The Impact of Cloud Computing Disruption in Platform Markets:

The Case of Cloud Gaming Platforms

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The Case of Cloud Gaming Platforms

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Executive Summary

The extraordinary rise of cloud computing services across all industries has come with many disruptive business models that have changed or upended the ways of incumbent firms. It has consequently become one of the topics that is top of mind for many business leaders when it comes to the threats and opportunities their businesses face. To help the analysis of the phenomenon a number of researchers have set out to research the impact of cloud computing disruption on firms, whether consumers or providers of cloud services. However, extant findings have fallen short of explaining the manifestation of such disruption in the increasingly prominent context of platform markets. Platforms are defined as a product or service that brings together multiple groups of users that obtain more value from the platform as it gets more users in either the same or the other user group. In other words, platforms are characterized by so-called multi-sided markets and network effects. This business context has not been explicitly researched in relation to cloud computing disruption which provides the motivation for this study.

In order to research cloud computing in a platform market context, a multiple comparative case study was executed into three cloud gaming platforms, Google Stadia, Nvidia GeForce Now and Playstation Now, to explore their impact in the gaming platform market. To this end, data was collected of the impact of the three cloud gaming platforms individually on to the incumbent console-platform situation, comprising the Playstation and Xbox consoles. A survey filled out by 21 experts was used to verify the data from the three cases and to help triangulate the data from other sources. Subsequently, the evidence from all three cases was combined with the results from the expert survey to obtain five themes that capture the manifest effects from cloud gaming disruption: (1) a dependency on internet quality, (2) a necessity for data center infrastructure, (3) cloud gaming business models, (4) service accessibility, and (5) new value propositions. A review of the extant scientific literature on the impact of cloud computing disruption in general yielded an exhaustive list of 24 previously identified effects: 5 on the consumer of the cloud service, 14 on the provider of the cloud service and 5 on the wider environment of actors, the so-called ecosystem of the platform firm. In a comprehensive comparison between these effects and the effects that were identified from the thematic analysis of the data on the three cloud gaming cases and the expert survey, similarities and differences were uncovered that provide an indication of the impact of cloud computing in platform markets.

Of the effects identified from literature to impact the cloud service provider, 9 were also observed in the cloud gaming market. These are: (1) the necessity for IT infrastructure, (2) the possibility for new products and services, (3) the greater service accessibility and availability, (4) the engagement of new customer segments, (5) the subscription and flexible revenue models, (6) the smaller customer lock-in effects, (7) the lowered barriers-to-entry for competition, (8) the harder differentiation from competition and (9) the better organizational agility. 5 effects were not found to be present, these are (1) the better economies of scale, (2) the higher degree of

service standardization, (3) the more direct relationship with the end-user, (4) the better quality-of-service and (5) the reduced customer confidence. On top of these differences and similarities with previously identified effects of cloud computing disruption, 3 novel effects were identified in the cloud gaming cases. These are: (1) the strong dependency on internet quality, (2) the networking-related technology performance metrics and (3) the necessity for proximity to users. These novel effects were found to be largely the consequence of the interactive nature of cloud gaming which puts strict requirements on the network conditions for a good service quality, which in turn necessitates sophisticated compute technology and software as well as investments in a data center network that is as close to the end-user as possible.

Despite the limited data on cloud gaming platforms acting as cloud service consumers, the study showed the presence of two more effects previously identified by extant literature to affect consumers of cloud services. These are: (1) the switch from capital IT expenses to operational expenses and (2) the outsourcing of security and scaling risks and consequently the acceptance of risks concerning IT availability. For the remaining three out of five effects from literature to affect cloud service consumers, no evidence could be found. These three are: (1) the new business model opportunities, (2) the better performance of cloud-supported operations and (3) the better organizational agility.

When it comes to the comparison of the ecosystem effects, four could also be identified in the cloud gaming cases: (1) the changing ecosystem roles, (2) the emergence of new ecosystem roles, (3) the greater necessity for ecosystem orchestration due to increased dependencies, and (4) the emergence of ecosystem-enabled value propositions. The remaining effect out of five that were previously found by literature to affect ecosystems, concerns the increase in knowledge spill-over effects. For this effect no evidence could be found in the cloud gaming cases. A novel effect was observed relating to the fact that cloud computing disruption does not affect complementors as strongly as do other disruptions. This is due to the ability of the cloud service providers to evolve the service's capabilities rather than make big upgrades that can leave previously acquired competencies of complementors useless.

The findings from this study are a contribution to knowledge on the effects of cloud computing disruption in a platform market context. It can provide business leaders with an insight into the possible consequences of such disruption in their own platform environment. The results do however relate to the specific case of cloud gaming and stem from a consideration of just three cases. Therefore, the study's results may be less applicable to other platform industries. Further research is required to address these limitations and consolidate the findings. Nevertheless, the indications provided by this study are a well-founded starting point for considering what impact must be expected and which opportunities and threats should be taken into account when dealing with cloud computing disruption in a platform market context.

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Glossary

5G	A cellular network technology that is to provide fast and stable data communications, including internet services, to primarily mobile devices.
All-you-can-play	A business model in which consumers pay to get access to a, often changing, catalog of content (e.g. Netflix).
B2B	A business to business business model aims to provide products or services to other firms instead of consumers.
Bandwidth	The total capacity of an internet connection denoted in Mbit per second (Mbps).
Broadband	The cabled internet connection that many have in their homes.
Economies of scale	The phenomenon where provisioning a larger quantity of a product or service leads to greater efficiencies and lower marginal costs.
GFN	Geforce Now, Nvidia's cloud gaming service.
GPU	Graphical processing unit: a chip that is dedicated to processing video data.
ISP	Internet service provider: a firm that provides broadband and cellular internet services to consumers.
Jitter	The phenomenon in internet communications where the delay (i.e. latency) in data delivery varies over time, often due to network congestion.
Latency	The total time it takes for data delivery between two locations over a network.
Packet loss	The phenomenon in network communications where bundles of data are lost along the route between source and destination, e.g. because buffers of intermediate nodes are overloaded.
Peering contract	The agreements network operators and digital content providers have with each other to be able to pass on network traffic between each other to reach the consumer.
PS Now	Playstation Now, Sony's cloud gaming service.

1 Introduction

1.1 Background

"A new generation platform, rather than a next generation platform". With these repeated words did general manager Phil Harrison launch the Google Stadia cloud gaming service in 2019. The service proved to provide new oil to the fire that is cloud gaming, a cloud computing-based value proposition that had up till that point not succeeded. It is but one example of how cloud computing-based platforms are attempting to disrupt existing industries. Cloud computing is shrouded in haziness when it comes to its exact definition. The confusion stems from the fact that "the cloud" is used to describe a plethora of services delivered over the internet. This includes both applications delivered over the internet as well as the hardware required to arrange that (Armbrust et al., 2009). Capturing the whole range of possible meanings, the International Organization for Standardization defines cloud computing as a "paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand" (ISO/IEC 17788:2014, 2014, p. 2).

This definition contains elements that deserve further elaboration. Firstly, broad network access refers to the ubiquity of cloud computing, accessible from anywhere, anytime, potentially through any device as long as there is an internet connection. Secondly, scalability and elasticity describes the fact that cloud computing allows the flexible use of resources as needed. A cloud provider can elastically scale and shrink the resources available to users as demand changes. Thirdly, pooled resources refers to the fact that a large capacity of resources are aggregated by a cloud provider to fulfil the demand of many different customers. These pooled resources are also characterized by multi-tenancy, where the data and computations of many different customers can be isolated from each other, even though these may be located and executed on the same server (Marston et al., 2011). This allows the cloud provider to service multiple different users with a single server. Lastly, on-demand self-service refers to the ability cloud computing gives customers to acquire computing capabilities as required, with minimal need for administration.

The market for cloud-based services is growing extremely fast. Between 2019 and 2020 the share of firms using cloud-based software or platforms doubled in nearly every sector in the Netherlands (Statista, 2021). As a result of this ongoing growth, many researchers have set out to see what the impact of such cloud service disruption is on the firm itself and on the broader market (e.g. Iyer and Henderson, 2012; Boillat and Legner, 2013; Clohessy et al., 2020). The many different environments in which cloud-based business models are being deployed has however left a lot of unknowns when it comes to its impact in different contexts.

Google's Stadia is an example of a cloud computing service that exists in an context that has had little attention in the literature on cloud computing disruption, namely the platform market context. Platforms are distinguished by their multi-sided market and the presence of network effects (Cennamo and Santalo, 2013; Rietveld and

Schilling, 2020). In the case of gaming platforms the multi-sided market comprises the end-user that plays the games and the complementor that develops the games. In this market, Stadia now stands to disrupt the primacy of the console incumbents, traditionally Sony, Nintendo and Microsoft. Each of these incumbents have their own console-based platform. However, since a few years they have been getting serious competition from cloud gaming disruptors. The first cloud gaming experience was demonstrated in the year 2000 by the Finnish company G-Cluster at the E3 gaming convention. Since then various others have also attempted to create cloud gaming services, but only recently has it regained a lot of steam with the release of Google Stadia in November 2019 and the announcement of Amazon Luna in September 2020. Nvidia already had its own service since 2013 called GeForce Now, which allows for playing games from various game vendors, such as Steam and Epic games, in the cloud. Incumbents have not been standing idly by. Sony was actually one of the first big companies to get involved with cloud gaming when it announced its Playstation Now service in January 2014. Microsoft reacted in November 2019 with its XCloud project which has recently launched under the name of Xbox cloud gaming.

1.2 Problem Statement

There have been many scientific publications that consider the field of cloud computing, and a few that delved into the topic of disruptive innovation in platform markets. However, the relationship between cloud computing disruption on the one hand and disruption in platform markets on the other hand has not yet been explored. De Reuver et al. (2018) identified the need for more research in this direction in more general terms, suggesting to consider the impact of disruption by digital platforms, both on the disruptor itself as well as the surrounding ecosystem. Petzold et al. (2019) and Rietveld and Schilling (2020) similarly, mention that disruption in a digital environment might be of a different nature, implying that further research is required to establish the exact role played by this environment.

1.3 Research Questions

Given the problem described above, this study aims to answer the following research question:

Research Question: *What is the impact of cloud computing disruption in platform markets?*

In order to answer this research question, a multiple comparative case study was executed which considers three cloud gaming platforms in the context of the gaming platform market (see section 3). A set of sub questions partly apply to these cloud gaming cases. The sub-questions are meant to successively inform an answer to the main research question. The first question that comes up concerns what knowledge

is already available on this topic. The findings from previous studies into this topic, even as it concerns different contexts, will help establish an insight into the nature of the impact of cloud computing disruption. Moreover, with the results of this present research, it serves a comparison between cloud computing disruption in a general sense and cloud computing disruption as it affects platform markets.

Sub-question 1: *What is the extant knowledge on the effects of cloud computing disruption?*

The logical next step is to consider the evidence that can be gathered from the three cloud gaming cases and the expert survey, and study the impact cloud gaming disruption has on the platform firm and wider ecosystem.

Sub-question 2: *Which patterns of impacts from cloud gaming disruption can be identified in the gaming platform market?*

When the impact of cloud gaming disruption is uncovered, the next step is to generalize the findings and to relate them to extant knowledge on the topic. This comparison serves the purpose of discovering which known effects are supported by the results of the study and to see whether the results yield novel effects. With an answer to this last sub-question all knowledge is available to formulate a solution to the main research problem.

Sub-question 3: *How does the impact of cloud gaming disruption in the gaming platform market compare to the extant knowledge on the effects of cloud computing disruption?*

1.4 Research Scope

The study's scope is bounded by a number of criteria. Firstly, the study considers only the firm and ecosystem level of analysis. It therefore aims to find the impact on firm-level aspects, such as business model, assets, competencies and organization, as well as on ecosystem-level aspects, such as ecosystem roles, ecosystem orchestration and inter-firm relationships. This means that any data on the individual or industry-wide level will not be included. Secondly, the research is interested only in the current manifestation of effects. The aim of the study is not to find the changes that have taken place in the effects resulting from cloud computing disruption in the platform market. Instead, the aim is to establish the impact of the disruption at the point in time when the research is conducted. Thirdly, the study only considers the selected cloud gaming cases in comparison to the incumbent console gaming market. This means that no other cloud gaming firms and data from their cases will be included.

2 Theoretical Framework

2.1 Foundational Research Fields

2.1.1 Ecosystems and platform markets

In recent years, the use of the ecosystem concept has gained popularity in the strategy literature. So much so, that it has almost attained buzz-word status. However, it's exact definition and applicability remain a point of discussion, which is why various authors have conducted analyses of the literature in order to clarify the definition of the concept as well as those of its numerous variations (e.g. Adner, 2017; Jacobides et al., 2018; Kapoor, 2018; Thomas and Autio, 2020). Although proposed definitions vary, conclusions seem clear: there is a meaningful place for the ecosystem besides all the other concepts that strategy literature has put forward over the years.

According to Thomas and Autio (2020) a combination of four characteristics account for ecosystems being different from such concepts as supply chains, networks and clusters, which might seem similar at first sight. Firstly, ecosystems show high degrees of participant heterogeneity. Participants originate from a variety of industries and may also be public organisations, like universities and governments. Secondly, ecosystems generate outputs comprising of inter-compatible, often modular, products and services, that could not be produced by a single participant alone. Thirdly, participants are highly interdependent in technological, economic and cognitive (e.g. cultural) respects. Fourthly, the governance of the ecosystem takes place primarily through non-contractual means and instead is accomplished through an alignment structure in which there is informal agreement about such facets as roles, power relationships, goals and collective identity.

Ecosystems are often organized around a hub firm that controls a platform product or service which facilitates the interaction between complementors and end users; the platform operates in a so-called multi-sided market. The hub firm sets the rules and determines standards that allow complementors to connect with the platform. These platform ecosystems are characterized by network externalities, which can also be cross-market (i.e. more complementing products will attract more consumers, and more consumers will attract more complementors) (Kapoor, 2018; Jullien and Sand-Zantman, 2020). Succesfully attracting participants to one or the other side of the market may then quickly escalate the platform's dominance (Van de Kaa et al., 2015). Because complementors are often not willing or able to produce complements for multiple platforms (so-called multihoming), the specific standards that are created by the platform owners play an important role in attracting complementors (Kapoor, 2018). In this regard, the findings of Van de Kaa et al. (2011) point to a number of factors that might influence a standard's success chance. Furthermore, the involvement of many different ecosystem members in the platform's success gives significance to the ecosystem's relational aspects which drives the need for astute ecosystem governance that manages the different interests and creates common goals and strategies (Thomas and Autio, 2020). All these characteristics are the cause of distinct competition dynamics between rival platforms striving to

obtain market dominance.

2.1.2 Disruptive Innovation

Disruptive technology is a concept that was thought up by Christensen (1997) to explain processes he observed where large and capable incumbent firms eventually lost out to much smaller challengers. Later, he renamed the concept to disruptive innovation to acknowledge that it is not the technology itself that is disruptive but the business model in which it is employed. Disruptive innovation happens when a disruptor firm launches an offering that, though inferior to the incumbent's offering in the market's main value dimension, provides superior performance in a second value dimension so that it can attract customers in a new or low-end market. Then, when the disruptor gradually improves it's offering over time, it may come to surpass the mainstream's minimum requirements regarding the main value dimension. When that happens the second value dimension becomes more important and mainstream customers would be enticed to switch to the disruptor's offering, allowing it to gradually seize mainstream market share from the incumbent (Christensen, 1997).

