On Demand Web-based Services: Implications and Market Structure

Pei-yu Chen
Tepper School of Business
Carnegie Mellon University
Email: pychen@andrew.cmu.edu

Shin-yi Wu
Information Technology & Operations Management Division
Nanyang Business School
Nanyang Technological University
Email: sywu@ntu.edu.sg
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Abstract

This paper investigates the impact of a digitally enabled outsourcing-- on demand web-based services-- as a way to build a firm’s supply management infrastructure. In contrast with traditional proprietary infrastructure maintained by firms, this new IT architecture, in the form of on demand supply management infrastructure, is characterized by plug-and-play, as a result of standardization, and the shift of fixed cost investments to variable cost computing, with which the adopting firm can “pay-as-you-go.” We show that the availability of this new IT architecture to build a firm supply infrastructure would lead to a more competitive market as it reduces the entry barrier to a market. We also study technology adoption in the market. We find conditions when both the new and old approaches to build supply infrastructure may coexist in the market, and when the proprietary infrastructure may be completely replaced by the on demand supply infrastructure. The impact of this new IT architecture on firm profitability is also investigated. Interestingly, the impact depends on the type of competition in the market: the availability of on demand Web-based services greatly reduces firm profitability in markets where firms sell homogeneous products; however, in markets where firms sell differentiated products, the new IT architecture may help firms enhance their profitability at the expense of the consumers.

Keywords: Web-based services, on demand, outsourcing, new IT architecture, technology adoption.
1. Introduction and Motivation

Investments in supply management infrastructure, including hardware, software and integration that are required to make business up and running, have represented the dominant expenses for firms. More recently, the increasingly intense global competition has created enormous pressures for firms to cut costs and improve their business performance, and many firms no longer see the strategic benefits of actually “owning” technology, either software applications or hardware, which has led firms to re-evaluate their supply management infrastructure strategy (Waugh, 2005). This trend together with the increasing electronic interconnections leads to a new outsourcing arrangement which is digitally enabled: on demand Web-based services. In specific, on demand Web-based services offer externally hosted and managed applications, content and services that are delivered as Web-based services and that offer flexible pricing models (Waugh, 2005).

The on demand solution—that grants firms the flexibility to purchase just the functionality they need in support of their supply management infrastructure -- is powered by the development of Web services, which are constructed on the Internet and employ an open and modular approach that promises to achieve interoperability and integration between disparate (or incompatible) software applications and systems (Hagel III and Brown, 2001). Although there are still many barriers to overcome to standardize server environments and there is still a long way to go to achieve seamless interoperability and integration, the technology market sees a need toward standardization and has prepared for it. Many big players in the market have made great efforts in formulating their Web services strategies that employ open standards in order to provide a platform capable of supporting different applications and systems, and made massive investments in the necessary infrastructure that is capable of supporting the real on demand
supply management for clients. For example, the “e-business on demand” pushed forward by IBM, the “.Net” strategy by Microsoft, “open network environment” by Sun, “network services” by Oracle and “Adaptive Enterprise” by HP. Albeit different names from different vendors, the goal of these strategies is to reduce the barriers for firms to buy or rent their information technologies as services provided over the Internet rather than owing and maintaining all their hardware and software internally (Hagel III and Brown, 2001).

The on demand solution offers several benefits compared to traditional infrastructure procurement strategy that results in a proprietary supply infrastructure. First of all, it cuts down the up-front fixed costs to build up the supply management infrastructure, such as the purchases and installations of hardware and software, as well as the expenses required for ongoing support and maintenance, not to mention the burden to integrate and deal with a mishmash of usually incompatible systems, due to the piecemeal technology purchases over time. Second, it reduces the setup time dramatically, increases operations efficiency and removes capacity constraints, allowing firms to adapt quickly to changes and opportunities in the marketplace — especially in a dynamic environment with rapid technology innovation and great business uncertainties. Faster cycle time and being responsive have been noted as important factors that drive firms to adopt outsourcing (Apte and Mason, 1995). As an example to demonstrate the benefits of on demand approach, Fluor, the $9 billion engineering and construction giant based in U.S., was able to cut down its fixed costs associated with IT from 95% to 25% and cut costs by a total of $85 million, after embracing the on demand solution. It was also able to set up a process in 70 hours, which would have taken three months if Fluor had bought all the equipment and done the installation itself (Rosenbush, 2004).
Although the on demand solution is essentially one form of outsourcing, which leverages the provider's expertise to support a cost-effective, reliable platform to run business, it differs from traditional IT outsourcing in that on demand Web-based services are digitally enabled outsourcing that is based on open standards. In specific, conventional outsourcing usually involves the delivery of a dedicated, customized infrastructure, with technologies and services tailored to an organization's unique needs, which 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). This 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 approach is toward a market-based relationship, with which, customers are usually not locked into a technology or a contractor for an extended time, rather, they can pay on a per-usage and per-module basis. On demand also differs from its predecessor, Application Service Provider (ASP). Under the ASP model, a hosting provider deploys a unique application instance per user on dedicated servers and charges customers a long-term or perpetual software and maintenance license (Waugh, 2005). On the other hand, the on demand solution offers greater flexibility without the need to make upfront investment commitment to purchase anything. Users can deploy the “platform” solutions consisting of multiple application modules and services, or they can unbundle the solution elements and pay only for the functionality or processes needed, owing to the open and modular nature of Web services.

