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Creating the conditions for new industry emergence: Generic complementary assets and the online gaming industry in Korea

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Creating conditions for digital industry emergence:

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Which conditions are needed for digital industries to emerge? Digital industries have unique characteristics that may affect innovation, including the peculiarity that their products are "incomplete" in two ways: 1) their boundaries are not fixed, and evolve over time, and 2) they do not have value except as part of a higher-level system. We propose a layered product architecture model for digital industries, with three complementary layers: a content layer, an infrastructure layer, and an access and service layer. These peculiarities of digital products help explain why South Korean firms were pioneers within the online games industry despite having been poorly equipped with both early technological capabilities and specialized complementary assets. We highlight the role of generic complementary assets (or availability of the complementary "layers" of digital products) in digital industry emergence and the role of strategic actors previously overlooked - governments and new entrepreneurial services firms - in providing these.

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1. Introduction

Which conditions are needed for digital industries to emerge? An important trigger for industry emergence is scientific and technological development (Malerba and Orsenigo, 1996; Phaal et al., 2011) or technological discontinuity (Munir and Phillips, 2002). Nevertheless, emergence of a new industry around the scientific or technological development also requires the development of complementary and enabling technologies and resources (Kapoor and Furr, 2015; Teece, 1986; Schilling, 2010). So far, however, the literature has considered the role of complementary and enabling technologies for tangible products, which can be characterized by materiality and clear boundaries. Less attention, however, has been paid to the emergence of purely digital goods and industries and what this means for the broader set of core and complementary capabilities and assets that are needed for such industries to emerge.

Digital products are made out of bitstrings sequences of 0s and 1s, and hence lack physical materiality. These products are “incomplete” in two ways: 1) their boundaries are not fixed, and evolve over time, and 2) they do not have value except as part of a higher-level system (Quah, 2003; Yoo et al., 2010). This distinguishes them also from digitized goods or smart products which still possess a tangible nature and can be used autonomously and independently from system-level complementary assets. Digital goods like mobile apps, online games or books are not only pervasive, but also regarded as a key factor of competitiveness and growth (OECD, 2015). Yet, we know surprisingly little about what drives and supports the emergence of digital industries.

We address this question by drawing on a case study of the online games industry emergence, relying on a rich dataset at the level of products, capabilities and complementary assets, as well as interviews with firms and supporting organizations. This industry is highly dynamic and accounts for a large share of income - double that of that of the music industry, and a quarter of that of the movie industry globally (Ad2, 2014; RIAJ, 2014). We seek to understand the counterintuitive dominant role in industry emergence of firms from South Korea (hereinafter Korea), despite the fact that Korea offered a hostile environment for new entrants, due to the economic dominance of large conglomerates, governmental regulation against video games as harmful to children, and institutional arrangements conducive to technological specialization patterns on incremental (rather than radical) innovation (Meyer et al., 2009; Stenholm et al., 2013; Zhang and Whitley, 2013). Korean firms had neither early technological capabilities in related industries nor specialized complementary assets. Indeed, the technological capabilities for online games development were more or less distributed across the world, with a strong cluster in the USA and Japan. The same holds true for specialized complementary assets. We find that, instead, it was a bundle of generic complementary assets, whose superior availability in Korea was at the core of the industry's emergence. Moreover, the bundle of generic complementary assets was provided by actors which are often not perceived by the strategic management literature as being relevant for creating competitive advantages, i.e. the government and new entrepreneurial services firms.

Overall, our contribution provides a broader theoretical basis for the understanding of the sources of digital industry emergence. Our study makes three contributions. First, we build on and extend the literature on complementary assets to capture the value of innovation (Teece, 1986; Kapoor and Furr, 2015). We show that the emergence of digital industries depends on (non-specialized) generic complementary assets which are not available within the firms' network or ecosystem, but are provided at the level of the national system. Second, we build on and extend the literature on product design strategies (Baldwin and Clark, 1997) to explore the nature of product architecture and of innovation in digital industries. We propose a layered product architecture model, with three complementary layers: a content layer, an infrastructure layer, and an access and service layer. Third, we stress the role of strategic actors generally ignored in the strategic management literature, the state and new entrepreneurial services firms, in the provision of such generic complementary assets.

The next section provides the theoretical framework. The research design and methods follows. We next describe the findings. A discussion follows.

2. Strategy and emergence of digital industries

2.1 Core resources and complementary assets

New industries often emerge from related industries as resources and capabilities can be extended and transferred to the needs of the new sector (Agarwal et al., 2004; Garnsey et al., 2008; Klepper, 2007; Klepper and Simons, 2000). Resources and capabilities can be core or complementary. Core resources and capabilities are necessary to develop a new product or process, and involve technological knowledge and knowledge of customer needs (Helfat and Lieberman, 2002). Complementary resources and capabilities, instead, include complementary technologies, access to distribution channels, competitive manufacturing and networks in service or manufacturing (Teece, 1986; Tripsas, 1997).

Teece's (1986) classification of specialized and generic assets highlights the importance of co-/specialized complementary assets with which the innovation has unilateral or bilateral dependence. Teece (1986) explains that these complementary assets may represent bottlenecks: "Should the asset turn out to be a bottleneck with respect to commercializing the innovation, the owner of bottleneck facilities is obviously in a position to extract profits from the innovator and/or imitators" (Teece 1986: 297). The concept of complementary assets thus helps to explain why, counter-intuitively, firms that are not responsible for the innovation itself may be able to capture value from it (Teece 1896). Possession of complementary assets may help buffer incumbents from radical technological change (Tripsas, 1997).

As only co-/specialized assets, due to their specifity and associated transaction costs (Williamson, 1985), are argued to be difficult to imitate and be accessed through markets, research has focused on them as a key factor in creating competitive advantages (see also Barney 1991). In contrast to co-/specialized assets, generic assets are "general purpose" assets with multiple applications which do not need to be adjusted to the innovation so that they can be easily contracted for on the market (Teece, 1986; Park and Steensma, 2012; Rothaermel et al., 2005). For this reason, they have not been typically regarded as scarce, and as an important element in creating a strong competitive advantage.

2.2 The firms' network and ecosystem: the contextual view

Firm-level technological and organizational resources and capabilities alone are not the only factors linked to industry emergence. The literature on collaborations, alliances and ecosystems extends the firm-level view and shows that many entrants commercialize emerging technologies through collaborations with large firms (Mowery et al. 1996; Shan, 1990), and that a firms' network may be beneficial for providing relational rents (Dyer and Singh, 1998). Adner and Kapoor's (2010) work also supports this view by emphasizing the ecosystem's role in new technology generation.

A few examples can help illustrate this. While, for example, in biopharma, biotechnology new entrants can provide new knowledge, pharmaceutical incumbents possess the complementary assets to commercialize their innovations, in a context where clinical trials, regulatory compliance, and marketing activities aimed at doctors all require very specialised experiences, not to mention networks of contacts in the appropriate domain (Arora and Gambardella, 1990; Powell et al., 1996). In turn, Rothaermel (2001) shows that incumbents in the pharmaceutical industry have used inter-firm cooperation with new biotech entrants as a strategy to both adapt and innovate successfully. Also, the availability of complementary technologies in the photovoltaic industry, like the materials of crystalline or amorphous silicon - core components within solar cells -, have been argued to play a key role in the industry's emergence (Kapoor and Furr, 2015). These examples show that the availability of complementary assets within a company's ecosystem may be decisive for value creation and appropriation (Kapoor and Furr, 2015).