The concept of disruptive innovation does not describe an event or an outcome. Rather, it describes the whole process as outlined above. According to Christensen et al. (2015) the theory is meant to help managers make a strategic choice between taking a sustaining or disruptive path. They also mention that small entrants that choose a sustaining strategy (i.e. a strategy that improves on existing value dimensions and therefore competes head-on) face steep odds against wealthier incumbents that would feel directly threatened. In a disruptive strategy the incumbent does not immediately feel the need to react because the disruptor is initially only targeting low-margin markets, which often don't fit in the incumbent's profit-maximizing strategy. This gives the disruptor time to develop its offering and capture market share. Others claim that the theory must also encompass other trajectories such as those taken by Uber and the iPhone. Both achieved great success in existing mainstream markets, posing direct threats to the incumbents, and thus being disruptive without following the original disruptive path (Si and Chen, 2020).

Over the more than 20 years of disruptive innovation literature since the inception of the theory, it has seen ongoing discussions regarding its usefulness and accuracy for describing real-world situations, notably with regards to its predictive capacity (Kumaraswamy et al., 2018). However, these objections have also been found to stem from the concept's use in situations that do not fully resemble the original idea (Si and Chen, 2020), such as with the examples of Uber and iPhone provided above. Various authors have suggested the concept to be applied at specific levels of analysis and to consider multiple perspectives which could counteract the current ambiguity of the concept. Kumaraswamy et al. (2018) proposed three new perspectives – relational, temporal and framing – to expand on the evolutionary perspective taken by Christensen (1997). They argue that these perspectives better address present-day realities, for instance with regards to the interconnected ecosystems that have become commonplace in many industries. Furthermore, Si and Chen (2020) offered

an expansion of the prevailing internal and external levels of analysis by proposing individual (internal), firm (internal), industry (external), nation/economy (external) and network (overarching internal and external) levels of analysis. They argue that different levels of analysis yield different findings suggesting that it should be made explicit in every research.

2.2 Disruption in Platform Ecosystems

There is a limited number of case studies that consider the relationship between disruptive innovation and platform competition. Ozalp et al. (2018) conducted one study to this end which examined the whole range of previous gaming platform wars. They found that because of the ecosystem of consumers and complementors that characterizes a platform, a platform firm faces the complex task of balancing the need to innovate, in order to stay attractive to consumers, with the need to stay accessible to complementors. Innovating a platform comes at the risk of destroying complementors' previous competencies. This then grants complementors the opportunity to reassess their commitment and allows competing platforms to seize market share. They conclude that gaming platform firms must invest in simplifying complement development as well as generate first-hand development experience which they can share with complementors too ease the transition to the platform's new generation. However, Cennamo (2018) warns of the paradox that, although this strategy is effective in the early stages of a new-generation platform, it may in fact result in decreased complement quality and diversity in the long-run due to market saturation and over-crowding of complements.

A case study into a disruptive entry by TiVo in the US' television market was conducted by Ansari et al. (2016) which highlighted the importance of both ecosystem management as well as framing for eventual success in platform markets. TiVo had to keep the support of the incumbents while also having to attract a critical mass of adopters. This tension is what Ansari et al. (2016) label as intertemporal coopetition. The study underscores the importance for disruptors to be flexible in setting a strategy. This is also mentioned by Khanagha et al. (2018) as a requirement to deal with the divergent interpretations (due to market heterogeneity) of the consequences of a disruptive innovation. Furthermore, Ansari et al. (2016) mention the importance of managing the diverse dyadic and multilateral coopetitive relationships that may exist in ecosystems. Notably, disruptors need to control the spill-over effects that may result from interactions with other ecosystem members in order to retain the support of envious third parties. Similar observations were done by Snihur et al. (2018). They uncovered what they label the disruptor's gambit, a process through which disruption can be executed successfully in platform markets: "a disruptor introducing a new [business model] sacrifices secrecy by forcefully proclaiming its arrival and disruptive intentions to create visibility, reduce uncertainty for carefully targeted ecosystem stakeholders, and initiate a virtuous framing-adaptation cycle" (Snihur et al., 2018, p. 1300). Their findings thus echo the significant role of the ecosystem on the path to success, underscoring the need for framing and flexibility on the disruptor side.

2.3 The Impact of Cloud Computing Disruption

2.3.1 The Effects on Cloud Consumers

All consumers benefit from the fact that they can outsource the information technology (IT) infrastructure that their use-case requires to a cloud service provider. There are various advantages resulting from this outsourcing. Firstly, outsourcing IT infrastructure results in a number of cost reductions. It allows the cloud consumer to exploit the economies of scale resulting from the provider aggregating the demand of many consumers. Furthermore, the cloud provider has more freedom to choose the location of its data centers, enabling them to build them where energy-costs are low (Armbrust et al., 2009). Outsourcing also negates the requirement for consumers to have dedicated IT knowledge and/or staff, which also avoids the costs and difficulties associated with acquiring that knowledge and/or staff. Marston et al. (2011) mention that about two thirds of companies' budgets for their own IT staffing go to maintenance of the infrastructure. Another cost-saving comes from the fact that cloud services enable solution sharing between different consumers (Iyer and Henderson, 2012). Secondly, outsourcing IT infrastructure allows consumers to also outsource the associated risks, such as those related to security and scaling (Iyer and Henderson, 2012; Clohessy et al., 2016). The latter of which is a big concern when having to acquire your own equipment, since predicting demand is often hard and having too little or too much computing capacity is both costly. Nevertheless, for some firms it is undesirable to outsource their risks. For example, some large organizations are wary of running critical applications on a cloud service since they need the assurance that it will always work (Marston et al., 2011). Thirdly, consumers can enjoy operational IT expenses which are often preferred as opposed to the capital expenses associated with building and maintaining an in-house IT infrastructure (Makhlouf and Allal-Chérif, 2019; Clohessy et al., 2017). An often mentioned result of this cloud computing-enabled outsourcing of IT infrastructure is that consumers can refocus their efforts back on their core competencies; the complexity of their IT resources is handled by the cloud service provider (Makhlouf and Allal-Chérif, 2019; Iyer and Henderson, 2012; Nieuwenhuis et al., 2018; Khayer et al., 2020).

An aspect where organizations in particular have been able to improve as a result of adopting cloud computing services is that of agility. According to Sambamurthy et al. (2003) organizational agility can be defined as "the ability to detect opportunities for innovation and seize those competitive market opportunities by assembling requisite assets, knowledge, and relationships with speed and surprise" [p.245]. They argue that it can be split in three capabilities, namely (1) customer agility, referring to the capacity of a firm to utilize its customers to explore opportunities and exploit them, (2) partnering agility, referring to the capacity of a firm to harness its ecosystem, and (3) operational agility, referring to the capacity of a firm to execute on opportunities effectively and efficiently. Liu et al. (2018) find that cloud infrastructure capabilities have a positive affect on customer agility and operational agility, but not on partnering agility. Other studies point to the improved customer agility of cloud consumers in a less explicit way. For example, Krancher et al. (2018) conclude that adoption of PaaS helps software developers by facilitating continuous feedback.

Similarly, Clohessy et al. (2020) report on a SaaS system adopted by organizations that helped predict the usage patterns of their customers. It has long been argued that IT-capabilities in general improve an organization's agility (Sambamurthy et al., 2003). However, research has also described the possible counter-productive effects of large IT-investments, which may hinder the organization's agility if IT competence is insufficient (Lu and Ramamurthy, 2011). In this regard, Liu et al. (2018) show that this effect does not exist for cloud-based IT, which might be due to the fact that in cloud services less organizational IT competencies are required because the complexity remains hidden, leading back to the benefits of outsourcing IT expertise discussed before.

Despite the reduced need for expertise when using cloud-based IT services, firms still need to develop cloud competencies to maximize the gains of cloud service adoption. Kathuria et al. (2018) found that being able to integrate cloud services with legacy systems and to dynamically capitalize on opportunities for aligning with external services and developing cloud services for new use-cases, have a significant positive effect on organizational agility and performance. What these positive effects entail was reported by Makhlouf and Allal-Chérif (2019). They found, for example, that administrative bodies were able to improve interaction with citizens, become more transparent, better manage public funds and accelerate services while increasing their quality. In the health care sector it improved access to patient data for doctors and allowed them to service remote patients. In the education sector it improved competition between educational institutions and the quality level of education provided. Moreover, it facilitated better collaboration between and among various actors in educational institutions, such as teachers, students and researchers. Between organizations collaboration also improved as well as the possibilities for collaboration (Iyer and Henderson, 2012). All in all, these benefits seem to come down to improved interaction, speed and access to data that constitute an overall boost in service quality and performance in the organizations that have adopted cloud services.

2.3.2 The Effects on Cloud Providers

The effects from provisioning cloud services are naturally different from those on cloud consumers outlined in the previous section. Much less research has been conducted when it comes to this impact. Nevertheless, a few themes can be identified from extant literature. Firstly, cloud computing technology allows service providers to capitalize on new business opportunities, enabled by novel value propositions on the one hand and improvements in accessibility and availability of existing services on the other hand (Clohessy et al., 2016). Owing to the nature of cloud services as being delivered over the internet (see section **??**), the technology allows cloud providers to have a much closer relationship with their customers (Boillat and Legner, 2013; Makhlouf and Allal-Chérif, 2019). In some instances, intermediate parties become obsolete (Nieuwenhuis et al., 2018; Clohessy et al., 2020). These direct relationships can be harnessed to collect user data and subsequently provide additional, even personalized services as well as accompanying expertise (Clohessy et al., 2017; Bani-Hani et al., 2017). Firms may adjust their services in real-time, and automat-

ically, as data on altered usage patterns and requirements comes in (Clohessy et al., 2017, 2020).

Further, when it comes to accessibility and availability, the delivery of cloud services makes it possible to engage more customer segments. Through cloud computing a service can technically be provided to anyone with an internet connection: users in any geographic region, on any device and at any time. Other customer segments that didn't previously have the financial means can be won over with cloud-enabled flexible pricing plans. By elastically scaling and shrinking the computing resources allocated to a customer according to their measured demand, the provider can charge them on a pay-per-use or pay-as-you-go basis or through various subscription plans (Boillat and Legner, 2013; Makhlouf and Allal-Chérif, 2019; Ojala and Tyrvainen, 2011a; Ojala and Helander, 2014). As laid out in the previous section, such operational expenses, as opposed to capital expenses, lower the barrier to entry for customers for whom prices were previously too high (Makhlouf and Allal-Chérif, 2019; Clohessy et al., 2017).

Secondly, transitioning to provisioning cloud services requires considerable investments but also results in operational cost reductions compared to the situation prior. A firm may decide to not outsource the IT infrastructure necessary for the cloud services it wants to provide. It then needs to acquire the computing resources itself and create support operations to manage and maintain them (Boillat and Legner, 2013). For firms transitioning from a non-cloud status quo, this is a rather large change which may entail internal changes (e.g. with regards to workforce composition) as well as environmental changes (e.g. concerning its ecosystem and value chain) (Nieuwenhuis et al., 2018). Transitioning to cloud-based service provisioning has been shown to reduce firms' operational costs. Multi-tenancy is the ability to allow multiple customers to make use of a single server or application simultaneously. It enables cloud providers to achieve a better utilization of their computing resources, allowing them to exploit economies of scale (Marston et al., 2011). It has also pushed providers to standardize and modularize their solutions to gain back some of the customizability that was lost at the hands of this multi-tenant model, which requires compatibility between different instances of the service (Boillat and Legner, 2013; Clohessy et al., 2020). This standardization is a notable change from the previous on-premise solutions which were often extensively customizable and configured according to customer requirements (Boillat and Legner, 2013). Clohessy et al. (2020) report on the cost reductions two companies achieved with regards to their customer relationship management. The cloud-based nature of their services simplified customer acquisition by enabling convenient payment methods and seamless checkout processes. Furthermore, both companies were able to lower their costs for customer support due to their cloud services allowing customers to independently configure their products and by enabling self-support facilities.

Thirdly, provisioning cloud services, as compared to non-cloud services, does not only have advantages. There are a number of factors that may provide challenges and threats in a cloud-based service market. Cloud providers have more uncer-

tainty when it comes to their revenue streams. The lock-in effects created by the large capital expenditures customers have to make in the traditional system are no longer present when companies charge according to a flexible model (Clohessy et al., 2017). In addition to this, the IT infrastructure required by companies to provision their services can, in a cloud computing world, be easily outsourced, meaning that the barriers to entry for firms in some cloud service industries become much lower (Clohessy et al., 2017). Consequently, firms in these industries face greater competition. This is further amplified by the difficulty some firms have with differentiating their services from competitors in a cloud-based service market (Clohessy et al., 2017). Competitors tend to walk down the same path towards a generic cloud-labeled value proposition, but distinguishing their services from one another must be done in other, more unique ways (Clohessy et al., 2016). Firms also face concerns about service up-time and data security. To sign up for cloud services means to have confidence that you'll have access to the service and sufficient control over your data despite relinquishing management thereof to the service provider (Clohessy et al., 2016, 2017). Cloud providers can however count on synergies between their cloud services and their existing technical and organizational (e.g. network and ecosystem) capabilities. Moreover, similar to cloud consumers, it enables organizations to work with more agility, owing to the fact that cloud services facilitate data collection and diffusion and are more easy to adapt to changing market environments (Bani-Hani et al., 2017; Nieuwenhuis et al., 2018; Clohessy et al., 2020).

2.3.3 The Effects on Ecosystems

Besides the effects cloud computing disruption has on the providers and consumers of such services, the technology also seems to impact the broader ecosystems surrounding them. Two main themes can be identified in literature in this regard. Firstly, the roles that actors in the ecosystem played traditionally, are not always equally useful in a cloud-based market. This may cause certain actors to have to change their roles or even to become obsolete. The more direct relationship that cloud service providers can have with their customers, allows them to much more easily replace intermediary actors, such as solution integrators and consultants. In effect, it facilitates vertical integration (Boillat and Legner, 2013; Clohessy et al., 2020). Additionally, completely new roles may emerge, for example those related to supplying products and services for enabling cloud functionality (e.g. IaaS-providers and server manufacturers) and to third-party services that can now be integrated with the focal service (Boillat and Legner, 2013; Nieuwenhuis et al., 2018). In the case of cloud-based enterprise software Nieuwenhuis et al. (2018) mention the new value-added services that could be provided, namely: financial consultation , license management, environmental consultation and service aggregation. This example is not necessarily universal, however, and every industry is likely to have its own opportunities for new value-added services. These emerging and shifting roles change the traditional value network, making it necessary for many parties involved to adapt their business models, something that some actors may actively (even aggressively) resist (Makhlouf and Allal-Chérif, 2019).

Secondly, owing to the cloud-enabled improvements in interaction between actors

of the ecosystem, new (and more) options for collaboration emerge (Clohessy et al., 2016). More collaboration may be a consequence of the emergence of new cloud-enabled value propositions, which are only possible through the combined efforts of multiple ecosystem actors (Clohessy et al., 2017; Iyer and Henderson, 2012). This is a second mechanism through which cloud technology enables new value propositions, the first one, discussed earlier, being related more to the value-added activities. The new relationships that may consequently emerge between ecosystem actors simultaneously generate new dependencies and relational issues, such as those with regards to trust and knowledge spill-over effects (Garrison et al., 2015; Clohessy et al., 2017). Therefore, cloud computing disruption is likely to lead to a need for more ecosystem orchestration and management (Iyer and Henderson, 2012).

2.4 Synthesis of Literature

A review of the extant literature, as discussed in the previous sections, yields a set of effects that is listed in tables 1, 2 and 3. Only the studies that explicitly considered the impact of cloud computing on providers, consumers and/or ecosystems were included in the list. A clear synthesis of these effects will allow for structured comparison in the analysis of the research results (see chapter 5).