This new approach for building the supply management infrastructure resonates particularly well for small businesses since it provides a way of getting capabilities and agility that is too expensive or too difficult to get otherwise. For bigger firms, this new business model also allows
them to increase operational efficiency, without having to worry about issues typically associated with traditional outsourcing arrangement. Indeed, in the ideal world of on demand Web-based services model, the standardized and pay-as-you-go nature of this new IT architecture reduces the concerns of lock-in and potential hold-up by the contractor, one of the most serious concerns for outsourcing, and thus makes it feasible to have a marketplace for on demand supply management. According to a recent research project conducted by AberdeenGroup in March 2005, on demand is already widely used: about 45% of companies surveyed have active on-demand supply management programs. Another 22% plan to initiate programs within two years. American Express Co., Saks, Goodyear, DreamWorks, and US Open are some well-known organizations that have deployed the on demand solutions.

In sum, the on demand solution provides a new way to construct supply management infrastructure for firms—characterized by plug-and-play and the shift of fixed cost from traditional proprietary infrastructure to a variable cost strategy with “pay-as-you-go”. This new IT architecture is termed by Hagel III and Brown (2001) as “Your Next IT Strategy” and is believed to be the third major revolution in the IT world, after mainframes and the Internet (Hamm, 2003). We are interested in studying how the availability of this new IT architecture may affect firm strategy and market structure (Figure 1).1

![Diagram](attachment:Diagram.png)

**Figure 1: Technology choices for the firm**

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1 Note we use the on demand Web-based services, new IT architecture and new technology interchangeably in this paper, while the old technology (or old architecture) means the old way to procure the proprietary supply infrastructure.
In specific, we seek to address the following research questions:

1. **Can the on demand Web-based services become the dominant way for firms to build their supply management infrastructure?**

2. **How does the availability of on demand solution affect pricing and market competition?**

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

Overall, our results show that the availability of the on demand solution as a way to build a firm’s supply infrastructure reduces the entry barrier to a market, making a market more competitive. We also study the adoption and diffusion of the new IT architecture. We find conditions when the old and new technologies can coexist in the market, and when the old IT architecture (characterized by fixed costs) will be completely replaced by the new IT architecture (characterized by variable costs). The impact of the new IT architecture on a firm’s profitability is also investigated. While we find that the new IT architecture greatly reduces a firm’s profitability in markets where firms sell homogeneous products, very interestingly, in markets where firms sell differentiated products, the on demand solution may help firms enhance their profitability at the expense of the consumers.

The rest of the paper is organized as follows. In Section 2, we describe how the traditional and new technologies are modeled, and study the impact of this new IT architecture on firms selling homogeneous goods in a market. We then extend the case to markets with differentiated goods in Section 3. Section 4 concludes the paper.

**2. The Impact of On Demand on Markets Where Firms Sell Homogeneous Goods**

**2.1. Model Setup**

Consider the simplified supply chain depicted in Figure 1, first consider a market where firms sell homogeneous goods with a downward-sloping demand curve in the market: $D(p)=a-p$, 

\[ D(p) = a - p \]
where \( p \) is the market price for the goods, and \( a \) captures the potential market size (in terms of total number of output units).\(^2\) There are two supply infrastructures (or technologies), \( F \) and \( V \), that a firm may adopt in order to produce goods to be sold to end customers. The \( F \) technology indicates traditional production technology or represents a firm’s choice to build and operate an in-house supply infrastructure, which is associated with a capacity constraint. For example, consider a machine capable of producing at most 100 units of goods per hour, once the machine is installed, the marginal cost for producing each unit (within the 100 units) is relatively small. However, to produce the 101\(^{st} \) unit, the firm will have to purchase another machine, thus the marginal cost for producing this unit is very high. It is clear that the cost curve for \( F \) technology is a stepped curve (Figure 2). To summarize, the \( F \) technology exhibits high fixed cost \( f \);\(^3\) but low marginal cost (which we normalize to zero) up to a certain capacity, \( \bar{q} \); that is, the marginal cost of production is assumed to be 0 up to \( \bar{q} \), and \( \infty \) after \( \bar{q} \). For our analysis, we assume \( \frac{a}{2} \leq \bar{q} \leq a \).\(^4\) In contrast, the \( V \) technology is a variable-cost technology with low fixed cost (which we normalize to zero) but high marginal cost, denoted as \( c \) (which represents the unit price the firm has to pay the service provider). One distinctive characteristic of the \( V \) technology is that capacity can be easily adjusted at a marginal cost \( c \), thus the cost curve for \( V \) technology from the adopting firm’s point of view is a smooth one (Figure 2). This \( V \) technology characterizes the new IT architecture (or the on demand supply infrastructure). Although the

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\(^2\) Note this downward-sloping demand curve is widely adopted in the microeconomics and IO literature.

\(^3\) We define fixed cost in the same fashion as previous literature did (Tirole, 1995). In specific, the fixed cost is a per-period cost and is only incurred for a positive output level. We also assume that output in one period can not be used in the other period.