2.3 The nature of digital industries: Complementary assets within a product architecture

Strategic management research on emergence of new industries has typically considered innovation in physical goods. Nevertheless, digital industries have peculiar characteristics which may extend to the way that they create and capture value from innovation. Their products exist in a non-physical, digital form, and they are "incomplete" in two ways. First, the boundaries of their products are not fixed but fluid, and evolve as producers and users add, change or remove functionalities (Yoo et al., 2010). Fixed boundaries around the product are crucial for models of product life cycle (Utterback, 1996), discontinuities and competences (Tushman and Anderson, 1986), and architectural innovation (Henderson and Clark, 1990).

Second, their value depends substantially on external elements which are not specialized to the product (such as access to broadband) and may not be provided by the firm's network or ecosystem. While it is also true that physical products are increasingly digitalized, or "entangled" with digital capabilities, leading to the emergence of a whole class of "smart products" such as cars with navigation systems, online marketing, or payment channels of most firms, "pure" digital products are a new product category which creates value only as part of a higher-level system (Kusunoki and Aoshima, 2010). This contrasts them from "merely" digitalized products. While some physical products may also be in need of complementary assets in the form infrastructures, they may still create value. Imagine e.g. cars which have, even when infrastructure is of poor quality, a value as a status good or as an experience good. Digital products, instead, have no value at all without an infrastructure. The complementarity of digital goods with other assets is therefore extremely strong, and the presence of a complementary or enabling technologies or assets not only increases the value of the good, but is necessary for their value. We therefore propose a characterization of digital goods as having a layered product architecture (see also Fransman, 2002; Krafft 2010). This layered architecture is also modular, but the concept of modularity developed for physical goods (Baldwin and Clark, 1997; Schilling, 2000) must be adapted if it is to support the conceptualization of innovation in digital products. The typical concept of modularity as a physical product design strategy involves the decomposition of modules, with a clear architecture and clearly defined and codified interfaces (Baldwin and Clark, 1997).[1] Modular architectures are flexible as modular components can be substituted and configured into a wide range of end products to meet specific customer needs (Sanchez and Mahoney, 1996). In the case of digital industries, instead, modules are often designed without having a clear idea of how they will be integrated with others and of the "whole" design (Yoo et al., 2012).

The product architecture of digital goods can be characterized by three layers, i.e. a layer of content and information, a layer of infrastructure, and a layer of access and service. The content and information layer (publishing, electronic commerce, music, or, in our case, online games) is involved in the creation of intangible products, the infrastructure layer is involved in the provision of complementary technologies (transmission technologies, devices and networks), and the access and service layer provides access to the transmission technologies. As in physical goods, in digital industries, this modular architecture facilitates the entry into the layers by allowing them to focus on their own activities while ignoring complementary activities that are a condition for entry (Fransman, 2002). But, for digital goods, their very value depends on the complementary relationship between the layers of content and information, infrastructure and access and service (Barnes, 2002). Indeed, the quality of the layers, such as the network conditions (delay, latency, speed), or the accessibility of the network (closeness, locality, price) affect other layers, such as consumers' decision to make use of digitally provided content and information (Dick et al., 2005). Network delay and network loss, for example, affect significantly a player's decision to leave

[1] It is important to notice that the concept of modularity has been also extended to services sectors (see Miozzo and Grimshaw, 2005).

an online game prematurely (Chen et al., 2009). Hence, in contrast to what we know from the resource-based view as applied to physical goods, the value of the product is contingent on external assets which may be neither co-/specialized to the product nor to the firm, but nevertheless "complete" the product. Strategic management scholars need to explore new theoretical models of innovations for products with incomplete boundaries.

Moreover, both the complementary resources and capabilities technologies, as well as the access to them have in the strategy literature been typically linked to the firm and its network. However, in the case of digital products, neither the firms' network nor its ecosystem may be able to provide the complementary infrastructure and service layers. An understanding of the emergence of digital goods industries means that we need to contemplate the role of complementary resources and capabilities beyond those provided by the firm's network, and include infrastructure and access provided by organizations outside the network, at the global, national, regional or industry system level (Tilson et al., 2010; Table 1).

-----------Table 1 about here-------------

3. Research design and methods

3.1 Overall principles of design

In order to understand how Korean firms seized new opportunities and led in the emergence of the online games industry despite lacking core resources and capabilities in related sectors, as well as specialized complementary assets, we adopted a looser design than a hypotheses-testing one. We adopt a qualitative research approach, and an analytical narrative method (Bates et al., 1998). While this method is clearly still in its infancy, it is promising because it helps to link historical particularity and causal generality (Goldstone, 1999; Pedriana, 2005). Following the analytical narrative method, we first explored the particular case in detail. Only after doing so, we were able to "define the universe of cases of which… [the] case is an element" (Bates et al., 2000: 696), and to develop implications out of this case. Hereby, we attempt to link the understanding of the particular case to advances in knowledge, and to "generalizable and falsifiable implications" (Bates et al., 2000: 700). We present them in the layered product architecture model as well as below in the discussion.

We identify a puzzle unique to the place and period under study (Bates et al., 2000), i.e. the counterintuitive emergence of the online game industry in Korea where large incumbents (*chaebol*) never entered the video game industry due to a public ban on Japanese videogames nor other related industries, and where entrants did not have a supportive institutional infrastructure. We contrast this case to that of other countries (see below). The study of the variation of industry emergence patterns is explicit here: why did Korean firms lead the early phase of industry emergence, and not other countries with early technological capabilities and resources in related sectors? Why did Korean firms, despite the absence in Korea of adequate institutional arrangements lead in the emergence of the industry while other countries with a supportive infrastructure did not?

In order to answer these questions, we decided to carry out a multiple case approach, addressing recent calls to analyze the emergence of industries in different contexts (Fuentelsaz et al. 2015; Gustafsson et al. 2015). We started with the identification of early high-performing online games. Games developed by Korean firms led by far, but we also found that early online games had been developed in many other countries. Next, we analyzed how resources and capabilities were distributed around the world. Our sampling was driven by observation of high-performing games and firms in countries with contrasting industry emergence conditions (e.g. USA, Korea and Japan). In order to replicate our findings, we extended the sample to modestly and low-performing countries (Canada, UK), ending up with a multiple case study design, comparing new industry emergence processes in Canada, Japan, Korea, UK and USA. We focused on groups of firms which emerged simultaneously across diverse countries, but with different competitive outcomes, in order to be able to construct "comparisons that clarify whether an emergent finding is simply idiosyncratic to a single case or consistently replicated by several cases" (Eisenhardt and Graebner, 2007: 27). As a result, the online games industry provided an interesting example as it is not only a new and important digital industry, but because the initial conditions that triggered industry emergence have been different across different countries.

We used the analytical narrative method to construct a story from the data (Langley, 1999). Our narrative did not only have to produce a chronological description of industry emergence, but also be linked to "concepts, understanding, and theory closely linked to data" (Ferlie et al., 2005: 119). Although we are not able to derive general laws from our analytical narrative, we nevertheless hope to contribute to develop, refine, and test theory-driven models, and to gain deeper insights in the complex workings of digital industry emergence (Bates et al., 2000; Wiles et al., 2010).

3.2 Case selection

The online games sector fits the description of Malerba (2007) of new industries as constituted by new knowledge and new markets. Online games constitute a new industry as the industry developed out of a niche that became sufficiently large to be classified as an own industry (Helfat and Lieberman,2002). The online games industry has standard features of a new industry: it is characterised by a high degree of knowledge-intensity (OECD, 2005), by being part of an emerging industrial complex with overlaps across sectors (de Boer et al., 1999), and by considerable economic importance (Siwek, 2007). With a global revenue of $ 24.4 bn, its size is more than a quarter of that of filmed entertainment ($ 92.71 bn) and nearly double that of the music industry ($ 15 bn) worldwide (all data for 2014; Ad2, 2014; RIAJ, 2014; Statista, 2014). In 2005, the market for online games became larger than the one for PC games (OECD, 2005a: 13).