Table 1: List of impacts on cloud consumers

Effects on cloud consumers	(Ojala and Tyrvainen, 2011a)	(Ojala and Tyrvainen, 2011b)	(Iyer and Henderson, 2012)	(DaSilva et al., 2013)	(Boillat and Legner, 2013)	(Rebsdorf and Hedman, 2014)	(Ojala and Helander, 2014)	(Clohessy et al., 2016)	(Hedman and Xiao, 2016)	(Clohessy et al., 2017)	(Nieuwenhuis et al., 2018)	(Liu et al., 2018)	(Makhlouf and Allal-Chérif, 2019)	(Khayer et al., 2020)	(Clohessy et al., 2020)
New products/services	x	x	x	x							x		x		
Capital IT investments become operational expenses	x		x	x	x					x	x		x	x	
Outsourcing of security and scaling risks; taking on risks concerning IT availability		x	x	x				x					x		
Cloud-supported operations perform better													x	x	
Better organizational agility			x							x	x	x	x		

Table 2: List of impacts on cloud providers

Effects on cloud providers	(Ojala and Tyrvainen, 2011a)	(Ojala and Tyrvainen, 2011b)	(Iyer and Henderson, 2012)	(DaSilva et al., 2013)	(Boillat and Legner, 2013)	(Rebsdorf and Hedman, 2014)	(Ojala and Helander, 2014)	(Clohessy et al., 2016)	(Hedman and Xiao, 2016)	(Clohessy et al., 2017)	(Nieuwenhuis et al., 2018)	(Liu et al., 2018)	(Makhlouf and Allal-Chérif, 2019)	(Khayer et al., 2020)	(Clohessy et al., 2020)
Necessity for IT infrastructure				x	x					x	x				x
Reduced operational expenses				x	x	x		x							x
Necessity for service standardization and modularization			x		x					x	x		x		x
More direct relationship with end-user					x								x		
New products/services	x							x		x					x
Greater service accessibility and availability	x				x		x						x		
Engagement of new customer segments				x	x			x		x					x
Better quality of service				x				x							x
Subscription and flexible revenue models	x			x	x	x	x						x		
Less customer lock-in				x		x				x					
Lowered barriers-to-entry for competition										x					
Harder to differentiate from competition								x		x					
Increased customer concern for service security and availability				x				x		x					
Better organizational agility								x		x	x				x

Table 3: List of impacts on ecosystems

Effects on ecosystems	(Ojala and Tyrvainen, 2011a)	(Ojala and Tyrvainen, 2011b)	(Iyer and Henderson, 2012)	(DaSilva et al., 2013)	(Boillat and Legner, 2013)	(Rebsdorf and Hedman, 2014)	(Ojala and Helander, 2014)	(Clohessy et al., 2016)	(Hedman and Xiao, 2016)	(Clohessy et al., 2017)	(Nieuwenhuis et al., 2018)	(Liu et al., 2018)	(Makhlouf and Allal-Chérif, 2019)	(Khayer et al., 2020)	(Clohessy et al., 2020)
Existing ecosystem roles change					x	x				x	x				x
New ecosystem roles emerge		x		x	x	x	x	x		x	x				x
Greater necessity for ecosystem orchestration due to increased dependencies			x					x		x					x
More knowledge spill-over effects										x					
Emergence of ecosystem-enabled value propositions	x			x	x						x				x

3 Methodology

3.1 Research Structure

A multiple comparative case study was chosen as a research model to explore the impact of cloud gaming disruption in the gaming platform market. This research model allows for examining the phenomenon of cloud computing disruption in a specific platform market context, which can then set the stage for an understanding of such disruption in other platform markets as well (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). Evidence on the impact from the three separate cases was used in a cross-case analysis to uncover patterns, differences and similarities between the three contexts. A survey allowed for verifying some of the findings for which the evidence could not provide a definite conclusion. Subsequently, results from the cross-case analysis were compared with the effects mentioned by the extant literature to identify how to impact of cloud computing disruption differs in the context of the gaming platform market. Figure 1 provides an overview of the research structure.

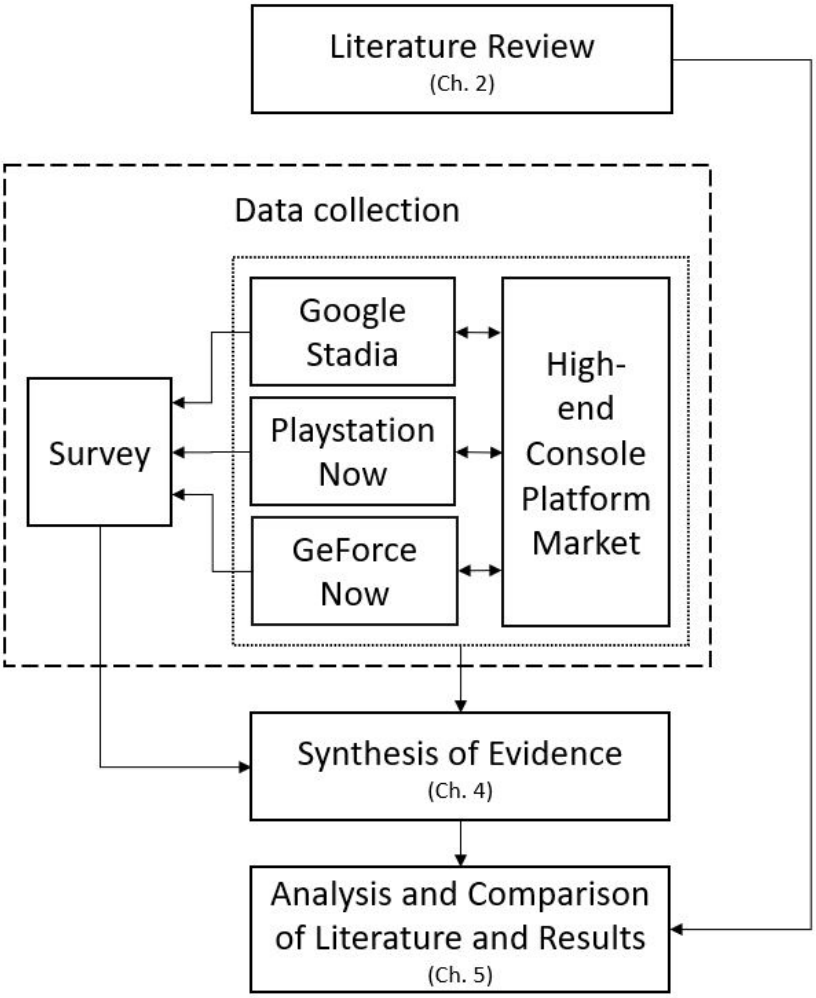

Figure 1: Diagram of the research structure.

3.2 Case Selection

Three cloud gaming platforms were picked for in-depth data collection and analysis. The cloud gaming industry comprises a multitude of cloud gaming services with a range of different value propositions. For example, some platforms are targeting mobile games, some arcade games and some are merely providing a B2B service, in which they provide the technology for third-parties to run a platform. The set of candidates for this study was limited to those services that operate in the same category of gaming as do the current high-end console gaming platforms, namely Sony's Playstation and Microsoft's Xbox. The set was further limited by the criterion that the service should at least be able to offer a similar experience to that offered by a Playstation and an Xbox. This excluded Microsoft's cloud gaming project, which at the time of selection was only available on android phones or tablets.

Table 4: Context-based theoretical sampling of cloud gaming services.

Platform	Distinguishing Context
Google Stadia	• No direct involvement or experience with the high-end gaming industry. Only gaming industry experience comes from its Android Play Store for mobile games. • **Outsider** to the high-end gaming platform market. • Expected to reveal the effects in a context of a progressive business model and novel features and characteristics which take advantage of the full potential of cloud gaming innovation.
GeForce Now	• Existing member of the gaming platform ecosystem through its business in GPUs required for gaming consoles and PCs. • **Vertical integrator** into the cloud gaming market by bypassing the console and PC manufacturers to provide its GPU and server capabilities directly to end users. • Expected to reveal the effects in a context of neither strong conservative or progressive pressures. Its brand is already known in the gaming industry and it has no gaming ecosystem to preserve or satisfy.
Playstation Now	• Possesses a large ecosystem with an extensive collection of games-related intellectual property and a large installed base in the gaming industry. • An important **incumbent** in the gaming platform market. • Expected to reveal the effects in a context of conservatively migrating an established gaming ecosystem to a cloud-based platform.

The last criterion that was used relates to the amount of data that is available for the service. Since this research builds on the insights gained from publicly available data, there must be a high degree of information available through both media channels as well as from the company itself. Therefore, cloud gaming services from large, publicly traded companies were preferred over smaller-sized services. This choice is

also in line with the intended comparison with Playstation and Xbox consoles, which can both be regarded large platforms. The three cloud services that best meet the above requirements are Google Stadia, Nvidia GeForce Now and Playstation Now. Further, these three services provide a convenient diversity of backgrounds, which helps make the research more representative. Table 4 lists the three services and the basis of the theoretical sampling.

3.3 Data Sources

A number of sources were used to study the three cloud gaming services. Firstly, information directly from the companies was used in the form of conference presentations, investor relations presentations and Q&As as well as earnings transcripts, blog posts, press releases and other kinds of reports. Secondly, interviews with company employees in the media were used, mostly available in the form of videos, podcasts and articles. Thirdly, news articles were used, sourced mainly from industry-focused website gamesindustry.biz and game development-focused website gamasutra.com. Lastly, the data collection also involved collecting the perspectives expressed in a number of opinion pieces, primarily, but not exclusively, from the two websites mentioned above. Table 6 outlines the details of the source material consulted for this study.

3.4 Expert Survey

In order to verify and help triangulate the gathered data as well as the themes and patterns that emerged from the data, a survey was send out to 208 experts per email or LinkedIn, Twitter or Facebook message. Among these were employees of gaming platforms, publishers and developers as well as scholars, journalists, consultants and analysts. Scholars were selected based on their scientific work related to cloud gaming technology and platforms. Journalists were selected based on the articles they had written about cloud gaming. Consultants and analysts were selected based on their relation to the cloud gaming market as evident from popular media articles and their social media profiles. 21 respondents filled out the survey. Table 5 shows the number of respondents per category.

Table 5: Number of respondents per category.

Role	No. of respondents
(Cloud) Gaming Platform	3
Game developer/publisher	2
Scholar/researcher	10
Journalist	2
Consultant/Analyst	3
Did not indicate	1

The survey consisted of 25 questions. The results to 7 questions were ultimately not included in the report because they turned out to be irrelevant after further analysis.

All respondents received the same survey. Although it is acknowledged that not all respondents have the same level of expertise in every category of questions, it was assumed that all respondents nevertheless had expert-level insights to share. Moreover, the results of the survey could be separated by respondent category so that the differences in judgements between categories could be made visible for analysis.

Table 6: Source material used per cloud gaming service under study.

Source	Details
Conference presentations	**All:** presentations given on the Game Development Conference (GDC) the Consumer Electronics Show (CES) and the Electronic Entertainment Expo (E3) between the unveiling of each service and 2021 (Stadia: 2018-2021; GFN: 2015-2021; PS Now: 2014-2021). This included presentations by developers, publishers and the cloud gaming services themselves. **Stadia:** presentations given at Google I/O and Google Games Dev Summit. **GFN:** presentations given at GDC and Nvidia's own GTC conference.
Investor communications	**All:** transcripts from earnings calls between service's unveiling and 2021, including questions and answers sessions with investors, sourced from seekingalpha.com and fool.com. **PS Now:** presentations given at Sony's investor relations meeting, the so-called IR Day, between 2014 and 2021, including questions and answers sessions with attendees. Reports released by Sony for IR Day.
Company documentation/ Company blog-posts/ Press releases	**Stadia:** blog posts from Stadia's development blog at stadia.dev and from Stadia's community blog at community.stadia.com as well as Google's general blog at blog.google.com. **GFN:** cloud gaming related blog posts at blogs.nvidia.com and the GFN website's information pages, as well as the broader Nvidia website (specifically web pages related the technology aspect of the service (e.g. servers)). **PS Now:** cloud gaming related blog posts at blogs.playstation.com.
Media interviews	**All:** interviews from a broad range of gaming, business and technology related websites with employees from the three cloud gaming platforms as well as from publishers and developers, found through extensive Google searching.
News articles	**All:** news reports from industry-focused medium gamesindustry.biz and game development-focused medium gamasutra.com. In addition, when relevant, the source article for a news report was consulted as well.
Opinion articles	**All:** opinion pieces sourced from a broad variety of websites, mainly from gamesindustry.biz and gamasutra.com.

3.5 Data Analysis

The body of data gathered allowed for a thorough analysis of the impact of the cloud gaming disruption on the platforms themselves as well as on their relations with other actors in their ecosystems. During consultation of each source, relevant passages where noted down, creating a list of excerpts, quotes and ideas related to the specific case under study. Data in the list was actively triangulated using other sources and data points. During the consultation of the sources this list was continually and iteratively reconsidered to find within-case themes. After this process, a complete overview of each cloud gaming platform emerged, which could

then inform a cross-case analysis in which the themes from each case could be cross-checked with the other two as well as with the results from the survey. For this step a thematic analysis was executed to the example of Ansari et al. (2016). Data points were fitted to a structure of themes and sub-themes to establish a common structure. Through this step, the differences and similarities between the cases could be unveiled, informing a more generalized perspective on the impact of cloud gaming disruption in the gaming platform market. Table 7 illustrates how this thematic analysis was done.

Table 7: Illustrative thematic analysis

Data/quote/excerpt	**Sub-themes**	**Themes**
To support this transition from client- to cloud-rendered applications, you will need a scalable server platform that can render and stream applications to millions of users concurrently. (Webpage on Nvidia's RTX server, nvidia.com)	Server criteria	**Data center infrastructure**
"The network environment is different for each client, and the technology is used to optimise that environment every time." (Jim Ryan, CEO Sony Interactive Entertainment, IR web meeting, 2019)	Networking criteria	
"You know better than me that Russia is a huge, huge country. A cloud streaming service obviously does require the location of servers reasonably close to the gamer, it's logistically very challenging." (Jim Ryan, CEO Sony Interactive Entertainment, tass.com, 2020)	Proximity to user	
"I can tell you about the infrastructure in some of the parts of the world where we have very, very large businesses, and they will not be conducive to, you know, an entirely streaming model for years and years and years." (Jim Ryan, CEO Sony Interactive Entertainment, gamesindustry.biz, 2019)	Bad network infrastructure	**Internet quality dependency**
As a minimum broadband speed, we recommend 5Mbps. We also recommend using a wired connection and limiting the use of other network connected devices to get the best experience. (Playstation blog post, blog.playstation.com, 2019)	In-home network factors	
GeForce NOW is an extension of the PC ecosystem. There is no cost for developers — games just run without difficult porting requirements — helping them reach millions of players who don't have game-ready PCs. (CEO of Nvidia Phil Eisler in a blog post, blogs.nvidia.com, 2020)	Existing developer environment	**Service accessibility**
"[A bigger market] has a lot of potential for alleviating the stress points in our industry with upward development costs and relatively stagnant unit costs." (Dustin Land, Programming Lead at ID Software, GDC presentation, 2019)	Larger addressable market	
"Different mechanics have different latency requirements, even within the same game. And even the same mechanic across two different titles can have wildly different behaviours and requirements." (Khaled Abdel Rahman, Product Manager at Stadia, Google I/O, 2019)	New development factors to take into account	
"the main difference is now you can have dozens or hundreds or thousands or millions of computers that can do stuff to help power the game. For example, use AI, bigger worlds or more realistic explosions etc." (Ken Moss, CTO of EU, gamesindustry.biz, 2019)	'Limitless' compute resources	**Value propositions**

4 Results

In this section the findings from the three cloud gaming cases is synthesized together with the results from the survey to establish five themes that capture the impact of cloud gaming disruption in the gaming platform market. The section outlines for each theme the evidence that was found and incorporates the survey results whenever these findings could not be triangulated from the case data alone or whenever the strength of a certain impact needed to be verified. The resulting framework of themes, sub-themes and their associated evidence informs the analysis done in chapter 5.