\(^4\) Since \( a/2 \) is the monopoly output, we assume the capacity to be 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, since it does not make much sense for a firm to invest more than the potential market size.
above cost structures for $F$ and $V$ are greatly simplified, they capture the distinctive nature of both technologies.

![Diagram showing cost structures for $F$ and $V$](image.png)

Figure 2: Cost structures for $F$ and $V$

The analysis starts by first considering the case when only the $F$ technology is available, which characterizes traditional way of building the supply management infrastructure and represents the status quo. We then study how the availability of the $V$ technology affects market competition and firm pricing and technology choice compared to the case when only $F$ technology is available.

2.2 Base Case: When Only the $F$ Technology is Available

**Result 1:** *When the $F$ technology is the only available technology, the market is characterized as follows (Figure 3):*

- *When $f > \frac{a^2}{4}$, there is no market at all.*
- *When $\frac{a^2}{9} < f \leq \frac{a^2}{4}$, the market is characterized by natural monopoly.*
• When \( 0 < f \leq \frac{a^2}{9} \), the market is characterized as oligopoly. In specific,

\[
\frac{a^2}{(n + 2)^2} < f \leq \frac{a^2}{(n + 1)^2}, \text{ (for } n \geq 2 \text{), the market is characterized as a n-player market.}
\]

![Figure 3: Market Structure when only F technology is available](image)

**Proof:** See Appendix.

Result 1 shows that when the traditional high fixed cost \( F \) technology is the only choice for firms, the market structure is deeply affected by how costly the fixed cost is. In other words, it depends on how high the “entry barrier” is, which in turn determines how many firms the market can sustain. When the entry barrier is too high, no firm may afford to enter the market. As the entry barrier lowers, the market may sustain more and more firms. This is the standard result from classical economic models. In the following section, we consider the case when \( V \) Technology becomes available.

**2.3 When the \( V \) Technology Becomes Available**

We are most interested in how the availability of the \( V \) technology will change the results obtained in 2.2 (i.e., when only the \( F \) technology is available), in specific, how the availability of the new technology affects potential entrant’s entry decision, a firm’s technology choice, pricing and profitability.

We consider a three-stage game. In the first stage, a potential entrant decides whether to enter the market given that a new technology becomes available. In the second stage, the firm decides
which technology to choose. In the third stage, all firms that enter compete by simultaneously setting their output level and then demand realizes. This is summarized in the following:

- Stage 1: entry decision (for any potential entrant)
- Stage 2: technology choice (for any firm in the market)
- Stage 3: output choice

We denote an incumbent’s and an entrant’s equilibrium strategies with the pair \((X, Y)\), in which \(X \in \{F, V\}\) indicates the incumbent’s technology choice, 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. 5

We now consider how the results obtained in Section 2.2 will change when the \(V\) technology becomes available.

2.3.1 The Impact of \(V\) Technology on Markets that are Monopolized Under the \(F\) Technology

This represents the case when \(\frac{a^2}{9} < f \leq \frac{a^2}{4}\). As shown in Result 1 (Figure 3), when \(\frac{a^2}{9} < f \leq \frac{a^2}{4}\), the \(F\) technology will result in a natural monopolist. That is, the market can sustain only one firm (call it the incumbent) with the \(F\) technology. We are interested in the following questions: How would the market structure change when the \(V\) technology is now available to any potential entrants? Will a potential entrant enter the market, although it would not do so if only the \(F\) technology is present? What’s the price equilibrium in the market?

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5 Note that there can be more than one incumbent or entrant.
Result 2: (Entry decisions and market structure) In the presence of the $V$ technology, the magnitude of $c$ determines whether a potential entrant will enter and the type of market the incumbent faces (Figure 4a,b).

- When $c > \frac{a}{2}$, no other firms enter! The incumbent continues to enjoy its monopolist position.

- When $\frac{a}{2} \geq c \geq a - \overline{q}$, the market becomes a competitive monopoly market (i.e., a contestable market). That is, there is only one firm in the market, yet the price is set at the competitive level (as opposed to the monopoly price).

- When $c < a - \overline{q}$, the market becomes a competitive market.

Proof: See Appendix.

This result suggests that when the variable cost of the new IT architecture 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. In particular, when $a - \overline{q} > c$, the market becomes a competitive market, where every firm in the market sets price at the competitive level. For higher value of $c$ but not too high ($\frac{a}{2} \geq c \geq a - \overline{q}$), the incumbent will continue to be the only firm in the market, however, 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 with the same price or a slightly lower price, so any price above $c$ will promote entry, given there are potential entrants waiting to enter the market when there is positive profit to be earned (note with the on demand approach, prompt entry is credible!). Thus, even though the incumbent is the only firm in the market, it
still charges the competitive price \( c \) when the \( V \) technology is present. That is, the market is a competitive monopoly.

Another interesting question to address is whether the incumbent, which is the only firm with the \( F \) technology, will continue to use the \( F \) technology.

**Result 3:** (Technology choice by the incumbent) When \( c \geq \frac{f}{q} \), the incumbent will continue to use the \( F \) technology. On the other hand, when \( c < \frac{f}{q} \), the incumbent will abandon the \( F \) technology and adopts the on demand approach in the long run, and the market is characterized by a perfect competitive market (Figure 4a,b).