Online games include single playing, but their attractiveness is the option to connect multiple players, which is why online games are also called MMO (massive multiplayer online) games. The earliest genre within MMO are MMORPG (massive multiplayer online role-playing games) (Janssen, 2014), the most important genre to date (Castronova, 2008; statista.com). The online games industry has early predecessors in many countries, in particular in the USA and Korea, but also in the UK, in Japan, and in Canada which allows for a multiple case study.

The early online games were text-based, the so-called text-based MUDs, or Multi-User Dungeon games (Wi, 2009). They were extremely simple games, but laid down the rules for the development of online games, such as levelling, strongly themed worlds, and social organization. The early MUDs were laid out in the style of a book. As in a book, the player is immersed in a world through text, and not through graphics as it would be the case in a videogame or in a movie. Within the MUD, the player can move from room to room, navigate with text commands like "/walk north", read a description of the room, interact with the objects and characters within a room, and participate in events that take place (Sanchez, 2009). Most importantly, players can interact with each other in the same world, usually in a role-playing style. Text-based MUDs are the direct predecessor of early graphic-based online games. In these early games, players typically negotiate a maze or dungeon, or fight with monsters, engaging in a role-playing game (also called MMORPG, see Wi, 2009) and creating a persistent universe (Yee, 2006). Later genres include racing or shooting games.

The first MUD was created in 1978 by Roy Trubshaw, followed by Richard Bartle, both at Essex University in the UK. Since then, games were developed by student clubs in universities around the world. MIST, developed at Essex University in 1986, was one of the first public access MUDs in the world. It run continuously, even during nights and weekends, and was free to use. Online games were extremely popular among university students, and students started to develop their own ventures out of these first games (Bartle, 2015).

The emergence of the industry can be linked to the release of the Korean game "Lineage" in 1998, which created a first large mass market of more than two million users. "Lineage" followed the prototype of the game "Nexus" which has been released in 1996 and created around 500.000 users, but which still was not fully graphic-based (interview Wi; see Table 2). In the initial phase of industry emergence, industry definition was, as typical for young industries, still ambiguous (Gustafsson et al., 2015: 8), and online games were also often called MUD games or graphical MUDs, referring to the more common acronym of Multi-User Dungeon games at that time. By the beginning of the 2000s, the term online or MMO games became more common. From the mid-2000s, player numbers exploded also for other games to millions. By the mid-2000s, the industry entered the growth phase, and an increasing number of firms entered the industry as it is typical for the growth stage in industry emergence processes (Gustafsson et al., 2015). In this paper, we focus on the initial phase of the industry, starting from the late 1990s (the release of "Nexus"') to the mid-2000s. We conceive of the period 1996-2005 as the early phase, and the decade until 1995 as the pre-industry emergence phase.

By the late 2000s, developers in the USA, Japan, Russia and elsewhere had entered the MMO market, though Korean firms maintained their dominant position. In 2015, among the top 10 leading MMO games by revenues, there were 4 games developed by Korean companies (Neople, Nexon, NCsoft, Neowiz/Smilegate[2]), 4 by US companies (Riot Games, Blizzard Entertainment, Valve), 1 by a company from Belarus (Wargaming.net) and 1 by a joint venture of a US and a Korean company (Nexon and Valve) (Mmos, 2016). In the free-to-play segment, the position of Korean firms was even stronger, with 6 games developed by Korean developers, 2 by US developers, 1 by a Korean-US joint venture, and 1 by a company from Belarus (statista 2014)[3]. It is thus clear that Korean firms had a dominant position since the early phase of the new industry.

In the early phase of industry emergence (1996 to 2005), about 18 high-performing online games with peak subscriptions over 200.000 have been released, with 6 Korean, 6 US, 2 Japanese, 2 Chinese, 1 Canadian and 1 UK game. Within this group, games developed by Korean firms created by far the largest markets, with over three million players in the case of "Lineage" and over one million in the case of "Legend of Mir 2 "; only in the end of this phase, US and Chinese firms entered with comparably high figures. Firms from other countries followed at a distance with markets of around 200.000 to 500.000 subscribers. While we also observe low-performing games developed by Korean firms, our analysis focuses on the question of why the most successful games were developed by Korean firms in the early phase of industry emergence (Table 2).

-----------Table 2 about here-------------

3.3 Data collection and analysis

Data Collection. We gathered data in stages. The research was carried out between 2012 and 2016. In the first stage, we assessed the factors affecting the emergence of the online games industry through game

[2] Neowiz and Smilegate formed a joint venture.

[3] Data on subscription-based MMO differ somewhat in their results, because they only contain games which must be subscribed to by players, and not the more popular free-to-play games. We therefore decided to include both types in order to compare Korea's competitiveness with that of other countries.

anthologies, including those published in original languages (e.g., Korean and Japanese), published interviews with executives from online games companies, industry documents, and interviews and e-mail exchanges with opinion leaders, industry experts, entrepreneurs and industry associations. These sources helped frame our understanding of the relevant technological capabilities for developing online games and the context for industry emergence.

Next, we searched for the earliest high-performing online games in the phase of industry emergence and analyzed the founders' background in order to understand better which types of technological knowledge were important in early game development. As mass markets only emerged after the development of the prototype "Nexus: Kingdom of the Winds" in 1996, we argue that the industry emerged around that time. This is in common with other papers that argue that the industry emerged in the late 1990s (Casson et al., 2014; Wi, 2009). For this early phase, we collected micro data on early MMO games by identifying the highest-performing games, based on either subscriptions (in the case of MMO games based on subscription) or number of users (in the case of MMO games based on free-to-play business models, introduced towards the end of the 1990s). We did so by using game anthologies, data on the websites of the games, and web-based databases (e.g. www.mmodata and www. mobygames). As the early online game developers were mainly start-ups and not listed on stock markets, company reports could be used in only a very few cases. We put special effort in searching for early high performing games outside the USA and UK, using original sources for Germany, Korea and Japan because we expected that entrepreneurs would exploit capabilities from related industries in engineering or videogames to develop the new industry.

We found that, in most cases, the early high-performing games were developed by teams or single founders which were closely related to hobbyist communities, mostly computer and engineering students, and that most of them had developed text-based MUD games. This holds true both for Korean and US games. There is one exception: the first Japanese game, released after 2000, is not directly linked to the MUD movement, but to existing expertise in online videogame development.

MUD development requires knowledge of software technologies that directly relate to the game, so-called game-development technologies (e.g. game engines), and software technologies that accommodate the game within its environment, i.e., system technologies such as database administration, network coordination, or server programming and technology[4]. Frequently, developers modify an extant game engine to create a new MUD, then release the game engine that the game is based on into the public domain as a tool for additional game creation. Over time, capabilities needed for game design, i.e. how the game "looks like" (e.g. visualisation techniques, plots, narratives) became more important[5]. All these technological capabilities – server operation, network, game design, game engine - are related to programming so that they have been mostly accumulated by students of engineering and computer science departments who experimented with early codebases (Table 3).

-----------Table 3 about here-------------

In order to understand whether superior technological capabilities in MUD development could explain the high performance of Korean online game developers, we decided to search systematically for

[4] Game engines provide the framework for the online game, and contain, depending on their design, functions regarding graphics, physics, sounds, data saving, game control and network codes (e.g. to define the maximum number of players or the underlying network). Given the network requirements, the development of game engines for online games tends to be far more complex than those for offline games. Furthermore, unlike offline games which do not require, by definition, server and network technologies, online games depend crucially on them as they help to deal with thousands and later millions of players which have to be accommodated on restricted server capabilities (Wi, forthcoming).