4.1 Theme 1: Dependency on internet quality

In a console gaming context the quality of gaming that users experience is determined for the most part by the compute hardware itself. Customers can be sure that a game which they buy for a Playstation or Xbox console can be played in the way it was meant by the developers. Cloud gaming, on the other hand, is delivered as a service over the internet. It has strict internet bandwidth and latency requirements and the quality of the user experience is very sensitive to network failings like jitter and packet-loss. The cloud gaming experience, therefore, becomes highly dependent on the internet quality and on those actors and factors that impact it. This theme captures the reality that the experience users have with cloud gaming platforms can not be completely controlled or guaranteed by the platform firm alone. The evidence from the three cases shows that a number of internet infrastructure and customer-related factors, external to the platform firm, influence the quality of experience that can ultimately be delivered to end-users. The factors belonging to each category are summarized in table 8.

4.1.1 Dependency on network-related factors

In managing their internet networks and customer traffic, the choices ISPs and network operators make, the malfunctions they have and the parameters they set can cause delays in the communication between data center and end-user, or completely shut it down. The specifics of data routing, congested network channels, network defects, the existence and details of peering contracts (i.e. the contracts which different network operators, ISPs and content providers sign with each other for exchanging and passing on internet traffic) and other parameters concerning the intermediate network nodes, are all of influence on the actual connection quality that customers get to the cloud gaming data center. This dependency network factors is clearly expressed in the following quote:

> *"You have used a very important word there: fragmentation, ISPs, different broadband capabilities. Broadband, let's say in Amsterdam, is rather different to broadband in Naples. And we have to get around that. [...] We are not gonna launch something that is not good, and when you have*

these environmental factor that are outside of sony's control it makes it difficult."

(Jim Ryan, CEO of Sony Interactive Entertainment, Zoomin Games, 2014)

Furthermore, the actual internet bandwidth available to a customer (i.e. the bit-rate) is sometimes reduced by competing regional demand which the ISP may not be able to adequately process. This effect was clearly demonstrated when at the start of the coronavirus pandemic various streaming services, among which Google Stadia, limited their bandwidth usage in order to facilitate the surge in internet traffic from home-workers and video-callers. The results for statement 1 in figure 2 show that the expert survey strongly supports the influence of these factors on the cloud gaming experience, with more than 95% of experts agreeing and none of them disagreeing.

Table 8: Factors influencing the quality-of-service of cloud gaming platforms.

External factors of cloud gaming experience quality	
Customer-related	ISP/Network-related
In-home networking devices	Scope of peering arrangements
In-home network settings	Details of peering contracts
Bandwidth of internet plan	Malfunctions, routing, switching, congestion
Proximity to the data center	Number of intermediate nodes

4.1.2 Dependency on user-related factors

When it comes to user-related factors there are a number of different angles to consider. Firstly, the networking devices used by customers in their homes, as well as the settings customers use on these devices have an effect on the connection quality that they enjoy. Each of these devices may limit the bit-rate, introduce additional latency and cause network-related problems like jitter and packet-loss. The impact of these factors on the cloud gaming quality of service is indicated for example by Nvidia's efforts to inform their users about possible internet hurdles introduced by their own networking devices. Furthermore, Nvidia has featured a number of routers on their website and provided so-called 'quality of service profiles' which conveniently set all parameters in the router's settings to the most favorable options. Google too offers a troubleshooting tool that indicates to users which settings on their routers might be limiting the performance of the service. Whether customers use cabled or wireless internet connections and, in case of the latter, whether they use the 2,4GHz or 5GHz frequency channels may all affect their quality of internet. The survey results for statement 2 in figure 2 confirm that these customer-side variables are indeed significant factors in the quality of service that can be achieved. More than 90% of experts agreed with the statement and none disagreed.

Secondly, despite the enormous speed of light, the time it takes for it to travel certain distances adds to the total latency, as indicated by the following comment made with regards to Stadia's networking technology:

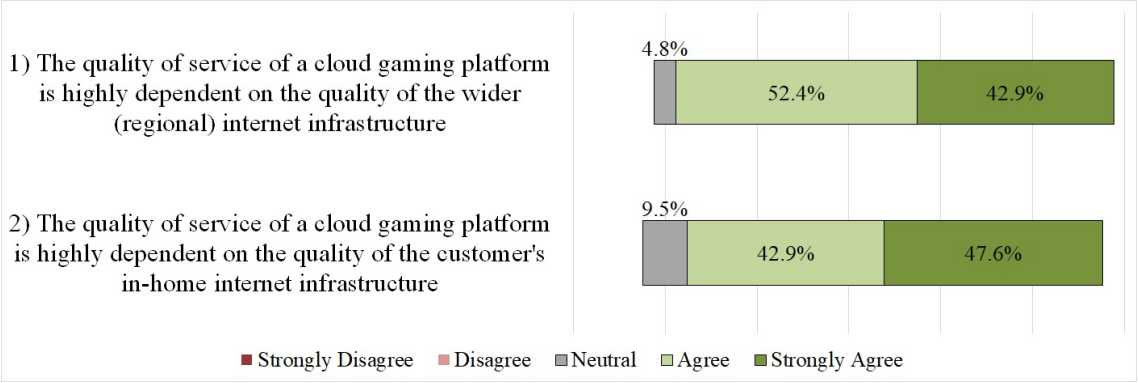

Figure 2: Survey questions about cloud gaming internet quality dependency.

> *"Our data centers have to be on the edge of the network as close as possible to the players, because [...] speed of light does factor into our latency calculations."*
>
> (Rob McCool, Engineering Lead Google Stadia, Google I/O, 2019)

The closer the data center is to an end-user the less latency the journey back and forth causes. However, consumers naturally live in different locations and they will therefore always be unequally affected by the latency added by the extra distance that needs to be travelled. Moreover, distance also introduces new hurdles along the way which may each in turn cause additional latency, packet-loss and other network problems. The quality of service that a cloud gaming platform can provide to a specific end-user therefore becomes dependent, in part, on the specific user's physical proximity to the platform's data centers. Of course, cloud gaming platforms try to mitigate this effect by building their data-centers in densely populated areas, close to as many people as possible. Nevertheless, many potential customers are located further away from these centers and their gaming experience is still affected.

Thirdly, the minimal bandwidth requirements set by the three cloud gaming platforms, 10mbps by Stadia, 5mbps by PS Now and 15mbps by GFN, tells potential customers which internet plan they must subscribe to with their internet service providers (ISP). In some countries, particularly in the United States, internet plans are often accompanied by data caps beyond which additional costs are charged and/or internet speed is throttled. Given the large amounts of data consumed by cloud gaming services and the extended gaming sessions that its users may engage in, these caps may be quickly exceeded and consequently impact the viability of cloud gaming, as noted by a journalist reflecting on Google Stadia:

> *"The limitations [...] are, however, pretty severe. The demands in terms of network connection quality are intense, and even for users whose networks can support that kind of usage, bandwidth costs or caps can pose a huge problem, especially on mobile devices"*
>
> (Rob Fahey, Editor for Gamesindustry.biz, gamesindustry.biz, 2021)

The dependency is not only on end-users though. As indicated by the following

quote regarding the data caps in countries like the United States, cloud gaming platforms are also dependent on the development of the services offered by ISPs:

> *"[Internet Service Providers] historically have a proven track record of adjusting to consumer demand. When music streaming started, bandwidth caps lifted. When video and TV streaming started, bandwidth caps lifted. We expect that to continue."*
>
> (Phill Harrison, General Manager at Stadia, gamesindustry.biz, 2019)

4.2 Theme 2: Necessary data center infrastructure

With cloud gaming, servers in data centers replace the console as a consumer product in the platform's business model. Along with this change in who owns the compute hardware, comes a change in the criteria that determine the performance of that hardware. Both involve the ultimate quality-of-experience for the money paid. But the way to get there is different for console- and cloud-based gaming platforms. In cloud gaming, it is not anymore the total compute capability that counts most. After all, contrary to gaming consoles, data centers can easily scale with demand. Rather, what matters is to what extend the platform firm can minimize the networking impact at the lowest infrastructure costs. To do this, cloud gaming platform firms need to acquire an extensive data center network with good coverage and sophisticated servers and software. These two dimensions are discussed next.

4.2.1 Criteria for servers and software

Providing compute resources for a large number of customers over the internet from data centers comes with its own requirements. For example, Google collaborated with AMD to design a custom GPU for its server architecture which optimizes for data center-related criteria, such as manageability, security and scalability. The extend to which these requirements can be met is, in part, dependent on the server architecture. Nvidia utilized its own innovations for GFN's RTX servers. These servers are designed specifically for cloud gaming and use the so-called Bluefield technology that offloads network management tasks from the compute hardware to a dedicated chip, clearing more resources and allowing for more concurrent players to be serviced by the servers. Besides data center-related metrics, the server architecture also plays a role in the quality of experience that can be delivered to the customer. For example, offloading the networking tasks to the Bluefield chip accelerates the network management tasks, improving the user's quality-of-experience. Both dimensions are mentioned in the following quote:

> *"GeForce Now infrastructure is costly. With bluefield we would improve our quality-of-service and concurrent users at the same time."*
>
> (Jensen Huang, CEO of Nvidia, GTC, 2021)

The survey results for statement 1 in figure 3 show that about 86% of experts agree that the sophistication of the cloud gaming server architecture plays a role in the quality-of-experience that can be delivered to the end-user. A sophisticated server

architecture can therefore be an important competitive advantage. Nvidia's RTX servers are, however, also available as a commercial product to third-parties, such as Nvidia's ISP partners within its GeForce Now Alliance (see section 4.2.2).

Nvidia's Bluefield technology also shows that the software back-end utilized by the cloud gaming servers also matters for the user experience. The network management tasks offloaded to the Bluefield chip, were first handled in software and took a significant load on the compute hardware handling game-related tasks. Further, sophisticated video capture capabilities and data encoding and decoding can reduce latency and improve the quality-of-experience for the end-user. The survey results for statement 2 in figure 3 confirm the significance of this dimension.

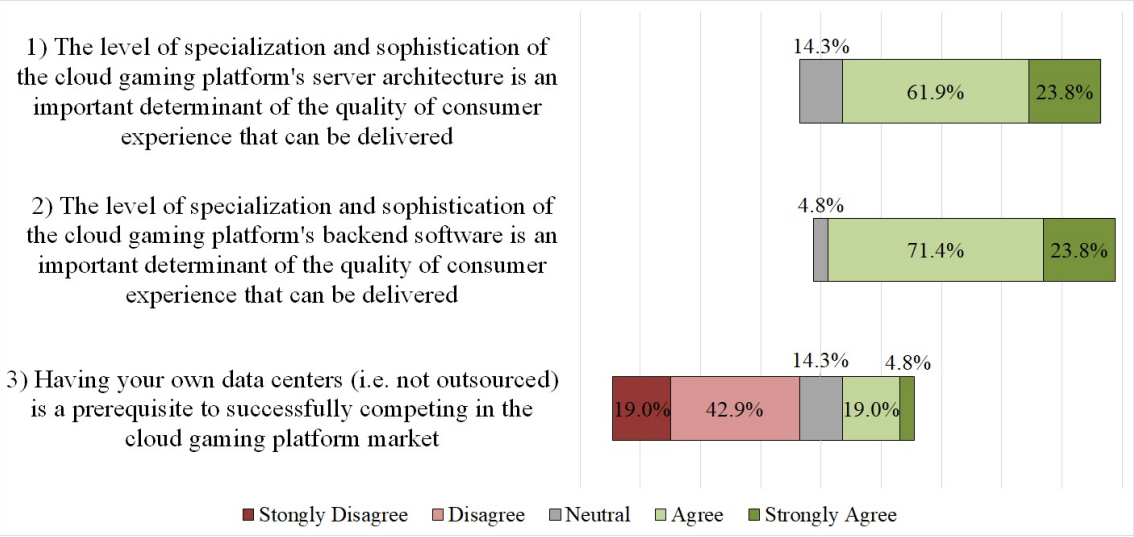

Figure 3: Survey questions about cloud gaming data center infrastructure.

4.2.2 Criteria for data center networks

For its Stadia cloud gaming platform Google is able to leverage its existing Google Cloud data center network which it had already built for its other cloud-based services. At the time of Stadia's launch, this data center network already covered more than 200 countries and territories in the world, easing a Stadia rollout. Many other companies do not already have such extensive data center assets and need to make the large investments associated with setting up additional data centers in the target markets. Moreover, for cloud gaming, data centers need to be as close to the end-user as possible, which provides an additional challenge on top of the costs, as indicated by the following quote:

> *"You know better than me that Russia is a huge, huge country. A cloud streaming service obviously does require the location of servers reasonably close to the gamer, it's logistically very challenging."*
>
> (Jim Ryan, CEO of Sony Interactive Entertainment, tass.com, 2020)

Sony and Nvidia both built new data centers to service their target markets. On top of that, both have also entered into partnership deals, aiming to complement

their own expansion. Sony has signed a memorandum of understanding (MOU) with Microsoft, its long-standing arch-rival in the field of gaming consoles, involving among other things the intention to research the utilization of Microsoft's data center assets for cloud gaming purposes. This way, Sony aims to get rid of the large capital expenses associated with expanding its data center operations under its own management, as illustrated by the following quote concerning the MOU with Microsoft:

> *"The approach to [Playstation] Now has been fairly capital intensive. If we move to a partnership that brings a greater variable cost component, that is definitely an opportunity."*
>
> (Jim Ryan, CEO of Sony Interactive Entertainment, IR Day, 2019)

Nvidia too has entered into a number of partnerships within its GeForce Now Alliance partner program. Members of the alliance, all of them ISPs, run their own data centers for which Nvidia provides the GFN servers and manages the software. Among others, Japan, South Korea, Russia and Australia have a GFN-based cloud gaming solution provided by an ISP in this way. The Alliance network allows Nvidia to expand its services to more markets while minimizing the costs associated with setting up the required data center network. The survey results for statement 3 in figure 3 show that about 62% of respondents disagreed with the statement that having your own data center network is a prerequisite to successfully competing in the cloud gaming platform market. Only about 24% agreed, showing that outsourcing this capability within such partnerships as those of Sony and Nvidia, does not necessarily compromise one's ability to compete. Partnerships thus seem to be a viable and attractive alternative within the cloud gaming market to developing one's own data center network.

4.3 Theme 3: Cloud gaming business models

4.3.1 Subscription models and complementor dissent

All three cloud gaming platforms use a subscription-based business model for the compute resources they provide. However, all three are different. For PS Now this subscription goes hand in hand with access to a content catalog. GFN on the other hand only charges a subscription fee for access to the compute resources. Only Stadia has a business model that resembles those of console platforms where customers have to buy each game separately. In the case of Stadia this can only be done in its own store. Each of the three business models is discussed next.

