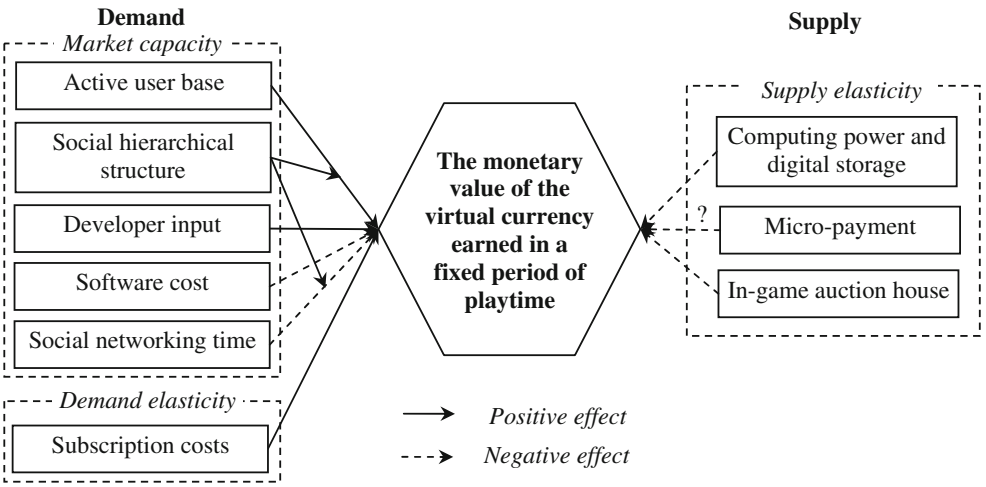

Fig. 1 The determinants of the monetary value of virtual goods

4 Data

We acquire the list of MMORPGs from MMORPG.com which provides the most comprehensive information about MMORPGs. Among more than 200 listed games, only 24 games are selected following the criteria that: (i) the game must be accessible to us via either Internet or local retailers; (ii) the game's currency must be traded in RMT markets; (iii) the currency should not be controlled by the provider (e.g., Second Life is excluded); (iv) the corresponding XFire data is available; (v) it allows an entry-level player to earn virtual currency.

The data collection consists of two parts. We first conduct a controlled experiment to collect the "domestic-currency" prices of a common product across various virtual worlds. In the context of MMORPGs, the only common product is a player's in-game productivity which depends on the specific game setting, the status of his/her avatar, and his/her gaming experience. However the context in each game is not comparable and thus cannot be controlled through surveying game players. Further there is no uniform standard on the levels of avatars across games. Given the challenge to setup a common baseline across different types of MMORPGs, we minimize the impact of providers' manipulation on players' productivity by asking subjects to play from the entry level of each game. The brief steps in the experiment are reported as following:

Step 1: Twenty-four games were installed in computers located in a multimedia lab. A pilot study was conducted by three experienced players. The main tasks were: (i) to check if every game has a friendly tutorial for the first-time players; (ii) to check for each game if the network connection to the game server is working; (iii) based on the results in (i) to (ii), to adjust initial game settings in each game in order to minimize the barrier for the first-time players.

Table 2 Measurement for independent variables

Factor name		Measurement
Active user base, N_i		Among XFire players, the number of players who played game i
The status of social hierarchical structure β_i		The number of months from the first launch date; the longer the period, the flatter is the social hierarchical structure in the game
Provider input U_i		The total number of members in the game development team
Software and subscription costs C_i	Subscription fee C_i^f	The monthly subscription fee that the player pays to play game i., for free game, $C_i^f = 0$.
	Game software price C_i^s	$C_i^s > 0$ if players need to purchase the game software package, otherwise $C_i^s = 0$
Computing power and digital storage D_i		Number of servers for game i
Micro-payment O_i		$O_i = 1$ if players can purchase virtual items with real money from the game provider, otherwise $O_i = 0$
In-game auction house A_i		$A_i = 1$ if game supports in-game auction house feature, otherwise $A_i = 0$
Social networking time W_i		Among XFire players, the average number of minutes spent in game i with connection to XFire

Step 2: We advertised this experiment among undergraduates staying in university halls and 99 undergraduates agreed to participate. Participants were ranging from people with experience in MMORPGs to people who had never played MMORPGs but just played games casually. The players were then randomly selected to play certain MMORPGs and there were 3–5 players for each MMORPG. This is to ensure a fair sample of players as real players in MMORPGs usually differ in skill level and gaming experience.