[5] Game design defines the game world and the game vision, including interface elements (e.g. leaderboards, level, badges), game mechanisms which are relevant for the game experience, and game mechanics.

information of how MUD-related knowledge was distributed across countries. Our search comprised of four steps. First, we made use of three MUD games-related websites (www.mudconnect.com; www.mudstats.com; www.topmudsites.com) and identified those MUDs where a starting date was available and which were developed within the pre-industry emergence phase (1986-1995). Second, in order to cross-check the validity of the information on these websites, we searched for the codebases of the first MUD games. The first popular codebase family was AberMUD, followed by others like TinyMUD or DikuMUD. Across these MUDs, core elements of the game design were different, with TinyMUD emphasizing the creation of content by players, and DikuMUD drawing on pen and paper role-playing games to offer compelling combat-based game play (Bartle, 2010: 29). We searched on the respective websites, e.g. on the "abermud.info" website where AberMUD-based games are listed. We found that most of these games were contained in the three MUD lists mentioned above. We identified in all these websites a strong bias towards later MUDs, and towards MUDs having been developed in Western countries. To avoid such biases, we, third, decided to search for MUDs which were hosted at the main universities of each country (as all early codebases had been developed by students). We started with search via codebase families. We did so by searching for top-level domains which ended with "*.edu" and, as common in Asia, with "*ac.jp" for Japan and "*ac.kr" for Korea, and combined this search with that of MUD servers. This step helped us to identify some Korean MUD communities. Fourth, as there was still a bias towards Western MUDs, we carried out searches on codebases in Korean, Japan, German and French, and contacted directly computer clubs and message boards in Japan (e.g. 2chan). All these stages helped us to find information on the name of the developers, the universities, the places, the time and the name of the code base in multiple countries involved in the development of online games. After this stage of research, we learned that there was an important gap: countries rich in terms of MUD-related technological capabilities were not necessarily those that had firms with the highest-performing online games.

We had not expected that the capabilities of online games development would be so widely distributed across different countries, and that we would identify relatively few MUD communities in Korea. Thus, it became obvious that the distribution of MUD technological capabilities does not explain the different outcomes. We therefore needed to re-theorize our results (Yin, 1994). We added into the analysis the role of complementary assets. We could exclude the role of specialized complementary assets as Korea shows in all related industries (videogames, PC games, software), a strong trade deficit, in contrast to the USA and Japan, and therefore refocused the analysis on other types of complementary assets, inspired by Teece's (1986) and Helfat and Lieberman's (2002) works on generic assets. Specifically related to online games, our interviews identified access to complementary transmission technologies and distribution channels to be important complementary assets. In this stage of research, we re-focused our analysis on the role and effects of generic complementary assets as an alternative driver of industry emergence. Subsequently, we undertook a detailed analysis of system-level complementary assets being most relevant for online games. We collected historical data on their provision across countries in the early phase of industry emergence. This included some of the same sources mentioned above, but we extended them and re-interpreted them given our new insights. Doing so, we were able to explain why Korean firms, despite being less equipped with both core and specialized complementary capabilities and resources, were able to capture economic rents from their innovation, and also to explain why so many innovators, like Canadian or UK MUD developers, were unable to capture them. Table 4 shows the sources.

-----------Table 4 about here-------------

Data Analysis. It is always difficult to draw the exact line between data gathering and data analysis because there is a constant effort to make sense of the data which are being collected. In the first stage of data analysis, we tried to find out as much as possible about how the factors that seemed to have contributed to industry emergence affected the process. This is partly because our initial (more general) question of why the online games industry emerged successfully in Korea was in later stages replaced by the more particular question of the role of system-level generic complementary assets in processes of digital industry emergence. This is why after the initial data analysis, we added an important next stage in which we collected data on relevant complementary assets. We first searched and discussed with industry experts which complementary assets had been relevant in the early online games industry emergence, and then analyzed how these complementary assets were provided across the different countries.

Formal analysis took place in three steps during the period 2012-2016. The first step was to write case histories that put together all factors that we could identify that affected the process of industry emergence, in particular the variety of technological capabilities which are needed and how they were spread around the globe. The second step involved several theoretical approaches that helped to think about this data. The theories we used referred to strategic management, innovation and information studies, and contributions that link entrepreneurship and industry emergence. These theories helped us to develop a new understanding of the data. The third step took place once we found theories that helped us to think about the variety of complementary assets needed to develop an industry (Teece, 1986; Kapoor and Furr, 2015), technology and information system studies on digital industries (Yoo et al., 2010; Tilson et al., 2010), and contributions on strategic industrial policies (such as those on Japan, i.e., Johnson, 1982 and Dore, 2000; South Korea, i.e, Amsden, 1992; and Taiwan, i.e, Wade, 1990). We used these concepts to develop our observations on industry emergence. This exercise led us to an appreciation of the role of system-level generic complementary assets.

4. Findings

4.1. Distribution of early technological capabilities

We first analyzed the development of early technological capabilities related to online games across countries. We focussed our analysis on the distribution of MUD-related capabilities, given our prior finding that early successful games were developed by teams with a background in MUD development. From our data, we derive three important insights on the distribution of early technological capabilities. First, all early MUD communities were located at universities. This is intuitive because only students of engineering and computer science departments were sufficiently capable to experiment with early codebases, and because networking infrastructures were only available through university networks. These results are consistent with findings that new entrepreneurial firms relying on scientific or engineering knowledge often emerge as research spin-offs from university or other research-intensive firms (Knockaert et al., 2011; Miozzo and Divito 2016; Rasmussen et al.,2011).

Second, the most important codebases were developed outside Korea. The earliest MUD, called MIST, was developed at the University of Essex in the UK, which makes the UK an early hub in MUD development. Also, the AberMUD, the first popular open source MUD, was developed in the UK (1987); the later TinyMUD in the USA (1989), the LPMUD in Sweden (1989), and the DikuMUD in Denmark (1991). Korea was a clear latecomer within the MUD movement. It developed its first MUD only in 1992 which was basically an adaptation of the already existing Danish DikuMUD to the Korean language.[6]

Finally, the majority of MUDs was developed in the USA. Out of a total of 421 MUD source codes that we identified in the decade before the industry emerged, more than half were developed in the USA (287), followed by the UK (22), Canada (20), Germany (17) and Sweden (16), and only then Korea (8) and other countries (Table 5). This means that early online game-related capabilities were largely accumulated by US developers, but also that capabilities were not scarce, and distributed across the world. Hence, with

[6] Compare also Wi (2009: 83) who argues that Korea was a late follower, starting only in the middle of the 1990s to experiment with MUDs.

regard to early online games technological capabilities, Korean developers did not outcompete US developers. The USA with its majority of early commercial MUD projects was equipped with much better conditions; Europe, and in particular the UK, was also home to quite a large hobbyist community of university-based MUD developers.

------------Table 5 about here--------------

We conclude from these findings that there is no simple linear relation between programming-based capabilities to digital industry emergence. The interesting question is therefore why did not more of the hundreds of hobbyist MUD programmers around the world develop successful online games? Why did Korean firms outperform those of other countries despite being a latecomer?

