The Impact and Implications of On-Demand Services on Market Structure

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This paper considers on-demand services and its impact on market structure, firm profitability and consumer welfare. The unique properties of on-demand services are the conversion of fixed costs to variable costs, removal of capacity constraint and fast setup time (which enables quick entry by any firm at any time when there is opportunity), while privacy and security concerns and switching costs have been noted as the biggest barriers from adopting on-demand services. With a stylized model capturing these benefits and barriers of using on-demand services, we established several results. First, we show that conversion of fixed cost to variable cost enables new and small firms to enter existing markets and leads to creation of new markets. Second, we show that competition and the threat of new entrants can be an important driver of a firm’s decision to switch to on-demand services. In addition, a firm’s barriers from using on-demand services can influence another firm’s entry decision. Third, we show that two identical firms may employ different technologies in equilibrium. Forth, we show that fast setup time and removal of capacity constraint associate with on-demand services make it impossible for firms to make supranormal return and would lead to perfect competitive market, even when there is only one firm, under very general conditions. Such result still holds even when there exists economy of scale (e.g., quantity discount) from using on-demand services. On the other hand, when there are barriers preventing firms from offering similar products and products are substantially differentiated, on-demand services can amplify this advantage of entry barrier by enabling firms to further increase prices and enhance their
profitability. Therefore, contrary to the common belief that on-demand services is best for firms offering commodity products, on-demand services is more profitable for firms with differentiated products.

Keywords: on-demand services, utility computing, cloud computing, outsourcing, technology adoption.

1. Introduction

On-demand services, sometimes known as utility computing or cloud computing, grants firms the flexibility to pay for various resources on a per usage basis—from simple storage, web hosting, computing power, software, database, to more complex services, such as sales, payment and billing, support, supply chain management, and even human workforce, almost everything is available as an on-demand service now. Empowered by the increasing electronic interconnections around the globe, this on-demand model is arguably the basis of an economic revolution (Feb. 1, 2011, CBS BNET.com) \(^1\). With on-demand services, firms no longer have to build and maintain their own infrastructure or go through long deployment cycle and complicated upgrade process, which frees up valuable resources for firms. For startups, on-demand services provide a quick and cheap alternative to implement ideas which might be impossible otherwise. Thousands of startups have been created by taking advantage of the on-demand solution.

Amazon Web Services EC2, Flexiant Flexiscale, GoGrid Cloud Hosting, and Rackspace Cloud are examples of on-demand computing providers that provide a fully virtualized computing environment on which organizations can run their Internet-based applications, eliminating their need to install, operate and support their own private networks, storage and hosts. Google App Engine, Microsoft Windows Azure platform, Salesforce.com Force.com, and Zoho Creator are examples of on-demand service providers that also provide software services and application development interfaces, along with their underlying networks, storage and hosts. Various applications are also available as a service over the

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\(^1\) http://www.bnet.com/feature/everything-you-need-to-build-a-startup-now-on-demand/6190768
Internet. Examples include Salesforce.com Salesforce CRM, Cisco WebEx, and Workday HCM. Firms also have access to workforce in an on-demand fashion online. For example, through Amazon Mechanical Turk or LimeExchange.com, firms can access global talent dynamically without the need of any long-term contract. Although many resources can be purchased on demand on a per-usage basis, IT resources, including hardware, software, services and IT workforce, represent the dominant on-demand market and will be our focus in the paper, and the insights from this paper shall generalize to other non-IT input.

While the term “on demand” has been used in different context, and different vendors have different “definitions” of the term—which can refer to either technology or application deployment or payment arrangement, in this paper, we use the term “on-demand” from the adopting firm’s perspective to describe IT resource and other input procurement that has the following two properties.

1. External Ownership: The IT resources that a firm relies on for its business are standardized and are hosted, managed and maintained externally by one or more third party resource providers. In contrast, for in-house infrastructure deployment, the firm has to incur costs to host, support and maintain it. The implication of this external ownership to firms is a reduction of fixed costs and setup time to use the IT resources and the elimination of needs to upgrade IT resources from time to time, which significantly lowers risk for firms since they can pull the plug on IT initiatives without a significant penalty (Heaney et. al., 2010).

2. Usage-based Pricing: The client firm pays according to the service received with limited upfront fee. In the simplest case, the firm pays a fixed fee for each unit of the service received. For example, Amazon.com’s Simple Storage Service (S3) charges 15 cents per gigabyte per month, and Elastic Compute Cloud (EC2) provides utility computing at 10 cents per hour, both with no upfront fee. There is also no minimum or upfront fee for companies to use Amazon Mechanical Turk to access the on-demand workforce. In all these services, firms pay only for what they use. The implication of this usage-based pricing is the change of cost structure (from fixed costs to variable costs) and relaxation

of capacity constraints for firms, and as a result, facilitating greater business agility through a more flexible, on demand technology infrastructure. As time goes by, it is likely that established companies, such as IBM, HP and Oracle, may follow Amazon’s lead to provide on-demand services with no upfront costs, according to Daniel Golding, vice president of Tier 1 Research (Laudon and Laudon, 2010).³

To summarize, on-demand services have three distinctive properties: conversion of fixed costs to variable costs, fast setup time and removal of capacity constraint. Despite the significant benefits promised by the on-demand model, several factors have also been noted as barriers of adopting the on-demand model, such as privacy and security and switching costs, etc. However, the validity of several of these factors has been widely debated, and it is also likely that some concerns will fade overtime as IT utility becomes more mature and more deeply understood. For example, it has been argued that privacy and security is not a major concern since established on-demand computing providers are well versed in security requirements and have been operating secure networks for some time (Heaney et al., 2010). On the other hand, the concerns of switching costs are likely to be alleviated as standards that promote plug-in and come-and-go mature and as IT infrastructure becomes real “utility,” like electricity.

We focus on industries in which IT resources represent the dominant costs to produce or deliver the products or services, although we believe the insights are also applicable to other industries facing outsourcing (or rent-vs.-own) decision (Shy and Stenbacka, 2003). Many Internet-based companies exhibit these characteristics, for example, Second Life (virtual world), Flickr (photo hosting/sharing), Picasa (photo hosting/sharing), YouTube, Skype, MySpace, Facebook, Twitter, eBay, Shutterfly (providing album design kit) and Playfish (gaming). In addition, companies producing services without the need for face-to-face interactions or digital goods (e.g., motion pictures) also represent good examples.

³ The above definition of “on-demand” does not concern about how it is implemented at the provider side but just how it is offered, as long as it possesses the properties outlined above. Many giant software companies claim to provide on-demand computing but charge hefty upfront fees for using these services; these will not be considered as on-demand services in this paper, rather, they are more like conventional IT outsourcing instead (Waugh, 2005). Amazon Web Service (AWS), on the other hand, represents a true on-demand example as it requires no upfront cost at all.
Among these firms, many have already embraced on-demand services model to build their IT infrastructure. For example, Playfish, a fast growing social games company,\(^4\) operates entirely on Amazon Web Services (AWS). By utilizing Amazon’s distributed infrastructure across the globe, Playfish can more quickly and reliably deliver its games to millions of players. Gumiyo, an online mobile commerce provider, also runs a complete production environment on Amazon Web Services. Monografias.com, one of the largest Latin American community-built content sites with tens of thousands of original essays and over 2 million unique visitors per day, also runs entirely on AWS.\(^5\) With on-demand services, it is possible for anyone with an idea and an Internet connection to quickly put together a company and be in business (Laudon and Laudon, 2010). We seek to address the following research questions:

1. **How does the on-demand model affect the adopting firms’ market performance, in terms of pricing, profitability and market competition?**

2. **Will the on-demand model take off? Will it replace the "owning" strategy?**

3. **What is the welfare implication?**

Since the key to analytical modeling is to capture the essentials of the problems by abstracting away from the details, we develop a model to capture the distinctive features of on-demand services, namely, its cost structure (mainly variable cost), elimination of capacity constraint and fast setup time (therefore, quick entry by potential entrants when there is an opportunity). Our model also considers the barriers of adopting on-demand services, such as privacy/security concerns and switching costs.