Step 3: Players were asked to start playing with a newly created avatar. This was to prevent players from using their existing (higher level) avatars (or have better items allowing them to earn virtual currency quicker). For players with no gaming experience on the assigned game, some basic tutorial or demo was provided to ensure that they were capable of an hour-long smooth game play. The timing started after the user completed the tutorial in the game. The lab assistants took note of the start time and stated the end time accordingly. This was to prevent participants from breezing through the tutorial and end up being lost in the game or without the controls. Once the time started, there was no pause. Participants were encouraged to play continuously for 1 h. They were permitted to signal for help.

Step 4: Near the end of the experiment, the lab assistants made an announcement of 10-min left to the player so that the player could locate a merchant or auction off all the inventory items to calculate the total amount of gold she or he had earned. This was to standardize their productivity in virtual currency. The lab assistant was allowed to take over the participants to find an in-game trader to sell items to ensure that the participants stuck to the 1 h timing. Begging for or getting gold or items from other players was not allowed. We then recorded each player's total earnings in virtual currency.

Step 5: After the experiment, players were asked to complete a short survey on their demographics and game experience. This was to control for players' personal characteristics that may affect their in-game productivity.

Through the experiment, we got information about each player's productivity/earning in virtual currency within one-hour playing time, as used in Eq. (1). Only one observation for game Hellgate London was excluded as the earning is exceptionally higher than the others'.

We collected the other part of the data through various online sources as listed in Table 3 which reports the descriptive statistics. In particular, we collected the exchange rates from virtual currency to the US dollar from MMOBUX.com. "MMOBUX compares prices and provides reviews for more than 271 online shops that sell currencies like World of Warcraft Gold, Eve Online ISK or Lord of the Rings Online Gold." As the virtual currency prices vary in shops and in gaming servers at different locations, we used the average price as the exchange rate. We then derived the monetary value of an avatar's in-game productivity following Eq. (1). Table 3 reports the descriptive statistics based on observations on December 30, 2007. In terms of the normalized standard deviation for the monetary value of an avatar's in-game productivity, the value over the 24 games is 1.95 while the average across the value for each game is only 0.60. It shows that our experiment can capture the differences across games but at the same time retain the similarities pertaining to each game.

5 Estimation

We first investigate a sectional dataset in which each unit represents the information of a player and her/his assigned game. Then robustness checks are conducted using panel data with cross-game and time series units. Referring to Fig. 1 and Eq. (2), as a baseline, we regress the difference in the monetary value of in-game productivity on the explanatory variables as listed in Table 3. Three variables on player's gaming experience, perceived learning curve of the game, and gender control any effect caused by a player's personal characteristics. Since all players were required to start playing using a newly created avatar and most of them did not have experience with the assigned games, players' in-game productivity could be biased due to the different learning curves across games. Players' productivity may be underestimated for games that require relatively longer learning period.

Before regressing, we remove variables that are highly correlated with others as shown in Table 4, e.g. pay to play, subscription fee and the number of servers. We then conduct a Breusch-Pagan/Cook-Weisberg test for heteroskedasticity which rejects the null hypothesis of constant variance (χ^2= 24.90). Using OLS with adjustment on the standard errors for heteroscedasticity,[10] we report the results in Table 5, column (a). It is clear that the estimate rejects the null hypothesis that all the coefficients of the model including the constant term equal to zero. Thus MMORPGs exhibit distinct monetary value in their common virtual goods.