**Proof:** See Appendix.

Result 3 is 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 in the markets (Porter, 1985; Tirole, 1995). However, Result 3 suggests that under some conditions \( (c < \frac{f}{q}) \), the incumbent may abandon its seemingly “advantageous” position altogether and acts just like any other firm in the market by adopting the new technology, setting the same price and limiting its output level to a level set by any other new entrant in the market. This is because the cost savings from outsourcing outweigh the strategic benefit of maintaining the high entry barrier. Another implication of this result is that if the variable cost of the new technology keeps dropping (may due to economics of scale from more firms adopting it or technology advancing), the traditional proprietary supply management infrastructure may be completely replaced by the on demand supply management infrastructure.
**Result 4:** (Firm strategy and price equilibrium) Based on all previous results, we can summarize firm strategy and the price equilibrium in the following diagrams (Figure 4a,b). Recall that firm strategy is denoted with the pair \((X, Y)\), in which \(X \in \{F, V\}\) indicates the incumbent’s technology choice, and \(Y \in \{F, V, 0\}\) represents a potential entrant’s strategy, while 0 denotes no entry.$^6$

- When \(a \geq \frac{a}{2} \geq \frac{a + \sqrt{a^2 - 4f}}{2}\):

  \[p = c, D = a - c\]
  \[\pi_i = \pi_e = 0\]

  \(\begin{array}{c}
  (V, V) \\
  a - \bar{q}
  \end{array}\)

  \[p = c, D = a - c\]
  \[\pi_i = c\bar{q} - f\]

  \(\begin{array}{c}
  (F, 0) \\
  \frac{f}{\bar{q}}
  \end{array}\)

  \[p = \frac{a}{2}, D = \frac{a}{2}\]
  \[\pi_i = \frac{a^2}{4} - f\]

  \(\begin{array}{c}
  (F, 0) \\
  a/2
  \end{array}\)

  Figure 4a

- When \(\frac{a}{2} \leq \bar{q} \leq \frac{a + \sqrt{a^2 - 4f}}{2}\):

  \[p = c, D = a - c\]
  \[\pi_i = \pi_e = 0\]

  \(\begin{array}{c}
  (V, V) \\
  \frac{f}{\bar{q}}
  \end{array}\)

  \[p = c, D = a - c\]
  \[\pi_i = c\bar{q} - f\]

  \(\begin{array}{c}
  (F, 0) \\
  a - \bar{q}
  \end{array}\)

  \[p = \frac{a}{2}, D = \frac{a}{2}\]
  \[\pi_i = \frac{a^2}{4} - f\]

  \(\begin{array}{c}
  (F, 0) \\
  a/2
  \end{array}\)

  Figure 4b

$^6$ Note that we assume \(\frac{a}{2} \leq \bar{q} \leq a\) as indicated in subsection 2.1.
Overall, the results suggest that the presence of the $V$ technology will erode monopoly power greatly. Under very general condition that $c \leq \frac{a}{2}$, the incumbent is forced to lower its price from $\frac{a}{2}$ (the monopolistic price) to $c$ (the competitive price, which is also the marginal cost under the $V$ technology) although it may still be the only firm in the market. One interesting implication of this result is that the new technology is more likely to have a higher impact on markets with larger sizes since the condition depends on $a$. In addition, under the conditions, most of the surplus accrues to the consumers in the market. As mentioned earlier, 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 ($c < \frac{f}{q}$). Interestingly, we also find that when the capacity level associated with the $F$ technology is high ($a \geq q \geq \frac{a + \sqrt{a^2 - 4f}}{2}$, or Figure 4a), only one of the two technologies ($F$ and $V$) may exist (i.e., only one technology has the market), but when the capacity level associated with the $F$ technology is at lower range ($\frac{a}{2} \leq q \leq \frac{a + \sqrt{a^2 - 4f}}{2}$, or Figure 4b), the two technologies may coexist in the market (i.e., the incumbent will retain their proprietary supply management infrastructure while the new entrant will adopt the on demand supply management infrastructure.)

2.3.2 The Impact of $V$ Technology on Markets That Are Non-Existent Under the $F$ Technology

This represents the case when $f > \frac{a^2}{4}$ (Result 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. We find that the introduction of the $V$ technology makes markets that are otherwise non-existent feasible under very general conditions. The result is summarized in Result 5.

**Result 5:** Markets that do not otherwise exist under the F technology are always feasible under the $V$ technology as long as $c \leq a$.

*Proof:* See Appendix.

Result 5 shows that as long as the cost of the new technology is not too high, new markets will be created. This is one of the important values created by the new technology. This result suggests that new technology not only has an impact on existing firms, but may bring new values to the market. 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.

### 2.3.3 The Impact of $V$ Technology On Markets That Have More Than One Firm Under the $F$ Technology

This represents the case when $0 < f \leq \frac{a^2}{9}$ (Result 1), when the market has more than two firms (i.e., oligopoly) under the $F$ technology. As before, we are interested in studying the impact of the new technology on the market structure. Using the same proof techniques in Result 2, we can show that:

**Result 6:** When $0 < f \leq \frac{a^2}{9}$, the presence of the $V$ technology changes the market structure from oligopoly to a perfect competitive market.