4.2. Distribution of specialized complementary assets

The possession of specialized complementary assets like brands, regulatory knowledge, value chains or user communities can also be excluded as an explanatory factor of Korea's leadership in online games. Until the 1990s, the Korean government had actively campaigned against video games as harmful to children, and created a number of regulatory barriers against the industry's creation, including a public ban on Japanese videogames, which made the entry into the games sector unattractive for both large conglomerates and new entrants. Video games were regulated by the Ministry of Health and several other ministries, and treated as akin to adult entertainment. Arcade centers, which were early drivers of the industry's growth in both the USA and Japan (Donovan, 2010), were not allowed in close proximity to schools, were limited in size to 165 square meters, and were forced to close at 10 pm at night (Yoshimatsu, 2005). To limit the consumption of video games, a 25% consumption tax and 10% special value added tax was placed on their sales. In addition to these direct regulations, the industry was strongly influenced by laws preventing the import of cultural content from Japan that were enacted following the Second World War and only came to an end in 2001 (Casper and Storz, 2013). These laws prevented the Japanese manufacturers of both arcade games and video game consoles from entering the market directly. An additional factor strongly impacting the development of the market for personal computer (PC)-based games, but also for the software industry in general, was the lax enforcement of copyrights in Korea prior to the late 1990s. During the 1980s and early 1990s, an estimated 71% of computer games distributed in Korea were pirated copies (Youm, 1999; Jong, n.d.). As a result, American and Japanese firms outcompeted Korean firms by far, leading to a strong Korean trade deficits in these sectors. So how did Korea take the lead in the online games industry despite its weaknesses in terms of core and specialized capabilities and complementary assets?

4.3 Infrastructure and services: a layered complementary architecture for Korean online games

As argued above, many countries other than Korea were equipped with core and specialized complementary capabilities. In what follows, we present our findings regarding the bundle of non-specialized complementary assets which our data shows have been critical to the emergence of Korea's online games industry.[7] We show that it was the availability of complementary infrastructure and service layers that created value for firms and customers.

[7] Other complementary assets like supply chains or access to finance have been, in the early phase of industry emergence, in general less relevant, as most games were produced in-house, and had relatively low development costs. Casson and Park (2014) show that also in Korea, venture capital played only in later phases of industry emergence an important role. Interestingly, though, venture capital for Korean firms was provided mainly by the Korean state. In our framework, such forms of venture capital could be understood as generic complementary assets.

Infrastructure as a complementary technology. Before the broadband emerged, content and information were transported with dial-up technologies. Hence, early online games (like the early text-based MUDs) also relied on them. However, dial-up connections are substantially more likely than broadband connections to produce delays during data transportation. As outlined above, the value of online games depends on the capacity for dense and real time interactions for games chats, exchange of virtual goods, and simulation of combats. Online games developers are therefore in need of a network infrastructure which allows fast and cheap transportation of data. Also, the more popular a game becomes, the more intense interactions and hence technological demands become.

By the end of the 1990s, an important new transmission technology, the so-called broadband technology[8], was introduced worldwide, and started to substitute narrowband dial-up technologies. Broadband network can be used for all kind of activities that involve the acquisition, storage, processing and distribution of knowledge (Røpke,2012). It allows for a faster transport of data through the upgrading of former technologies by new technologies such as DSL technologies (ADSL, SDSL, ADSL 2, etc.), cable modems, and, to a lesser extent, glass fibre technologies.[9]

Broadband transmission technologies are a complementary asset to online games since they increase substantially the value and utility of the game. Without this complementary asset, even the most sophisticated online games do not have value for players, as the transmission of data is lagged, which

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[8] Definitions of broadband differ widely, also depending on the technical progress. See the helpful overview on "How broad is broadband" (OECD, 2001: 6). A broadband line is defined as a line (DSL, cable, fiber and others) that offers high download speed. Indeed, Czernich et al (2011) define broadband lines as lines with download speeds of at least 256kbit/s. Nevertheless, we refrain from a fixed definition as internet access speeds are increasing all the time, so that the "broadband" is a moving target (ITU, 2003).

[9] The use of technologies differed across countries. For example, Korea preferred in the early beginnings ADSL technologies, whereas in the USA, cable television companies started to offer modem services (Yun et al., 2002; Gillet et al., 2004).

works as a barrier towards the interaction between players and to the more complex operations. Put differently, being a complementary resource, the game would be with without value if a complementary transmission network did not exist or performed poorly[10]. Players want to exchange commodities, chat or fight simultaneously without latency, as this is the reason why online game are preferred over offline ones. Also, that prices affect demand holds true in general, but it is all the more relevant for those content and information goods which are featured by always-on connections like online games. Considering the substantial playing time of many online game players, broadband users with an unmetered broadband connection faced lower input requirements. Hence, a high-quality network in terms of speed and price is at the core of an online games industry emergence.

The USA was an early adopter with the first commercial broadband provision in 1995 (http://about.rogers.com/about/our-history); Japan followed in 1996 (Waseda, 2007), and Korea in 1998 (Ginsburg, 2004). However, already from 1999 onwards, Korea's broadband penetration rate was above-average[11], and its broadband network was six times faster than that of Japan, ten times that of the USA and Canada, and twenty times that of the UK. Also prices were much lower, with prices per 100kbit/s that ranged from half those of Japan, to a tenth of those of the UK. As early online games in the 1990s were subscription-based (Superdata 2016) – in contrast to the present where the group of users of free-to-play online games is six times larger than for the subscription-based games – the users therefore had to pay twice, once for the game, and once for the broadband. Table 6 provides a cross-country comparison of download speed and prices.

[10] Moreover, the network's nature is generic as it has multiple applications, can be easily converted to produce other goods, and does not need to be adapted to a specific innovation (Park and Steensma, 2012).
[11] See appendix 2 for penetration rates.

-----------Table 6 about here-------------

Access to distribution channels as complementary service. Korea's broadband transmission network led in terms of speed and prices, but a complementary technology can only increase the value of the digital good when users can access it. [12] This is why the access to the network layer is a further important complementary asset, and why broadband and the access to it should be considered as a bundle. The key constraint regarding the access to broadband is the "last mile" because the end link between consumers and connectivity has proved to be disproportionately expensive to solve. Even compared to the costs associated with rolling out broadband wire and hardware across the expanses of the globe, last-mile connections have been plagued with technological issues and high costs, so that they have become the real constraint facing the use of broadband in most countries (ITU, 2003a). This problem can be solved in two ways: either by linking individual households to the network, or by linking organizations to it. What differentiates Korea from other countries is that strong efforts were placed into solving the "last mile" problem. As a result, already in the beginning of 2001, 57.3% of Korean internet households were connected to broadband, compared to 11.1% in the USA (Lee et al., 2003). But that is not the whole story, there was also a dramatic development of internet cafés, i.e., organizational access solving the "last mile" problem.

Korean private-run internet cafés, called PC Bangs, were established largely in the proximity of schools and universities and facilitated the access to broadband for students. Most of the PC Bangs were equipped with broadband networks and high-end PCs, and were strongly dedicated to gaming (Hyundai Research, 2000). PC Bangs were often founded by middle managers and other workers who were laid off from the

[12] The core role of the system explains why online games are also called a "system technology" (Hyundai Research 2000).

large conglomerates in the wake of Korea's economic crisis in 1997 (Casper and Storz, 2013), and had a major advantage over arcades in that there were no restrictions preventing them from being located near schools (Yoshimatsu 2005: 163). As a result, many of the gaming rooms catered to Korean youth, who could easily afford the typical usage rates of about $1 an hour and would frequent the centres after school and on weekends and holidays (Casper and Storz, 2013).

The popularity of PC Bangs started with the online game "Starcraft", released by the US company Blizzard Entertainment in 1997, in which teams were organized to compete against each other. PC Bangs allowed access to the broadband network in the very early phase of industry emergence – broadband was introduced in Korea in 1998 – and became an important distribution channel for game developers. Indeed, for "Lineage", the first successful Korean online game which was released in 1998, NCSoft derived between 70% to 80% of its revenue from subscriptions paid for by owners of PC Bangs (Yoshimatsu, 2005: 162; Park, 2005: 300; Wi, 2009).