[10] We use the adjustment on the standard errors as suggested by Davidson and MacKinnon (1993), who report that this method tends to produce better results when the model really is heteroskedastic. This is technically supported by STATA 11.

Table 3 Descriptive statistics (98 players for 24 games)

Variable	Source	Unit	Mean	Min	Max	Std. Dev.
The monetary value of the virtual currency earned in one-hour playtime	Experimentation; www.MMObux.com	USD	0.0059515	4.23e-6	0.06219	0.01159
Pay to play	www.mmorpg.com; &game websites	–	0.6531	0	1	0.4784
Subscription fee	www.mmorpg.com & game websites	USD	9.0016	0	14.99	6.8401
Game software price	www.mmorpg.com & game websites	SGD	21.8744	0	49.99	17.4804
Size of the provider	Game websites	–	665.1939	0	3164	996.1047
No. of active players	www.XFire.com	–	7475.337	53	108851	23837.45
Playtime per capita	www.XFire.com	Minutes	198.92	22.20	421.20	77.89
No. of months from the first launch	www.mmorpg.com & game websites	–	34.8367	1	104	24.8736
Micro-transaction	www.mmorpg.com & game websites	–	0.3061	0	1	0.4633
In-game auction house	Game websites	–	0.5612	0	1	0.4988
Number of servers	Game websites	–	34.194	1	329	71.7104
Player's gaming experience	Survey	Days	412.5	0	3316	682.7593
Player's Gender	Survey	1 = Male	0.8265	0	1	.3806
Theme of the game	www.mmorpg.com	Fantasy 71.4%, Modern 5.1%, Science Fiction 23.5%				

Specifically, the results provide strong support to hypotheses H4.1, H4.2, and H6.

We further remove the variables "gender" and "perceived learning curve" as their effects on the dependent variable are not statistically significant. We next incorporate a dummy variable for World of Warcraft considering it persistently has much larger player base than all other games. The results are reported in Table 5, column (b). There is no change in the signs of all variables and their significance levels.

The coefficient of "number of months from the first launch" is negative and significant. Following the discussion in Section 3, the longer it has been since the launch of the game, the flatter is the social hierarchical structure. This cross-section estimation suggests that the monetary value of in-game productivity is generally lower in older games, a strong evidence of the negative impact caused by the gradient of the social hierarchical structure.

The coefficient of "average social networking time" is negative and significant. The coefficient of the interaction term is positive and significant. They together provide strong support for hypotheses H4.1 and H4.2. As shown in Fig. 1 and Table 2, the in-game time spent with connection

Table 4 Correlations between variables

		V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12	V13	V14
V1	Pay to play	1													
V2	Subscription fee	0.96	1												
V3	Micro-transaction	−0.93	−0.89	1											
V4	In-game auction house	0.46	0.43	−0.40	1										
V5	Software price	0.62	0.70	−0.71	0.34	1									
V6	Size of developer	0.40	0.44	−0.37	0.08	0.38	1								
V7	No. of servers	0.29	0.33	−0.27	0.12	0.40	0.15	1							
V8	No. of active players	0.13	0.16	−0.16	0.17	0.37	−0.06	0.94	1						
V9	Average gaming time	0.07	0.17	−0.03	0.01	0.25	0.28	0.04	0.01	1					
V10	No. of months from the first launch	0.08	0.09	−0.07	−0.41	−0.17	0.00	0.11	0.03	0.17	1				
V11	Modern genre	0.18	0.21	−0.16	0.21	0.11	−0.13	−0.06	−0.06	0.04	0.10	1			
V12	Science fiction genre	−0.02	−0.03	0.06	0.29	0.06	0.06	−0.20	−0.12	0.00	0.00	−0.13	1		
V13	Gender	0.18	0.21	−0.16	0.03	0.25	0.08	0.10	0.07	0.11	0.04	−0.01	0.14	1	
V14	Game playing experience	−0.08	−0.07	0.08	0.17	0.04	0.15	0.14	0.17	0.01	−0.10	−0.07	0.11	0.11	1
V15	Game learning curve	0.08	0.09	−0.03	0.19	0.10	0.16	−0.11	−0.11	0.20	−0.07	−0.05	0.16	0.05	0.05