Overall, our results identify that the relative cost efficiency of building internal IT infrastructure (i.e. the owning strategy) versus the on-demand strategy, the potential size of the market, the capacity constraint associated with building internal IT infrastructure, barriers from using on-demand services as

\(^4\) Playfish creates games for friends to play together over social and mobile platforms such as Facebook, MySpace, Bebo, Yahoo!, iPhone, iPod Touch and Android. Playfish’s mission is to change the way people play games by providing more social and connected experiences. Each of the company’s titles has been a top 10 hit on Facebook, including Pet Society, which is the platform’s most popular game – and single biggest app – and enjoyed by more than 11 million people every month. As of May 2009, Playfish had more than 27 million active monthly users and has multiple games in the top 10 on Facebook. http://www.playfish.com

\(^5\) http://aws.amazon.com/solutions/case-studies
well as market conditions (i.e., constraints on the number of firms/products) are important factors to understand the adoption and effects of the on-demand model. We identify conditions when firms will adopt on-demand services. We also find that while on-demand services greatly reduce a firm’s profitability in markets where there is no constraint on firm entrance with same or similar products. In markets where the number of firms/products are constrained (i.e., products are substantially differentiated and stay that way), on-demand services can actually increase market prices and help firms further enhance their profitability at the expense of the customers. Therefore, contrary to the common belief that on-demand services is best for firms offering commodity products, on-demand services is more profitable for firms with differentiated products. In addition, our results suggest that competition and the threat of new entrants (the fact that a potential entrant can enter the market by on-demand services quickly and cheaply) can be an important driver of a firm’s decision to switch to on-demand services. Moreover, an incumbent firm’s barriers from using on-demand services can negatively influence a potential entrant’s entry decision, suggesting that a key success factor for the on-demand services to take off is to alleviate the incumbent firms’ barriers from adopting the on-demand model.

The rest of the paper is organized as follows. In the next section, we survey relevant literature. Section 3 introduces our model, and analyses and results are presented in Section 4. We consider two extensions in Section 5. Section 6 concludes the paper.

2. Literature Review

This research relates to the literature on buy vs. rent, IT outsourcing and ASP (Application Service Provider) pricing, and general outsourcing in the economics literature.

In general, the decision of whether to buy or rent an asset is essentially a decision of whether to pay a flat fee for unlimited consumption or to pay for each time of consumption. Flat-fee vs. pay-per-use pricing has been widely studied in the literature. Marketing literature has considered the tradeoffs of offering flat-rate and pay-per-use options in different settings, such as health club membership, telephone calling plans and home videos (Knox and Eliashberg, 2009) as well as consumers’ choices given the flat-rate and pay-per-use options (Lambrecht & Skiera, 2006). Information Systems literature also considered
when it is optimal to offer fixed-fee pricing vs. usage-based pricing in the context of information goods/services (Sundararajan, 2004; Wu and Banker, 2010). Varian (2000) has also identified several circumstances where content providers’ profits can increase with information goods sharing and renting. However, the focus of this literature has been on the service providers’ profits and strategy but does not concern about the market implications or the consequence of the service providers’ strategy on the market structure.

IT Outsourcing is a phenomenon where a user organization (client) transfers property or decision rights over IT infrastructure to an external (vendor) organization (Loh and Venkatraman 1992). Previous literature on IT outsourcing has looked at the determinants of a firm’s make-vs.-buy decision (Malone et. al. 1987; Gurbaxani and Whang, 1991; Ang and Straub 1998; Grover et al. 1996; Apte and Mason 1995; Wholey et al. 2001; DiMaggio and Powell, 1983; Loh and Venkatraman, 1992; Ang and Cummings, 1997), and contract design between the service provider and the client to deal with the relationship-specific investments involved in conventional outsourcing (Whang, 1992; Richmond et al., 1993 and Gopal et al. 2003). Since on-demand computing is essentially one form of IT outsourcing because it leverages the provider's expertise to support a cost-effective, reliable platform to run business, the extensive literature on IT outsourcing is relevant. However, on-demand computing in our paper differs from traditional IT outsourcing considered in previous literature in several unique ways. First, on-demand computing is digitally-enabled outsourcing over the Internet based on standard interfaces and functionalities that are available to all user firms, while conventional outsourcing usually involves the delivery of a dedicated, customized infrastructure, with technologies and services tailored to a firm's unique needs. Second, conventional outsourcing often entails the transfer of human and physical assets from the client to the service provider, who in turn "leases" those resources back to the customer (Thomas, 2003). As a result, conventional outsourcing usually involves a fixed payment for a specific amount of output during a usually long contract period. In other words, conventional outsourcing arrangements are better described as a hierarchical relationship (Gurbaxani and Whang, 1991), while the on-demand model is toward a market-based relationship. These distinctive properties of on-demand services open a new
array of research questions. This research therefore extends the IT outsourcing literature by considering this newly available outsourcing arrangement, which is digitally enabled and market-based. In addition, the focus of most of the existing literature on IT outsourcing has been limited to the relationship between a service provider and a user firm. This research complements the literature by considering the market implications from adoption of on-demand services, specifically the impact of on-demand services on the equilibrium market prices and competition in the markets.

Our research also adds to recent studies on ASP (Application Service Provider) and SaaS (software-as-a-service) markets. ASP and SaaS are certainly special cases of the on-demand model. Several papers looked at the determinants or tradeoffs of adopting ASPs or SaaS (Smith and Rupp, 2003; Hagel 2002; Murphy 2005; Singh, Shelor, Jiang, and Klein 2004; Sharma and Gupat, 2002; Xin and Levina, 2008). Some other papers study the contract design and pricing of ASP/SaaS services (Cheng and Koehler, 2003; Susarla, Barua, and Whinston, 2003; Ma and Seidmann, 2004). These papers focus on the relationship between vendors and adopting firms. Our paper investigates the impact of a firm’s choice of infrastructure design on the market it operates in, by providing a stylized model that captures the major tradeoffs and the unique differences between on-demand services and the traditional “owning” approach. This allows us to understand the long-term impact of the new technology on the adopters’ performance, which, to our knowledge, has not been studied before.

This paper is also related to the economics literature on outsourcing. In particular, this paper is highly relevant to Shy and Stenbacka (2003), which investigates a firm’s outsourcing decision in a Hotelling model with two (brand-producing) firms and substantially differentiated products. In their model, a firm can produce the input in its own plant by investing F to create the production line for the input or by purchase the input from the input supplier with a constant price. Two major results are that outsourcing increases price; second, despite of market structure in the input-producing industry, the equilibrium is that both brand-producing firms will buy from the same input-producing firm, suggesting that one dominant input-producing firm is likely. While we do also find outsourcing increases price in the case that products are substantially differentiated, we are able to point out the source of this feasibility of
price increase is due to constraints on the number of firms/products. In case that there is no barrier preventing firm entry with similar products, then outsourcing with on-demand services will lead to competitive market by lowering prices because on-demand services create a fast and cost-efficient way for any potential entrant to enter the market when there is positive profit to be made. Moreover, we extend this research by considering barriers of outsourcing, such as privacy and security costs and switching costs. In addition, while Shy and Stenbacka (2003) has put more focus on input-producing market, we consider richer settings of the market structure of the end product market, e.g., when products are not perceived as different or when there are no constraints preventing similar products to be offered by firms, and when markets are not saturated or when markets are non-existent (i.e., demand not served at all) prior to the era of on-demand computing; all these settings are not considered in Shy and Stenbacka (2003).

3. Model

Consider a market where firms face a downward-sloping demand curve in any given period: \( D(p) = a - p \) (or equivalently, \( p = a - D \)), where \( p \) is the market price for the goods, and \( a \) captures the potential market size (in terms of total number of output units) and \( D \) is the market demand.\(^6\) In each period, the firms in the market compete by setting output to maximize the profit.\(^7\) To avoid confounding effects, we assume that output is perishable, in the sense that output in one period cannot be used in later periods. This is relevant to the nature of many computing resources/demand. For example, when computing resources are used to serve customer transactions, one cannot predict what transactions will be performed next, and computing resources cannot be allocated until the transactions actually occur. Similarly, for storage, one cannot store data in period 0 in advance for data need in the next period, unless the data is also stored there in the next period.

There are two IT infrastructure alternatives (or technologies), \( F \) and \( V \), that a firm may adopt in order to produce goods or delivery service to be sold to their customers. The \( F \) technology indicates proprietary

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\(^6\) Note this downward-sloping demand curve is widely adopted in the microeconomics and IO literature.

\(^7\) We also check the results when firms compete by setting price, and all insights obtained hold. This is because a Cournot output game with endogenous entry and no entry barrier works like a Bertrand price game. As a result, they achieve the same results.
infrastructure and technology, while the V technology represents on-demand services. The key differences between the two technologies are their differences in cost structure, the elimination of capacity constraint and fast setup time by on-demand services. However, firms may also face barriers (e.g., privacy and security concerns and switching costs, etc.) from adopting on-demand services. These differences are reflected in the following setup.