Own store model
Google Stadia uses a more traditional business model in which customers need to buy each game they want to play on Stadia in the platform's own store. Therefore, there are no external store's that sell games for the stadia platform. Additionally, users pay a subscription fee for the compute resources made available to them through the platform. This subscription also includes a relatively small all-you-can-play catalog of freely playable games.

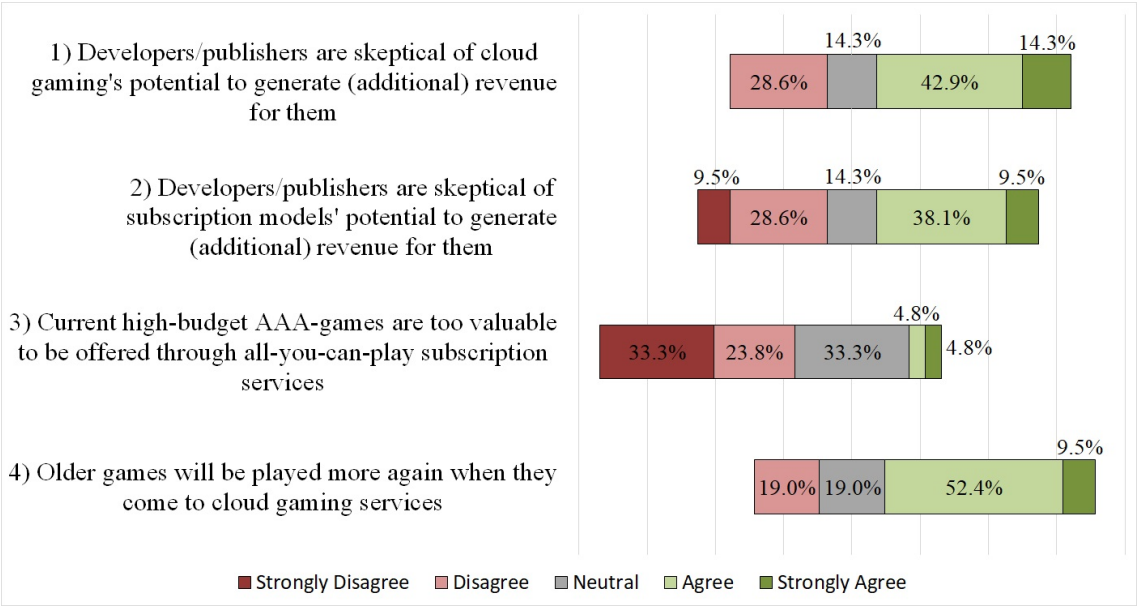

Figure 4: Survey questions about cloud gaming revenue models.

Bring-your-own-games model
Although initially marketing itself as the Netflix of games GFN has since explicitly denounced the resemblance. It charges a subscription fee for access to its cloud gaming servers but the actual games that can be played are not contained within an all-you-can-play content catalog. Instead, the service allows customers to play games they already own on a number of online game stores. Initially all games available on these stores were playable through GFN. However, a number of prominent publishers (a.o. Activision Blizzard, 2K Games and Bethesda) revoked their permission when the service became commercial at its official launch. Although no official reasons were provided, it has become clear that it concerns disputes over the contract, which did not involve a commercial component. GFN's business model generates no additional revenue for the publishers and developers, even though it became a paid service which lends a large part of its value from the games it can offer.

The survey results confirm the existence of a general scepticism among publishers and developers towards cloud gaming's ability to generate them revenue. Statement 1 in figure 4 shows that a majority of about 57% either agree or strongly agree; about 29% disagree. Nevertheless, many developers do also note the advantages of GFN's business model, which takes no fees away from game revenue and opens up new customer segments (see 4.4).

All-you-can-play model
Mainly due to Netflix, the all-you-can-play subscription model has become closely associated with services that facilitate immediate access to a specific type of content. With cloud gaming fitting in this same category, many expect it to use the same business model. However, as evidence from PS Now's case shows, the game development industry is less receptive to this business model. After some experimentation with a rental model, Sony landed on the all-you-can play subscription

model for PS Now. As it stands, the service boasts a relatively large catalog of games which nevertheless is composed of mostly older titles. This is due to the fact that games with long development cycles and high development and marketing costs (AAA games) are considered by many publishers and developers to be too valuable to be made immediately accessible at zero additional cost on a subscription based service. It is uncertain if revenues generated from such a service can compensate the costs incurred. Since the compensation model is often based on the total playtime with respect to the other games on the service, a low player count due to for example unsatisfied critics in the press poses a large risk to such large and expensive game development projects. Sony itself, besides platform owner, is also a game publisher and has up till now also not made its own new AAA-games available on PS Now. The reasoning is captured well in the following quote:

> *"we are not going to go down the road of putting new released titles into a subscription model. These games cost many millions of dollars, well over $100 million, to develop. We just don't see that as sustainable."*
> (Jim Ryan, CEO of Sony Interactive Entertainment, gamesindustry.biz, 2020)

The survey results for statement 3 in figure 4 show that most experts don't agree with this sentiment, with about 57% disagreeing with the statement that AAA-games are too valuable to be offered on an all-you-can-play subscription service. Only 10% of respondents agreed with the statement lending credibility to the idea that all-you-can-play business models can be valuable to both end-users as well as complementors. In another way PS Now's business model does however offer complementors an interesting proposition. It gives developers and publishers renewed opportunity for generating revenue from their back catalog. As mentioned, PS Now's catalog offers many older games. Besides games from the PS4 and PS3 console generations, the service also includes PS2 games that were ported to PS4. The attractiveness of this model is supported by the survey as evidenced from the results for statement 4 in 4. 62% of respondents think that older games will be played more again when they become available on a cloud gaming service like PS Now. When it comes to the overall developer scepticism towards subscription models the survey respondents have mixed opinions, as evidenced by the results for statement 2 in figure 4. Just short of 50% of respondents agree that developers and publishers are skeptical of subscription models' ability to generate them additional revenue. About 40% disagrees. Crucially, the two game developer/publisher respondents as well as the two journalists all agreed with the statement, which adds credibility to the majority in agreement.

4.3.2 Business partnerships

A striking business model is the GFN Alliance discussed above, which is a B2B construction where Nvidia provides its cloud gaming platform to ISP partners. Nvidia supplies the servers and the software and the partners manage the data centers and have the autonomy to decide on many other facets associated with running a cloud gaming service, such as the business model, pricing, branding, layout and promotions. The benefit obtained from the GFN Alliance partnerships does however bring mutual benefits, as indicated by the following quote:

"By placing NVIDIA RTX Servers on the edge, GeForce NOW Alliance partners deliver even lower latency gaming experiences. And this gives partners an opportunity to show the value of their broadband and 5G infrastructure to customers."

(Phill Eisler, General Manager at GFN, Nvidia Blog, 2021)

The partnership thus allows Nvidia to deliver its GFN service, via its partners, to more markets by making use of ISPs local edge servers which reduce the distance to the customer, reduce latency and therefore improve the gaming experience. On the other hand, Nvidia believes its service will be valuable to ISPs for marketing its core services.. Another novel business model is the provisioning by the Ubisoft+ subscription plan insided Stadia. Through Ubisoft+ users get access to the complete collection of Ubisoft games for a fixed monthly fee. On Stadia, it is an additional plan that customers must sign up to besides the regular Stadia subscription. Although, not all Ubisoft games have been ported to Stadia yet, users can also access the regular services where they can simply download the games they wish to play to their devices.

4.4 Theme 4: Service accessibility

4.4.1 The addressable market is expanded

Cloud gaming platforms have a number of features and characteristics that allow them to appeal to customer segments that were not engaged with AAA-gaming platforms before. Although the survey results for statement 1 in figure 5 show that a large part of cloud gaming customers are thought to be mostly people who already play high-end games, publishers and developers nevertheless expect cloud gaming to expand the total addressable market enormously, as demonstrated by the following quotes:

"We estimate that Stadia's entry into the market expands our reachable audience by a factor of 10."

(Dustin Land, Programming Lead at ID Software, GDC, 2019)

"We believe that cloud is going to have a tremendously positive impact on total addressable market in our industry over the long term."

(Andrew Wilson, CEO of EA, Earnings Call Q3 2021, 2021)

Three characteristics of cloud gaming are at the root of this expansion are shortly considered next. Firstly, consoles as consumer products are replaced by compute resources delivered from data centers as a service. For consumers this means that the necessity to buy a physical product to play games is no longer present, removing the cost barrier. This allows cloud gaming platforms to attract the consumers for whom the console prices are too high. However, as also indicated in the survey results to statement 2 in 5, the pricing of the internet services required for cloud gaming takes over as new barrier. About 43% of experts agree that the pricing is important inhibitor of cloud gaming's popularity. About 24% disagree.

Secondly, with cloud gaming platforms there are no downloads and updates. Since cloud gaming platforms keep the hardware under their own management, the game files are all kept in their data centers. Consequently, the process consumers go through with console-based platforms to download and update games on their home devices is instead taken care of at once in the cloud gaming platform's data centers. With game files becoming increasingly large this problem remains a barrier for some customer segments. The convenience cloud gaming platforms provide of quickly getting into games, without the download or update beforehand, attracts another customer segment as illustrated by the following quote concerning the composition of GFN's customers:

> *"Dad is busy now and he doesn't have as much time to play games as he used to have. [...] The average play time on GeForce Now is between 20 and 30 minutes, and so that 30 seconds of getting in and out of a game is very important to them"*
>
> (Phil Eisler, General Manager of GeForce Now, GDC, 2016)

With regards to this cloud gaming feature Nvidia has also pursued contracts with publishers and developers to obtain updates before they are actually released so they can prepare and set it up in their data centers. This could then allow for zero waiting time for users after the update is officially released.

Another customer segment that is uniquely addressed by cloud gaming platforms is that of gamers that want to play their games on devices that do not normally have the compute resources to run them. This is particularly interesting on portable devices like laptops, tablets and smartphones, which would allow users to keep playing high-end games while on the go. The survey results for statement 5 in figure 5 confirms that this cloud gaming feature is likely to engage part of the mobile gaming segment with AAA-gaming. However, this does seem to be under the condition of sufficient 5G network development, as indicated by the survey through statement 3 in figure 5. About 62% of respondents agree that the expansion of 5G coverage is a crucial factor in the growth of cloud gaming services.

4.4.2 Developer Environment

The accessibility of the cloud gaming developer environment is characterized by a few notable peculiarities. Firstly, two of the cloud gaming platforms considered in this research, PS Now and GFN, utilize existing gaming ecosystems. Therefore, games do not need to be ported to them, but must simply be developed for the existing gaming ecosystem in question. PS Now runs games developed for Playstation consoles and GFN runs PC games, without adaptation required. This means that these cloud gaming services can benefit from a large collection of existing complements that are immediately compatible with their platform. Stadia on the other hand uses its own toolkit and software stack which requires developers to specifically build their games for the platform or to port it from another.

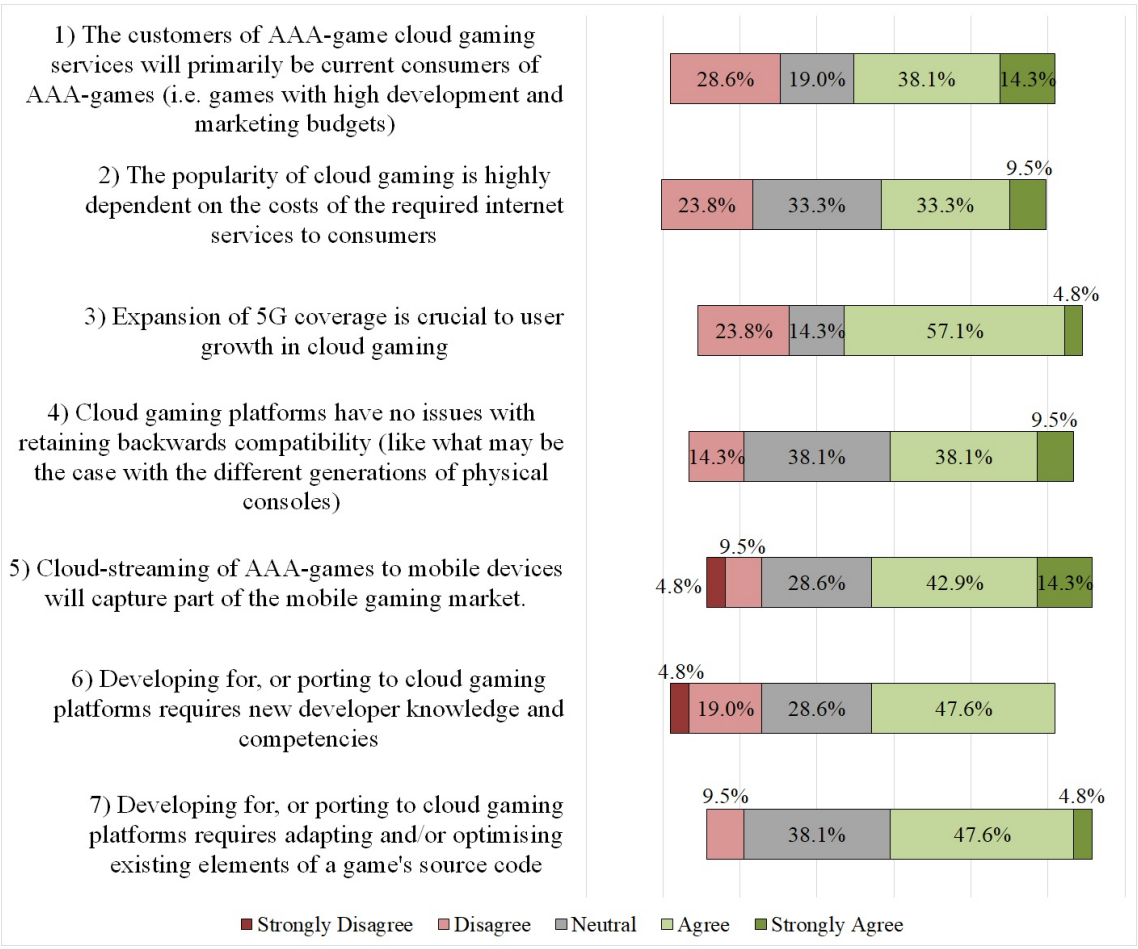

Figure 5: Survey questions about cloud gaming accessibility.

Secondly, cloud gaming platforms have the potential to be upgraded and improved in small steps. Both Stadia and GFN evolve their compute resources as new components and architectures become available. This departs from the generational development of console-based platforms, where completely new architectures are designed for each new console generation. A negative side-effect of this is that often games from the previous generation console become incompatible with the new generation. The evolutionary development of cloud gaming alleviates this issue with backwards compatibility, as also indicated by the survey results through statement 4 in 5. About half of respondents agree to the question of backwards compatibility no longer being an issue with cloud gaming platforms. About 14% disagree. PS Now uses the standard Playstation console architecture adapted for data centers, and is therefore likely to stick with the console's generational platform development.