Table 5 OLS estimates with adjustment for heteroscedasticity (Dependent variable: Difference in the monetary value of in-game productivity as measured by US Dollar)

Variables	(a)	(b)	(c)
Micro-transaction O_i	−0.01053171*** (0.0028538)	−0.00970252*** (.0029713)	−0.00502806** (.0022811)
In-game auction house A_i	−0.00616508** (0.0029624)	−0.00587662* (.0031795)	−0.00170679 (.0020675)
Size of the provider U_i	4.4e-7 (1.19e-06)	5.1e-7 (1.14e-06)	−2.19e-6** (8.56e-07)
Number of active players N_i	−3.7e-7 (1.35e-06)	−5.7e-7 (1.24e-06)	1.33e-6 (8.28e-07)
Average social networking time W_i	−0.00341715*** (0.0011798)	−0.00371756*** (.0011728)	−0.00334689*** (.0012681)
Number of months from the first launch β_i	−4.8891e-4*** (0.000169)	−5.2212e-4*** (.0001768)	−1.4874e-4 (.0001426)
$N_i \times \beta_i$	1.0e-8 (3.63e-08)	2.06e-08 (3.47e-08)	−3.71e-08 (2.23e-08)
$W_i \times \beta_i$	6.301e-5*** (0.0000237)	6.946e-5*** (.0000243)	2.79e-5 (2.5e-5)
Modern genre	0.00226074 (0.0027104)	0.00257801 (.0028281)	-0.00509547** (.0019674)
Science fiction genre	0.01637622*** (0.0043966)	0.01570467*** (.0043556)	0.00465000* (.002606)
Gender	−0.00214127 (0.0020172)	–	–
Player gaming experience	3.06e-6** (.0006558)	2.96e-6 (2.01e-06)	7.2e-7 (1.07e-06)
Perceived learning curve	−8.589e-5 (5.9698e-4)	–	–
World of Warcraft	–	−0.02073423 (.0254013)	0.01408789 (.0267669)
Constant	0.02275580*** (0.0078528)	0.02142594*** (.0077283)	0.01582353** (.0070436)
Observations	92	98	98
R-squared	0.554	0.545	0.424

Robust standard errors in parentheses

***$p<0.01$, **$p<0.05$, *$p<0.1$

to XFire, as measured only for XFire users gives us an approximation of the time with need of social networking in a game. Hence it represents the relative non-transferable production resulted from in-game social networking. Market potential for RMT decreases with the amount of non-transferable production. In turn, less demand for RMT results in a lower price of virtual goods. The positive coefficient of the interaction term indicates that steeper social hierarchical structures strengthen the negative effect of social networking time on the price of virtual goods.

The estimated coefficient of "the size of developer" is positive but insignificant, thus cannot support hypothesis H3. Interestingly, the coefficient of "Micro-payment" is significantly negative, which shows that a competition effect from the primary market dominates the game provider's incentive to maintain a high profit margin with micro-payment. Given micro-payment is negatively correlated with subscription fee at −0.93, this indirectly provides support for H1.

The negative and significant coefficient of an "in-game auction house" as stated in hypothesis H6 indicates that games with an in-game auction house are associated with approximately lower prices of the virtual goods in RMT market, responding to the relatively higher price elasticity of supply.

Interestingly, the coefficient of "Science Fiction genre" is significantly positive, which suggests that the virtual goods in science-fiction games are relatively more expensive than in fantasy games. Considering the dominant position of fantasy games in virtual worlds, this finding suggests that popularity may not lead to higher earnings in RMT markets.