**F technology:**

The F technology is characterized with high per-period fixed cost $f$, which are the costs associated with operating and maintaining the technology, which may include expenses related to IT staffs, infrastructure support, ongoing maintenance, data backup services, software licenses, application upgrades etc. For example, at the beginning of the year, a firm has to make commitment on resources required to operate proprietary technology, ensure data security and integrity and determine the amount of maintenance and intensiveness of backup etc., for the entire year. The amount of this per-period fixed cost determines the capacity a firm has in a period. Note that this per-period fixed cost is different from the initial purchase cost for technology. The initial purchase cost is a one-time cost to “own” the technology. However, without incurring the operating and maintenance costs, the technology remains unproductive. In addition, since a technology usually, if not always, lasts for several periods, therefore, the operations and maintenance costs (i.e., the per-period fixed costs) are recurring every period. It has been argued that the maintenance and operating costs associated with technology are several times of the initial purchase price of technology, therefore, the per-period fixed costs in which maintenance and operating costs are included play more important role in future technology strategy when new technology becomes available. In fact, for any existing firms with their own in-house technology, the initial acquisition costs of technology are already sunk, therefore, they should not influence the decision of whether to switch to on-demand services in the future. To reflect reality that many existing firms already have their own “in-house” technology before on-demand services become widely available, we assume these costs are sunk and do not explicitly model such costs. For new entrants, the inclusion of the initial purchase costs for F technology will, of course, just make the “owning” strategy even less attractive compared to on-demand
services, i.e. the V technology. We also note that while the per-period fixed cost determines the maximum capacity, it is NOT necessarily linked to the actual output level. That is, the firm may use or produce less than the maximum capacity. This per-period fixed cost, \( f \), is defined in the same fashion as in the literature (see e.g., Tirole, 2003, pp. 307-308).\(^8\) Given this definition of per-period fixed cost, once this per-period fixed cost is committed, the marginal cost involved in producing output in the same period is minimal (which we normalize to zero) up to the maximum capacity, \( \bar{q} \). Note also the output is not necessarily tangible; it can be intangible service capacity. This suggests that the cost curve for \( F \) technology is a stepped function (Figure 1). Moreover, for our analysis, we assume \( \frac{a}{2} \leq \bar{q} \leq a \) (denoted as A1) in order to accommodate potential competition among firms.\(^9\)

**V technology (i.e., on-demand services)**

The V technology characterizes on-demand services, which is externally hosted, managed and maintained, and thus the per-period fixed cost associated with using such technology is minimal compared to the case of owning and maintaining in-house infrastructure.\(^10\) As noted by the CEO of MileMeter, a firm adopting the utility computing: “*I don’t need to have a systems administrator or a network administrator by running my business on Amazon Web Services.*” Recall that Amazon Web

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\(^8\) To be clear, there are two types of fixed costs involved (Tirole, 2003, Ch. 8) to build in-house infrastructure. First, a firm may incur a one-time cost (\( s \)) to purchase and install the technology, which may be a sunk cost (depending on whether the firm can liquidate the investments or not). Second, a firm also incurs per-period (e.g., per year) fixed costs, \( f \), to support and maintain the technology infrastructure. For the purpose of this study, we do not explicitly consider the sunk cost, \( s \), for two reasons. First, we may assume that the sunk cost associated with \( F \) technology is already amortized into the per-period fixed cost \( f \). Second, our main interest of this paper is to study, given any market condition (or equilibrium) under the traditional technology \( (F) \), how the new technology may change the market prices and competition. Since existing firms already incur the purchase costs, therefore, such costs should not play a role in future technology strategy. All qualitative results/insights still hold even if we include \( s \) in the model, because the inclusion of sunk cost, \( s \), to our model only affects the initial market condition when only \( F \) technology is available by increasing the thresholds of market entry decisions under \( F \) technology, but the qualitative results remain.

\(^9\) Since \( a/2 \) is the monopoly output, we assume the capacity is greater than \( a/2 \), so that the monopoly outcome is achieved. On the other hand, we assume that the capacity is no greater than the potential market size to allow room for competition.

\(^10\) External technology ownership is reflected in our model in the following ways: 1. a firm adopting on-demand services does not have to incur any fixed costs to operate and maintain its own technology. This is captured by the absence of fixed costs for using on-demand services. 2. Since technology is setup and maintained externally, a firm adopting on-demand services does not have to go through lengthy deployment cycle and complicated upgrade process from time to time, as a result, it can enter a market quickly when there is profit to be made. This is reflected by our assumption that a potential entrant can enter market quickly when there is an opportunity.
Services (AWS) provides various computing resources and services to companies on a per usage basis without any upfront cost. Therefore, we normalize the (per-period) fixed cost associated with the \( V \) technology to zero.  \[11\] Another distinctive property of the \( V \) technology is that it offers firms the flexibility by allowing firms to pay for what they use. Without loss of generality, we assume that an adopting firm pays a unit cost of \( c \) for each unit of output (i.e., on-demand services provider charges the firm \( c \) for each output). That is, a firm’s capacity can be easily adjusted at the per-unit cost \( c \), thus the cost curve for \( V \) technology is a smooth one (Figure 1). The scalability of the on-demand model has been cited as one of the major reasons of why firms adopt it as a primary way to build their IT infrastructure.

Another distinctive property of \( V \) technology is fast setup time. This is captured in our model by assuming that a potential entrant can enter the market with \( V \) technology right away when there is an entry opportunity. We also assume that firms may face different levels of barriers from using the \( V \) technology to reflect the current reality. For example, some firms may feel that on-demand services will endanger privacy and security concerns (denoted by \( ps \)), while some other firms may feel that established service providers are more able to safeguard their privacy and security due to economies of expertise by these specialized providers and are in favor of them (i.e., \( ps=0 \)). Firms switching technology from \( F \) to \( V \) may also face switching costs (denoted by \( sc \)). Since new companies and startups have nothing to lose, especially since they do not have or cannot afford their own in-house technology, they likely face low barriers of adopting on-demand services, and in fact, many may appreciate the expertise provided by on-demand service providers (i.e., \( ps=0 \)). On the other hand, existing firms likely face higher barriers from adopting the \( V \) technology due to possible switching costs (\( sc \)) on top of possibly also higher privacy and

\[11\] While some costs (e.g., Internet services) are still needed in using on-demand services, the costs of the Internet and the hardware to use on-demand services are actually marginal, compared to the hefty fixed costs of creating, operating and maintaining the IT infrastructure in house. The key in this assumption is that everyone can afford this inexpensive costs associated with using on-demand services, therefore, these costs do not present barriers of adoption. Same is true with using electricity, water or phone services, in which we also have to pay a certain fixed fee to use them, but these costs are so small compared to running own power generators, etc. and as a result can be ignored without changing the results qualitatively. Also, even though some on-demand services providers do charge upfront fees, these fees are again small compared to running proprietary infrastructure. On the other hand, zero upfront fee is also widely used (e.g., Amazon; please also see more examples given in the introduction of the paper). Furthermore, charging a non-trivial non-zero upfront fee would be just another special case of the \( F \) technology, rather than true “on-demand” given most industry people’s definition.
security concerns \((p_s)\) because of valuable information they have accumulated over time. To reflect the different concerns faced by these different firms, we model potential entrants and existing firms differently. Specifically, we assume that a fraction of potential entrants do not face any privacy and security concern (i.e., \(p_s=0\)) for using \(V\) technology, and that there are always potential firms waiting to enter a market with \(V\) when there is profit to be made in the market and when \(V\) technology is available. This reflects reality because in this Internet age and with the on-demand solution, everyone with an idea can enter the market if the market presents profitable opportunities. For existing firms with in-house technology, on the other hand, they likely faces non-zero barriers \((p_s+sc)\) from using on-demand services, and these barriers will lower the benefits from using \(V\) technology and will therefore influence a firm’s decision of whether to switch technology.

\[\text{Figure 1: Cost structures for } F \text{ and } V\]

Although the above model for \(F\) and \(V\) are simplified, they do capture the distinctive nature of the on-demand model compared to the traditional strategy, specifically, its cost structure (mainly variable cost), elimination of capacity constraint and fast setup time as well as its barriers of adoption. We also point out that what matters the most to the analysis is the relative magnitudes of fixed costs and marginal costs between these two technologies as well as the presence/absence of capacity constraint, which our model captures, and the insights from our research should still hold as long as the fixed cost of \(V\) is much smaller than the fixed cost of \(F\) such that a significant number of potential entrants can afford it, and the marginal cost of \(F\) is much smaller than the marginal cost of \(V\).
Table 1 outlines the symbols we use in the main model.