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

3. The Impact of on demand on Markets Where Firms Sell Differentiated Products

In Section 2, we consider how the availability of on demand as a new way to produce goods affects market structure and firm competition in markets where firms sell homogeneous products. Now we consider the case of firms selling differentiated products in the market, and study how the availability of the new technology affects firm competition in this market.

3.1. Model Setup

To consider the impact of this new approach to build supply infrastructure on markets with differentiated goods, we adopt the classical (also the most widely used) product differentiation model, the Hotelling model. In this 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 product and have a reservation price, $r$, for their ideal product. For a product that is not ideal for a customer, the consumer will incur a “misfit cost” per unit of length, $t$, which also captures the degree of differentiation. Technology characteristics are as described in Section 2.1. Again, we are interested in knowing how the availability of the new IT architecture in the form of variable cost computing affects the competitiveness of the market, pricing and consumer welfare.

We consider the case that firms’ locations on the line are fixed and that each location can accommodate at most one firm (e.g., due to patent protection).\(^7\) Since our focus here is to study

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\(^7\) Note that in the case that there is no restriction on firm locations (i.e., more than one firm may co-locate) or no restriction on firm entry, it eventually becomes the case considered in Section 2, and the results there would apply. In this section, we consider other scenario that would yield different results from what have been obtained in Section 2.
how this new IT (V technology) impacts a firm when there are some restrictions on firm entry, we consider the simplest case that would give us the necessary insights by assuming that the feasible product offers in the market are 0 and 1 on the line, perhaps due to technology constraints and/or firms’ capabilities. That is, we consider the case of at most two firms in the market.8

As before, we consider first the case when there is only the F technology, which represents the status quo, and then we consider how the results may change when the V technology becomes available.

3.2. When Only the F Technology is Available

**Result 7:** *(Market Structure When Only F Technology is Available) (Figure 5)*

- When $\frac{t}{2} \leq f \leq \min\{r-t, \frac{r^2}{4t}\}$: there is only one firm in the market.

- When $0 \leq f \leq \frac{t}{2}$: there are two firms in the market.

![Figure 5: Market Structure When Only F Technology Is Available (The Case of Differentiated Products)](image)

As in the case of markets selling homogeneous products, the “entry barrier”, in the form of fixed cost from the F technology, determines how many firms can be supported by the market when the F technology is the only choice for firms. When the fixed cost is high, only one firm will enter, but as the fixed cost drops, the market may sustain more firms.

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8 That is, the market is saturated when there are two firms. This is a common assumption for models utilizing the Hotelling model.
3.3. When V Technology Becomes Available

Given that there are at most two firms in the market, each with three possible strategies: Don’t enter (denoted as 0), Enter and Adopt F Technology (denoted as F), and Enter and Adopt V Technology (denoted as V), we can establish the payoff matrix under each strategy combination. Without loss of generality, we call the two potential firms in the market as A and B, which are located at 0 and 1 respectively, if they enter the market. We summarize the payoff matrix in Table 1.9

<table>
<thead>
<tr>
<th>B chooses 0</th>
<th>B chooses F</th>
<th>B chooses V</th>
</tr>
</thead>
<tbody>
<tr>
<td>A chooses 0</td>
<td>( \pi_A = 0 , )</td>
<td>( \pi_A = 0 , )</td>
</tr>
<tr>
<td></td>
<td>( \pi_B = 0 )</td>
<td>( \pi_B = r-t-f )</td>
</tr>
<tr>
<td>A chooses F</td>
<td>( \pi_A = r-t-f )</td>
<td>( \pi_A = r-t-f )</td>
</tr>
<tr>
<td></td>
<td>( \pi_B = 0 )</td>
<td>( \pi_B = 0 )</td>
</tr>
<tr>
<td>A chooses V</td>
<td>( \pi_A = r-t-c )</td>
<td>( \pi_A = r-t-c )</td>
</tr>
<tr>
<td></td>
<td>( \pi_B = 0 )</td>
<td>( \pi_B = 0 )</td>
</tr>
</tbody>
</table>

3.3.1 The Impact of V Technology on Markets That Are Monopolized Under the F Technology

This represents the case when \( \frac{t}{2} \leq f \leq \min \{ r-t, \frac{r^2}{4t} \} \) (from Result 7), where the fixed cost associated with the F Technology is so high that the market can sustain only one firm.

9 To make the V technology of practical use, we assume that \( c < t \).
**Result 8:** When \( \frac{t}{2} \leq f \leq \min\{r - t, \frac{r^2}{4t}\} \), the market is characterized as natural monopoly under the F technology. However, with the availability the V technology:

- there is always entry where the entrant adopts the V technology
- the incumbent will also drop the F technology and choose the V technology.
- the profit level of the incumbent can increase even though there is competition.

*Proof:* See Appendix.

This result suggests that the F technology may be completely replaced by the new technology in markets which are previously characterized as a monopoly market. In addition, we find that, in contrast to the case of firms selling homogeneous products where 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 makes in markets where firms sell differentiated products and there are some restrictions on firm entry. This is because the firms are able to pass the variable cost to consumers by increasing their prices when products are differentiated, while they would absorb the fixed cost when the F technology is used (see more discussions in Result 10). This result suggests that market type is an important factor in understanding the true impact of the new technology.