However, the coefficients of "Number of active players" and its interaction with "Number of months from the first launch" are not significant. One weakness of this study is that the data on exchange rates, the number of active players and the average gaming minutes were captured at one date (Dec.31, 2007) rather than as a time-series collection. Considering the fluctuation of exchange rates in RMT markets, the estimation results are subject to a time-robustness test. Among the factors identified in Fig. 1, only exchange rates, the number of months from the first launch, active players and the total gaming minutes among the XFire samples may vary over time. Using another set of data collected as of Apr. 30, 2008 while keeping the result from the original experiment, we repeat the above regression and get similar results as reported in Table 5, volume (c). Note that hypothesis H3 is again not supported. This result suggests that the developer size is not among the main factors driving an RMT market.

To conduct a more rigorous check on the determinants of the price of the common virtual goods, we further collect three months of data (June, July and August, 2008) from the corresponding resources listed in Table 3 and perform fixed-effect estimates with a robust estimator of variance on the cross-game monthly panel data. Since the fixed effects model has captured game-varying but time-constant effects, we exclude all the variables in Table 3 that are constant over

time. Thus the remaining model examines the impacts on price from the active user base, social networking time and their interaction with the social hierarchical structure. Incorporating the time series data also enables us to check any convergence of price within a three-month time horizon. Table 6, volume (d) reports the results. The estimation results are consistent with hypotheses H2.1, H2.2, H4.1, and H4.2.

Interestingly, both the coefficient of "Number of active players" and the coefficient of "Number of months from the first launch" are significantly positive. This is different from the results in Table 5 where the coefficient of "Number of active players" is insignificant and the coefficient of "Number of months from the first launch" is significantly negative. Note that the cross-MMORPG estimations reported in Table 5 attribute the variance of the dependent variable to the difference between games while the fixed effects estimations reported in Table 6 mainly reflect the change of a game along a three-month period of time. The difference in the effects of active user base suggests that market expansion in the short run increases the demand for virtual goods in a MMORPG. But in the long run MMORPGs with a larger user base do not necessarily possess a price premium in RMT markets. This is consistent with our finding of an insignificant effect from World of Warcraft as shown in Table 5.

The contradictory result in the effect of "Number of months from the first launch" may be due to the inrush of student players in the summer vacation period during June to August. Being the main force of online gamers, students would have more free time for gaming in this period, which may increase the demand in RMT markets.

The estimate with month dummies as reported in column (e), Table 6 confirms our explanation by showing the significantly positive and increasing coefficient of the month dummy. Using the subsample of free to play games, the estimate as reported in column (f), Table 6, results in a quite remarkable adjusted R-square (0.982 much higher than the value 0.144 generated by the subsample of pay-to-play games). Further, comparing the coefficients of all independent variables except for the constant between columns (e) and (f), we find that the proposed determinants exhibit a more substantial influence on free-to-play games than on pay-to-play game. This is reasonable by considering that the RMT of virtual items is one of the most important profit models for free-to-play games, and thus the game providers intend to cultivate highly responsive demand for RMT.

Given the above findings on the tension between the size of the user base, social networking engagement and the monetary value of virtual goods in the RMT market, a follow-on question is the endogeneity between them, i.e. whether higher monetary value of virtual goods would translate into more or less playtime. We justify this issue through demand and supply in the RMT market. First, the existing empirical study on the relationship between RMT and game provider performance cannot identify a causal relationship between the RMT transaction volume and playtime for those MMORPGs in which RMT is not encouraged (e.g., World of Warcraft) (Jung et al. 2009). Even for those typical Korean MMORPGs in which game providers profits from RMT, e.g., Seal Online and Lineage, null hypotheses on the causal effects between revenue and playtime and between price and transaction volumes in the RMT market are both rejected (Jung et al. 2009). Second, the market structure makes it not profitable for normal players to supply the RMT market. Huge supply from gold farming in MMORPGs results in intensive competition in the RMT market. As cheating, add-ons, hacking, etc. are widely used in gold farming studios to produce virtual goods—an observation resulted from our formal interview with gold-farming studios in China, their productivity is far beyond that of