The important role of internet cafés in the early phase of industry emergence contrasts strongly to the situation in the USA and Japan, where not only very few internet cafés existed, but, where they did, were mainly associated with other target groups. The Wi-Fi hotspots at cafés like Starbucks were targeted at mobile business people and not at gamers, and either had a too low transmission volume for games or blocked online game sites altogether due to security reasons (Rombel, 2002). Lan Centers instead were aimed at gaming, but they were mostly linked to universities, less commercially-oriented, and often opened only a few hours over the weekend and, most importantly, only emerged much later, i.e. in the late 2000s (one of the first Lan Centers was founded at Eastern Michigan University's Student Center in 2006). Contrasting to the US, a number of *manga-cafés* (*manga kissa*) have been established in Japan which were commercially and entertainment-oriented. They offered beverages and snacks for an audience being interested in Japanese comic (*manga*) books, and later extended also to the provision of internet connection and game consoles. However, these internet cafés have been established only in the beginning of the 2000s and hence later than in Korea where establishment started in the middle of the 1990s and have also been much less in number (around 3000 in the year 2000). Moreover, if they were linked to games, they focused on offline, and not online game consoles (White Paper 2003; Kinzai 2008[13]). Hence, manga cafés were less targeted at an online gaming audience, but their business model was rather a mixture of a library, including virtual media, and a coffee shop.

These cases are different from that of Korea where internet cafés have been pervasive and mainly targeted at online gamers. Also, though an international industry classifications for internet cafes is lacking, by the end of the 1990s already around 14.000 internet cafés were founded, a much higher number than in other countries, and their number grew to about 22.000 during the 2000s (Appendix 3).

5. Concluding discussion

We propose that digital goods such as online games can be considered as one layer within a three-layered product architecture. Online games provide content within the information and content layer. In order to create value, they are, however, in need of complementary assets, provided by broadband (layer of infrastructure), and by access routes, provided by individual households connections and, in particular, in the industry's early phase, organizational access through internet cafés. Our findings have important implications regarding the role of generic complementary assets in digital industry emergence and of the role of strategic actors previously overlooked – governments and new entrepreneurial services firms – in providing these.

[13] See also Kinzai (2016) for later years.

5.1 Generic complementary assets and industry emergence

We build on the literature on complementary assets (Teece 1986; Tripsas 1997) and extend this to show the role of generic complementary assets for digital industry emergence. Contrary to what we know from the resource based view, our data show that in the case of emergence of Korean online games, relevant complementary assets have been generic rather than specialized in nature.

Generic complementary assets are argued not to be tailored to the innovation and have multiple applications. Teece (1986) does not consider them to be the key to profiting from innovation. Similarly, Chiu et al. (2008: 878) note that "generic complementary assets offer little or no competitive advantage to a firm". As it is assumed that generic assets can be easily contracted for on the market (Rothaermel et al 2005: 53), or easily developed by the firm itself (Chiu et al., 2008), the underlying assumption is that generic assets are generally available. This is why there is a natural tendency to oversee that they may also be scarce or of insufficient quality, and why research has focused instead on specialized complementary assets (Yli-Renko et al., 2001 Chiu et al., 2008; Rothaermel et al., 2005). Nevertheless, in the cases studied, we show that these generic complementary assets have not been generally available on the market or were provided at a lower quality and higher price in other countries, and hence could neither be contracted for, nor, given the capital investments involved, provided by firms themselves or their ecosystem or network of collaborators.

Although generic assets are already considered in the early works of Teece (1986), there is value in distinguishing a "generic complementary asset perspective" which offers a distinct, but complementary view on how new industries emerge. This holds in particular for the case of digital products, for which the availability of complementary "layers" is essential. In our case, it was the availability of generic complementary assets, i.e., of the broadband technology network and access to distribution channels, which allowed innovative Korean MMO firms to “profit from innovation”, to borrow Teece’s famous words. Hence, although, technically the network and access are separate goods, they are better understood in terms of “layers”, or in the form of a mutually complementary bundle of activities to online games. Such a “generic complementary asset perspective” differs from the resource-based view in important categories such as the unit of analysis, sources of competitiveness, and mechanisms that sustain it (Table 8).

----Table 8 about here ------

A perspective on industry emergence which takes into account the role of generic assets may offer different normative implications for strategy formulation at both the government and firm level. For example, according to the resource-based view, firms should put effort into the creation, accumulation, access to, and protection of core capabilities and specialized complementary assets, both within the firm and within its network. Core and specialized complementary assets are also important in a “generic complementary asset perspective”, but an effective strategy may be instead to identify complementarities between existing specialized assets and generic ones which are external to the firm but available at the system-level. Furthermore, a focus on generic assets may help explain why certain firms in certain countries may exhibit leadership when technological capabilities may be more widely distributed across the world. Normally, strategic management research tends to focus on firms in a single country. Hence, taking a ”generic complementary asset perspective” may be helpful to extend the firm-level perspective, which is dominant in strategic management research, to a system-level view.

By the same token, the “generic complementary asset perspective” and existing views would come to different conclusions about the choice of strategies. While firm- and network-level capabilities are a necessary condition for processes of industry emergence, the “generic complementary asset perspective” stresses the collective dimension of industry emergence processes, and the complementarity of firm capabilities and generic assets.

It should be added that we could not identify specialized complementary assets of Korean firms and their networks that were crucial in the early phase of industry emergence. In particular, we expected that Korean popular art with its “cute culture“ (Hjorth, 2009) might have been an important specialized asset, but for early online game development, arts like graphics were of minor importance compared to programming capabilities (Choi, 2011). In the early years of industry emergence, the Korean media industry even licensed art from US firms because it stated a “lack of content“ in the domestic supply of arts (Shim, 2002). In the later phase of industry growth, these complementary assets became more important, and their supply has been supported by governmental agencies which initiated a number of industry-specific cultural and educational policies as well as a number of internet training initiatives, reaching 3.4 million people, including one million housewives by the end of 2000 (Yun et al., 2002). These policies did not play a role in the initial phase of industry emergence. However, they also indicate that the nature of required complementary assets may change during different phases of industry emergence.

We extend the view on complementary assets by arguing that broadband technologies and access to distribution channels have been an important generic complementary asset in the process of industry emergence. What, however, happens, when such critical generic assets are not provided? In the following section, we put forward the argument that besides the market – which played an important role in providing distribution channels – governmental agencies have played an important strategic role. We call these “strategic state actors”.

5.2 Strategic state actors: implications for public policy

The empirical evidence in this paper is primarily concerned with firms and issues of emergence of new industries, but they hint at some important implications for public policy. The provision of generic complementary assets described above invites reflections on the role of the state. The state as an actor in industry emergence is widely overseen in the strategic management literature, which tends to focus on capabilities and specialized complementary assets provided by firms (Collis and Montgomery, 2008). While more recent contributions consider the role of supporting institutions, and hence, the role of public policy in providing institutions, the institutional scope tends to be narrowly defined, and is often restricted to intellectual property rights, and product and labour market regulation (Teece, 2006: 24-26; Wu et al., 2014; Fuentelsaz et al., 2015). While some of these aspects also play a role in the case of the Korean online gaming industry – in particular the low price of the complementary technology as a result of deliberate competition policies – such a perspective would underestimate the role of technological infrastructure in processes of industry emergence: In the case considered here, it was less a supporting institutional environment that induced the emergence of a new industry in Korea, but the direct provision of generic complementary technologies in the form of broadband networks (and its investments into it) by the Korean government.