### 3.3.2 The Impact of V Technology on Matured Markets

We next consider the case when the market is “matured” (in the sense that there are already two firms in the market and the market can at most accommodate two firms given our setup), this happens when the F technology is not too expensive \( 0 \leq f \leq \frac{t}{2} \).
Result 9: When $0 \leq f \leq \frac{t}{2}$, the market is characterized by two firms in the market and both adopt the F technology when the V technology is not yet available (from Result 7). When the V technology becomes available, interestingly, firms may change their technology choice according to the relative cost factors of the V and F technology (Figure 6). In specific:

- When $f \leq \frac{c}{3}(1 - \frac{c}{6t})$, both firms continue to use the F technology, thus there is no market for the V technology.
- When $\frac{c}{3}(1 - \frac{c}{6t}) \leq f \leq \frac{c}{3}(1 + \frac{c}{6t})$, one firm will abandon the F technology and opt for the V technology while the other firm will continue with the F technology.
- When $f \geq \frac{c}{3}(1 + \frac{c}{6t})$, both firms will abandon the F technology and adopt the V technology.

![Figure 6: Firm Strategy under different combinations of $f$ and $c$ (Note: there are two firms in the market, A and B, and their strategies are summarized with the pair (X,Y))](image)

This result suggests that the new technology can also have important impact on markets that are already matured. In specific, firms may change their technology choice. Most interestingly,
firms that were symmetric under the $F$ technology may adopt different strategies when the $V$ technology becomes available. For example, 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 is also contrary to classical economic results that usually have symmetric firms in the equilibrium; this result establishes a case when asymmetric firms may be the equilibrium without assuming any firm heterogeneity ex ante.

Another interesting question to explore is how the adoption of $V$ technology affects firm pricing. In markets where firms sell homogeneous products, we have shown that the availability of $V$ technology creates downward pressure on firm prices. Consistent with Result 8, Result 10 shows that firm prices can go up with the adoption of the $V$ technology.

**Result 10:** *(The Impact of $V$ Technology on Pricing)* Equilibrium prices in markets where firms sell differentiated products always increase when one or more firms adopt the $V$ technology.

**Proof:** See Appendix.

This result suggests that consumer surplus can actually go down with the $V$ technology. This is because firms actually pass, all or a part, of the variable cost, $c$, to the customers, while firms absorb the fixed cost and treat it as sunk cost in the case of the $F$ technology, which then leads to higher competition (since firms treat fixed costs as sunk costs). This is evident from the prices charged by firms. In specific, 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 marginal costs are passed over to consumers, and consumers pay a higher price now. In the case that only one of the firms switch to the $V$ technology, a part of the marginal cost is passed over to the consumers. *So contrary to the markets with homogeneous products, where the $V$ technology may erode all the market power a firm has, in markets with differentiated products, the $V$ technology may help firms in enhancing their profitability at the expenses of the consumers.*
While traditional view of outsourcing suggests that increased outsourcing enabled by IT would lower prices and benefit buyers (Grover and Ramanlal, 1999), we show that it depends on the market type. For markets selling differentiated products, increased outsourcing (in our case, through on-demand computing) may actually raise prices and reduce consumer surplus!

4. Discussions and Conclusions

The new IT architecture, in the form of on demand Web-based services, has promised companies a cheaper and more efficient way of doing business. In the ideal world of on demand Web-based services, it can free companies from huge fixed cost investments and long lead time involved in building proprietary infrastructure 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 this new IT architecture on firm strategy and market structure.

We have established several interesting results. We show that the availability of the new technology reduces the entry barrier to a market. In markets where products are considered as perfect substitutes, the presence of the new technology for production greatly erodes the monopoly power of the incumbent, and the new technology may result in a perfect competitive market under very general conditions. We also find conditions when the traditional production technology may be replaced by the new IT architecture. In addition, we find that when the capacity level associated with traditional production technology is high, only one technology will be adopted in the market in equilibrium (i.e., all firms in the market adopt the same technology). Overall, our results indicate that the new IT architecture is welfare-enhancing in markets where firms sell homogeneous products. The increased social welfare comes from two sources: from market expansion (due to lower prices charged by firms) and from the creation of new markets. Consumer surplus also increases with the new technology due to lower prices charged by firms.
For markets where firms sell differentiated products, we find that when the fixed cost associated with building an internal proprietary supply infrastructure is high, there is always entry with the new technology, and the incumbent will also change from in-house to outsourcing by adopting the on demand supply management infrastructure. Most interestingly, the profit level of the incumbent can increase even though there is competition due to the availability of the new IT architecture. In cases where the market is matured and all firms use the \( F \) technology when it is the only choice, we show that firms may change their technology choice when the new technology becomes available. Moreover, under some conditions, firms may end up adopting different technologies, resulting in equilibrium with asymmetric firms without any assumptions of ex ante firm heterogeneity. Surprisingly, we find that consumer surplus can actually go down with the introduction of the new technology when firms sell differentiated goods in the market. This is because firms can actually pass, all or a part, of the variable cost to the customers when they use the new technology, while firms would absorb the cost in the case of \( F \) technology with fixed costs. So contrary to the markets with homogeneous products, where the new IT architecture may erode all the market power a firm has, the new approach to build a firm’s supply infrastructure may help firms in enhancing their profitability at the expenses of the consumers in markets where firms sell heterogeneous products.