4.4.3 New facets to cloud game development

The games developers create may be strongly impacted by the bit-rate (i.e. actual speed of data transfer per second) and latency of the internet connection between end-user and cloud gaming platform. Some genres of games are affected more than others by a bad internet connection. In a similar fashion, individual game mechanics may be affected differently by bad network conditions, as becomes clear from the following quote concerning latency:

> *"It is important to note, different mechanics have different latency requirements even within the same game. And even the same mechanic across two different titles can have wildly different behaviors and requirements."*
>
> (Khaled Abdel Rahman, Product Manager Stadia, Google I/O, 2019)

The way a game is experienced further depends on the experience level of the player. Casual players are less likely to be impacted by high latency than experienced players, as noted in the following quote:

> *"A more experienced player might be looking to do [...] things that are not feasible at high or inconsistent latency."*
>
> (Khaled Abdel Rahman, Product Manager Stadia, Google I/O, 2019)

Certain types of games are therefore less suitable to be played on cloud gaming platforms. The impact of various network conditions is something that developers have to keep in mind when developing a game for a cloud gaming platform. In this regard their own programming also has an impact on the extend to which network conditions may affect the game experience. As evident from the following quote, cloud gaming platforms may optimize their data center network, servers and backend software, but improvements in user experience also come down to the games themselves:

> *"We believed we could achieve significant savings and significant improvements and enhancements to the player experience by starting our optimizations at the very earliest literal possible point, which is on the game*

engine level"

(James Altman, Director of Publishing Operations at Bethesda gamesindustry.biz, 2019)

Through Statements 3 and 4 in figure 5, the survey results confirm that the games themselves, and therefore the developers, have a hand in minimizing the network related issues impacting the user experience on cloud gaming platforms. About half of experts agree with new developer knowledge and competencies being part of developing for cloud gaming platforms. The same holds true for the adapting and optimising of source code. Respectively, approximately 24% and 10% disagree. Stadia is different from GFN and PS Now in terms of this development environment as it uses its own unique software architecture to which games need to be adapted if they are to run on the platform. GFN and PS Now simply play existing games without additional (porting) requirements. More specifically, GFN runs any PC game and PS Now runs any PS4 or PS3 game (and PS2 games ported to PS4).

4.5 Theme 5: New value propositions

This theme captures the various changes that were observed affecting gaming platforms' complementors. The sub-themes discussed in this section include both positive and negative effects, but all of them alter the set of possibilities that are open to publishers and developers with regards to their complementary products for cloud gaming platforms.

4.5.1 Cloud-native functionality boosts creative options

The remote computing characteristic of cloud gaming platforms allows for a number of unique capabilities that open up the creative opportunities of complementors. Firstly, having compute resources in a data center instead of in a consumer-owned console allows these resources to be flexibly expanded or contracted depending on the type of game being played. Consequently, much more computationally intensive games can be run, opening up the possibility for a range of discovered and undiscovered features to be implemented in games. For example, The game Orcs Must Die! 3 uses the extensive data center resources for a game mode that included many more Orcs than console-based platforms would be able to handle.

Real-time physics simulations and machine learning algorithms are regarded as promising technologies that could leverage this cloud gaming functionality. Google itself developed StyleTransferML, a machine learning algorithm that adapts a game world in real-time according to a style pattern of choice. And Google's Stream-Connect allows for split-screen functionality, requiring the rendering of multiple perspectives simultaneously, which was removed from many console-based games in favor of better graphics and other computationally intensive tasks.

Secondly, the nature of cloud gaming platform as being many game instances concentrated in a single location, namely the data centers, is the possibility of having multiplayer gaming sessions with many more concurrent players. The geographical

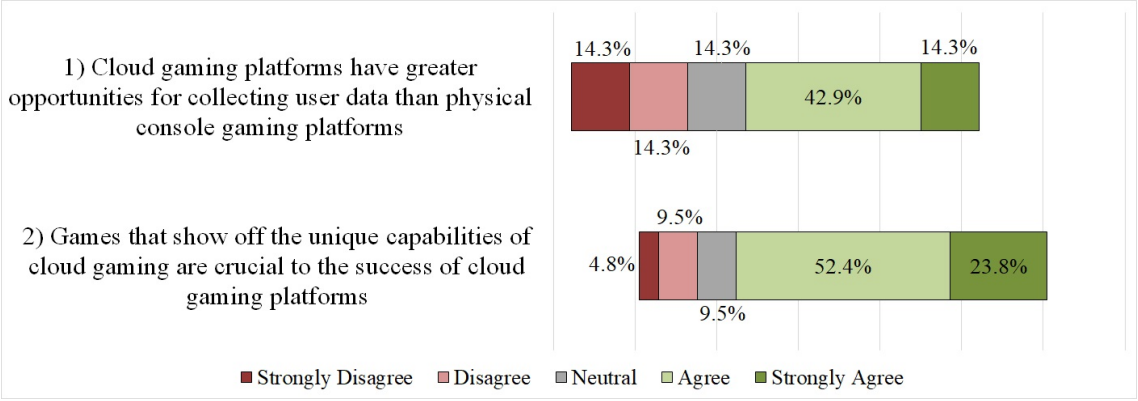

Figure 6: Survey questions about cloud gaming value propositions.

proximity of the compute hardware removes the latency and consequent synchronization issues that would otherwise be present between different players.

4.5.2 Data collection and advertising

Given that in cloud gaming all the user activity is handled on the platform's data center servers the potential is there to collect player data. The results of the survey confirm this through statement 5 in figure 6. More than 57% of respondents agreed that cloud gaming platforms have greater opportunities for collecting data than console-based platforms. This data may be leveraged by developers and publishers to gain insight into their games about for example what elements work and which do not. Moreover, data may be used by complementors to inform their marketing campaigns. Knowledge about how and what one plays can be very valuable in this regard. Google in particular may be able to connect data from its different products to form a more comprehensive view of the persons involved. Both GFN and Stadia support hyperlinks that redirect interested people straight to what might be a demo of a game, reducing the barrier between advertisement and sale.

4.5.3 Game security and fairness

Running games on remote servers instead of consumers' own hardware removes the threat of security issues and cheating as indicated by the following quote:

> *"There are a lot of consumer benefits: Play now, no patches, no cheating. And there are publisher benefits: no digital rights management problems, no piracy."*
>
> (James Altman, Director of Publishing Operations at Bethesda gamesindustry.biz, 2019)

Where gaming hardware and software is in the hands of consumers, it is sensitive to being used or adapted for piracy, where unofficial copies of games grant access without proper compensation for developers and publishers. Cloud gaming makes the management of access much more watertight since the actual game files exist only on remote servers and the hardware running them in remote data centers. This

also means that it removes the possibility for people to develop ways to cheat in games, which can sometimes spoil much of the fun that other get from playing the game.

4.6 The cloud gaming value network

To facilitate the comparison it is useful to establish how the relationships in the gaming platform market are impacted at the hands of cloud gaming disruption. Therefore, the value networks of the console and cloud platform markets are depicted in figures 7 and 8 respectively. The cloud gaming platform value network also shows the parts of the network that are specific to either GFN or Stadia. These parts represent relationships that do not exist in the other cases.

A visual inspection of the two value networks immediately reveals a difference in complexity, which is partly explained by the different business models of the three cloud gaming cases that are included in the diagram. A few things should be noted:

1. *Cloud gaming platforms have more value proposition for both end-users and complementors.* Console gaming platforms simply provide the core gaming experience, whereas cloud gaming platforms additionally offer gaming on low-end devices, no downloading and updating and new types of games, which may for example leverage cloud gaming's extensive compute resources.

2. *Although the ISP has a role in the console platform market, it emerges as a much more important actor in the cloud gaming platform value network, providing the internet bandwidth required for a smooth cloud gaming experience.* In addition, the cloud gaming value network also depicts the business model of the GFN Alliance in which Nvidia provides its cloud gaming technology to ISP partners. These ISPs then go to market with the same value propositions as would GFN.

3. *The data center network providers is pictured separately.* Although all three cloud gaming platforms studied still mostly operate their own data center network, there are clear indications that a cloud gaming platform is not necessarily also the provider of compute resources. As pointed out before the memorandum of understanding about Sony's intention to use Microsoft's compute resources, and, again, the GFN Alliance in which Nvidia's technology runs in the ISPs data centers demonstrate this. In a scenario where platform and data center operator are fully separate, the component manufacturer would als be no longer be connected to the gaming platform firm in the value network diagram.

4. *Stores are only present in the GFN business model, where they fulfill a different role.* As indicated in the results section GFN utilizes online game stores to give its customers access to the games they already own. In this business model game stores fulfill the task of passing on to the platform the information on whether a user owns a game or not.

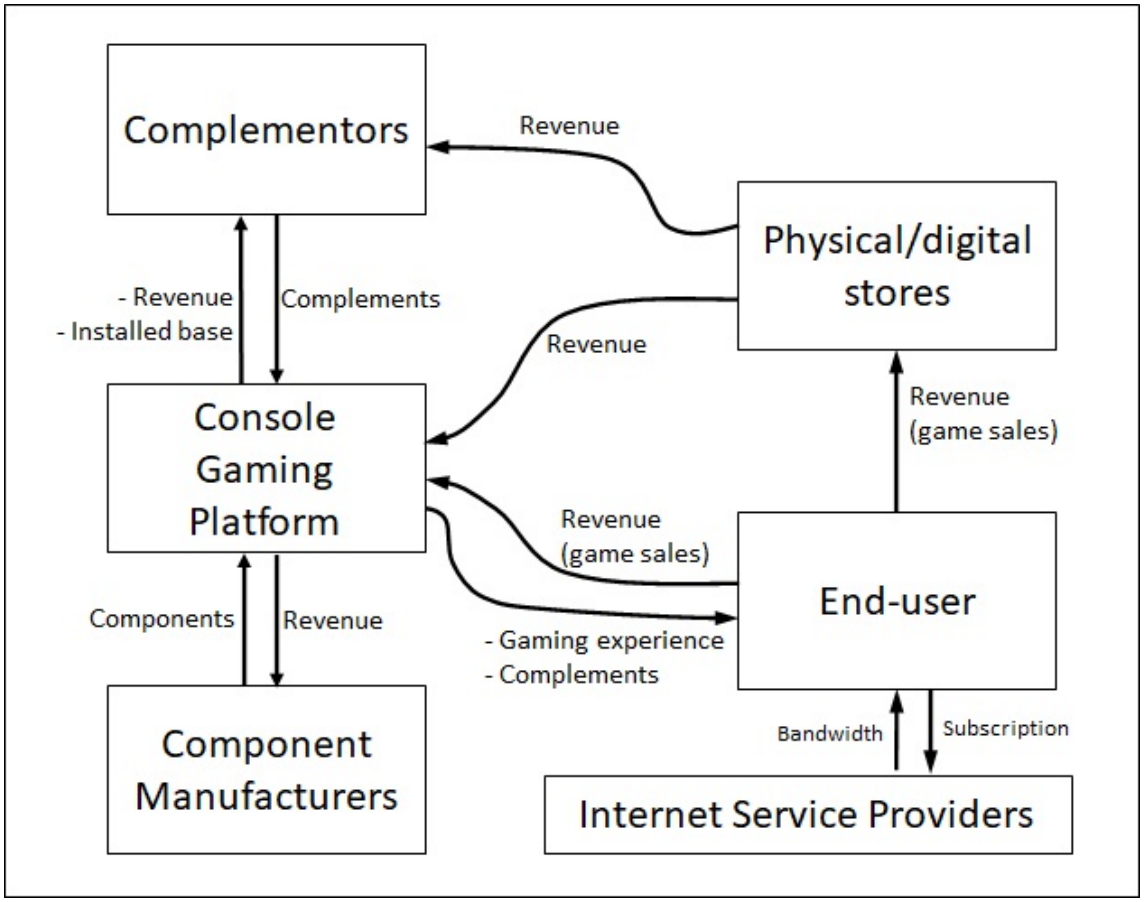

Figure 7: The value network of the console gaming market.

5. *Stadia takes on the role of game store.* Contrary to PS Now and GFN, Stadia's business model requires games to be bought in Stadia's own store. Consequently, Stadia is the only one of the three cases to take on this role.

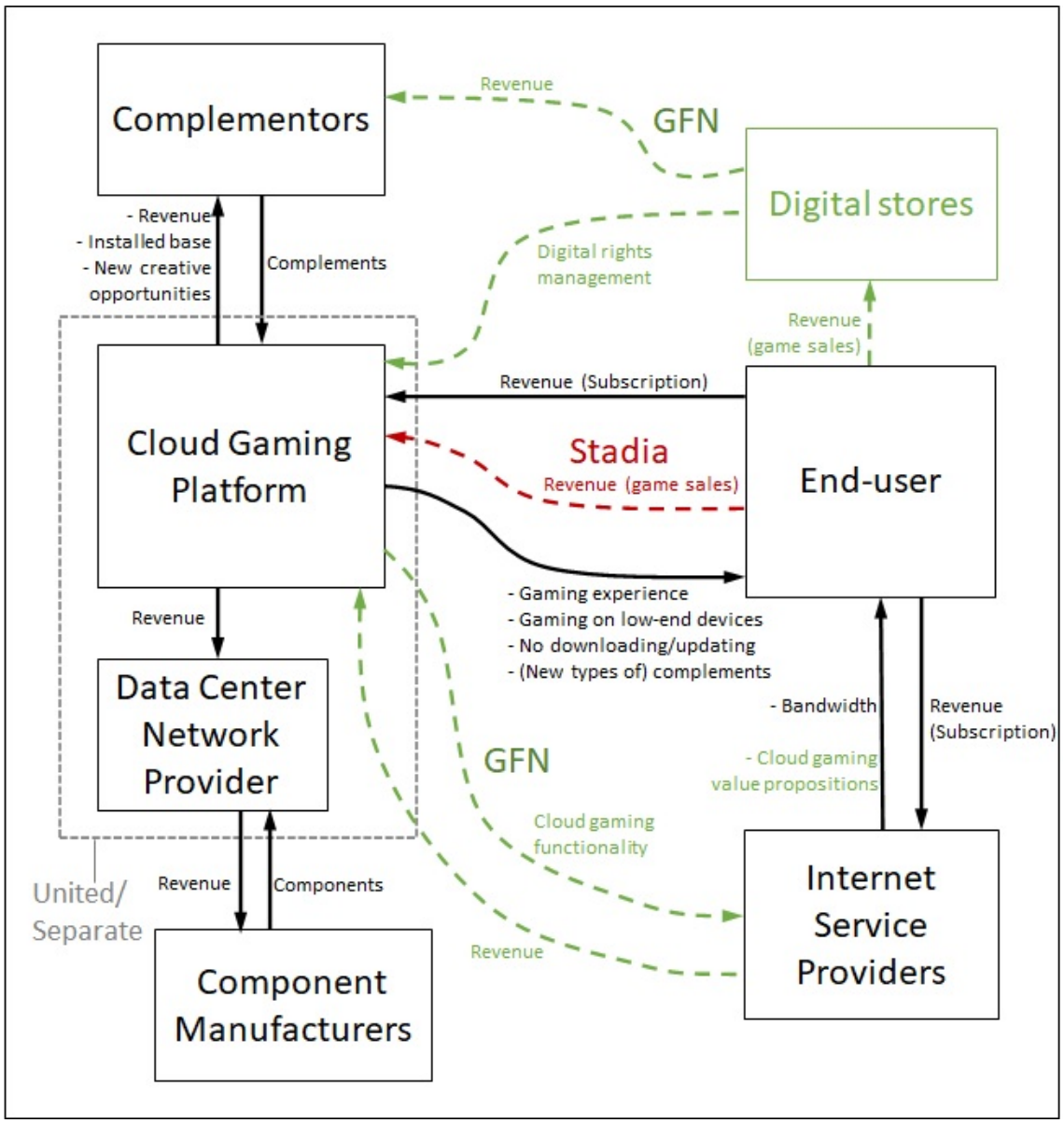

Figure 8: The value network of the cloud gaming market.