This view of state agency in new industry emergence adds to existing contributions on the strategic role of non-market actors in processes of industry emergence (Dahlander and Wallin, 2006; Lazzarini, 2015). Lazzarini (2015), building on developmental state literature on East Asia, argues that industrial policies may eventually lead to sustainable competitive advantages under certain conditions of global production networks, geographical specifity, and government capabilities. Our work suggests that the role of the government goes beyond the formulation of industrial policy as framework conditions, and calls attention to the motivated agentic processes behind industry policy formulation. We use the term agentic processes not in the sense of interpretative frameworks (like, for example, Feldman 2000) but because the government can act as a non-market entrepreneur that provides important complementary assets for innovation. This role has been clearly played also by the US government from the 19th century up to the present, including the impulse for the education of scientists and engineers which populated the R&D labs of "big business" through the Morrill Land-Grant Act of 1862 and Hatch Act of 1887, and the support of aeronautics in the 1920s, with the Contract Air Mail Act. More recently, the US government had an active role in developing the ARPANET and the NSFNET, which became available commercially as the Internet. Also, the funding by the National Institutes of Health for the life sciences has been critical to the development of the biopharmaceutical industry and entrepreneurial ventures such as those found in Silicon Valley (Lazonick 2008; Mowery, 1999; Robertson and Langlois, 1995).

By including these aspects of state agency in our understanding of digital industry emergence, it forces us to think about the diversity of actors in such processes. The performative model of complementary assets that emphazises agency – in the form of entrepreneurial capabilities – as depicted in Figure 1 captures these aspects in a schematic form and proposes early industry emergence as a cycle of knowledge creation by innovators whose commercialization is affected by a variety of actors and the provision of both specialized generic complementary assets.

We do not claim that in all cases of industry emergence both type of actors – market and non-market - and both types of complementary assets – both specialized and generic – are relevant, but we claim that we should extend our understanding of industry emergence to cases where non-market actors and generic assets are at the core. Indeed, many other new digital industries emerged in Korea in the 1990s included online shopping, B-B e-commerce, search engines, and online stock trading (Chon et al., 2005;

MIC/NCA, 2000: 32-44; Shin et al., 2012). As research in strategic management has, so far, neglected the role of generic complementary assets, it also has tended to neglect the role of strategic state actors in triggering the emergence of digital industries.

5.3 Limitations

This paper focuses on the initial phase of the online gaming industry and stressed the role of generic complementary assets. We do not discuss the role of other types of complementary assets in later stages, and how their nature may change. Also, we do not discuss which other industries may benefit from which types of generic assets. While we believe that our insights hold true for a number of digital industries, this paper was limited to exploring one digital industry, the online games industry.

Table 1: Layered product architecture of digital goods

Layer	**Activities**	**Capabilities and resources**	**Provision**	**Condition of value creation and capture**
Content and Information	• Creation and packaging of intangible product • Diversity of content and information provision • Creative content and publishing (text, graphics, sound)	Core capabilities	Firm level and its context (firm, network, ecosystem)	**Integrating layers/availability of complementary layers**
Infrastructure	• Provision of transmission technologies (e.g. DSL, glass fibre) • Provision of devices (e.g. computer hardware, operating system) • Provison of network (e.g. cables, network standards)	Complementary technologies	System level: global, national, regional, industry level	
Access and Service	• Access to transmission technology • Security, payment systems	Access to distribution channels, service networks		

Table 2: **Best performing online games during early industry emergence (1996-2005)**

Developer/ Publisher	Country of Origin	Title	Year released	Peak subscriber in year released (or earliest available)	Peak subscriber between 1996-2005	Company founded	Source
Nexon	Korea	Nexus: Kingdom of the Winds	Early 1996	n.a.	500.000 to 1,000,000+ (1996)	1994	1 mio: http://www.isc.hbs.edu/resources/courses/moc-course-at-harvard/Documents/pdf/student-projects/Korea_Online_Game_Cluster_2006.pdf Up to 500.000: interview Jong Wi
Origin Systems/E.A.	USA	Ultima Online	01.09.97	100,000 (1998)	250,000 (2003)	1983/ since 1992 division of E.A.	mmodata.blogspot.com
Vircom Interactive	Canada	The 4th Coming	1998	n.a.	500,000* (2002)	1994	https://archive.is/BP1YQ
NCsoft	Korea	Lineage	01.11.98	100,000 (1998)	3,212,081 (2003)	1997	mmodata.blogspot.com
Verant Interactive/	USA	Everquest	01.03.99	150,000	550,000 (2004)	1995 (inhouse	mmodata.blogspot.com

Sony Online Entertainment						developer for Sony)	
Sonic Team/ SEGA	Japan	Phantasy Star Online	2000	n.a.	235,000* (2001)	2000 (1988 as subdivision of SEGA)	http://gamers-online.net/godl/pso/main.html
Jagex	UK	Runescape	1999/ 2001	24237 (2002)	500,000 (2005)	1999 (name only), 2001 (company)	mmodata.blogspot.com
Mythic Entertainment	USA	Dark Age of Camelot	2001	120,000	250,000 (2003)	1995	mmodata.blogspot.com
WeMade Entertainment	Korea	Legend of Mir 2	2001	600,000 (PCU) (2002)	1,000,000 (PCU**) (2005)	2000	mmodata.blogspot.com
Square Enix	Japan	Final Fantasy XI	2002	185,000	550,000 (2004)	1975 (Enix), 1983 (Square), 2003 (Square Enix)	mmodata.blogspot.com

Netease	China	Westward Journey Online 2	2002	349,181 (PCU) (2004)	554,000 (PCU) (2005)	1997	mmodata.blogspot.com
NetEase	China	Fantasy Westward Journey	2003	356,377 (PCU) (2004)	1,043,000 (PCU) (2005)	1997	mmodata.blogspot.com
NCsoft	Korea	Lineage 2	2003	896,210	2,107,348 (2005)	1997	mmodata.blogspot.com
Sony Online Entertainment	USA	Star Wars Galaxies	2003	300,000	300,000 (2003)	1995	mmodata.blogspot.com
WEBZEN	Korea	Mu Online	2003	407,589	407,589 (PCU) (2003)	2000	mmodata.blogspot.com
Sony Online Entertainment	USA	Everquest 2	2004	150,000	330,000 (2005)	1995	mmodata.blogspot.com

Blizzard	USA	World of Warcraft	2004	400,000	5,600,000 (2005)	1991	mmodata.blogspot.com
Gravity	Korea	Ragnarok Online	2004	783,134 (PCU)	798,175 (PCU) (2005)	2000	mmodata.blogspot.com

Note:
Table restricts to best performing games with peak subscriptions above 200,000. For more information, see Appendix 1.

All other information (year released, developer MUD experience etc.) are taken from http://mmos.com/editorials/oldest-mmorpgs, www.bcg.nl/documents/file13973.pdf, https://en.wikipedia.org/wiki/Comparison_of_massively_multiplayer_online_role-playing_games, and the respective Wikipedia pages of the games and developers.

* Number of users, game had a free-to-play model.
** Peak Concurrent Users (PCU) is the highest number of users playing within 48 hours. It is used for games with no subscription data available, or games that are not subscription-based. For comparison, World of Warcraft (West) had a PCU of around 440,000 in 2005.

Table 3. Capabilities of firms which developed early best performing online games (1996-2005)

Title	Country of Origin	Year released	Capabilities and core knowledge needed
Nexus: Kingdom of the Winds	Korea	1996	Song helped developed Korean DikuMUD game engine in 1992 at KAIST. This game engine, called KITMUD, adapted the "Western" DikuMUD to the Korean language, and was the earliest MUD in Korea.
Ultima Online	USA	1997	Extensive across core team; lead designer developer of Worlds of Carnage and Legend MUD
The 4th Coming	Canada	1998	Vircom Int. is specialised in Internet infrastructure and client-server solutions and the fourth coming is their only game. They subsequently sold the game to other companies and it is now marketed by Dialsoft.
Lineage	Korea	1998	Song helped developed Korean DikuMUD game engine
Everquest	USA	1999	Lead designer a MUD player and developer of shareware RPG games
Phantasy Star Online	Japan	2000	Although the studio was SEGA's most prominent developing team, Sonic team had previously not worked on online games. SEGA had, however, developed MMORPG "Dragon's Dream" before.
Runescape	UK	1999/ 2001	Lead Developer Andrew Gower developed his own graphical MUD 'DeviousMUD' during time at Cambridge University and based Runescape on this MUD.
Dark Age of Camelot	USA	2001	Lead designers developed numerous online games before (MUD and graphical online RPG, FPS).