One interesting application of our model is that it can be used to study the fee structures for firms offering this new computing paradigms or similar outsourcing services. 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.
Overall, our paper has provided some interesting insights regarding the potential development and impact of the on demand business model. However, our analysis also suffers some limitations. First of all, we do not consider the costs in vendor selection, contracting, adoption and integration for adopting the on demand model, although the costs associated with these activities are likely to be much lower compared to traditional outsourcing and are likely to be further reduced as the Web services architecture is fully adopted. Moreover, some other strategic factors, such as security and potential loss of control, which we do not consider in this paper, may concern firms’ technology acquisition strategy. Future research may want to extend this research by incorporating these strategic factors and consider more complicated cost structure. In addition to operational efficiency, on demand Web-based 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:


Appendix

Proof of Result 1:

Given \( m \) firms in the market, we can derive the equilibrium per-firm revenue, denoted as \( R(m) \).

We say a market can sustain at most \( n \) firms when the condition: \( R(n+1) < f \leq R(n) \) is satisfied.

That is, every firm in the market will make a loss if an additional firm enters.

- When there is only one firm:

  Since the monopoly revenue is \( \max x(a-x) = \frac{a^2}{4} \), with \( x^* = p^* = \frac{a}{2} \), we know that the firm’s total profit (net of investment costs) is at most \( \frac{a^2}{4} - f \). Therefore, the firm will invest in \( F \) as long as \( f \leq \frac{a^2}{4} \) and when \( f > \frac{a^2}{4} \), there is no market at all.

- When there are \( n \) firms (\( n \geq 2 \)):

  Let’s first consider the duopoly case. In the output game, the Cournot-Nash equilibrium \((x_1^*, x_2^*)\) solves:

  \[
  x_1^* = \arg \max (a - x_1 - x_2^*) \cdot x_1 - f \quad \text{and} \\
  x_2^* = \arg \max (a - x_1^* - x_2) \cdot x_2 - f
  \]

  The solution is \((x_1^*, x_2^*) = (\frac{a}{3}, \frac{a}{3})\), thus the total profit is at most \( \frac{a^2}{9} - f \), and a firm will only invest in \( F \) if and only if \( f \leq \frac{a^2}{9} \). So if \( f \) is greater than \( \frac{a^2}{9} \), in equilibrium, only one firm will invest in the \( F \) technology. But when \( \frac{a^2}{16} < f \leq \frac{a^2}{9} \), the market could accommodate two firms. It is not hard to show that when \( \frac{a^2}{(n+2)^2} < f \leq \frac{a^2}{(n+1)^2} \), the market is characterized as \( n \)-player market (\( n \geq 2 \)).
Proof of Result 2:

• Suppose there are \( n - 1 \) new entrants in the market, i.e. there are a total of \( n \) firms in the market including the incumbent. Note that the incumbent has already invested in the \( F \) technology, and we assume the entrant does not want to invest in the \( F \) technology, but opt for the \( V \) technology at marginal cost \( c \). The incumbent’s reaction curve is 

\[
x_I^* = \frac{a - (n - 1)x_E^*}{2}
\]

while each entrant’s reaction curve is 

\[
x_E^* = \frac{a - x_I^* - c}{n}
\]

It is not hard to show that the equilibrium output level is 

\[
x_E^* = \frac{a - 2c}{n + 1} \quad \text{for each entrant}
\]

and 

\[
x_I^* = \frac{a}{n + 1} + \frac{n - 1}{n + 1} c
\]

for the incumbent.

1. If \( x_I^* = \frac{a}{n + 1} + \frac{n - 1}{n + 1} c < \bar{q} \), the market price is thus 

\[
p^* = \frac{a + (n - 1)c}{n + 1}
\]

and the per-firm profit for each entrant is 

\[
\pi_E^* = \frac{(a - 2c)^2}{(n + 1)^2}
\]

Foreseeing this profit, an entrant will enter only if 

\[
p^* - c = \frac{a - 2c}{n + 1} \geq 0 \quad \text{and} \quad x_E^* = \frac{a - 2c}{n + 1} \geq 0
\]

implying that when \( c > \frac{a}{2} \), no entrant enters and the incumbent continues to enjoy its monopolist position. Note also that under the condition that \( \frac{a}{2} \geq c \), the entry will only stop when 

\[
\pi_E^* = \frac{(a - 2c)^2}{(n + 1)^2} = 0
\]

that is, when 

\( n \to \infty \), i.e. a competitive market with equilibrium price equal to marginal cost \( c \).

2. If \( x_I^* = \frac{a}{n + 1} + \frac{n - 1}{n + 1} c \geq \bar{q} \), it means the incumbent will dump all its capacity into the market at zero cost. As a result, an entrant will face the residual demand: 

\[
D(p) = a - \bar{q} - p
\]

in the case that the incumbent continues to use the \( F \) technology. With this residual
demand curve, the symmetric Cournot equilibrium output level is \( x_E^* = \frac{a - q - c}{n} \) for each entrant and \( x_I^* = \bar{q} \) for the incumbent. The market price is thus \( p^* = \frac{a - \bar{q} + (n - 1)c}{n} \), and the per-firm profit for each entrant is \( \pi_E^* = \frac{(a - \bar{q} - c)^2}{n^2} \). Foreseeing this profit, an entrant will enter only if \( p^* - c \geq 0 \) and \( x_E^* \geq 0 \), implying that \( c \) has to be no greater than \( a - \bar{q} \) for an entrant to enter with the \( V \) technology. Note also that under the condition that \( a - \bar{q} > c \), the entry will only stop when \( \pi_E^* = \frac{(a - \bar{q} - c)^2}{n^2} = 0 \), that is, when \( n \to \infty \), i.e. a competitive market with equilibrium price equal to marginal cost \( c \).