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<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
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<tr>
<td>(a):</td>
<td>The potential market size in terms of total number of output units in the product market.</td>
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<tr>
<td>(c):</td>
<td>The cost per unit output faced by firms from using (V) technology (i.e., the price charged by on-demand services providers).</td>
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<tr>
<td>(D):</td>
<td>The market demand.</td>
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<tr>
<td>(F):</td>
<td>The proprietary in-house technology.</td>
</tr>
<tr>
<td>(f):</td>
<td>The per-period fixed cost of the (F) technology.</td>
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<tr>
<td>(p):</td>
<td>The market price for the goods produced by firms.</td>
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<tr>
<td>(ps):</td>
<td>Privacy and security concerns from using the (V) technology.</td>
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<tr>
<td>(q):</td>
<td>The maximum capacity associated with the use of the (F) technology.</td>
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<tr>
<td>(s):</td>
<td>The sunk cost of the (F) technology.</td>
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<tr>
<td>(sc):</td>
<td>Switching costs for existing firms switching technology from (F) to (V).</td>
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<td>(V):</td>
<td>On-demand services.</td>
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We assume that in pre-\(V\) period (capturing the time before the arrival of the new technology \(V\)), only the \(F\) technology is available, and the firms first make the entry decisions simultaneously and then make the output decisions simultaneously given the entry decisions. We derive the equilibrium under this case to represent the market conditions when only \(F\) technology is available. Note that without any change in technology, the market is in stable condition and no more firms may enter the market because entering entails a loss. When \(V\) technology, i.e. on-demand services, becomes available, it presents a new opportunity to all firms: for existing firms, they can change their technology if the on-demand model offers higher profits; for new firms, it opens opportunities to enter a market not possible otherwise. Note that for the purpose of the paper, pre-\(V\) period (when only \(F\) is available) is simply added to illustrate that several different market conditions can be formed and also to establish the number of incumbent firms (which have in-house technology) in these markets. Our interest, however, is the post-\(V\) period results, i.e. how the availability of \(V\) may change existing market conditions, in particular, whether there is new entry and whether the incumbent firms will switch to \(V\) or not.
In post-V period, we assume that V technology becomes available to any existing and potential firms. The fast setup time and flexibility of capacity properties of V allows any potential firm to enter the market at any time. Note also the per-period fixed cost associated with F expires at the end of a period (while the technology is still there and will remain productive as long as the firm incurs another per-period fixed cost). Given that the initial purchase cost of technology is sunk, the incumbent firms can choose between continuing with F by incurring another per-period fixed cost or switching to V technology completely in the post-V period. All firms that are in the market compete by setting output. Our main interest is to study how the availability of the V technology may change the firms’ pricing, technology choice, and profitability.

4. Analysis and Results

4.1 Base Case: When Only the F Technology is Available (Pre-V period)

Benchmark Case 1 (Derivation of Market Conditions under F technology): During pre-V period, only F technology is available, the market is characterized as follows (Figure 2):

- (O1) When \( f > \frac{a^2}{4} \), there is no market at all.
- (O2) When \( \frac{a^2}{9} < f \leq \frac{a^2}{4} \), the market is characterized by a natural monopoly, with market price \( \frac{a}{2} \).
- (O3) When \( 0 < f \leq \frac{a^2}{9} \), the market is characterized as oligopoly (i.e., the market has more than one firm) with market price \( \frac{a}{(n+1)} \). Mathematically, when \( \frac{a^2}{(n+2)} < f \leq \frac{a^2}{(n+1)} \) (for \( n \geq 2 \)), the market is characterized as a n-player market.

![Figure 2: Pre-V period: Equilibrium market structure when only F technology is available](image)

\(^{12}\) Please see the Appendix for proofs of all Results and Propositions.
Benchmark Case 1 establishes the “pre-V” market conditions a firm faces. It shows that when the traditional high fixed cost $F$ technology is the only choice for firms, the market structure is affected by how high the per-period fixed cost, $f$, is. When the fixed cost is too high, no firm may afford to enter the market, and the demand is not served in this market. As the fixed cost lowers, the market may sustain more and more firms when firms compete by setting output level. The result that fixed costs form entry barrier and generate imperfectly competitive market is a standard result from the economics literature.

Benchmark Case 1 forms different “pre-V” market conditions to study the impact of the $V$ technology. Denote the firms existing in pre-V period as the incumbent firms. In the following section, we consider the case when $V$ technology becomes available and show how it affects market competition given different “pre-V” market conditions to start.

**4.2 When the $V$ Technology Becomes Available (Post-$V$ period)**

We are most interested in how the availability of the $V$ technology in post-$V$ period will change the market outcome obtained in pre-$V$ period (i.e., Section 4.1 when only the $F$ technology is available), specifically, how the availability of the new technology affects a potential entrant’s entry decision, an incumbent firm’s technology choice, pricing and profitability. As noted earlier, introduction of new technology presents a new opportunity to both existing firms and potential entrants: for existing firms, they can change their technology if new technology provides higher profits; for new firms, it opens opportunities to enter a market not possible otherwise. Also note that new firms will ONLY enter the market when the privacy and security concerns from using $V$ are not significant; those face high barriers from using $V$ will not choose to enter at all. As noted earlier, new companies and startups have not much to lose, and we assume there are potential firms with $ps=0$ waiting to enter the market as long as there is positive profit to be made.

In this new period, the incumbent, which adopted the $F$ strategy in pre-$V$ period, will decide whether they will continue their $F$ technology by incurring another per-period fixed cost, $f$, or will switch to the new technology $V$ or quit. An incumbent firm likely faces higher barriers from switching to the $V$ technology; such barriers may include privacy and security concerns (i.e., $ps>0$) and switching costs from
switching from $F$ to $V$ (i.e., $s_c > 0$). As a result, the relative benefits from switching to $V$ compared to sticking with $F$ will be lowered by $p_s + s_c$.

We denote an incumbent’s and a potential entrant’s equilibrium strategies with the pair $(X, Y)$, in which $X \in \{F, V, 0\}$ indicates the incumbent’s decision of using $F$ or $V$ or drop out the market, and $Y \in \{F, V, 0\}$ represents a potential entrant’s strategy: $F$ stands for entry with the $F$ technology, $V$ for entry with the $V$ technology, while 0 denotes no entry for the potential entrant. We now consider how market structure would change when the $V$ technology becomes available.

4.2.1 The Impact of $V$ Technology on Monopoly Markets

This represents the case (O2) from Benchmark Case 1. Under these conditions, the market has only one firm (call it the incumbent) in the market when only $F$ technology is available. We are interested in the following questions: How would the market structure change when the $V$ technology is now available to any firm? Will a potential entrant enter the market, although it would not do so if only the $F$ technology is available? What is the price equilibrium in the market?

We consider first whether an entrant will enter the market when $V$ technology becomes available and the price it will charge when using $V$ technology, assuming that the incumbent continues to use the $F$ technology. Since the three distinctive properties of the $V$ technology may play different roles in driving competition, we unpack the effects in order to get a deeper understanding by investigating the effects brought by each property. We first consider how the move to variable cost impact competition, absence of fast setup time and elimination of capacity constraint.

13 Note that there can be more than one incumbent or entrant. In addition, even though we derive the equilibrium under a one-shot game, the equilibrium is the same for each period in a repeated game after $V$ becomes available. This is because the presence of $V$ technology and the assumption of perishable output make intertemporal issues, such as tacit-collusion (when Folk theorems apply) or entry deterrence by the incumbent, irrelevant. With $V$ technology, an entrant does not need to face the prohibitive fixed costs to enter and does not need to face any loss even if it enters and faces no demand. As a result, it is not a credible threat for the incumbent to make a loss in the current period in order to deter entry because the entrant can enter at a later period when the incumbent depletes its resources or raises its prices. For the same reason, $V$ technology also makes it impossible for existing firms in the market to collude to maintain positive profit. This is because there is no barrier of entry, and any firm can keep entering whenever there is a positive profit to be made, aside from the fact that it is also difficult for all firms to coordinate on a strategy to make tacit collusion equilibrium hold.
**Result 1:** When there are \( n-1 \) entrants with \( V \) technology \((n \geq 1)\) and one incumbent,

(a) When the incumbent uses \( F \) and capacity constraint does not bind,\(^{14} \) the market price is \( \frac{\alpha + (n-1)c}{n+1} \).

(b) When the incumbent uses \( F \) and when capacity constraint binds (i.e., corner solution achieved),

\[
\text{the market price is } \frac{a-q+(n-1)c}{n}.
\]

(c) When the incumbent uses \( V \), the market price is \( \frac{\alpha + nc}{n+1} \).

Comparing Result 1 to the price obtained in the Benchmark case, firms are able to pass some of the variable cost to consumers when one or more firms use the \( V \) technology. As \( n \) increases, a firm will be able to pass more variable cost to consumers. Whether a firm can make positive profit or not thus depends on the number of firms in the market, whether the profit is high enough to cover the residual variable cost, and for the incumbent, it also depends on the tradeoff between reduction of fixed costs and the residual variable cost. Although market price increases with \( c \), a firm using \( V \) also faces higher residual variable costs and is less likely to make a profit out of a high cost.

The most interesting properties of on-demand services are fast setup time and elimination of capacity constraint, enabling fast entry by any firm at any time. Our next result shows that, when on-demand services are not too costly, these properties make it impossible for any firm to make positive profit and would deplete all market profits.

**Result 2:** In the presence of the \( V \) technology, the magnitude of \( c \) determines whether a potential entrant with \( ps=0 \) will enter and the type of market the incumbent will face, given the incumbent uses the \( F \) technology to compete:

- When \( c > \frac{a}{2} \), no other firm enters. The incumbent continues to be the monopolist.

\(^{14} \frac{\alpha + (n-1)c}{n+1} \leq \bar{q} \)
- When \( a - q \leq c \leq a \), the market becomes a competitive monopoly market (i.e., a contestable market). That is, there is only one firm in the market, yet the equilibrium price is at the competitive level (as opposed to the monopoly price).