Legend of Mir 2	Korea	2001	Company founded by the original developers of Legend of Mir, the previous installment. The company also provides hosting services for third party games in Korea.
Final Fantasy XI	Japan	2002	Neither the company nor the developers had previous experience with online games.
Westward Journey Online 2	China	2002	The company was a pioneer in the development of internet services in china. It developed the earlier installment of this series.
Fantasy Westward Journey	China	2003	See above (Westward Journey Online 2).
Lineage 2	Korea	2003	See above (Lineage, with MUD experience)
Star Wars Galaxies	USA	2003	LucasArts had limited experience with online games, however Sony Online Entertainment previously developed Everquest among other games. The creative director was lead designer for Ultima Online (see above) with MUD experience

Mu Online	Korea	2003	The company had no previous experience with online games. Mu Online was its first game.
Everquest 2	USA	2004	See above (Everquest). The lead designer worked on the first installment of the series as well (MUD experience)
World of Warcraft	USA	2004	Although WoW is Blizzard's first MMORPG, the company had a lot of experience with high capacity game servers, from previous games such as Diablo 2, Star Craft, War Craft 3. The lead programmer and many other staff members worked on installments of the Everquest series.
Ragnarok Online	Korea	2004	The company had developed a single player RPG before, but had no experience with online games.

Note:
For sources, see Table 2.

Table 4: Data Sources

Source of data	Type of data	Use in analysis
Business reports	Game anthologies, including business histories written in Korean and Japanese: Aruede et al 2006; Bartle 2010; Burka 1993; Castronova 2008; Farirar 2012; Herz 1997; Herz 2002; Graft2009; Kawaguchi 2014; Kim 1997; Kim et al 2009; Ok 2011; Yun 2009; Sanghun et al 2008; Internet-based archives (http://www.hardcoregaming101.net/korea/part1/korea1.htm; https://en.wikipedia.org/wiki/Chronology_of_MUDs; http://mmodata.blogspot.de; https://en.wikipedia.org/wiki/Comparison_of_massively_multiplayer_online_role-playing_games)	Development of analytical narratives
Semi-structured interviews with opinion leaders, industry experts and entrepreneurs	6 interviews with Japanese and Korean professors in the fields of computer science, strategic management and humanities 2 interviews with Korean online companies in June 2013 6 interviews with Japanese online companies in January and April 2013	Interviews aimed at understanding the general setting of online games, in particular the scope of necessary capabilities and the recent developments within the industry
External key informants	Interviews in 2012, 2013 with leading business associations (e.g. JOGA/ Japan Online Games Association), industrial policy agencies (METI) and industry analysts; e-mail exchange with persons who formerly participated in MUD communities as well as with experts on digital industries in the US, Japan and Korea	Triangulation of informants' assertions and recollections
Annual reports	Annual reports of top online game developers	Fine-grained data of actions and performance; triangulation of informants' assertions and recollections
Industry reports	White Paper on Korean Game/Kocca; ITU Reports (e.g. 2003); reports of KGDPI (e.g. 2004); OECD reports (e.g. 2001); FCC report (2009); World Bank (2014)	Fine-grained data of industry development and international comparison of broadband technology development
Fairs and conferences	Tokyo Game Show; Big Site; Game Developers Conference	Scope and change of necessary capabilities in the industry over time
Business press	Articles about the online gaming industry; 2006-2016; examples: Herz 2002 (http://archive.wired.com/wired/archive/10.08/korea.html)	Tracking external developments to the online gaming industry
Game Databases	MUD listings from http://mudstats.com, http://topmudsites.com, http://mudconnect.com	

Table 5: Technological capability development: distribution of MUD communities before industry emergence (1986-1995)*

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Year N.A.	Total
USA	0	1	8	12	22	28	42	36	60	78	0	287
UK	1	2	0	3	1	1	3	3	2	6	0	21
Canada	0	0	0	0	2	1	4	3	7	3	0	20
Germany	0	0	0	0	2	3	2	1	5	4	0	17
Sweden	0	0	0	2	2	3	2	1	1	5	0	16
Korea**	0	0	0	0	0	0	1	0	3	0	4	8
Netherlands	0	0	0	0	0	2	1	1	2	2	0	8
Australia	0	0	0	0	1	0	1	1	2	0	0	5
Denmark	0	0	0	0	1	2	1	0	0	0	0	4
Finland	0	0	0	0	1	0	1	0	1	1	0	4
Austria	0	0	0	0	1	1	0	0	0	1	0	3
Norway	0	0	0	0	1	2	0	0	0	0	0	3
Russia	0	0	1	0	0	0	0	0	1	1	0	3
Italy	0	0	0	0	0	0	0	0	1	1	0	2
Luxemburg	0	0	0	0	0	0	0	1	0	1	0	2
Poland	0	0	0	0	0	0	0	0	1	1	0	2
Japan***	0	0	0	0	0	0	0	0	0	0	1	1
Other	0	0	0	1	1	3	1	2	3	2	0	13
Total	1	3	9	18	35	46	59	49	89	106	5	420

Note:
*The first MUD was launched in 1979 and hosted at the University of Essex (written in MUDDL language), later extended to MUD1.
**The first Korean MUD, the KIT-MUD, was hosted in 1992 at the KAIST. Jake Song, Korean's early entrepreneur in online games, participated in the KIT-MUD development at KAIST (see Table 3).
***The Japanese entry is a computer club, the Kyoto University Micro Computer Club (KMC, https://www.kmc.gr.jp/)

Sources: see method section.

Table 6: Broadband transmission technologies: speed, prices and penetration (2001)

	US	**Canada**	**UK**	**Japan**	**Korea**
Download speed (kbit/s)	768	960	500	1,500	**8,000**
Price per 100 kbit/s (US$)	5.57	3.26	7.89	1.7	**0.68**
Penetration (Subscriptions per 100 Inhabitants)	4.45	9.15	0.56	3.04	**16.9**

Note:
This table includes the first systematic across country data on speed and prices which have been recorded. Data are from 2001. Broadband subs/100 inhabitants (2002): ITU 2003a,21; Broadband as % of all internet subs (2002):): ITU 2003a,21; Download speed (kbit/s) (2002) : ITU 2003a,21; Price per 100 kbit/s (US$) (2002) : ITU 2003a,21; 100kbit/s as % monthly income (2002) : ITU 2003,21

Table 7: Perspectives on industry emergence

	Resource-based view	Contextual resource-based view	Generic complementary asset perspective
Unit of analysis	Firm	The firms' networks and ecosystem	Firms embedded in system
Sources of competitiveness	Firm capabilities plus specialized complementary assets	Firm capabilities plus specialized complementary assets and the firm's close environment (inter-firm linkages, user communities)	Firm capabilities plus specialized and generic complementary assets
Mechanisms to create competitiveness	Firm-level development of resources, firm-level barriers to imitation	Networks' barriers to imitation	Provision and access to complementary layers
Responsibility for provision	Firms	Firms and their networks, consumers, suppliers	Market and state
Locus of effort	Internal to the firm	Internal to the firm including "relational" users and firms	External to the firm, but related to institutional setting of firms

Appendices and references have been deleted due to space constraints are provided on request.