\textit{Proof of Result 3:}

If the incumbent is using the \( V \) technology instead, there are a total of \( n \) firms with the \( V \) technology in the market including the incumbent. The incumbent’s reaction curve is \( x_I^* = \frac{a - (n - 1)x_E^* - c}{2} \) while each entrant’s reaction curve is \( x_E^* = \frac{a - x_I^* - c}{n} \). As a result, the equilibrium output level is \( x_I^* = x_E^* = \frac{a - c}{n + 1} \), and each firm gets a profit of \( \left[ \frac{a - c}{n + 1} \right]^2 \).

However, as long as there is positive profit to be made, firms keep entering. As a result, in the long run, there is zero profit to be made. However, if the incumbent keeps the \( F \) technology, it has profit margin for quantity up to its capacity constraint, with the market price, \( c \), which gives the firm a total profit of \( c\bar{q} - f \). When this profit is greater than zero, or equivalently, i.e. when \( c < \frac{f}{\bar{q}} \), the firm will keep the \( F \) technology. Otherwise, the firm will opt for the \( V \) technology.

\textit{Proof of Result 5:}
Result 1 shows that when $F$ is the only technology available for firms and $f > \frac{a^2}{4}$, the market does not exist because no firm would enter the market. However, with the presence of the $V$ technology, and $c \leq a$, there is positive profit to be made, and thus there is always entry until there is zero profit to be made, when the market price equals to $c$.

*Proof of Result 6:* The same arguments in Result 2 apply here.

*Proof of Result 7:*

When There Is Only One Firm

When there is only one firm, denoted as $A$, which can locate either at 0 or 1, in the market, we can show that:

- Under the case where the misfit cost is relatively small to reservation cost, $\frac{t}{r} \leq \frac{1}{2}$, it is profitable for firm $A$ to cover the whole market with a price, $r-t$, which just makes the farthest customer indifferent between buying and not buying. In sum, $p_A = r - t$, $q_A = 1$ and $\pi_A = r - t - f$.

- On the other hand, when $\frac{1}{2} \leq \frac{t}{r}$, we have $p_A = \frac{r}{2}$, $q_A = \frac{r}{2t}$ and $\pi_A = \frac{r^2}{4t} - f$.

When There Are Two Firms

When there are two firms (both adopting $F$, given $F$ is the only technology available), denoted as $A$ and $B$, which are located at 0 and 1, respectively. We can show that the prices charged by these two firms are $p_A = p_B = t$, $q_A = q_B = \frac{1}{2}$ with $\pi_A = \pi_B = \frac{t^2}{2} - f$.

With these values, Result 7 is derived.

*Proof of Result 8:
Directly from the payoff table, we can see that there is always incentive for entry with the \( V \) technology (since Enter and Adopt \( V \) Technology strategy dominates the Don’t Enter strategy). Also, when the entrant, say B, enters with the \( V \) technology, the incumbent can continue with \( F \) or choose \( V \) instead, depending on which payoff is higher. With \( c \leq t \) and \( \frac{t}{2} \leq f \), we have

\[
\pi_A(F,V) = \frac{t}{2} + \frac{c^2}{18t} + \frac{c}{3} - f \leq \frac{t}{2} + \frac{t^2}{18t} + \frac{t}{3} - f = \frac{t}{2} + \frac{7t}{18} - f < \frac{t}{2} = \pi_A(V,V).
\]

In other words, we have \( \pi_A(F,V) \leq \pi_A(V,V) \), thus, the incumbent will drop the \( F \) technology in the long run since choosing \( V \) yields a higher profit.

In addition, with \( \frac{t}{r} \leq \frac{1}{2} \) and \( \frac{t}{2} \leq f \), we have \( \pi_A(F,0) = r - t - f \leq r - t - \frac{t}{2} \leq \frac{t}{2} = \pi_A(V,V) \)

and with \( \frac{t}{r} \geq \frac{1}{2} \) and \( \frac{t}{2} \leq f \), we have \( \pi_A(F,0) = \frac{r^2}{4t} - f \leq \frac{4t^2}{4t} - f \leq t - \frac{t}{2} \leq t = \pi_A(V,V) \). In other words, we have \( \pi_A(F,0) \leq \pi_A(V,V) \), thus, the profit level of the incumbent can increase even though there is competition. QED.

**Proof of Result 9:** It can be derived directly from Table 1 by comparing the payoffs.

**Proof of Result 10:**

When both firms adopt \( F \), the prices they will charge is \( t \).

When one firm, say A, chooses the \( F \) technology while the other firm, B, chooses the \( V \) technology: \( p_A = t + \frac{c}{3} \), \( p_B = t + \frac{2c}{3} \).

When both choose the \( V \) technology, the prices charged by these two firms are \( p_A = p_B = t + c \).