Table 6 Fixed-effect estimates (Dependent variable: difference in the monetary value of in-game productivity as measured by US Dollar)

Variables	(d)	(e)	(f)
Number of active players N_i	3.23e-08*** (3.82e-09)	3.23e-08*** (3.86e-09)	3.41e-08*** (2.14e-09)
Average social networking time W_i	−1.00e-10*** (1.56e-11)	−9.98e-11 *** (1.57e-11)	−1.05e-10*** (1.96e-11)
Number of months from the first launch β_i	6.50e-07** (3.15e-07)	–	–
$N_i \times \beta_i$	−4.83e-10 *** (8.50e-11)	−4.83e-10*** (8.57e-11)	−5.19e-10*** (2.87e-11)
$W_i \times \beta_i$	1.95e-12*** (3.48e-13)	1.95e-12*** (3.48e-13)	1.94e-12*** (4.18e-13)
July, 2008	–	6.11e-07 (7.38e-07)	9.65e-07** (3.88e-07)
August, 2008	–	1.30e-06 ** (6.38e-07)	1.73e-06*** (4.59e-07)
Constant	−.000073 *** (.000017)	−.0000455*** (5.19e-06)	−.0000166*** (3.53e-06)
Adj. R-square	0.482	0.482	0.982
No. of observations	66	66	20

Robust standard errors in parentheses

***p<0.01, **p<0.05, *p<0.1

normal players. With disadvantages both in scale and in production cost, normal players are easily squeezed out from the supply side of the RMT market. Hence both the empirical evidences and the real world practice cannot support the assumption of the endogeneity of playtime with the monetary value of virtual goods. Table 7 summarizes the analyses that support a specific hypothesis. Note that as subscription fee and the number of servers (as the measurement for the game provider's resources in computing power and digital storage) are highly correlated with micropayment status and the active user base respectively, hypotheses H1 and H5 are not necessarily included in the estimation.

6 Conclusion and implications

Drawing on the demand and supply theory in classic economics, this study investigates the determinants of monetary value of virtual goods across MMORPGs. We choose the fixed-period of in-game earning measured by domestic currency as the common product across various MMORPGs, and derive its monetary value by combining the data collected through experimentation and from RMT markets. Our empirical findings highlight the important effects of scale, user engagement and game age on the monetary value of virtual goods in RMT markets. First, although a large active user base may not indicate a price premium for an MMORPG in RMT markets in the long run, it does increase the potential demand and thus the monetary value of virtual goods in RMT markets in the short run. Second, user engagement that requires collaboration and social networking weakens the transferability of in-game production through RMT markets and accordingly reduces the incentive to trade in RMT markets. Further, the social hierarchical structure in such synthetic worlds is closely related to game age. Newer games consist of more entrant-level players. Given their relatively lower productivity in earning virtual items compared to those higher-level players, entrant-level players generally perceive more benefit from real-money trading of virtual items. Thus a steeper social hierarchical structure with relatively more entrants would strengthen the effect of scale on the monetary value of virtual goods. On the contrary, if virtual goods provided in RMT markets are not perfect substitutes of in-game production (e.g., social networking is crucial for advancement), a larger proportion of entrant-level players may even decrease the demand of RMT markets. This is why we observed that a steeper hierarchical structure strengthens the negative effect of user engagement on the monetary value of virtual goods.