- When \( c < a - q \), there is entry and the equilibrium price is at the competitive level, \( c \).

The key takeaway from Result 2 is that fast setup time and removal of capacity constraint associated with on-demand services intensify competition and lead to perfect competitive market, regardless of the number of firms in the market, as long as on-demand services is not too costly. Specifically, Result 2 suggests that when the unit cost of on-demand services faced by firms is not too costly (\( c \leq \frac{a}{2} \)), it greatly erodes the incumbent’s monopoly power, which the incumbent enjoys when \( F \) is the only technology available. When \( c \leq \frac{a}{2} \), the equilibrium market price will be \( c \) no matter how many firms are in the market.

When \( a - q \leq c \leq \frac{a}{2} \), the incumbent is able to keep all entrants out by credibly threatening to price a little bit lower than \( c \) and serve all market demand \((a-c)\) in case an entry occurs. However, even though the incumbent can prevent entry and is the only operating firm in the market, it will not price higher than the competitive price, \( c \). This is because for any price above \( c \), there is positive profit to be earned for an entrant, so any price above \( c \) will promote entry, given there are potential entrants waiting to enter the market if there is positive profit to be earned (note that with \( V \) technology, prompt entry is possible because of fast setup time empowered by on-demand services). Thus, the market changes from monopoly to competitive monopoly when \( V \) technology becomes available. On the other hand, when \( c < a - q \), the incumbent cannot prevent entry even by lowering price. This is because even with a price lower than \( c \), the incumbent cannot serve all market demand given its capacity constraint, and the unserved demand will still be willing to pay for \( c \) for an entrant’s product/service. Even so, an entrant cannot profitably price above \( c \) either because again positive profits attract more entrants until all profits are depleted.
Therefore, when the cost of using $V$, $c$, is low enough, the market changes from monopoly in pre-$V$ period to a perfect competitive market after $V$ becomes available.

Given Result 1 and Result 2, a following question to address is whether the incumbent, as the only firm with the $F$ technology in pre-$V$ period, will continue to use the $F$ technology after $V$ becomes available. We summarize the market equilibrium in Result 3 and Proposition 1.

**Result 3**: (Technology choice by the incumbent) When the marginal cost associated with $V$ is relatively high ($c \geq \max\{\frac{f'}{q}, a - \sqrt{a^2 - 4f'}\}$, where $f' = f - psI - sc$ and $psI$ is the incumbent firm’s privacy and security concerns associated with the use of $V$ technology and $sc$ is the switching costs of switching from $F$ to $V$), the incumbent continues to use the $F$ technology by incurring per-period fixed cost, $f$; when it is relatively low ($c < \max\{\frac{f'}{q}, a - \sqrt{a^2 - 4f'}\}$), the incumbent abandons the $F$ technology and switches to the $V$ technology or drop out the market (Figure 3a, b).

Result 3 shows that $c$ (relative to $f$), $psI$, $sc$, $a$ and $\bar{q}$ determine whether an incumbent firm will switch to on-demand services or not. A firm is more likely to switch as $c$, $psI$, $sc$ and $\bar{q}$ get lower and as $a$ gets higher. As expected, privacy and security concerns ($psI$) and switching costs ($sc$) will increase the barriers to switch to the $V$ technology. In the case where on-demand services have become so cheap that entry cannot be prevented, an incumbent which faces high barriers of using on-demand services may be forced to drop out of the market or adopt on-demand services and let-go these barriers. Result 3 is also interesting because classical economic and strategy literature suggests that fixed cost represents a form of entry barrier, and entry barriers bring market power to the firm (Porter, 1985; Tirole, 2003). However, fixed costs as a form of entry barrier applies to the situation where all firms face the same technology. When the new technology is relatively cost efficient and the cost savings outweigh the strategic benefit of entry barrier associated with maintaining the in-house infrastructure, Result 3 suggests that the incumbent should abandon its proprietary technology and its seemingly “advantageous” position.
**Proposition 1**: (Firm strategy and price equilibrium) Based on Results 1, 2 and 3, we can summarize firm strategy and the price equilibrium in the following diagrams (Figure 3a, b). Recall that firm strategy is denoted with the pair \((X, Y)\), in which \(X \in \{F, V, 0\}\) indicates the incumbent’s decision to use F or V or exit the market, and \(Y \in \{F, V, 0\}\) represents a potential entrant’s strategy, in which 0 denotes no entry.

- **When the capacity constraint associated with \(F\), \(\overline{q}\), is large** (mathematically,
  \[
  \frac{a + \sqrt{a^2 - 4f'}}{2} \leq \overline{q} \leq a \quad \text{or equivalently,} \quad \frac{f'}{\overline{q}} \leq \frac{a - \sqrt{a^2 - 4f'}}{2} \quad \text{where} \quad f' = f - ps - sc
  \]
  ![Figure 3a](image)

- **When the capacity constraint associated with \(F\), \(\overline{q}\), is relatively small** (mathematically,
  \[
  \frac{a}{2} \leq \overline{q} < \frac{a + \sqrt{a^2 - 4f'}}{2} \quad \text{or equivalently} \quad \frac{f'}{\overline{q}} > \frac{a - \sqrt{a^2 - 4f'}}{2}
  \]
  ![Figure 3b](image)

A few interesting observations can be made from Proposition 1:

1. It shows that when the capacity constraint associated with \(F\) is relatively large (Figure 3a), then either there is only the incumbent firm in the market with \(F\) technology, or there are multiple firms in the market and all use \(V\) technology. That is, only one of the two technologies (\(F\) and \(V\)) may
exist in the market. This result suggests that it is still possible for an incumbent to prevent entry with new technology by investing in expanding capacity, although this is a very costly strategy and can deplete the incumbent firm’s profit quickly too.

2. We can also see from Figure 3a that as the barriers of using $V$ faced by the incumbent increase, the cutoff point from $(V, V)$ to $(F, 0)$ decreases. That is, in anticipation of the incumbent being more likely to stick to $F$ technology because of higher barriers of switching to $V$, a potential entrant, regardless of level of privacy and security concerns, will choose not to enter at all even when the cost of $V$, $c$, doesn’t change. This result is interesting as it shows that barriers of using new technology, such as the privacy and security concerns and switching costs, faced by incumbent firms can influence market outcome by influencing other firms’ entry decisions.

3. When the capacity constraint associated with $F$ is in the lower range, then there is a region where both technologies may coexist in the market (Figure 3b) -- the incumbent will retain $F$ technology while the new entrants will adopt the $V$ technology.

4. Our results also suggest that the $F$ technology may be completely replaced by the $V$ technology when the cost of the $V$ technology relative to the $F$ technology is low ($c < \max\{\frac{f'}{q}, \frac{a - \sqrt{a^2 - 4f'}}{2}\}$).

Therefore, as the variable cost of the new technology keeps dropping (due to economies of scale from more firms adopting it or advance in technology) and when the barriers such as privacy and security concerns and switching costs from using on-demand services are low, we may see all firms adopt on-demand services.

Overall, Proposition 1 suggests that the presence of the $V$ technology will erode monopoly power greatly. Under very general condition of $c \leq \frac{a}{2}$, the incumbent is forced to lower its price from $\frac{a}{2}$ (the monopolistic price) to $c$ (the competitive price, which is also the unit cost under the $V$ technology) even though it may still be the only firm in the market. The driver of this result is the fast setup time and flexibility of capacity empowered by $V$ technology, which enables any potential entrant to enter the
market at any time. On the other hand, the unit cost of using \( V \) to produce output determines market price. Accordingly, the market expands, as measured by the purchasing demand, from \( \frac{a}{2} \) to \((a-c)\). Another interesting finding of our result is that the new technology is more likely to have a higher impact on markets with larger potential sizes since the condition depends on \( a \). That is, we will see \( V \) technology more likely to sustain in larger markets, and will be adopted in these markets earlier than in smaller markets.

4.2.2 The Impact of \( V \) Technology on Markets That Are Non-Existent

This represents the case when \( f > \frac{a^2}{4} \), i.e. (O1) in Benchmark Case 1, where the fixed cost associated with the \( F \) technology is so high that no firm enters when the \( F \) technology is the only technology available in the market. It is straightforward to show that the introduction of the \( V \) technology makes markets that are otherwise non-existent feasible under very general conditions.

**Proposition 2:** Markets that do not otherwise exist under the \( F \) technology are always feasible under the \( V \) technology as long as \( c \leq a \).