5 Analysis

5.1 Comparison of effects at the firm-level

The impacts on cloud gaming platforms can be naturally expected to correspond with those indicated by literature to affect cloud providers. This section considers each of the effects obtained from extant literature listed in table 2. First the effects are discussed that were corroborated by evidence from the cloud gaming cases and expert survey, and then the effects for which no evidence could be found. This section also presents novel effects not previously mentioned by literature.

5.1.1 Supported effects

Necessity for IT Infrastructure
Providing cloud-based services also requires the provider to develop an IT infrastructure to support it. Although, a substantial part of the literature explicitly mentions this facet (DaSilva et al., 2013; Boillat and Legner, 2013; Clohessy et al., 2017; Nieuwenhuis et al., 2018; Clohessy et al., 2020), many also skim over it, as in many cases cloud providers outsource their required IT infrastructure. In the cloud gaming market the necessity to build and operate data center networks is a clear change from the previous console-based situation. Google could mostly utilize its existing Google Cloud network while Sony and Nvidia had to invest in building new data centers to provision their cloud gaming services.

Greater service accessibility and availability
In line with extant literature the accessibility and availability of cloud gaming platforms has improved compared to console-based gaming platforms (Ojala and Tyrvainen, 2011a; Boillat and Legner, 2013; Ojala and Helander, 2014; Makhlouf and Allal-Chérif, 2019). The evidence implicates three primary factors in this effect. Firstly, the removal of up-front costs associated with console-based gaming platforms, which are replaced by subscription-based revenue models. Secondly, the convenient and quick access users get to games. As demonstrated by all three cloud gaming platforms, downloads and updates are taken care of behind the scenes. The large compute resources available to cloud gaming platforms reduce loading times to further speed up access to games. Both Stadia and GFN support access to games through hyperlinks, which allows users to enter into a game like they open a website. Thirdly, the possibility to access cloud-based gaming on low-end devices. All three cloud gaming services considered in this research are available through dedicated applications on a range of devices and even the browser. This makes the high-end gaming proposed by the present cloud gaming services essentially accessible through any device. The evidence does however also indicate a factor that reduces accessibility to the service: the requirement for a strong and stable internet connection, which is not for everyone and everywhere available. This factor is not present in most cloud computing services and is unique to real-time interactive applications like cloud gaming (see novel effects).

Table 9: Comparison of the effects of cloud computing disruption impacting cloud providers.

Effects on cloud providers	**Literature**	**Study results**
Necessity for IT infrastructure	x	x
Better economies of scale	x	
More service standardization	x	
More direct relationship with end-user	x	
New products and services	x	x
Greater service accessibility and availability	x	x
Engagement of new customer segments	x	x
Better quality of service	x	
Subscription and flexible revenue models	x	x
Less customer lock-in	x	x
Lowered barriers-to-entry for competition	x	x
Harder to differentiate from competition	x	x
Reduced customer confidence	x	
Better organizational agility	x	x
Strong dependency on internet quality		x
Networking-related technology performance metrics		x
Necessity for proximity to users		x

New products and services
Extant literature found that cloud service providers get opportunities to exploit new products and services (Ojala and Tyrvainen, 2011a; Clohessy et al., 2016, 2017, 2020). One strong indication from the cloud gaming cases that also indicates this effect is Nvidia's GFN Alliance, in which Nvidia supplies its complete cloud gaming platform to ISP partners in the alliance. As described in the results section, these partners can determine most aspects of their business models themselves, including brand and pricing. Complementor relations and technology development, are still handled by Nvidia. Licensing out a gaming platform in this way is made possible by the cloud computing ability to deliver compute resources as a service instead of as a product. As a result, ISPs can integrate cloud gaming in their existing internet services to leverage the synergies. Another indication of new cloud-enabled services in the cloud gaming market, is the ability to collect more data. Advertisers, complementors and others can use the platform's data collection services to gain novel insights in gaming behaviour and adapt accordingly (Bani-Hani et al., 2017; Clohessy et al., 2017, 2020).

Engagement of new customer segments
Closely related to the question of accessibility and availability is that of new customer segments. The results from this study support the findings from previous literature that cloud computing services can engage new segments of customers (DaSilva et al.,

2013; Boillat and Legner, 2013; Clohessy et al., 2016, 2017, 2020). As described in the results (section 4.4.1) these segments mostly consist of customers who are on a budget, who have little time or want to play on-the-go. Additionally, the evidence indicates the possibility for new game formats by harnessing the compute capabilities of cloud gaming data centers to implement compute-heavy functionality like machine learning and physics simulation algorithms. In turn, such new types of complements stand to attract new customer segments to cloud gaming as well.

Subscription and flexible revenue models
All three cloud gaming cases use a subscription-based revenue model, where users pay fundamentally to access the compute resources. This denotes a change from console platforms, an effect that is in line with observations made in a substantial portion of the literature (Ojala and Tyrvainen, 2011a; DaSilva et al., 2013; Boillat and Legner, 2013; Rebsdorf and Hedman, 2014; Ojala and Helander, 2014; Makhlouf and Allal-Chérif, 2019). Contrary to the cases discussed in many of these studies, pay-per-use or pay-as-you-go revenue models are not found in the cloud gaming market. The likely cause is the difference in customer. Where B2B businesses may choose to use a pay-per-use or pay-as-you-go model - for example Amazon Web Services and Salesforce (DaSilva et al., 2013) or enterprise software vendors (Boillat and Legner, 2013) - B2C businesses often aim to keep the payment structure easy to understand, making a fixed-fee subscription the preferred model.

Less customer lock-in
In line with extant literature the evidence from the cloud gaming platform cases shows reduced customer lock-in effects (DaSilva et al., 2013; Rebsdorf and Hedman, 2014; Clohessy et al., 2017). For console-based gaming platforms the up-front costs of buying the device and the additional costs associated with acquiring the games generate a lock-in effect for users. Cloud gaming platforms do not have the console and thus do not have the up-front costs. Furthermore, as suggested by the evidence from the PS Now and Stadia cases, cloud gaming drives the use of all-you-can-play business models which grant users immediate access to a catalog of games for a subscription fee. With these two elements coming together, switching platforms would no longer be discouraged by the previous purchase of either a console or games, leaving few lock-in effects. Although Stadia has an all-you-can-play model only in part, and PS Now has one with mostly older titles, this still strongly reduces the lock-in effects that cloud gaming platforms enjoy compared to console-based platforms.

Developers too experience lock-in effects from the investments made to acquire the competencies and expertise necessary for developing for a specific gaming platform. In the generational development pattern that console platforms traditionally have, incumbent developers stand to see their competencies destroyed due to a new compute architecture or software stack (Ozalp et al., 2018). The absence of these potentially disruptive events may therefore actually generate stronger lock-in effects for gaming platforms when it comes to the competencies of their complementors (DaSilva et al., 2013; Rebsdorf and Hedman, 2014).

Lower barriers-to-entry for competition
Lower barriers-to-entry into the market for cloud-based competition was indicated as an effect on the cloud provider by Clohessy et al. (2017), and is in line with observations from this study. The evidence shows that firms can outsource the necessary data center infrastructure, as confirmed through the expert survey and supported by Sony's intention to work with Microsoft's data center capabilities. Furthermore, the internet-based service delivery model of cloud gaming platforms bypasses the hurdles of bringing to market a physical console. Although substantial barriers-to-entry remain, such as the recruitment of enough qualitative complementors, these are mostly not unique to cloud gaming platforms.

Harder to differentiate from competitors
An effect found by Clohessy et al. (2016) and Clohessy et al. (2017) that differentiation from competition is harder in a cloud-based environment, was also corroborated by the cloud gaming cases. The redundancy of the physical console takes away a significant differentiating dimension. However, when it comes to the compute resources, evidence from the expert survey suggests that there are substitute dimensions in the cloud gaming technology that can (partly) compensate this loss in differentiation possibilities, namely the sophistication of server and back-end software. The main reason for why it is harder to differentiate from competitors in the cloud gaming platform market is the absence of a generations-based platform development. The implication is that cloud gaming platforms can easily implement features and capabilities that have been shown to work well. Other differentiating factors present in gaming platforms, such as the (exclusive) complements and business models, remain present.

Better organizational agility
The evidence from the cases corroborates the effect that cloud computing services increase a firm's organizational agility, as mentioned in literature (Clohessy et al., 2016, 2017; Nieuwenhuis et al., 2018; Clohessy et al., 2020). As discussed above, cloud gaming platforms have the ability to keep evolving, adding improvements in small steps at a time. This stands in contrast to the generational approach of console gaming platforms. The evolutionary improvements that cloud gaming platforms can implement allow them to more easily make changes to the platform's technology, particularly to the compute resources in the data centers. This enables them to respond quicker to opportunities as they arise. Furthermore, the increased possibilities for data collection in cloud gaming platforms, as confirmed by the expert survey, allows firms to gain more insights in customer behaviour and preferences, in turn facilitating quick execution on opportunities. In the literature review (section 2.3.1) it is mentioned that the concept of organizational agility can be split in three sub-components: customer agility, partnering agility and operational agility (Sambamurthy et al., 2003). The above indications of increased organizational agility in the cloud gaming platform market align with the customer and operational subcomponents, supporting findings by Liu et al. (2018) that only these, and not partnering agility, are improved by cloud infrastructure capability.

5.1.2 Novel effects

The evidence from the three cloud gaming cases indicate the presence of additional and novel impacts, not mentioned in literature, in relation to cloud gaming data center infrastructure. The interactive nature of gaming combined with the remote service provisioning of cloud services, introduces much stricter networking requirements for the data center network and its components. The evidence shows that two factors are important. Firstly, the capability of servers and back-end software to reduce the impact of network factors on the service quality. And secondly, the proximity of data centers in the provider's data center network to the customer. The distance must be adequately small to reduce the impact of data travel times and network hurdles on the gaming experience. These criteria are not mentioned by extant literature as most of the cloud services studied, and most of the cloud services that presently exist, are not characterized by real-time interaction where the slightest network shortcomings can make or break the service.

5.1.3 Unsupported and absent effects

Some impacts mentioned by literature were not found to be present in the cloud gaming platforms. Others could not be conclusively proven to be present given the evidence obtained in this study. These effects are discussed next.

Better economies-of-scale
No evidence was found that cloud gaming achieves economies-of-scale compared to the console-based platforms. The studies that found this impact indicate that it is the result of the ability of some cloud service providers to merge supportive operations and centralize them in one geographic area (DaSilva et al., 2013; Boillat and Legner, 2013; Rebsdorf and Hedman, 2014; Clohessy et al., 2016, 2020). Cloud gaming's networking requirements and need to have data centers as close as possible to the end-user does however not allow for far-reaching centralization.

Less customization options
With regards to economies-of-scale, the advantages obtained by centralisation are partly because these businesses standardize their services, which, for services that used to provide custom solutions, goes hand in hand with a reduction in service customization options (Iyer and Henderson, 2012; Boillat and Legner, 2013; Clohessy et al., 2017; Nieuwenhuis et al., 2018; Makhlouf and Allal-Chérif, 2019; Clohessy et al., 2020). Gaming consoles have always been standardized mass-produced products, and with cloud gaming no significant customization options are lost.

More direct relations with the end-user
There was also no evidence found to indicate that cloud gaming platforms enjoy a more direct relationship with their customers, as indicated by Boillat and Legner (2013) and Makhlouf and Allal-Chérif (2019). This is likely because current console gaming platforms already posses a rather direct connection to their end-users through their own cloud capabilities. For example, Playstation and Xbox consoles

have their own game stores and customer support already runs through online channels. On the other hand, it can be argued that improved data collection capabilities would allow also for even more intimate customer relationships

Better quality of service
Not supported by the cloud gaming cases is also the effect that cloud computing services deliver a better quality of service (DaSilva et al., 2013; Clohessy et al., 2016, 2020). A prominent theme in the evidence from the cloud gaming cases is their dependency on network and internet connection quality for the service quality. Various problems, such as competing demand, packet loss and jitter, can severely worsen the gaming experience. Moreover, latency is by definition much higher for cloud gaming platforms than for console gaming platforms, owing to the distance that needs to be travelled between data center and customer. By itself, this may already constitute an unacceptable degradation in gaming experience for the experienced player. It may however be expected that the quality of cloud gaming services in itself will further improve going forward as the networking problems mentioned above are increasingly resolved, as seen in cloud gaming's own history.

Less customer confidence in security and availability
No conclusive evidence was found to indicate that customers are much more concerned about service security or availability, as indicated by some studies (DaSilva et al., 2013; Clohessy et al., 2016, 2017). Some increase in this metric may nevertheless be expected given that bad network conditions may shut of access to a cloud gaming service completely.

5.1.4 Cloud gaming platforms as cloud consumers

As demonstrated by the intention of Sony to partner up with Microsoft for PS Now's data center infrastructure, cloud gaming platforms may also be cloud consumers. This makes the impacts related to cloud consumers listed in table 1 relevant to cloud gaming platforms as well. The evidence and survey results discussed in theme 2 with regards to Sony's memorandum of understanding with Microsoft indicate the advantage of outsourcing: it achieves the conversion of capital expenses, necessary for building data centers, into operational expenses. This effect was also mentioned by extant literature with regards to cloud consumers (Ojala and Tyrvainen, 2011b; Iyer and Henderson, 2012; Garrison et al., 2015; Clohessy et al., 2017; Nieuwenhuis et al., 2018; Makhlouf and Allal-Chérif, 2019; Khayer et al., 2020). Furthermore, outsourcing the required data center network to a third-party eliminates the risks associated with scaling up the available resources to accommodate increased demand (Iyer and Henderson, 2012; Garrison et al., 2015; Clohessy et al., 2016; Makhlouf and Allal-Chérif, 2019). Despite these modest conclusions, further comparison of the effects associated with cloud consumers to those in the cloud gaming cases is futile. None of the three cloud gaming providers considered in this research has officially procured cloud services elsewhere. Table 11 shows the comparison, including the other effects that could not be corroborated by the evidence in this study.

Table 10: Comparison of the effects of cloud computing disruption impacting cloud consumers.

Effects on cloud consumers	Literature	Study results
New business model opportunities	x	
Capital IT expenses become operational expenses	x	x
Outsourcing of security and scaling risks; taking on risks concerning IT availability	x	x
Cloud-supported operations perform better	x	
Better organizational agility	x	

5.2 Comparison of effects at the ecosystem-level

Cloud computing disruption can also have a profound impact on the broader ecosystem surrounding a firm. Extant literature indicated six effects in this regard. In this section, these effects are compared to the evidence from the cloud gaming cases.

5.2.1 Supported effects

Existing ecosystem roles change
In line with extant literature the cloud gaming cases support the observation that some ecosystem roles change due to cloud computing disruption (Boillat and Legner, 2013; Rebsdorf and Hedman, 2014; Clohessy et al., 2017; Nieuwenhuis et al., 2018; Clohessy et al., 2020). The console and cloud gaming platform value networks discussed in the results section show that the roles of game store and component manufacturer have changed or are likely to change in the future. The game store's role, in fact, has changed differently in each cloud gaming case. PS Now's all-you-can-play subscription model has made the store obsolete. In GFN's business model the store remains the place to buy your game, but additionally it gains the role of verifying for GFN whether the user owns the game so that it can be played on the cloud service. Stadia's business model has no external game stores but instead runs its own store, which at the same time is also the only place where one can buy games for Stadia. When it comes to component manufacturers, the survey results and Sony's intention to use Microsoft's compute resources in the future suggest that their customer may switch from gaming platform firm to data center operator. Another role change relates to complementors who, in a cloud gaming setting, have to start considering the performance of their game experience from a networking perspective. The evidence indicated that certain game genres and mechanics suffered from bad network conditions more than others. It also showed that certain adaptations can be done to optimize a game's source code for such network conditions.