Table 7 Hypotheses testing result summary

Estimate hypothesis	a	b	c	d	e	f
H2.1	?	?	?	Y	Y	Y
H2.2	?	?	?	Y	Y	Y
H3	?	?	N	–	–	–
H4.1	Y	Y	Y	Y	Y	Y
H4.2	Y	Y	Y	Y	Y	Y
H6	Y	Y	?	–	–	–

? insignificant; Y supported; N not supported;— not tested

This study may contribute to the literature on virtual worlds from the following perspectives. First, following Hagel and Armstrong's work (1996), who extended the classic economic theory of demand into the field of virtual goods, this study goes further by identifying the determinants of the market value of virtual goods in U.S. dollars. Different from conventional digital products (e.g. software, MP3 digital music), virtual goods generated in virtual worlds do not fulfill material needs. Although both are in digital form and subjected to the impact of the existing user base, the value of virtual goods is highly socialized. This is supported by our empirical evidences that not only the size of the active user base, but also its hierarchical structure and users' social networking activities impressively affect the monetary value attached to virtual goods

Second, to the best of our knowledge, this is the first empirical study on virtual worlds with a cross-sectional dataset. The existing empirical research on real-money trading of virtual goods focuses on Korean games in which game providers participate in real-money trading (Huhh 2005; Jung et al. 2009). This study provides a balanced and rigorous study by covering a broader spectrum of MMORPGs including those developed by Asian companies (e.g. Scions of Fate) and western companies (e.g. Star Wars Galaxies Online) and those in which RMT is encouraged (e.g. Lineage 2) or discouraged (e.g. World of Warcraft).

Third, this study suggests enriching virtual content and encouraging players' in-game collaboration and social networking as two instruments for game providers to fight against gold farming. Following this study, we conducted formal interviews with three gold-farming entrepreneurs in China. The interviews reveal that gold farming has evolved from labor-intensive workshops to a technology-intensive "industry" with a sophisticated supply chain dedicated to hacking, fraud and theft in virtual worlds. As MMORPG providers are striving for a balance between attracting more users and at the same time deterring gold farmers, promoting social networking activities (e.g. participating guilds and group-based quest) may be a more effective approach compared to those measures that increase the barriers of real money trading for both normal players and gold farmers, e.g. banning suspicious ID and binding virtual assets to player identity.

The limitations related to the current study open a few research opportunities. First, in the experiment, we asked

participants to play the game for only 1 h. Thus it is not clear if the results are sensitive to the playtime assigned to each participant. Future research may use playtime as a control variable and recruit more participants from different locations without compromising the number of participants for the experiment.

Second, in the experiment, we only allowed players to start from the lowest level in order to minimize the manipulation from game settings on players' in-game productivity. An alternative approach is to compare the monetary value of the highest-level avatar listed in the RMT market across different types of online games. This may introduce more interesting variables related to the context of virtual worlds and help us understand the value of an avatar's social networking characteristics. The challenge is how to control the effects of specific game design and storyline pertaining to each game.

Lastly, this study does not consider virtual worlds with user-generated content which are very different from MMORPGs due to the creation embodied in virtual goods. This is also a direction we are going to pursue in future research.

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Qiu-Hong Wang is an Associate Professor in the Department of Information Management and Information Systems, School of Management, Huazhong University of Science and Technology, China. Her research focuses on the economics of information security, virtual economy and pricing. She received her Ph.D. in information systems from the National University of Singapore. Her research work has been published in or accepted by Journal of Management Information Systems, Decision Support Systems, Communications of the ACM, and various conferences such as International Conference on Information Systems, Hawaii International Conference on System Sciences,

Workshop on the Economics of Information Security, and Pacific Asia Conference on Information Systems.

Viktor Mayer-Schönberger is the Professor of Internet Governance and Regulation at the Oxford Internet Institute / University of Oxford.

Xue Yang is an Assistant Professor in the Department of Electronic Business, School of Management (Business), Nanjing University (NJU), China. Her current research interests include electronic commerce and mobile commerce, IT product trial and usage, virtual team behavior and e-learning. She received her PhD from National University of Singapore (NUS). Her research work has been published in Information and Management and various conferences such as International Conference on Information Systems, International Conference on Human-Computer Interaction, Americas Conference on Information Systems, and Pacific Asia Conference on Information Systems.