Proposition 2 shows that as long as the cost of the new technology is not too high, new markets will be created. This result is driven by the conversion of fixed cost technology to variable cost technology. Without hefty fixed costs, a market can be served as long as the variable cost to serve the demand is not too large. We have observed many web startups taking advantage of on-demand services to capitalize their ideas. For example, Powerset, which provides service for natural language search, are able to enter this new market without hefty setup costs by using on-demand services (Laudon and Laudon, 2010). This is one of the important values created by on-demand services. This result suggests that new technology not only has an impact on existing firms, but can also bring new values to the market by providing new products/services and fulfilling new demand. Previous research studying the value of IT focused mainly on the business value accrued to firms utilizing it. However, it is also important to consider the value
accrued to the consumers and the value from new markets in order to fully estimate the value created by IT.

4.2.3 The Impact of V Technology on Competitive Markets

This represents the case of (O3: $0 \leq f \leq \frac{a^2}{9}$) in Benchmark Case 1 when the market has more than one firm under the $F$ technology.

**Proposition 3:** In a duopoly or oligopoly market under $F$ technology, the presence of the $V$ technology changes the market to a perfect competitive market.

This result is driven by fast setup time and flexibility of capacity associated with the use of $V$ technology, which enables any firm to enter the market right away when there is positive profit to be made. The market price again is determined by the unit cost associated with using $V$ technology.

Altogether, these results suggest consumer surplus increases with the availability of the $V$ technology because of lower prices in the market. In addition, social welfare also always (weakly) increases as a result of reduction of deadweight loss (because of lower prices) and/or creation of new markets.

5. Extension:

We have established many interesting results in the previous section. In this section, we try to investigate whether the insights obtained in the previous section still hold by relaxing two assumptions used in the previous analysis: constant unit cost from using $V$ technology and no constraints on the number of firms/products in the market. This allows us to better understand the impact of on-demand services under different market conditions.

5.1 Non-linear usage fee for using $V$ technology

In the previous sections, for analytical tractability, we assumed constant unit cost (or linear usage fee) faced by firms using $V$ technology. Although many on-demand services providers charge constant unit cost (e.g., AWS), several on-demand services providers try to lock in their clients by charging non-linear usage fee in the form of quantity discount. In this case, a firm using on-demand services faces lower marginal costs when they produce more, leading to economies of scale. The economics literature has
suggested that economies of scale tend to lead to winner take all (or natural monopoly) market since a firm can serve market demand more cheaply than two firms can, each serve half of the demand. An interesting question to ask is whether the insights that V technology can easily lead to competitive market still hold when V technology also entails economies of scale.

To investigate this, we relax the assumption by assuming that on-demand services providers charge nonlinear usage fee in the form of quantity discount for firms using V, this translates to decreasing marginal costs faced by firms adopting V. Consider a general function where unit cost faced by a firm using V is decreasing in the quantity purchased: $C(q) = c \times (1 - \frac{b}{2}q)$ where $q$ is the quantity purchased, and $b$ is the volume discount parameter. When $b=0$, it becomes constant unit cost considered before, and as $b$ gets bigger, the discount becomes bigger as more quantity is purchased. To ensure that marginal cost is always positive, we need to pose a constraint on the magnitude of $b$ where $b < \frac{1}{a}$. The total costs faced by a firm which produces $q$ output and uses V technology is therefore a concave function $T(q) = C(q) \times q = c \times \left(1 - \frac{b}{2}q\right) \times q = -\frac{bc}{2}q^2 + cq$. This cost function suggests that there are economies of scale in using V, making V even more attractive compared to the case of constant unit cost. Moreover, it also suggests that a firm has more advantage the more it produces/purchases under V technology because it faces lower costs. An implication is that the market is more competitive when there is only one firm with V technology in the market. When there is competition with V technology with quantity discount, the price level is actually higher compared to the case of only one firm with V technology. This is because a firm can get lower costs by producing more and therefore price lower. We first examine the effect of nonlinear usage fees of V on product pricing, absence fast setup time and removal of capacity constraint.

**Result 4:** When there are $n-1$ entrants with V technology and one incumbent,

(a) When the incumbent uses F and capacity constraint doesn’t bind, the market price is

$$\frac{a(1-bc)+(n-1)c}{n+1-2bc},$$

which is decreasing in $b$. 
(b) When the incumbent uses F and capacity constraint binds (i.e., corner solution achieved), the market price is \( \frac{(a-\bar{q})(1-bc)+(n-1)c}{n-bc} \), which is decreasing in \( b \).

(c) When the incumbent uses V, the market price is \( \frac{a(1-bc)+nc}{n+1-bc} \), which is decreasing in \( b \).

Result 4 suggests that higher quantity discount (or higher economies of scale) would lead to lower pricing because of lower average costs faced by firms using V compared to the case of no economies of scale. Our next result shows that fast setup time and removal of capacity constraint can intensify competition even in light of economies of scale.

**Result 5:** (Entry decision and market structure) In the presence of V technology and non-linear usage fee \( T(q) \) with using V, the magnitude of \( c \) determines whether a potential entrant with \( p_s=0 \) will enter and the type of market the incumbent will face, given the incumbent uses the F technology to compete:

- When \( c > \frac{a}{2} \), no other firm enters. The incumbent continues to be the monopolist.

- When \( a-\bar{q} \leq c \leq \frac{a}{2} \), the market becomes a competitive monopoly market. That is, the incumbent remains the only firm in the market, yet it cannot price above \( p_c = \frac{(2-ab)c}{2-bc} \), which equals to \( c \) when \( b=0 \) (no quantity discount) and decreases as \( b \) increases.

- When \( c < a-\bar{q} \), there is always entry and all new entrants make zero profits, and the incumbent cannot price above \( p_c = \frac{(2-ab)c}{2-bc} \), which equals to \( c \) when \( b=0 \) and decreases as \( b \) increases.

Result 5 shows that all insights from Result 2 still hold except that the competitive price under the case of non-linear usage-based pricing becomes even smaller when there is volume discount. When \( b=0 \) (no volume discount), it becomes \( c \), exactly what is derived in Result 2. As \( b \) increases, price decreases. That is, as the volume discount with the use of V technology increases or as economies of scale increases, we can expect that lower market price will be attained, regardless of the number of firms in the market. This seems to be intuitive as firms can expect lower average cost under volume discount compared to the case without. Therefore, lower market price is expected as a result of lower average cost. On the other
hand, it is also surprising. The literature has suggested that when there are economies of scale, it can lead to natural monopoly as a first mover can take advantage of lower costs by producing more and drive other entrants out of the market. However, under V technology with economies of scale, even though a firm can still expect lower costs by producing more, market price is driven low too, leading no extra advantages. This is because in the presence of V technology, an entrant can still always come in right away when there is positive profit to be made. This threat of prompt entry makes it impossible for a firm to make positive profits even in the presence of economies of scale, since it is a credible threat for a new entrant to take away all demand by pricing a little lower. This is made possible because of the two properties of V: fast setup time and no capacity constraint.

We next investigate how economies of scale from using V affect an incumbent’s decision of using F or V. Similar to the arguments before, in equilibrium, any firm using V will attain a profit of zero, this is because there will be potential firms enter the market as long as there is profit to be made and a potential firm can easily take all demand away by pricing a little lower. Therefore, equilibrium profit of using V is zero as before, regardless of the number of firms or whether the firm is incumbent or not. An incumbent’s decision to switch to V or not therefore depends on the profit it can obtain by keeping F. As shown in Result 4, when there is volume discount, the market price will be lower, therefore, the incumbent will face lower profits when c is not too high. Since the profit that can be achieved using F decreases, while the profit and barriers of using V remain the same, the incumbent becomes less likely to keep F and more likely to switch to V when V technology offers economies of scale.

We also verify that propositions 2 and 3 still hold in the case of non-linear usage fee with using V. There is, however, one thing worth noting, which we summarize below.

**Proposition 4**: when on-demand services providers charge non-linear usage fee $T(q)$ with $b > 0$ (i.e., there is economies of scale from using V), in equilibrium, there is only ONE firm in the market with V technology (there might be other firms using F but only one firm with V), yet the firm with V makes zero profit.
This result is very interesting as it suggests that even though the market is competitive when \( V \) technology becomes available, in equilibrium there is only one firm in the market with \( V \) technology when there is economies of scale using \( V \) technology to produce. This is because it is cheaper for a single firm to serve demand than having two firms splitting demand, and one firm can always successfully drive out entry by producing more and charging less. However, even as the only firm in the market, this firm cannot make positive profit because doing so invites entry, and an entrant can always come in and take all demand away by pricing lower—again, a result empowered by fast setup time and no capacity constraint with the use of \( V \) technology.

5.2 Differentiated Goods Market: When there exists constraints that prevent firms from offering products that are perceived the same

In the model considered in Section 3, there is no constraint preventing firms from offering same or similar products. As shown in our results, in such a market, the availability of \( V \) technology can lead to perfect competitive market easily since \( V \) technology makes it credible for a potential entrant to come in promptly when there is positive profit to be made, and makes it not possible to earn supranormal return even when there is only one firm in the market. While in many markets, especially in the digital world, it is difficult to prevent firms from offering similar products to enter the market, in some markets, legal mechanisms or technology constraints may exist that prevent firms from offering products that are perceived the same. We investigate how this product constraint affects the results obtained before. Necessary insights can be obtained by considering a simple setting of the Hotelling model with at most two firms (and two products). The Hotelling model is the most widely used model for considering limited competition with differentiated products, and is also the model considered by a relevant paper, Shy and Stenbacka (2003), that studies a firm’s outsourcing decision. In the case that there is no limit in competition, all our previous results hold.