New ecosystem roles emerge
The evidence from the cloud gaming cases indicates the emergence of two new ecosystem roles: data center network provider and internet service provider. This corroborates the findings of a large portion of extant literature that mention the emergence of new ecosystem roles as an effect of cloud computing disruption (Ojala and Tyr-

vainen, 2011b; DaSilva et al., 2013; Boillat and Legner, 2013; Rebsdorf and Hedman, 2014; Ojala and Helander, 2014; Clohessy et al., 2016, 2017; Nieuwenhuis et al., 2018; Clohessy et al., 2020). ISPs make an entry into the cloud gaming platform ecosystem due to the far-reaching dependency of cloud gaming services on the internet connection quality that users get. Data center network providers become part of the ecosystem as cloud gaming platform outsource their data center network. In the three cases considered in this study this has not been extensively applied, although Sony has indicated its intentions and Nvidia has supplied its platform to partner ISPs who operate their own data centers.

Greater necessity for ecosystem orchestration due to increased dependencies
The cloud gaming cases demonstrate a great dependency on network conditions for a qualitative gaming experience. The evidence shows that many user- and network-related factors influence the stability and strength of an internet connection. These dependencies create a need for orchestration by cloud gaming platform firms, an effect that was also mentioned in extant literature (Iyer and Henderson, 2012; Clohessy et al., 2016, 2017). Nvidia made an effort to instruct GFN customers on which networking devices to buy and created 'quality-of-service'-profiles for them to allow all networking parameters to be set to the optimal option. Google too offers a troubleshooting tool with similar intentions for Stadia. Another demonstration of ecosystem orchestration efforts comes from Sony and Nvidia that need to persuade complementors to permit their games on their subscription-based gaming platforms. PS Now's all-you-can-play business model has been met with complementor skepticism with regards to its ability to generate them revenue. GFN's business model does not provide a revenue stream for developers at all, which has left complementors wondering if a part of the newly created value should be theirs to capture.

Table 11: Comparison of the effects of cloud computing disruption impacting ecosystems.

Effects on ecosystems	**Literature**	**Study results**
Existing ecosystem roles change	x	x
New ecosystem roles emerge	x	x
Greater necessity for ecosystem orchestration due to increased dependencies	x	x
More knowledge spill-over effects	x	
Emergence of ecosystem-enabled value propositions	x	x
Less disruption of complementors		x

Emergence of ecosystem-enabled value propositions
The cloud gaming cases demonstrate in two ways the emergence of ecosystem-enabled value propositions, an effect that was found by various studies (Ojala and Tyrvainen, 2011a; DaSilva et al., 2013; Boillat and Legner, 2013; Nieuwenhuis et al., 2018). Firstly, the GFN Alliance brought cloud gaming capabilities into the service offerings of ISPs. From these partnerships Nvidia gained footholds in the market

for broadband and cellular network services, which, as indicated by the evidence as well as the expert survey, are of great importance to the success and popularity of cloud gaming platforms going forward. ISPs upped the desirability of their internet service plans. This mutual interest gives rise to this new value proposition where cloud gaming services can be provided as part of an internet subscription plan. Secondly, game publisher Ubisoft offers its own subscription plan on the Stadia platform. Echoing the evolution of gaming platforms towards subscription-based business models, and noting the questions raised with regards to the value these models generate for complementors, Ubisoft brought its own games to Stadia in the form of its own subscription service. The value propositions allows customers to play Ubisoft games on a cloud gaming platform while retaining the subscription-based payment structure.

5.2.2 Novel effects

Developers invest time and money in building the competencies and expertise to work with the intricacies of a specific platform. In cloud gaming such investments do still need to be made, and switching to another platform would require different competencies to be built again. However, the evidence indicates that with cloud gaming platforms, platform firms have the possibility to evolve the platform slowly, improving it in small steps instead of in generations known from console gaming platforms. This closely relates to the findings of Ozalp et al. (2018) who found that the generational transitions of console gaming platforms often destroy complementors' competencies leading to their disruption and their potential switch to a competitor. This evidence indicates that the evolutionary development possible in cloud computing platforms strongly reduces the potential for such generational disruption. Since software-based services already possess the property of continuous improvement, this effect is unique to cloud computing services that replace user-owned compute resources. As soon as these compute resources are brought under the management of the service provider it can make evolutionary improvements which the consumer is not able to do.

5.2.3 Unsupported and absent effects

More knowledge spill-over effects
The evidence did not yield any indications of knowledge spill-over effects in the cloud gaming platforms' ecosystems. However, given the identified ecosystem-enabled value propositions and business models it is likely that more knowledge spill-over takes place in the cloud gaming platform market compared to the console platform market. These effects can be expected especially where firms connect in a provider-supplier relationship or in a partnership, such as in the GFN Alliance, in GFN's relationship with online vendors and in the data center agreement between Sony and Microsoft (Clohessy et al., 2017).

6 Conclusion

This research project aimed to study the phenomenon of cloud computing disruption in platform markets from empirical reality by examining cloud gaming platforms and their entry into the gaming platform market. To that end a multiple comparative case study was done into the cloud gaming platforms of Google Stadia, Nvidia GeForce Now and Playstation Now. The data was supplemented with the results from an expert survey to create a well-grounded overview of the phenomenon. The results were compared with the effects mentioned in extant literature to arrive at conclusions on the similarities and differences with the cloud gaming platform cases. The successive steps subsequently informed answers to the research questions.

A review of the literature on cloud computing disruption was done to answer the first sub-question: *which effects from cloud computing disruption have been found up till now?* The literature review revealed 24 distinct effects that could be divided into those that affect cloud service consumers, those that affect cloud service providers and those that affect the cloud service's ecosystem. The resulting framework allowed for comparison against the results from the other sub-questions to inform a solution to the main problem.

An extensive thematic analysis yielded an answer to the second sub-question of this research: *which patterns of impacts from cloud gaming disruption can be identified in the gaming platform market?*. Five themes captured the effects present in each of three cloud gaming cases. Firstly, a dependency on internet quality. In all cases there is evidence of numerous network- and user-related factors that impact the quality of the internet connection required for a good cloud gaming experience. Secondly, the necessity of data center infrastructure, which also requires the building of data centers in proximity to customers and the optimising of servers and back-end software for the networked environment. Thirdly, the business models used in a cloud gaming context. The evidence showed that subscription-based services are ubiquitous and that other business models have emerged that leverage a partnership with other parties. Fourthly, the greater accessibility of cloud gaming platforms, which clearly showed its potential for expanding the addressable market by appealing to mobile gamers and consumers on a budget, with little time or an interest in new types of games leveraging cloud-native functionality. Lastly, the evidence indicated the possibilities for new value propositions using the cloud's unique capabilities.

A comparative analysis was done, using the themes and associated evidence identified from the cloud gaming cases and expert survey and the framework of effects obtained from extant literature. This analysis allowed for answering the third sub-question of this research: *how does the impact of cloud gaming disruption in the gaming platform market compare to the extant knowledge on the effects of cloud computing disruption.* Of the 19 effects associated with cloud service consumers and cloud service providers, 12 were also observed in the cloud gaming platform market. 8 were not supported or completely absent. The comparison also unveiled 3 novel effects relating to the nature of cloud gaming platforms as interactive ser-

vices. Firstly, the strong dependency of cloud gaming platforms on the quality of the internet connection that their customers have. Secondly, the networking-related performance metrics for all technological components of cloud gaming platforms. Thirdly, the necessity of the platform to be in proximity to its customers in order to limit latency and other network issues. The same analysis was done at the ecosystem level of analysis to answer the second component of the third sub-question. Of the 5 effects of cloud computing disruption on ecosystems found in literature, 4 were corroborated by the evidence from the cloud gaming cases. One novel effect was discovered, relating to the ability of cloud gaming platforms to make continuous improvements to their compute resources. By evolving the technology complementors can adapt smoothly and in parallel. This is contrary to the generations-based development of console gaming platforms where complementor competencies were often lost in the transitions to a next generation.

6.1 Practical significance

Cloud computing business models have already been a great disruption in the broader economy and have likely passed through the mind of every business leader. Nevertheless, this study can provide novel insights into the impact of cloud computing disruption in platform markets that may inform the direction and strategies of platform and non-platform businesses alike.

The study shows that cloud computing disruption in a platform market context has potentially far-reaching consequences for the platform firm and all of its ecosystem members. This calls on every ecosystem actor to understand and closely manage the effects of the disruption and to protect or adapt their business models when necessary. For the disrupting platform firm, the results of this study indicate which effects can be expected and which threats and opportunities may arise as a consequence. It also shows which changes may happen to its ecosystem in terms of roles and relationships. Both of these facets can aid in planning ahead to ensure the support from crucial ecosystem partners. For other ecosystem members, such as complementors and incumbent platforms, the study offers insight into the incentives and targets of the disrupting cloud platform and offers indications to opportunities offered by the disruption of the market.

The results are particularly useful for platforms that, similar to cloud gaming services, are characterized by a high degree of interactivity with the customer. For these services the results indicate novel effects that point to new dimensions of competition. The study shows that these factors can be significant inhibitors or enablers of a qualitative customer experience. Firms should make sure that in their plans they allocate sufficient means to these new competitive dimensions in order to stay ahead of the competition.

6.2 Scholarly significance

The main contribution of this study is to the body of research on the impact of cloud computing disruption. Besides providing further evidence for a number of previously identified effects, the results also add a platform market perspective. The findings provide indications on which effects are present in the platform market context and which are not. Furthermore, this research provides evidence of novel effects of cloud computing disruption, which can be added to future considerations of cloud computing platforms. Researchers can also use these findings in combination with extant literature on this topic to direct a more holistic view on the impacts of cloud computing disruption.

The results of this study are mostly specific to disruption driven by cloud computing-based business models. They nevertheless also offer insights into the nature of disruption in platform markets in general. Therefore, the study contributes to the research stream on disruption in platform markets, which has mostly been geared towards investigating the disruptive process as opposed to the ultimate impact thereof (Ansari et al., 2016; Snihur et al., 2018; Khanagha et al., 2018). Although a generalized perspective on the question of disruption in platform markets is bound to be deficient given the variant contexts in which platform markets may exist, this study's results can still contribute to knowledge on the range of possible impacts and on the mechanisms through which these impacts come about. This can subsequently aid the theorizing of low-level frameworks that are more accurate in predicting the effects that certain disruptions may have in specific platform market contexts.

The business-related literature focusing on cloud gaming itself is rather limited. A few works focused on the case of disruption by a cloud gaming company called G-cluster from a business model (Ojala and Tyrvainen, 2011a) and value network perspective (Ojala and Tyrvainen, 2011b; Ojala and Helander, 2014). The present study's results are closely aligned with the results from these G-cluster studies, and corroborates their results. The present findings contribute to this stream of literature a comprehensive list of effects of cloud gaming disruption in the gaming platform market. Which can enable scholars to better understand the disruptive forces present in this market and to propose

6.3 Limitations

The present research comes with its own share of limitations. Firstly, the study only considers three cases, which limits the capacity to detect the full diversity of effects from cloud computing disruption. For practical reasons the study also examined only large cloud gaming platforms with significant market reach, strong branding and great financial strength. Consequently, insights from smaller cloud gaming platforms, that are certainly active in the market in significant numbers, are not incorporated into the results of this study.

Secondly, the case of cloud gaming yields results that are very specific to that market and technology. Cloud gaming is almost unique amongst cloud computing services

in its strict requirements for strong and stable network conditions. This unique context has led to some results that likely do not generalize well to other cases of cloud computing disruption of platform markets.

Thirdly, aside from the expert survey, this research could only use publicly available information. Therefore, despite the best efforts to filter out such views, the results are prone to having been influenced by marketing talk and inaccurate statements. Solid primary sources, such as interviews or surveys with persons directly involved, would have provided a stronger foundation for this research.

6.4 Future research

The results of this study as well as the study's limitations described in the previous section point to interesting possibilities for future research. Firstly, additional research should be done into the impact of cloud computing disruption in platform markets, to verify the results obtained by this study and see which effects hold in a platform environment different from that of the cloud gaming market. As mentioned in the previous section, cloud gaming represents a rather unique cloud computing business model, research of other cloud computing platforms is required to consolidate the findings. Further, this research could be redesigned to incorporate more cases or different cases such as smaller cloud gaming firms.

Secondly, the evidence to the cloud gaming cases considered in this study was inconclusive on the presence of a number of effects identified by previous literature. More research is needed to investigate whether these effects are in fact absent and whether it is due the platform market context or some other factor.

Thirdly, this study considers cloud gaming platforms primarily from a cloud provider perspective. Consequently, it investigates primarily the impact of cloud computing disruption on platform firms as cloud providers. An interesting avenue for future research that remains under-explored by this study is to examine the impact of cloud computing disruption on platform firms as cloud consumers.

Fourthly, and closely related to previous suggestion, this research was primarily focused on investigating the impact of cloud computing disruption on the platform firm and its ecosystem. However, taking the perspective of other ecosystem member, and complementors in particular, may indicate a totally different set of effects from cloud computing disruption, providing an alluring possibility for further research into this topic.

Lastly, the research stream on disruption in platform markets is primarily interested in the disruptive process and how it unfolds in various environments. A fruitful avenue for future research is therefore the investigation of the process of cloud computing disruption in platform markets. This can supplement the results to this study to create a comprehensive understanding of all aspects of cloud computing disruption as it unfolds in and ultimately impacts on platform markets.

6.5 Management of technology perspective

As many scholars of disruptive innovation will say: it is not the technology itself that is disruptive, it is the business model in which the technology is implemented that makes it disruptive. In other words, a technology alone does not go far, more elements have to come together. This idea is one of the fundamental pillars of the MOT program which aims to connect multiple academic disciplines to allow for a holistic view on the impact and uses of technologies.

This research is well aligned with the objectives of the MOT program. By incorporating key concepts from the coursework of 'business process management', 'emerging and breakthrough technologies' and 'technology, strategy and entrepreneurship', as well as from specialization courses provided by Instituto Superior Técnico in Lisbon, this study offers an example of how the MOT program can be leveraged to research real-life technology-related business problems and analyse them through a solid theoretical lens.

When it comes to the meaning of this study's findings for the MOT program, there are a three notable points to consider. Firstly, the findings raise questions on whether strategies for attracting and retaining customer segments are still suitable and effective. The lower barriers-to-entry for competition, the fewer possibilities for differentiation from competition and the reduced lock-in effects for end-users at the hands of cloud computing disruption all seem to point to a changed environment that makes it much harder for firms to attract new customers and hold on to existing ones. This aspect of cloud computing disruption should be further explored in the course on High-tech Marketing where methods and strategies for attracting and retaining customer segments are discussed.

Secondly, the novel effect from cloud computing disruption identified by this study concerning the reduced potential for disruption of complementors, has consequences for the way in which standards and formats achieve and hold a dominant position. The evolutionary development facilitated by cloud computing technology where the compute hardware is in the hands of the service provider, reduces the number of potentially disruptive events, particularly generational product upgrades. The discussion in the course Technology, Strategy and Entrepreneurship on standards and formats should also consider how technology can lock-in and/or protect a standard's dominance by removing such disruptive events.

Thirdly, the study provides evidence of the variation in effects that may result from a disruption depending on the context in which it takes place. Thereby it points to possible variations in the way in which disruptive processes unfold in different contexts. These indications can be taken into account when considering the coursework for Emerging and Breakthrough Technologies which is concerned, in part, with how innovations move forward to achieve widespread adoption and possibly disruption of existing industries.

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