In the Hotelling model, consumers are uniformly distributed with density 1 on a “linear city” of length 1 (from 0 to 1). Consumers’ preferences are reflected by their locations on the line. Consumers demand at most one unit of the good and have a reservation price, \( r \), for their ideal good. For a good that
is not ideal for a customer, the consumer will incur a “misfit cost” per unit of length, t, from their ideal good. Note that t captures the degree of differentiation and a firm’s market power. The smaller t is, the better substitutes the two goods become, and the less market power the firms have. Given this, the utility a customer at location x gets from a good, say at 0, with price P will be r-P-tx. Technology characteristics are as described in Section 3.

Similar to Shy and Stenbacka (2003) as well as all other studies based on the Hotelling Model, we consider the case that firms’ products or services are exogenous, which suggests that firm locations on the line are fixed, according to the terminology of the Hotelling model. A firm can employ whatever available technology of their choice to produce and/or deliver their products or services. As noted earlier, given the assumption that there is constraint preventing firms from offering identical products, no firm co-locates. We consider the simplest case that would give us the necessary insights by assuming that there are only two feasible product/service configurations: 0 and 1 on the line. Several reasons, such as technology constraints, patent coverage, and/or firms’ capabilities, may lead to limited number of product offerings. That is, we consider the case that the market can accommodate at most two firms. Note that in the case that there is no restriction on firm locations (i.e., more than one firm may co-locate or firms can locate anywhere on the line), firms will keep entering whenever there is positive profit to be made, and it will eventually crowd the line and become the cases considered in Sections 3 and 4, and the results there would apply.

As before, our main interest is to consider how the V technology will change the market structure in pre-V period. Similar to the previous setting, we assume that a firm considering adopting on-demand services may face barriers of adoption, which may include privacy and security concerns and switching costs etc., and such barriers may influence a firm’s technology decision and entry decision. Several interesting results, summarized in Proposition 5, are found:

**Proposition 5:** When there are constraints on the number of firms and products offered, after V becomes available,
(a) There is always entry in a market characterized as natural monopoly in pre-V period as long as
\[ c \leq \frac{t}{2}. \] Incumbent will switch from F to V when \( c \leq \frac{t}{2} \) and when the barriers of using V faced by
the incumbent is below a certain positive threshold. The profit of the incumbent increases despite
there is competition now as long as \( r < 2t \).

(b) In a market characterized as two direct-competing firms (both use F) in pre-V period and assume
the barriers of switching to V faced by these two firms are \( ps_A + sc_A \) and \( ps_B + sc_B \), the
following figure summarizes the technology choices by the two firms in equilibrium:

![Figure 4: Firm Strategy under different combinations of f and c with no barrier of using V. When
firms face barriers of using V, the lower curve is moving up by \( \min \{ps_A + sc_A, ps_B + sc_B\} \) while
the upper curve is moving up by \( \max \{ps_A + sc_A, ps_B + sc_B\} \). (Note: there are two firms in the
market, A and B, and their strategies are summarized with the pair \((X, Y)\)]](image)

(c) Prices always goes up when one or more firms adopt the V technology.

Proposition 5(a) states that the on-demand services will saturate markets that are not yet saturated by
inviting entry. That is the maximum number of firms allowed in market will be achieved. In our case, we
assume the maximum number of firms allowed in the market is two, so there will always be two firms in
the market with the availability of V technology. When the constraints are removed, then we can expect
there is no limit of entry and entry will keep coming until all profits are depleted, and results obtained in
Section 4 will apply. In addition, even when the incumbent faces positive privacy and security concerns
and switching costs, the incumbent firm may still choose to abandon the F technology by not committing
to the per-period fixed cost required to use $F$ when on-demand services become available. As a result, when privacy and security concerns and switching costs from adopting on-demand services are alleviated, the $F$ technology may be completely replaced by on-demand services in markets that are previously characterized as a monopoly market. Moreover, we find that, in contrast to the case of market where there is limited constraint preventing firms from offering similar products, in which the incumbent profit always goes down when there is entry, the incumbent’s profit can actually increase in the face of new entry made possible by the new technology as long as $r<2t$. This is because the firms may pass the variable cost to customers by increasing their prices when customers value different goods, while they would absorb the fixed cost when the $F$ technology is used.

Proposition 5(b) characterizes the conditions when both $F$ and $V$ can co-exist and when $F$ may be completely replaced by $V$. Consistent with the finding from Shy and Stenbacka (2003), we show that a firm’s technology choice (or outsourcing decision in their terminology) relies on the relative cost efficiency of the $F$ and $V$ technologies. We add to this research by showing how such technology choice is also affected by firms’ respective barriers of using $V$. Specifically, several observations are in order:

1. According to the lower curve in Figure 4, the likelihood of $V$ being adopted in the market increases with $f$ and decreases with $c$ and $\min\{ps_A + sc_A, ps_B + sc_B\}$. That is, when $V$ technology becomes more cost efficient relative to $F$ technology and when any one firm faces less barriers from using $V$, $V$ will be adopted by some firm in the market.

2. The region of $(V,V)$, where all firms adopting $V$, increases with $f$ and decreases with $c$ and $\max\{ps_A + sc_A, ps_B + sc_B\}$. That is, when $V$ technology becomes more cost efficient relative to $F$ technology and the barriers from using $V$ are generally low, we will start to see $F$ technology being completely replaced by the $V$ technology.

3. Furthermore, the region, where firms adopting different technologies, increases with differences in firms’ barriers (i.e., $\max\{ps_A + sc_A, ps_B + sc_B\} - \min\{ps_A + sc_A, ps_B + sc_B\}$). This suggests

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15 When consumer reservation price is very high ($r>2t$), a firm is still better off being a monopolist because it can charge hefty monopoly price that is a function of $r$. 

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that on-demand services are more likely to co-exist with $F$ technology when firms face very different barriers from adopting $V$.

4. An interesting observation from Figure 4 is that firms that were symmetric under the $F$ technology may adopt different technologies when the $V$ technology becomes available. For example, when both firms face the same barriers or no barriers and when 

$$\frac{C}{3}(1 - \frac{C}{6t}) \leq f \leq \frac{C}{3}(1 + \frac{C}{6t})$$

we have one firm choosing $F$ and the other firm choosing $V$. This result establishes a case when asymmetric firms may be the equilibrium without assuming any firm heterogeneity ex ante.

In contrast to results obtained in Section 4, which suggest the availability of $V$ technology creates downward pressure on firm prices, Proposition 5(c) shows that firm prices can go up with the adoption of the $V$ technology when there are constraints on the number of firms/products allowed in the market. This suggests that consumer surplus could go down with the $V$ technology. This is because while there is positive variable cost, $c$, firms actually pass, all or a part, of this, to the customers. In the case of the $F$ technology, firms have more incentive to reduce price (and less incentive to reduce supply) because the variable cost is zero, which then leads to higher competition. On the other hand, with on-demand services, the positive variable costs make firms less likely to engage in such price competition. This is evident from the prices charged by firms. Specifically, when both firms choose the $V$ technology, the prices charged by them are $p_A = p_B = t + c$, while the prices are $t$ when both of them adopt the $F$ technology. So all variable costs are passed over to customers, and customers pay a higher price for the same product/service. In the case that only one of the firms switch to the $V$ technology, a part of the variable cost is passed over to the consumers. While traditional view of outsourcing suggests that increasing outsourcing enabled by IT would lower prices and benefit buyers (Grover and Ramanlal, 1999), we show that this does not apply to markets where there is barrier that prevents firms from offering identical products/services, in which case, on-demand services can actually amplify the “barriers,” allowing firms to further raise prices and reduce consumer surplus.
This finding that prices can go up with outsourcing replicates what is found in Shy and Stenbacka (2003), which considered a two firm market in the same Hotelling model. However, we are able to point out the source of this increase in prices is due to constraints on the number of firms/products, and outsourcing helps to amplify this “barriers” of entry for incumbent firms. Outsourcing alone without constraints on entry does not convey this price-increase advantage to firms. As shown in Section 4, when there is no constraint on firm entry (beyond the fixed costs associated with technology choice, if F technology is chosen), then outsourcing (on-demand services) will in fact lead to lower prices (competitive prices).

We would also like to point out that although the literature has shown that firms have more incentives to reduce price when marginal costs are zero, and this is why we observe higher competition in industries with high fixed costs, like in the airline industry. However, in this literature, firms essentially face the same technology (or cost structure); it does not consider whether availability of fundamentally different technology will strengthen or relieve this result. Our results suggest that on-demand services can make such an already competitive market even more competitive when there are no constraints on the number of firms/products allowed in the market (Sections 3 and 4). In the case where the number of firms/products is constrained, on-demand services can make the market even less competitive even though more firms may be in the market in post-\(V\) period.

6. Discussion and Conclusions

On-demand services, powered by increasing electronic interconnections around the globe and standardized interfaces, have promised companies a cheaper and more efficient way of doing business. In the ideal world of on-demand services, it can free companies from huge operation and maintenance costs as well as long deployment cycle and frustrating upgrade processes over time associated with in-house infrastructure and applications by allowing them the flexibility to pay or rent the functionality they need on a per-module or per-usage basis. We investigate the impact of on-demand services on firm strategy and market structure.
The unique properties of on-demand services are the conversion of fixed cost technology to variable
cost technology, fast setup time and elimination of capacity constraint (therefore, quick entry by potential
entrants when there is an opportunity), while privacy and security concerns have been noted as the biggest
barrier from adopting on-demand services. With a stylized model capturing the benefits and barriers of
using on-demand services, we have established several interesting results.

In general, we show that the conversion of fixed cost to variable cost enables entry and leads to
creation of new markets, which are not feasible under fixed cost technology. This explains why many web
startups are able to enter and survive markets even in markets where products and services are difficult to
differentiate. For example, Jungle Disk, Vembu and Zmanda in the rather homogeneous online data
backup service industry; Sorenson Media and Twistage in the online video platform industry; and
TicketLeap and TicketMaster in the online ticketing industry; all of these firms use Amazon Web
Services (AWS) to provide their services. Moreover, we have also observed many new products/services
being offered with on-demand services. For example, Gumiyo, the first end-to-end mobile commerce
platform, has had a complete production environment running on the AWS platform (just within three
weeks) since the beginning. Tal.Kit, enabling users to create a forum in the Web sites, also runs 100% on
AWS. 99designs.com, which provides a design marketplace to connect designers around the world with
design-deficient clients, also runs entirely on AWS today.\(^{16}\) We expect to see more innovative products
and services being offered as on-demand services become even cheaper.

On the other hand, fast setup time and elimination of capacity constraint associated with on-demand
services would wipe out market profit completely because it enables any firm to enter the market anytime
when there is positive profit to be made, leading to competitive market even when there is only one firm
in the market. This explains why a firm in this digital age is difficult to obtain supernormal return even
when there seems no “competition” or no identical product is present. On the other hand, in markets
where there exist barriers that prevent similar products to be offered, we show that the market prices and
profit level of the incumbent can increase further even though there is competition due to new firm

entering the market with on-demand services. Also, surprisingly, we find that consumer surplus can actually go down with the introduction of on-demand services where firms sell differentiated goods and barriers are present that prevent entry with similar products. This is because firms can actually pass, all or a part, of the variable cost to the customers when they choose the variable cost technology over the fixed cost technology, while in the case of $F$ technology, competition is more intense because firms have incentive to lower prices when firms incur mainly fixed costs. This suggests that on-demand services can amplify any market barriers by further enhancing firms’ profitability at the expenses of the customers. When market barriers do not exist, then on-demand services lead to lower prices. Overall, these results suggest that the impact of on-demand services depend on whether any market barriers are present.

We also identify conditions when firms decide to “rent” rather than to “own” a technology. In cases where the market is competitive and all firms use the $F$ technology when it is the only choice, we show that firms may change their technology choice when on-demand services become available. Under some conditions, firms may end up adopting different technologies, resulting in equilibrium with asymmetric firms without any assumptions of ex ante firm heterogeneity. We also show that the threat of new entry with availability of on-demand services can make an incumbent firm switch to on-demand services. These results may explain why there are many companies switching from the in-house infrastructure to on-demand services. For example, Monografías.com, the largest educational site in Spanish, has moved away from an in-house technology (which they have used for more than 10 years) and runs entirely on AWS today. Pixamba, a business software development and media services company, and Unfuddle, a company provides bug and issue tracking, also switched from the limit-capacity and high-fixed-cost infrastructure to AWS entirely. In some cases, we find that an incumbent firm’s barriers from using on-demand services can negatively influence a potential entrant’s entry decision, suggesting that a key success factor for the on-demand services to take off is to alleviate the incumbent firms’ barriers from adopting the on-demand model.

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17 http://aws.amazon.com/solutions/case-studies
One major contribution of our study is that our analyses provide theoretical foundation and evidence for the potential of on-demand services. For providers of on-demand services, our results suggest that the unit cost faced by firms and barriers from using on-demand services (especially those faced by incumbent firms with own in-house infrastructures) are important factors to the future of on-demand services. Since small firms and startups likely face smaller barriers of using on-demand services, we have seen thousands of startups being created with on-demand services. However, to have on-demand services become the dominant “infrastructure” choice for all firms, it is important to reduce the barriers faced by incumbent firms with own in-house infrastructure. How to ensure data security and privacy at both the implementation and perception levels and lower switching costs faced by incumbent firms are important tasks for on-demand services providers. Our results also offer promise to startups or any entrepreneur with ideas that they would be able to survive in the markets with the use of on-demand services. Our results also offer guidance to incumbent firms (i.e., those with in-house infrastructure) regarding whether they should change their technology strategy or not.

Another interesting application of our model is that it can be used to study the fee structures for on-demand services providers or similar outsourcing service providers. Typically, a service provider charges either a fixed fee per period (analogous to the $F$ technology) or per-usage cost (analogous to the $V$ technology). As shown in this paper, the fee structure can have important implications on the market outcome and pricing structure in the market.

While our paper has provided some interesting insights regarding the potential development and impact of on-demand services, our analyses also have some limitations. First of all, we do not consider the market of on-demand services, and we take the price charged by on-demand services provider as given (this is applicable when there is only one on-demand services provider or when the market of on-demand services is competitive so all firms offer the same price). We do not think the insights obtained in our research will change even if the market of on-demand services is considered. Shy and Stenbacka (2003) has studied how market structure of input-producing firms impact firms’ outsourcing decision and showed that in equilibrium, all firms will choose the same input-producing company. This offers evidence
that all firms face the same cost of on-demand services. We also did not consider the costs in vendor selection, contracting, adopting and integration costs for on-demand services, although the costs associated with these activities are likely to be much lower compared to traditional outsourcing or purchasing own technology, and they are likely to be further reduced as on-demand services advance. In addition, in reality, it is also possible that firms face different costs in acquiring different technologies. It will be an interesting question to explore how different costs face by different firms influence market outcome.

Second, we do not consider how on-demand services influence product design/offerings. Although some people argue that outsourcing and the use of common infrastructure can lead to lower product differentiation, we believe that on-demand services can reinforce a product differentiation strategy because on-demand services free firms from high operation and maintenance costs and allow firms to focus more on their core business issues and product innovations rather than on technology. Many firms find the on-demand computing model reduces the burden of maintaining technology, allowing firms to free up resources to do smarter and more creative things.\(^\text{18}\) This is the spirit of “utility” computing: while water and electricity are critical for all firms, using it on-demand allows firms to focus more on product innovations. On-demand’s lower costs reduce the risk of trying out new ideas, which encourages imaginative entrepreneurs to take more chances (Maneker, 2011), and contrary to common belief, it may foster product differentiation and enhance quality. As pointed out in Laudon and Laudon (2010), by providing Amazon Web Services (AWS), Amazon hopes one day to make it possible for anyone with an idea and an Internet connection to begin to put together the next Amazon.com. Firms should be competing based on their ideas, not based on whether to own the computing technology (or power generator) or not, the whole idea of “on-demand services.” It will be an interesting future research to examine whether product differentiation will increase or decrease with on-demand services.

Third, our approach also does not consider the case when the demand may be stochastic over time due to the market uncertainty. However, our model can apply to the cases when the \textit{expected} potential

market demand is the same over time and when the firm has to make decisions before the end market demand is realized.

Forth, we assume the privacy and security costs take the role of “fixed” costs, regardless of demand. This is applicable when we assume a firm can make an infrastructure investment to protect privacy and security, regardless of how much data is stored. However, one can also argue that privacy and security costs increase with demand. In this case, it can be accommodated in our model by adding a constant term to the variable cost, or an alternative explanation is that part of the variable cost paid is related to privacy costs.

Future research can also extend this research by considering quality of service of on-demand services. In practices, on-demand services providers may offer different level of services and different cost structures. Also, while we assume each firm will choose one of the technology choices, it is interesting to investigate if the firm would mix both. Exploring how the complementarity between the two technologies affects market structure and firm competition could provide new insights about the impact of the on-demand model. In addition to operational efficiency, on-demand services also have the potential to improve customer relationship and satisfaction and enhance product/service quality (Krishnan, et. al. 1999), which may change the demand function in the market. This is also an interesting area to expand this research.

Reference:


