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The Impact of Information Technology on Vertical Relationships

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The Impact of Information Technology on Vertical Relationships

by

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This dissertation has three parts that study the impact of information technology on competition and vertical relationships from different perspectives.

The first part focuses on an electronic market where product information is important for consumers to identify their ideal product and the Internet greatly reduces consumers' search cost. The model studies how reduced search cost influences social welfare and retailers' incentive to provide product information. It is found that if technology reduces consumers' search cost to evaluate products and compare prices, sellers who invest in providing valuable information may not be able to recover their investments. Therefore, by lowering sellers' incentive to pro-

vide product information, reduced search cost may negatively impact social welfare as consumers have to search more to identify their ideal product. The study also shows that sellers need to develop the capability of, and reputation for, information provision in order to make profits, even though some consumers and sellers may free ride.

The second part extends the first model. In the second model, the manufacturer decides whether to distribute products through the electronic or the physical channel, or through both the channels. In the model, different channels have different search costs for consumers, different abilities to offer product information, and different reach to consumers. The model suggests that the manufacturer uses both the channels when product information is very valuable and product information is largely about digital attributes, or when the product information is not valuable. The model also suggests that when the manufacturer chooses to sell through both the channels the manufacturer need not sell through the most well-known electronic retailer. This part also discusses the case where the manufacture is vertically integrated. That is, the manufacturer itself operates in one of the channels.

The third part continues the second part and focuses on firms' vertical integration (VI) strategy. It examines firms included in 1995-1997 InformationWeek 500 and COMPUSTAT database to study the impact of competitive environment on how IT affects the level of vertical integration. It is found that the competitive environment moderates the impact of IT on vertical integration - in more dynamic environments IT is associated with a decrease in VI, and in more stable environments IT is associated with an increase in VI.

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Chapter 1

Implications of Reduced Search Cost and Free Riding in E-Commerce

1.1 Introduction

It is argued that electronic markets are frictionless and therefore more efficient than physical markets. In fact price comparison engines (a.k.a shopbots) may eliminate all search costs. For instance, if a consumer wants to purchase a book on the Internet, she can visit pricescan.com and receive real-time price information from more than 20 book sellers. The consumer can then jump directly to one seller's website to make the final purchase. However, an important function of a market is to provide information services for consumers to assess their satisfaction from consuming the product as well as information about how to use the product after purchasing it. This information is costly to provide. If some firms provide this information but do not make any sales because of the presence of price comparison engines/shopbots, it reduces their incentive to provide this information.

The free riding problem was first examined by Telser [102]. He argued that retail competition might dissuade retailers from offering presale services. Retailers providing presale information, incur additional costs, therefore they must charge a higher price compared to those who do not provide these services. A consumer may be convinced to purchase the product by the services provided by the retailer. However, the consumer may buy the product from another retailer who charges a lower price. In this way, retailers who do not provide the service free ride on those who provide the service.

Many researchers have studied instances of free riding. Singley and Williams [96] found that free riding consumers take advantage of salesperson's expertise and time, but have no intention of buying from the store. They note that free riding increases the price disparity between free riding and non-free riding retailers, and drives consumers not currently free riding to free ride in the future. Free riding also leads to less information and services provided for consumers, and therefore leads to less demand for the product [78]. In spite of the free-riding problem, in physical markets full-service sellers still exist as high search cost deters consumers from free riding. However, in electronic markets, the distance between any two stores is just a click away. If the reduced search costs enable consumers to easily find lower prices, it is not clear if any seller would provide free information service.

In the model presented in this chapter, we examine a market where information service is valuable to consumers, and retailers compete to sell a set of horizontally differentiated products. In particular, we examine the incentives of sellers to provide free information service when consumers' search costs are reduced. The paper is related to the literature in economics and in information systems. First, in the search cost literature [107, 90, 100] consumers search for lower prices for commodity products. In this literature consumers don't need any information service; they simply search for lower prices. This literature therefore sidesteps the free riding problem. In this paper consumers have to first search for and receive product information before purchasing the product.

Second, Alba et al. [2] and Bakos [9] make the point that electronic markets not only lower search cost for price information but also lower search cost for product information. Electronic markets enable consumers to easily compare products sold by competing vendors. Therefore, by providing product information, sellers can differentiate themselves and decrease consumers' price sensitivity. This point is also made by Lal [66], Lynch and Ariely [59], and Zettelmeyer [115]. In these models sellers sell heterogeneous products, therefore, service providers do not need to worry about the free riding problem. In the model presented in this chapter, sellers sell homogeneous product, so product information is, to some extent, a public good.

Third, the literature suggests that lower search costs should make electronic markets more efficient than comparable physical markets and the market price should go down to the competitive price [16]. However, in markets where consumers need information service before their purchase, it is expected that competitive price would eliminate the sellers' incentive to provide information service and may prevent the likelihood of trade, thereby reducing social welfare.

It is found that as long as a certain proportion of consumers have a positive search cost, some sellers do provide free information service. Even in the presence of free riding, sellers are better off incurring the costs of providing free information service and having the reputation as sellers who provide information service, as against sellers who always free ride. It is also found that as the competition in the market increases, fewer sellers provide free information service.

In this market a decrease in search cost has a direct and an indirect impact on the social welfare. The direct impact is that a decrease in search cost increases social welfare by decreasing the cost of each search. The indirect impact is that it reduces social welfare by reducing sellers' incentives to provide information service, which in turn increases the amount of search required by consumers. The net impact of reduced search cost on social welfare depends on which effect is stronger. This suggests that if free riding is also considered, a decrease in search cost may increase or decrease social welfare.

The rest of the chapter is organized as follows. The model and its assumptions are described in section 2. The equilibrium is presented in section 3 and section 4 examines the impact of different parameters on the equilibrium. We conclude in section 5 with a discussion of the main results.

1.2 The Model

There is a continuum[1] of risk neutral sellers, with mass S. A retailer sells different categories or classes[2] of products. In this model sellers are electronic retailers who compete by selling N ($N \geq 2$) horizontally differentiated products for a product category. The paper examines the case of a specific product category. Sellers are of two types. A proportion α ($0 < \alpha < 1$) of the sellers, called type-1 sellers, have the reputation for and the capability to provide free pre-sale information service. The rest of the sellers, called type-2 sellers, do not provide any information service. The main difference between the two types of sellers is that type-1 sellers can choose whether to provide information service for a specific product category, while type-2 sellers do not have the ability to provide any information service[3]. It is assumed that the sellers' ability to provide information service is independent of the model i.e., α is exogenous.

The objective of providing the information service for a specific category is to help consumers identify their ideal product and to provide information about how to use and maintain the product[4]. It may be noted that information service serves

[1] This implies that the number of sellers is very large and can be regarded as infinite. This assumption is widely used in the search cost literature [13, 17, 90].

[2] A book retailer sells books and books on Game Theory may be considered a product category. Similarly, an Electronic Goods' store sells consumer durables, and Projection TVs may be considered as a product category.

[3] Type-2 sellers can't provide information service, as sellers need to first incur a significant sunk cost to build the infrastructure for providing information service. For example, providing information service requires a significant investment in technological capabilities and domain expertise that may be beyond the type-2 sellers capacity. It is also an enduring reality of electronic markets that there exist sellers who never provide information service.

[4] It is assumed that the information service is objective. The consumers may also believe that the retailers provide an unbiased description of the products, and they are more likely to trust the information service provided by the retailers compared to the information service provided by the

more than one purpose. First, it helps consumers in identifying the product that fits them best. Second, information service is useful to consumers as it provides information about how to use and maintain a product. Therefore, the information service for a specific category helps consumers receive the maximum utility from consuming their ideal product. Every consumer who visits a type-1 store can access the information service, if the type-1 seller provides information service for that category, regardless of whether she purchases at that store. All sellers procure products at constant marginal cost, which is normalized to zero without loss of generality. However, type-1 sellers incur a cost of $V > 0$, if they provide information service for a specific product category. This cost is independent of the number of consumers who visit the electronic store to access the information service.

There is a continuum of risk neutral unit demand consumers with mass B. A consumer in the model is interested in the specific product category under consideration. However, each consumer has one ideal product (i.e., 1 out of N in that product category) that maximizes her utility and she derives a utility of $R > 0$ from consuming this product. However, if a consumers purchases a product at random, she receives an expected utility of $r > 0$ where $r < R$. It is assumed that each product matches B/N consumers and that each consumer needs the information service to identify her ideal product.

It is also assumed that there are two types of consumers. A proportion β ($0 < \beta < 1$) of the consumers have zero search cost. These consumers enjoy the process of visiting stores and evaluating different products. Hence they are

manufacturers.

referred to as shoppers [100]. The remaining consumers have a positive search cost K ($K > 0$). These consumers are referred to as non-shoppers. Therefore, the impact of electronic markets on consumers' search costs can be interpreted as decreasing K. As is common in this literature, it is also assumed that consumers have perfect recall i.e., they can return to any seller they have previously visited without any additional cost. It is also assumed that $r > K$, i.e., the product category is important to consumers so that they will always make a purchase.

1.3 Market Equilibrium

Each seller takes as given the consumers' equilibrium behavior and the strategy of the different types of sellers, and chooses its strategy to maximize expected profits. For a specific product category, sellers choose their information service and pricing strategy. First, the type-1 sellers determine whether to provide information service for that product category. If a type-1 seller provides information service for a specific product category, it is refereed to as type-1a seller for that product category. If a type-1 seller does not provide information service for a specific product category, it is referred to as a type-1b seller for that product category. Therefore for each product category, there are three types of sellers, type-1a, type-1b, and type-2. Of course as stated above, type-2 sellers do not provide information service for any product category. It is to be noted that for a given product category, all the sellers sell all the N products.

We focus on the symmetric equilibrium (as in Varian [107] and Stahl [100]), where type-1 sellers choose to provide information service for a specific product category with the same probability and sellers set prices according to the price distribution function of their type. Let θ be the probability that a type-1 seller provides information service for the product category under consideration, and $f_g(\cdot)$, $F_g(\cdot)$, $h_g(l_g)$ ($g \in \{1a, 1b, 2\}$) denote the density, cumulative distribution, and the highest (lowest) price charged by type-g sellers for this product category. Given that all the products in the category have the same expected demand, it is assumed that a type-1 seller charges the same price for all the products in the category[5]. It is clear that there is no pure strategy equilibrium where all type-1 sellers provide information service for a specific product category[6].

Consumers need the information service to identify their ideal product. The value of information of information service is the difference in utility from buying their ideal product after receiving the information service, R, and the utility of buying a product at random, r. Consumers know who has the ability to provide information service i.e., they know who is a type-1 seller and who is a type-2 seller[7]. However, consumers do not know if a type-1 seller provides information service for their category of interest, unless they visit the type-1 seller. Therefore, a consumer will search for information service, if the value of the information service, $R - r$, is greater than the expected cost of finding the information service. However, if the

[5]This assumption is stronger than necessary. The results hold as long as the difference between the utility from consuming the ideal product and a non-ideal product is greater than the search cost K. The assumption of equal prices is just used to simplify the exposition.

[6]If all type-1 sellers provide information service for a specific product category, then each type-1 seller has an incentive to not provide information service for that product category and to charge a slightly reduced price.

[7]For example, consumers know that Amazon.com and Barnesandnoble.com provide information service. Therefore consumers visit one or more of such stores to identify their ideal product in the product category of interest. On the other hand, consumers are sure that some on-line stores never provide information service for any product.

value of the information service is lower than the expected cost of finding the information service, a consumer may not search for information service, and may buy a product at random. In this paper we focus on the case where the value of information service, $R - r$, is greater than the expected cost of finding the information service so that consumers search for information service. Later the case where the cost of finding the information service is greater than its value is briefly discussed.

If the value of information service, $R - r$, is greater than its expected cost, consumers will search for information service to identify their ideal product. After having identified their ideal product a consumer may search for lower price amongst type-2 sellers. In other words, a consumer's search strategy is divided into two stages. In stage-1, if she decides to search for information service, she will search amongst type-1 sellers for information service. In each visit to a type-1 seller, she will learn the prices charged for the N products in that category, and assess the information service, if the seller provides information service for that category. In stage-2, she will search for lower price. Since she knows that, on average, a type-2 seller charges a lower price (as some type-1 sellers incur a cost to provide information service), in stage-2 she will only search among type-2 sellers. As stated earlier shoppers have zero search cost and non-shoppers have a positive search cost K, where K is the cost of visiting an electronic store for a specific product category, and learning the prices charged. For each visit in stage-1, the non-shoppers incur an additional cost to check if the seller provides information service. If this seller provides information service, the non-shoppers incur an additional cost to read this information. It is assumed that compared to K, the cost of checking for and reading the information is ignorable [8].

A shopper has zero search cost. Therefore, in stage-2 a shopper will search the whole market to find the lowest price. On the other hand, a non-shopper's decision to search in stage-2 is contingent upon whether the expected gain from an additional search outweighs her search cost K. That is if q is the lowest price a non-shopper has observed in stage-1 and q satisfies:

$$\int_0^q (q-p)\,f_2(p)dp = \int_0^q F_2(p)dp \leq K \tag{1.1}$$

she will stop and purchase at the type-1 seller charging q. Otherwise, she will visit type-2 sellers until she finds a seller whose price q satisfies equation (1.1).

Proposition 1.1 *Let $E\pi_g(\cdot)$ ($g \in$ {1a, 1b, 2}) be the expected profits of a type-g seller from a specific product category. In equilibrium,*
(a) $E\pi_g(p) \leq \pi_g^*$ for every price p, and $E\pi_g(p) = \pi_g^*$ for every price p in the support of $F_g(\cdot)$.
(b) $\pi_{1a}^* = \pi_{1b}^*$.

For a specific product category a type-1 seller chooses to provide information service with probability θ, and each type-g seller sets a price according to $F_g(p)$. In equilibrium, all the sellers of one type have the same expected profits. Moreover, type-1a and type-1b sellers also have the same expected profits, otherwise θ is not the equilibrium probability. For example, if $\pi_{1a}^* < \pi_{1b}^*$, a type-1a

[8] The cost of checking for and reading the information is ignored here for simplicity. The results in this paper are not influenced by the cost of checking for and reading the information in stage-1.

seller would be better off if it were to stop providing information service for that specific category.

In the equilibrium, each type-1 seller charges a price that satisfies equation (1.1). Otherwise, no consumer will purchase from that seller. As long as equation (1.1) holds, no non-shopper has an incentive to search in stage-2. Therefore, consumers' equilibrium search behavior is; (a) a non-shopper, as long as equation (1.1) is satisfied, always stops her search in stage-1 after visiting a type-1a seller, and purchases her ideal product from the type-1 seller charging the lowest price that she has seen in her search sequence, (b) a shopper, after identifying her ideal product in stage-1 will search the whole market in stage-2 and purchase her ideal product from a type-2 seller charging the lowest price for that product. Therefore, as in Stahl [100], in equilibrium, type-2 sellers are only able to sell to shoppers at the competitive price ($p = 0$) and $F_2(p)$ degenerates to a point ($p = 0$). Note that when entering the market the type-2 sellers aim to make small positive profits, but competition forces them to charge the competitive price. On the other hand, type-1 sellers charge positive prices and make strictly positive profits[9]. Finally, equation (1.1) can be rewritten as:

$$q \leq K \tag{1.2}$$

It is clear from the equilibrium behavior of sellers and consumers that no type-1 seller charges the competitive price, and that all shoppers search and purchase in stage-2 from type-2 sellers at the competitive price. It is also clear that

[9]Assume that type-1 sellers make zero profits. Then type-1a sellers should charge positive prices to recover V. If the lowest price that type-1a sellers charge is $l_{1a} > 0$, a type-1b seller can always make positive profits by charging $l_{1a} - \varepsilon > 0$. Therefore, a contradiction to proposition 1.1. In other words type-1 sellers always charge positive prices and make strictly positive profits.

type-1 sellers only sell to non-shoppers. A non-shopper searches a sequence of type-1 sellers until she finds information service (i.e., finds a type-1a seller). After receiving the information service she purchases her ideal product from the seller charging the lowest price in the sequence of type-1 sellers visited by her. Of course, if a non-shopper visits a type-1a seller as the first seller she visits, she will purchase her ideal product from this type-1a seller.

Proposition 1.2 *For a type-1 seller charging p, its expected demand from a specific product category is:*

$$D_{1a}(p) = \frac{(1-\beta)B}{\alpha S}\frac{1}{1-(1-\theta)[1-F_{1b}(p)]} \tag{1.3}$$

$$D_{1b}(p) = \frac{(1-\beta)B}{\alpha S}\frac{\theta[1-F_{1a}(p)]}{\{1-(1-\theta)[1-F_{1b}(p)]\}^2} \tag{1.4}$$

For a specific product category, a type-1b seller never charges a price higher than or equal to h_{1a}, otherwise, no consumer will return to buy from this seller. It can also be shown that h_{1b} is infinitely close to h_{1a}. Or, equivalently, the support of $F_{1b}(\cdot)$ is $[l_{1b}, h_{1a})$.

Proposition 1.3 *All type-1a sellers charge the same price for all the products in a product category, i.e.,* $l_{1a} = h_{1a} = K$.

The equilibrium price distribution of type-1b and l_{1b} and h_{1a} are as shown below.

$$F_{1b}(p) = 1 - \frac{1}{1-\theta}\left(1 - \sqrt{\frac{p}{h_{1a}}}\right) \quad \text{p} \in [\text{l}_{1b}, \text{h}_{1a}) \tag{1.5}$$

$$l_{1b} = \theta^2 h_{1a}, h_{1a} = \frac{\alpha S}{(1-\beta)B}\frac{V}{(1-\theta)} \tag{1.6}$$

From equation (1.6) and proposition 1.3,

$$\theta^* = 1 - \frac{V}{K}\frac{\alpha S}{(1-\beta)B} \tag{1.7}$$

The above analysis assumes that non-shoppers search until they find information service, i.e., they search until they visit a type-1a seller. In other words if the value of information service, $R - r$, is greater than its expected cost, K/θ, a non-shopper will search until she finds information service. To see this assume that a non-shopper has visited several type-1b sellers and has not yet found a service provider. If the lowest price that she has observed so far is q, she will continue to search for information service if the expected value from another search is greater than her search cost i.e., if $\theta(R - r) + (1 - \theta)\int_{l_{1b}}^{q} F_{1b}(p)dp > K$. However, as long as $R - r > K/\theta$, $\theta(R - r) + (1 - \theta)\int_{l_{1b}}^{q} F_{1b}(p)dp$ is always greater than K. As a result non-shoppers will always search until they find information service, and all the results discussed above hold. On the other hand, if $R - r < K/\theta$, some non-shoppers may purchase without receiving information service. In this paper we are interested in examining the incentives of sellers to provide free information service when information service is valuable for consumers to identify their ideal product. The case when $R - r < K/\theta$ is not discussed further, as information service is not very important in these markets.

1.4 Equilibrium Analysis and Implications

We first examine the impact of the proportion of type-1 sellers (α), proportion of shoppers (β), and search cost (K) on the competition and the type-1 sellers' incentive to provide free information service (θ^*) for a specific product category. The impact of α, β, and K on social welfare is analyzed subsequently.

1.4.1 Managerial Implications

Result 1.1 *(a) There is no equilibrium where all type-1 sellers provide information service for a specific product category i.e.,* $\theta < 1$*; (b)* θ *decreases with* α *and increases with* B*.*

A manager needs to investigate both market related (α and B) and search cost related parameters (K and β) to arrive at the firm's information service and pricing strategy. First, as long as non-shoppers search for information service, type-1 sellers make positive profits whereas type-2 sellers make zero profits. The reason is that non-shoppers purchase from type-1 sellers at positive prices whereas shoppers purchase at type-2 sellers at the competitive price. The point is that the price competition amongst type-2 sellers competing for zero search cost consumers drives their prices down to the competitive level. The analysis in this paper suggests that in markets where information service is valuable to consumers, sellers who do not provide any information service will find it difficult to make positive profits.

In this model profits are the economic rents of the reputation for and the capability to provide free information service. From a managerial perspective, if consumers value information service, sellers need to establish themselves in the information service market in order to make positive profits. This is true even if some sellers and consumers free ride. Intuitively, non-shoppers visit a sequence of type-1 sellers for information service. However, as non-shoppers cannot distinguish between type-1a and type-1b sellers they may visit some type-1b sellers before they visit a type-1a seller in their search for information service. Therefore, if a non-shopper visits a few type-1b sellers before visiting a type-1a seller, after receiving the information service from a type-1a seller, she may go back and purchase from a visited type-1b seller charging a lower price. This enables type-1b sellers to charge positive prices and make positive profits.

Type-1a and type-1b sellers make equal profits. This is explained as follows. A non-shopper, on visiting a type-1b seller, may continue to search for information service amongst type-1 sellers. However, a consumer may not purchase from a type-1b seller if it later visits another type-1b seller charging a lower price. On the other hand if a consumer visits a type-1a seller as the first seller she visits, she always stops her search and purchases from this type-1a seller. This is because a type-1a seller's price makes another search unprofitable for a non-shopper. Therefore, in equilibrium the savings of a type-1b seller from not providing information service for a specific category are equal to the expected loss from consumers continuing to search for information service. The nature of the mixed strategy equilibrium is such that it makes a type-1 seller indifferent between being a type-1a or a type-1b seller.

In this way type-1 sellers make equal profits and are indifferent to free riding. The key point is that in equilibrium no seller can profitably (i.e., make more profits than type-1a sellers) free ride on other sellers by charging a lower price.

It is clear that the incentive of type-1 sellers to provide free information service (θ) decreases with the increase in the proportion of type-1 sellers (α). In other words, the higher the proportion of type-1 sellers, fewer type-1 sellers provide information service for a product category. It is interesting that in a market where information service is valuable to consumers, if there is an increase in the number of sellers with the capability to provide information service, i.e., if the market becomes more competitive, a smaller proportion of type-1 sellers provide information service. This is due to the fact that the profits of each type-1 seller decreases with the increase in competition (an increase in the proportion of type-1 sellers) as the profits from selling to non-shoppers is shared amongst a larger number of type-1 sellers. However, the profits of type-1a sellers decrease more than the profits of type-1b sellers, causing some type-1a sellers to switch to becoming type-1b sellers, resulting in a lower θ [10]. It is also apparent that as the demand (B) for a product category increases, the probability that a type-1 seller will provide information service for that category increases.

Result 1.2 *(a) θ increases with K and decreases with β; (b) There exists a $K' > 0$, and $\beta' > 0$, such that when $K \leq K'$, or $\beta > \beta'$, no seller provides information service, i.e., there is no market with sellers providing free information service.*

[10] It can be easily shown that $E\pi_{1a} = (1-\beta)BK/(\alpha S) - V$ and $E\pi_{1b} = \theta(1-\beta)BK/(\alpha S)$. It is clear that $|\partial E\pi_{1a}/\partial\alpha| \geq |\partial E\pi_{1b}/\partial\alpha| = \theta\,|\partial E\pi_{1a}/\partial\alpha|$.

It is clear that the incentive to provide information service generally decreases, with a decrease in the search cost, and with an increase in the proportion of shoppers. Given other parameters, if the search cost is very low, or the proportion of shoppers is very high, a manager should decide not to provide free information service, as the firm would not be able to recover the cost of providing this service. It is said that high search cost may lead to market failures [9]. However, this research suggests that low search cost may also lead to market failure, as consumers may not have access to information service to identify their ideal product. This suggests that when search cost is very low, firms should provide information service only when they are able to charge for the service. This fee can be implemented in different ways. For instance, some sellers ask consumers to pay for the information service, and in some electronic stores consumers need to register by providing biographical information before they can receive the information service. Therefore, there are circumstances where increased search costs not only increase sellers' profits, but also benefit consumers by increasing sellers' incentive to provide information service.

1.4.2 Social Welfare Analysis

This section examines the impact of α, β, and K on social welfare. Let BTS and STS be the consumers' and sellers' total surplus. Consumers' total surplus BTS is equal to $B \cdot R - TP - TSC$, where TP is the consumers' total payment, and TSC is the consumers' total search cost. It is straightforward that each consumer, on average, visits $1/\theta$ type-1 sellers. Since the cost of visiting a type-1 seller for a non-shopper is K, the total search cost is $(1-\beta)BK/\theta$. Sellers' total surplus is $STS = TP - S\alpha\theta V$. Therefore, social welfare, W is,

$$W = B \cdot R - (1-\beta)B\frac{K}{\theta} - S\alpha\theta V \tag{1.8}$$

Therefore, $\partial W/\partial\theta = (1-\beta)BK/\theta^2 - S\alpha V$. From equation (1.7), it is clear that $(1-\beta)BK > S\alpha V$, so $\partial W/\partial\theta > 0$. The intuition is that an increase in θ has two effects; (i) it increases social welfare by lowering consumers' total search cost for information service, as there are a higher number of type-1a sellers, and (ii) it decreases social welfare by increasing sellers' cost of providing information service, as more type-1a sellers incur the information service cost V. However, the first effect outweighs the second. Therefore, when more sellers provide information service, social welfare increases. The other parameters also influence social welfare. Equation (1.8) can be written as $W = w(\theta(\alpha, \beta, K), \alpha, \beta, K)$. In other words, each parameter has two effects on social welfare. First, it has a direct impact. Second, it also influences social welfare by influencing θ.

The impact of a decrease in K on social welfare is examined first. The direct impact of a decrease in K is that social welfare increases as consumers' cost of each search is reduced. The indirect impact of a decrease in K is that it decreases social welfare as a decrease in K decreases a seller's incentive to provide information service (θ). The total impact of a decrease in K is determined by the sum of the direct and the indirect impacts and can either increase or decrease social welfare. It is straightforward that $\partial^2 W/\partial K^2 < 0$. That is, as K decreases (so θ also decreases), the direct impact dominates the indirect impact as long as θ is sufficiently high. In other words, when there are a large number of type-1a sellers a decrease in K increases social welfare by reducing consumers' search cost, as there are still enough service providers in the market. However, below a certain value of θ a decrease in K causes the indirect impact to dominate the direct impact. In other words, when there are a small number of type-1a sellers to begin with, a decrease in K reduces social welfare by reducing type-1 sellers incentive to provide information service and as a result consumers have to search a much larger number of type-1 sellers to find information service, even though the cost of each search is reduced. The impact of an increase in the proportion of shoppers (β) on social welfare is analogous to the impact of a decrease in K. This analysis suggests that depending on the value of θ, a decrease in search cost (K) or an increase in the proportion of shoppers (β), may increase or decrease social welfare.

Next the impact of the proportion of type-1 sellers (α) is examined. The direct impact of an increase in α is a decrease in social welfare as it increases society's cost of information service. The indirect impact of an increase in α is a decrease in social welfare as it reduces a seller's incentive to provide information service. Therefore an increase in α unambiguously reduces social welfare.

1.5 Conclusion

The model presented here examines a market where information service is costly to provide but has the characteristics of a public good. Consumers on the other hand use the information service to identify their ideal product. However, after receiving the information service consumers may search for a lower price. The paper examines the competition in horizontally differentiated markets where information service is valuable to consumers to identify their ideal product and where technology reduces consumers' search cost. The analysis suggests that in this setting a seller needs to develop the capability of and reputation for service provision to make positive profits. Otherwise, no non-shopper will visit them for service and purchase from them. This is true even though there are sellers and consumers who free ride. The analysis also suggests that a seller cannot make positive profits by free-riding all the time. It is interesting to note that when the competition in the market for information provision increases, fewer sellers provide information service. In the market examined in this paper, increased competition amongst information service providers is not in the interests of the incumbent firms as well as the society at large. Obviously, incumbents do not prefer increased competition as it reduces their profits. Similarly, from social welfare perspective, an increase in competition reduces social welfare. It is also clear that if the search cost is too low, or if the proportion of shoppers is very high, no seller will provide any free information service.

The model also provides another interesting social welfare result. A decrease in search cost may increase or decrease social welfare. When a large proportion of sellers provide information service, a decrease in search cost increases social welfare by decreasing the cost of each search. On the other hand, if the proportion of sellers providing information service is low, a decrease in search cost reduces social welfare by reducing sellers incentive to provide information service which in turn increases the amount of search required by consumers. This suggests that if free riding is also considered, a decrease in search cost may increase or decrease social welfare. As indicated earlier all these results apply to horizontally differentiated markets where information service is valuable for consumers to identify their ideal product. If the expected utility of buying a product at random is not very different from searching for information service to identify ones ideal product, the above results need further exploration.

Appendix

Proof of Proposition 1.2 A common result in the search cost literature is that there are no point masses in $F_{1b}(\cdot)$. The intuition is that some consumers will visit two or more type-1b sellers for a specific product. If there is a point mass at p' the type-1b sellers charging p' can increase its profits by lowering the price slightly. This violates proposition 1.1.

Since no shopper purchases from type-1 sellers, the expected demand of type-1 sellers comes from non-shoppers. Each non-shopper keeps on searching type-1 sellers until she finds a type-1a seller. Each search finds a type-1a seller with probability θ. Therefore, in the first round, on average, $\theta(1-\beta)B$ non-shoppers will find information service and the rest $(1-\theta)(1-\beta)B$ non-shoppers will continue to search. Therefore, $(1-\theta)^{n-1}\theta(1-\beta)B$ non-shoppers need to search exactly n sellers to find information service. Each type-1 seller, irrespective of whether it provides information service for this product category is sampled by a specific consumer with the same probability $1/(\alpha S)$. Therefore, in the n^{th} round, it is visited by $(1-\theta)^{n-1}(1-\beta)B/(\alpha S)$ non-shoppers.

The demand of a type-1a seller charging p comes from two kinds of non-shoppers: (i) those who visit this seller as the first type-1 seller they visit. They will stop and purchase at this seller, so the expected demand from this kind of consumers is $(1-\beta)B/(\alpha S)$, (ii) those who visit $n-1$ (n=2, 3, ...) type-1b sellers before visiting this seller. Each of these consumers will purchase from this seller if it charges a price lower than the $n-1$ type-1b sellers she has already visited. As a result, $[1-F_{1b}(p)]^{n-1}(1-\theta)^{n-1}(1-\beta)B/(\alpha S)$ non-shoppers will purchase from this seller in the n^{th} round. Summing these,

$$D_{1a}(p) = \frac{(1-\beta)B}{\alpha S}\sum_{n=1}^{+\infty}[(1-\theta)(1-F_{1b}(p))]^{n-1} \Rightarrow \text{Equation (1.3)}$$

The expected demand of a type-1b seller charging p is derived by summing the expected demand from consumers who receive information service in the n^{th} ($n=2,3,...$) round. For any non-shopper who receives information service in the n^{th} ($n=2,3,...$) round, she will return and purchase at a type-1b seller if and only if she has visited this seller in the first $n-1$ rounds, which occurs with probability $(n-1)/[(1-\theta)\alpha S]$, and that this seller's price is the lowest in the sequence of sellers visited, which occurs with probability $[1-F_{1b}(p)]^{n-2}[1-F_{1a}(p)]$. So the demand from these non-shoppers is $(1-\theta)^{n-1}\theta(1-\beta)B[1-F_{1b}(p)]^{n-2}[1-F_{1a}(p)](n-1)/[(1-\theta)\alpha S]$. $D_{1b}(p)$ is calculated by summing up these demands. ■

Proof of Proposition 1.3 This is proved by ruling out the possibilities that $l_{1a} \neq h_{1a}$.

For a specific product, a type-1b seller never charges a price higher than or equal to h_{1a}, otherwise, no consumer will buy this product from this seller. Suppose that there exists a p' such that $h_{1b} < p' < h_{1a}$. If p' is in the support of $F_{1a}(\cdot)$, then from equation (1.3), we have $D_{1a}(h_{1a}) = D_{1a}(p')$, as no consumer visits more than one type-1a seller. Since $p' < h_{1a}$, $E\pi_{1a}(h_{1a}) > E\pi_{1a}(p')$, which violates proposition 1.1. So, no type-1a seller charges p', i.e., $F_{1a}(p') = F_{1a}(h_{1b})$. The type-1b seller who charges h_{1b} will earn profits only from consumers who first visit this seller and then immediately visit a type-1a seller charging h_{1a}. If this seller charges p', its expected demand does not change, but p' is strictly higher than h_{1b}. So if it charges p', a price not in the support of $F_{1b}(\cdot)$, it will be strictly better off. This also violates proposition 1.1. Therefore, h_{1b} is infinitely close to h_{1a}. Or, equivalently, the support of $F_{1b}(\cdot)$ is $[l_{1b}, h_{1a})$.

Since it has been already shown that h_{1b} is infinitely close to h_{1a} and $F_{1b}(p)$ is continuous, there are just two possibilities that need to be considered.

(1) Suppose that $l_{1a} < l_{1b}$. Then one can always find a p' such that $l_{1a} < p' < l_{1b}$. It is clear that $D_{1a}(l_{1a}) = D_{1a}(p')$.Therefore, $E\pi_{1a}(p') = p'D_{1a}(p') - V > E\pi_{1a}(l_{1a})$. This violates proposition 1.1.

(2) Suppose that l_{1a} is in the support of $F_{1b}(p)$. Then we have:

$$\begin{cases} E\pi_{1a}(h_{1a}) = \dfrac{(1-\beta)B}{\alpha S} h_{1a} - V \\ \\ E\pi_{1a}(l_{1a}) = \dfrac{(1-\beta)B}{\alpha S} \dfrac{1}{1-(1-\theta)(1-F_{1b}(l_{1a}))} l_{1a} - V \end{cases}$$

Solving $E\pi_{1a}(l_{1a}) = E\pi_{1a}(h_{1a})$,

$$F_{1b}(l_{1a}) = 1 - \frac{1}{1-\theta}\left(1 - \frac{l_{1a}}{h_{1a}}\right) \tag{1.9}$$

Since l_{1a} is in the support of $F_{1b}(\cdot)$, the type-1b seller who charges l_{1a} will have:

$$E\pi_{1b}(l_{1a}) = \frac{(1-\beta)B}{\alpha S}\frac{\theta[1-F_{1a}(l_{1a})]}{[1-(1-\theta)(1-F_{1b}(l_{1a}))]^2}l_{1a}$$

Substituting equation (1.9) into the above equation, results in $E\pi_{1b}(l_{1a}) = [(1-\beta)B/(\alpha S)]\theta[1-F_{1a}(l_{1a})]h_{1a}^2/l_{1a}$. Suppose that $\tilde{p}$ is in the support of $F_{1b}(p)$, and $\tilde{p}$ is infinitely close to h_{1a}. So $l_{1b} \leq l_{1a} \leq \tilde{p}$. If it charges $\tilde{p}$, its expected profits will be $E\pi_{1b}(\tilde{p}) = [(1-\beta)B/(\alpha S)]\theta[1-F_{1a}(\tilde{p})]\tilde{p}$. From $E\pi_{1b}(l_{1a}) = E\pi_{1b}(\tilde{p})$, yields:

$$[1-F_{1a}(\tilde{p})]\tilde{p} = [1-F_{1a}(l_{1a})]\frac{h_{1a}^2}{l_{1a}}$$

Since it is always true that $l_{1a} \leq \tilde{p} < h_{1a}$and $F_{1a}(l_{1a}) \leq F_{1a}(\tilde{p}) < 1$, the equation above never holds. In sum, $l_{1a} = h_{1a}$. Since any $q \in [l_{1b}, h_{1a}]$ satisfies equation (1.2), it is straightforward that a type-1a seller charges K. ■

Deduction of Equations (1.5)-(1.6) Equation (1.3) and equation (1.4) can be rewritten as:

$$\begin{cases} D_{1a} = \dfrac{(1-\beta)B}{\alpha S} \\ \\ D_{1b}(p) = \dfrac{(1-\beta)B}{\alpha S}\dfrac{\theta}{\{1-(1-\theta)[1-F_{1b}(p)]\}^2} \end{cases} \tag{1.10}$$

In the equilibrium, every type-1b seller has the same expected profits. Assume that both p and $\tilde{p}$ are in the support of $F_{1b}(\cdot)$, and $\tilde{p}$ is infinitely close to h_{1a}. Therefore,

$$\begin{aligned} E\pi_{1b}(\tilde{p}) &= \lim_{\Delta \to +0} \frac{(1-\beta)B}{\alpha S} \frac{\theta}{\{1-(1-\theta)[1-F_{1b}(h_{1a}-\Delta)]\}^2}(h_{1a}-\Delta) \\ &= \frac{(1-\beta)B}{\alpha S}\theta h_{1a} \end{aligned} \tag{1.11}$$

Solving $E\pi_{1b}(p) = E\pi_{1b}(\tilde{p})$, results in equation (1.5). Since $F_{1b}(l_{1b}) = 0$, $l_{1b} = \theta^2 h_{1a}$. As $E\pi_{1a} = [(1-\beta)B/(\alpha S)]h_{1a} - V$, solving $E\pi_{1b}(\tilde{p}) = E\pi_{1a}$ results in equation (1.6).

Chapter 2

Information Technology and Manufacturer's Distribution Strategy

2.1 Introduction

The IS literature has examined the impact of information technology on markets in terms of the implications of reduced search costs [9, 16]. The salience of reduced search costs is manifested in the increasing reach of the electronic channel [36]. However, a key function of the market is to provide product information that enables consumers to identify their ideal product [24, 44, 54, 86]. In the physical distribution channel, retailers provide product information through product demonstrations and test-drives. On the other hand, in the electronic channel, technologies such as *Visualization* are improving and allowing electronic retailers to provide increasingly sophisticated information to consumers. Jiang and Benbasat [62] study virtual product experience (VPE) technology where visual control allows consumers to manipulate web product images and functional control enables consumers to experience different features of a product. For example, at Landsend.com, consumers can create images of their body shape to virtually "try on" apparel items to see how an item will fit them [105].

A manufacturer has to decide how to distribute its products to the ultimate consumers. A manufacturer's distribution strategy is influenced, among other things, by the characteristics of the product (i.e., the information services required to demonstrate, use, and service the product [85]) and the nature of the competition in the retail market [104]. Prior research also suggests that not all products are sold through every channel [18]. Therefore, the objective of this research is to analytically examine how the reduced search cost and the increasing reach of the electronic channel, along with the increasing ability of the electronic channel to provide product information, affect a manufacturer's distribution strategy.

The distribution literature indicates that if the manufacturer sells through independent retailers, two kinds of externalities need to be considered — pricing and service externality [22]. The pricing externality is that each retailer makes pricing decisions to maximize its own profits but does not consider the manufacturer's profits. This causes the retailer to charge a retail price that is different from the price that maximizes the manufacturer's profits. A manufacturer may also expect the retailer to provide information services, such as product demonstrations and test-drives, that increase a consumer's demand, utility for the product, and the willingness to pay [111]. The second externality deals with the provision of such information services, as the retailer may not have the incentive to provide as much information service as the manufacturer would like. The free-riding problem makes this externality more complex than the pricing externality [78, 102]. For example, if each consumer receives product information at a service provider and then purchases from a non-service provider for a lower price, no retailer would provide these information services. Free riding, therefore, leads to a reduction in information service provided to consumers, which leads to reduced demand for the product [78]. A suboptimal level of information service may reduce the manufacturer's profits.

The literature in Marketing has studied the above problems largely in the context of the traditional physical channel [56, 58, 60, 79]. However, the electronic channel has different characteristics compared with the physical channel. First, the retailers in the electronic channel provide different levels of information services compared with the retailers in the physical channel. Retailers in the physical channel can provide information about both digital and physical attributes of products, whereas retailers in the electronic channel can provide information only about digital attributes [66]. For example, if a consumer wants to purchase a new brand of perfume, she can't ascertain through the electronic channel whether she likes the perfume, without examining it at a physical store. On the other hand, the product information electronic retailers can provide for books is almost as rich as that provided by any physical retailer. Second, consumers' search costs are significantly reduced in the electronic channel [2, 59]. Reduced search costs in the electronic channel may enable consumers to receive product information from one channel and then purchase from another channel for a lower price.[1]

The IS literature has examined the impact of reduced search cost on price competition in the retail environment [9, 16, 23, 27, 98]. Empirical studies in this area find substantial price dispersion. In general, electronic markets exhibit as much price dispersion as traditional markets.

There is also a literature that examines the interaction between physical and electronic channels [20, 21, 48, 87, 115]. For example, in Chen et al [20], conventional retailers use the electronic retailer (i.e., the referral intermediary) to price discriminate between the price-sensitive consumers in the electronic channel and the retailer's other customers. Similarly, Riggins [87] considers the difference in the characteristics of electronic and conventional channel consumers, and shows how the "digital divide" can be used by multi-channel retailers to achieve better segmentation. Zettelmeyer [115] examines the competition between two integrated manufacturers who operate in both the channels. He finds that when the reach of the Internet is high, neither firm provides information in the conventional channel, and only one of the firms offers information in the electronic channel. However, in his model, both channels have the same ability to offer product information, and consumers incur the same search cost in both channels. The difference between the two channels is that the electronic channel incurs a much lower (zero) marginal cost of offering information.

[1] In one survey [92], 66 percent of the consumers said that they browsed using one channel while purchasing in another. Similarly, Ratchford, Lee, and Talukdar [86] show that about 39 percent of the respondents used the Internet to get information before they purchased vehicles from dealers.

The objective of this study is to examine the manufacturers' distribution problem in an environment where product information is important for consumers to identify their ideal product, and there are two channel alternatives that have different search costs for and reach to consumers and different capabilities to provide product information. A manufacturer's distribution problem, then, is to choose a distribution strategy that induces retailers to make pricing and information service decisions that maximize the manufacturer's profits. Specifically, this paper examines the impact of information technology on three key variables that impact the functioning of markets: (i) consumers' reduced search cost on the Internet, (ii) increasing reach of the electronic channel, and (iii) the different types of product information offered in different channels. In other words, given the different search costs, reach, and information service capabilities across different channels, when should a manufacturer sell through the physical channel, the electronic channel, or both the channels?

This study differs from the extant literature in four important ways. First, the IS literature has examined retailers' price competition in the electronic channel [9, 10, 11, 16]. In contrast, this paper focuses on the impact of reduced search cost on manufacturers' distribution strategy. Second, as discussed above, a key role of the market is to provide product information to enable consumers to identify their ideal product. This paper differs from the distribution channel literature as it examines the manufacturer's distribution strategy in an environment where product information is important for consumers to identify their ideal product, and different channels have different capabilities to provide product information. Third, the IS literature on information provision focuses on information that can be delivered electronically [10, 11, 35]. In this paper we divide product information into two parts: information about physical attributes and information about digital attributes. We examine how the two types of information influence manufacturers' and retailers' decisions. Finally, the literature examining the interaction between physical and electronic channels focuses on how the characteristics of consumers in the electronic channel can be used to achieve more efficient price-discrimination and segmentation [87]. In contrast, this paper examines how the informational characteristics of the product affect a manufacturer's distribution strategy.

This study has two main results. First, it shows that the manufacturer will decide to add an electronic channel in addition to selling through the physical channel either when product information is very valuable and product information is largely about digital attributes, or when the product information is not valuable. Second, when the reach of the electronic channel increases, it is not always beneficial for the manufacturer to sell through both the channels. In this environment the manufacturer may sell only through the physical channel even though the electronic channel can provide a comparable level of information. Also, when the manufacturer sells through both the channels, it need not sell through the most well-known electronic retailer in the electronic channel. This paper also examines the environments where the manufacturer has its own electronic store and where the retailer has stores on both the channels (e.g., Circuit City and Circuitcity.com).

The rest of the chapter is organized as follows. The assumptions of the model and the timing of the game are described in section two. Section three presents the equilibrium. The results of the analyses are presented in section four, and section five discusses some extensions. The limitations of the model are discussed in section six. Section seven concludes the chapter.

2.2 The Model

2.2.1 Assumptions

A manufacturer produces two horizontally differentiated products at a constant marginal cost, which is assumed to be zero without loss of generality. The manufacturer can sell to consumers through independent retailers in the physical (conventional) channel, or the electronic channel, or both. There are two independent retailers, retailer C and retailer E,[2] that operate in the physical (conventional) and the electronic channel, respectively. Each retailer sells both products, if it sells. The model is symmetrical in the following sense. Each of the two products perfectly fits half of the consumers where each consumer purchases only one product, and has a unit demand for that product. However, consumers need product information to identify their ideal product. Each consumer receives a utility of Φ_h from consuming her ideal product and a utility of Φ_l ($\Phi_l < \Phi_h$) from consuming the non-ideal product.[3] This setup is similar to Lal and Sarvary [66] except for the fact that here

[2]The duopoly environment is commonly used in the literature. This also reflects our interest in the interaction between the two channels. That there is only one retailer in each channel does not mean that the manufacturer chooses only one retailer in each channel. For example, in the physical market, the manufacturer may divide the market into several exclusive territories (e.g., in terms of geography), and in each territory it may choose one retailer. The duopoly model is also applicable to this environment. Please see section 6 for further discussion on this issue.

[3]In this paper, for ease of exposition, we use ideal/non-ideal products to explain how information increases consumers' expected utility. Of course, information can increase consumers' expected

each retailer sells the same set of products.

Product information consists of two parts: information about physical characteristics and information about digital characteristics.[4] Product information helps consumers to identify their ideal product. With full information (i.e., information about both characteristics), consumers can identify their ideal product with a high probability θ_h and get an expected utility of $R = \Phi_h\theta_h + \Phi_l(1-\theta_h)$. Without any product information, consumers can only choose their ideal product with a low probability θ_l ($\theta_l < \theta_h$), and if they purchase, they get an expected utility of $r < R$ ($r = \Phi_h\theta_l + \Phi_l(1-\theta_l)$). With only part of the product information, consumers can identify their ideal product with a probability between θ_l and θ_h and get an expected utility between r and R.[5]

It is assumed that each retailer can decide whether to provide product information. In different channels product information is provided to consumers in different ways. In the physical channel product information is provided via product demonstrations, trials and test-drives, and face-to-face communication. To offer product information, the retailer in the physical channel incurs a (periodic) fixed cost of V_C (e.g., to build show rooms and stock products, to train its salespersons to demonstrate products and answer questions, and so on). Retailers in the electronic channel do not need to incur such costs and only post information about digital

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utility in other ways. For example, consumers can get higher expected utility by receiving information about how to use and maintain a product. Our results hold as long as information increases consumers' expected utility, no matter how many products the manufacturer makes and retailers carry.

[4] Digital characteristics are attributes that can be communicated through text, pictures, and sound. Physical characteristics are attributes that can only be communicated through touch, taste, and smell.

[5] Φ_h, Φ_l, θ_h, and θ_l are used to derive the expected utilities, R and r. The rest of the model is developed in terms of R and r. Φ_h, Φ_l, θ_h, and θ_l are not used in the paper any further.

attributes on their web sites. The cost of providing product information in the electronic channel, V_E, is therefore very low compared with V_C. However, the retailer in the physical channel can offer information about both physical and digital characteristics, whereas the retailer in the electronic channel cannot offer information about physical characteristics (please see Lal and Sarvary [66] page 487-488 for an excellent discussion about the difference in information service provision between the two channels). Therefore, the retailer in the electronic channel is only able to provide consumers with information about digital characteristics of the product. With information about digital characteristics only, consumers get an expected utility of R_D ($r < R_D < R$).

The mass of consumers is normalized to 1, without loss of generality.[6] Consumers incur a positive search cost K_C in the physical channel. In the electronic channel their search cost, K_E, is greatly reduced. The search cost in the physical channel is the transportation cost of visiting the physical retailer, whereas the search cost in the electronic channel is the cost of identifying and reaching the electronic store's web site. For expositional simplicity we assume that the cost of providing product information for the electronic retailer, V_E, and the consumers' search cost in the electronic channel, K_E, are zero.[7] However, consumers are heterogeneous in terms of their willingness to transact through the two channels. It is assumed that all the consumers can purchase through the physical channel. However, a fraction

[6]In this setup the number of consumers and the demand is fixed. However, we have solved the case where this assumption is relaxed. The results in this paper are invariant to this assumption.

[7]This assumption implies that if both the channels are chosen, retailer E will always provide product information. However, we have solved the model where retailer E incurs a positive cost to provide product information, and consumers incur a cost to visit the electronic retailer. All the results in this paper remain valid in that model.

β of these consumers also consider transacting through the electronic channel. We refer to these consumers who can purchase at both the channels as multi-channel consumers. This implies that a proportion $1 - \beta$ of consumers can only purchase through retailer C.[8] We refer to these consumers as physical-channel consumers.[9] It is also assumed that a retailer cannot price discriminate against consumers on the basis of their access to different channels.

2.2.2 Sequence of Moves

This is a three-stage game. Figure 2.1 shows the sequence of moves in the game. In stage 1, the manufacturer decides the channel structure. That is, it chooses whether to sell through retailer C only or through both the retailers.[10] Then the manufacturer decides the price structure to charge to the retailer(s). It is assumed that the manufacturer adopts a two-part tariff [56, 58, 60, 79, 104] consisting of a wholesale price P_M and a fixed fee W. According to the Robinson-Patman Act, the manufacturer should treat the retailers uniformly. Thus, the manufacturer is "prevented from giving different terms to different retailers in the same retailer class (discoun-

[8]These consumers do not purchase in the electronic channel. There may be several reasons for this. For example, they may have no access to the Internet, they may not know the electronic store's location on the web, or they may not feel secure about purchasing through the electronic channel. US Census Bureau [93] statistics suggest that E-Commerce sales constitute less than 3 percent of retail sales.

[9]Here it is assumed that the physical retailer reaches every consumer in its market (or its exclusive territory). We do not consider consumers who can transact only through the electronic channel, as this proportion may be very low. Adding this category of consumers only adds to the complexity of the model without adding any new insights. The results in this paper are attributable to the consumers who can purchase from both the channels. Please see section 6 for further discussion on this issue.

[10] Later in the paper we also consider the alternative of choosing retailer E only, and the alternative of the manufacturer itself selling through the electronic channel.

ters, merchandisers, etc.), unless these reflect correspondent cost differences.” In this model, it is assumed that the manufacturer incurs the same cost to sell to the two retailers, and as a result, the manufacturer cannot discriminate between the retailers by charging them different fixed fees or different wholesale prices. It is also assumed that the manufacturer has little control over the retailers’ information service strategy, i.e., it is expensive for the manufacturer to write and enforce contracts specifying provision of product information.

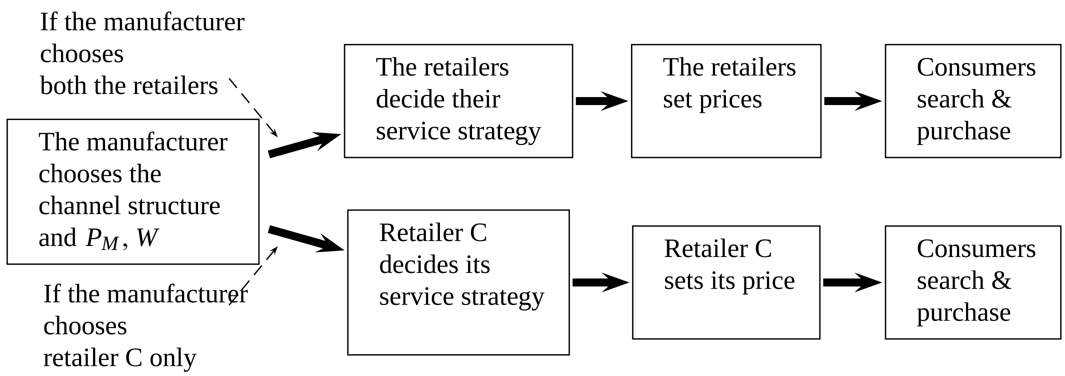

Figure 2.1: Sequence of Moves

Retailers accept any contract that gives them a non-negative profit. Once the channel structure is determined, retailers move in the next two stages. In stage 2, retailers decide whether to provide product information. In stage 3, they set their prices. Let P_C (P_E) be the price charged by retailer C (retailer E). This two-stage game for retailers is introduced because the information provision decision has greater commitment attached to it, whereas pricing decisions can be more easily changed [58].[11] Once retailers set their prices, their information provision and

[11]For example, in the physical channel, to provide product information a store has to invest in well-stocked showrooms and hire and train knowledgeable salespersons. In contrast to these com-

pricing decisions become known to consumers. Consumers then choose their search strategies to maximize their surplus. For example, if one retailer provides product information and the other doesn't, then consumers who can purchase at both the channels have many choices. They may purchase directly from the information service provider, or they may purchase directly from the non-service provider for a lower search cost or lower price but get a lower expected utility, or they may receive product information at the information service provider and then purchase from another retailer for a lower price.

2.3 The Market Equilibrium

The manufacturer has two choices: sell through retailer C only, or sell through both the channels. Let π_M^C be the manufacturer's profit if it chooses retailer C only, and π_M^{both} if it chooses both the channels. If the manufacturer chooses retailer C only, retailer C has monopoly over all the consumers. Each consumer receives a surplus of $R - K_C - P_C$ if retailer C provides product information, and a surplus of $r - K_C - P_C$ if retailer C doesn't provide product information. As a result, if retailer C provides product information, it charges $R - K_C$ and sells to every consumer. Retailer C's profits are then $\pi_C = (R - K_C - P_M) - W - V_C$. On the other hand, if retailer C doesn't provide product information, it charges $r - K_C$ and makes a profit of $\pi'_C = (r - K_C - P_M) - W$. Therefore, if the manufacturer chooses to sell through retailer C only, retailer C will provide product information

mitments that are costly to make (and once made, costly to reverse), the pricing decisions can be more easily changed.

if $\pi_C \geq \pi'_C$ (that is if, $R - r \geq V_C$) and will not provide product information otherwise. The manufacturer's strategy is to choose a wholesale price and a fixed fee to maximize its profits. For example, the manufacturer may charge $W = 0$ and $P_M = R - K_C - V_C$ when $R - r \geq V_C$, and charge $W = 0$ and $P_M = r - K_C$ when $R - r < V_C$.[12] Therefore,

$$\pi_M^C = \begin{cases} R - K_C - V_C & \text{if } R - r \geq V_C \\ r - K_C & \text{if } R - r < V_C \end{cases} \tag{2.1}$$

The subsequent analysis focuses on the cases where both the channels are chosen. As is apparent here, subgame perfection is the appropriate solution concept in this game. Therefore, we identify the equilibrium behavior using backward induction i.e., we first specify consumers' search strategy, followed by retailers' pricing and service strategy, and finally the manufacturer's pricing and channel strategy.

2.3.1 Consumers' Search Strategy

Once retailers' product information and pricing strategies are set, consumers choose their search strategy based on their search cost, and the pricing and information service strategies of the retailers. Let $U_C(U_E)$ be the utility of purchasing the product if a consumer receives product information from retailer C (retailer E). U_C is R when retailer C provides product information and r when retailer C doesn't provide product information. Similarly, U_E is R_D when retailer E provides product information and r when it doesn't.

[12]This is one of the many optimal solutions that maximizes the manufacturer's profits.

A consumer who can purchase only at the physical channel receives a surplus of $U_C - K_C - P_C$ from purchasing from retailer C. If this surplus is nonnegative the consumer purchases from retailer C. A multi-channel consumer may have four alternative search strategies. She can get a surplus of $U_C - K_C - P_C$ if she receives product information from retailer C and purchases from retailer C, and a surplus of $U_E - P_E$ if she receives product information from retailer E and purchases from retailer E. These two search strategies do not involve free riding.

In the third strategy, a multi-channel consumer can get a surplus of $U_C - K_C - P_E$ if she receives product information from retailer C and purchases from retailer E. Note that this free-riding strategy is considered only when retailer C provides more valuable product information. The benefit of free riding is that a higher level of product information allows the consumer to identify her ideal product with a higher probability. However, if retailer C doesn't provide product information, there is no need for a multi-channel consumer to free-ride by visiting retailer C first and then purchasing from retailer E. The consumer will be better off purchasing directly from retailer E.

A multi-channel consumer's fourth choice is to visit retailer E for product information and then purchase from retailer C, and get a surplus of $U_E - K_C - P_C$. Note that this free-riding strategy is considered only when retailer E provides product information but retailer C doesn't. A multi-channel consumer chooses her search strategy from the four alternatives to maximize her surplus.

Each retailer decides its information service and pricing strategy to maximize its expected profits. The above analysis shows that the higher the U_E, the more likely that multi-channel consumers will purchase from retailer E. In other words, providing product information doesn't decrease demand. As it is assumed that the cost of providing product information in the electronic channel is zero, retailer E always provides product information and $U_E = R_D$. Given retailers' information service and pricing strategies, consumers may follow different search strategies giving rise to different equilibria. The different cases when both the retailers are chosen are examined below.

When both retailers provide product information, a multi-channel consumer receives an expected utility of R from purchasing the product if she receives the product information from the physical retailer. She receives a utility of $R_D < R$ if she receives the product information from the electronic retailer. This difference in the utility received is determined by where she receives the product information, not by where she purchases the product. In this case a multi-channel consumer has three choices: (1) visit and purchase from retailer C, (2) visit and purchase from retailer E, and (3) free ride by visiting retailer C and then purchasing from retailer E (it can be easily shown that in this particular case purchasing directly from retailer C dominates visiting retailer E and then purchasing from retailer C).

Case 1 When both retailers provide product information and $R - R_D \leq K_C$, the strategy of purchasing directly from retailer E dominates the free-riding strategy of visiting retailer C and then purchasing from retailer E. The reason is that the surplus from the free riding strategy is $R - K_C - P_E$. Given that $R - R_D \leq K_C$, this surplus (i.e., $R - K_C - P_E$) is less than the surplus of $R_D - P_E$ from purchasing directly from retailer E. Therefore, there is no free riding in this case. The intuition is that when the value of information about physical characteristics ($R - R_D$) is lower than the cost of receiving it (K_C), a multi-channel consumer has no incentive to incur the search cost to free ride. As a result, she visits at most one store. She purchases from retailer C if $R - P_C - K_C > R_D - P_E$ and purchases from retailer E otherwise. This case is referred to as Case 1.

Case 2 When both the retailers provide product information and $R - R_D > K_C$, a multi-channel consumer always first visits retailer C for full product information. The reason is that in this case the surplus from free riding by visiting retailer C first and then purchasing from retailer E is $R - K_C - P_E$. Since $R - R_D > K_C$, this surplus (i.e., $R - K_C - P_E$) is greater than the surplus of $R_D - P_E$ from purchasing directly from retailer E. After visiting retailer C for full product information, a multi-channel consumer purchases from retailer C if $P_C \leq P_E$ and purchases from retailer E otherwise. The intuition is that when the value of information about physical characteristics ($R - R_D$) is greater than the cost of receiving it (K_C), a multi-channel consumer will always get the information. Therefore, the multi-channel consumer is likely to free-ride in this case. This case is referred to as Case 2.

Case 3 In the next case, when the manufacturer chooses both the retailers, only retailer E provides product information, i.e., $U_C = r$, and $U_E = R_D$. As the search cost in the electronic channel is zero, a multi-channel consumer will always first visit retailer E for information about digital characteristics, as the surplus from purchasing from retailer C after receiving the product information from retailer E is always greater than the surplus from purchasing directly from retailer C. Therefore, the multi-channel consumer is likely to free-ride in this case. The consumer receives a surplus of $R_D - P_E$ if she purchases from retailer E, and a surplus of $R_D - K_C - P_C$ if she purchases from retailer C. The consumer will purchase from retailer C if $P_E - P_C > K_C$ and from retailer E otherwise. This case is referred to as Case 3.

As stated earlier, if the cost of providing product information (V_E) and the search cost (K_E) in the electronic channel are positive, retailer E may not provide product information under some circumstances. As a result, additional cases arise in such an environment. For example, there may be a case where no retailer provides product information when the manufacturer chooses both the channels. However, including these additional cases makes the model more complex without changing any results or adding new insights.

In sum, the physical-channel consumer who can purchase only through the physical retailer always purchases, as long as she receives a non-negative surplus. As stated above, the multi-channel consumer needs to decide where to receive product information, and where to purchase. The multi-channel consumer will purchase from retailer C if $P_E > P_C + g$, where g can be described as the electronic retailer's price premium. This price premium reflects retailer E's advantage in search cost and its disadvantage in the product information it can offer to consumers. Therefore, g is contingent on U_C (either R or r), R_D, and K_C. In case 1, where both retailers provide product information, $R - R_D \leq K_C$, and there is no free riding, g is $K_C - (R - R_D)$. In case 2, where both retailers provide product information but $R - R_D > K_C$, the multi-channel consumer will always first visit retailer C for product information. Retailer E then must offer a discount so that P_E is below

Table 2.1: Case Description and retailer E's Price Premium

Case #	Case Description	U_C	g
Case 1	Both retailers provide information and $R - R_D \leq K_C$	R	$K_C - (R - R_D)$
Case 2	Both retailers provide information and $R - R_D > K_C$	R	0^-
Case 3	Only retailer E provides information	r	K_C

P_C, otherwise no consumer will purchase from retailer E. Therefore, in this case g would be 0^-(i.e., negative and infinitely close to zero), which means that retailer C has a small price premium over retailer E. In case 3 where only retailer E provides product information, the multi-channel consumer will always first visit retailer E for product information. Retailer E can then prevent these consumers from free riding by charging $P_E < P_C + K_C$. Therefore, in this case g would be K_C. Table 2.1 shows retailer C's information service level and retailer E's price premium in different cases

2.3.2 Stage 3: Retailers' Pricing Strategy

As stated earlier, after both retailers decide their information service strategy the price premium of retailer E over retailer C, g, is determined. The multi-channel consumer purchases from retailer C if $P_E > P_C + g$ and purchases from retailer E otherwise. Of course, the physical-channel consumer can only purchase from retailer C. This type of price competition has been studied in the literature on price promotions [81, 84]. One common result in this literature is that there is no focal pure-strategy equilibrium, thus, mixed-strategy equilibrium has to be considered. The intuition is that if one retailer charges a fixed price, another retailer will have an incentive to slightly lower its price and sell to all the multi-channel consumers. In the mixed-strategy equilibrium each retailer chooses its price from its equilibrium price distribution, and it receives the same expected profits by charging any price in the support of the distribution. Mixed strategy is interpreted as price promotion in the theory literature and as price dispersion in empirical studies [97]. Let $F_C(p)$ and $F_E(p)$ be the equilibrium (cumulative) price distribution function of the physical and the electronic retailer.

Proposition 2.1 *When both the channels are chosen the two retailers' price distribution function and profits are as shown below:*

(A) The equilibrium price distributions are:

$$F_E(p) = \begin{cases} \frac{1}{\beta}\left[1 - \frac{(1-\beta)(U_C - K_C - P_M)}{p - g - P_M}\right] & \text{when } p < U_C - K_C + g \\ 1 & \text{otherwise} \end{cases} \tag{2.2}$$

$$F_C(p) = \begin{cases} 1 - \frac{(1-\beta)(U_C - K_C - P_M) + g}{p + g - P_M} & \text{when } p < U_C - K_C \\ 1 & \text{otherwise} \end{cases} \tag{2.3}$$

(B) Retailers' profits are:

$$\begin{cases} E\pi_C = (1-\beta)(U_C - K_C - P_M) - W - v_C \\ E\pi_E = \beta[(1-\beta)(U_C - K_C - P_M) + g] - W \end{cases} \tag{2.4}$$

Table 2.2: Retailers' Expected Profits in Different Cases

Case #	Retailers' Expected Profits
Case 1	$E\pi_{C1} = (1-\beta)(R - K_C - P_M) - W - V_C$ $E\pi_{E1} = \beta[(1-\beta)(R - K_C - P_M) + K_C - R + R_d] - W$
Case 2	$E\pi_{C2} = (1-\beta)(R - K_C - P_M) - W - V_C$ $E\pi_{E2} = \beta[(1-\beta)(R - K_C - P_M)] - W$
Case 3	$E\pi_{C3} = (1-\beta)(r - K_C - P_M) - W$ $E\pi_{E3} = \beta[(1-\beta)(r - K_C - P_M) + K_C] - W$

Where υ_C is V_C if retailer C provides product information, and 0 if it doesn't. All the proofs are in the appendix. Equation 2.4 shows retailers' profit functions in the general case. For each specific case, retailers' profit functions are calculated by substituting specific g and U_C (shown in Table 1) into the general case (Equation 2.4), and are shown in Table 2.2. For convenience, we use the following notation for the retailers' profits under different cases.

2.3.3 Stage 2: Retailers' Information Service Strategy

This section answers the question: if the manufacturer chooses both the channels, who will provide product information to consumers? As retailer E always provides product information, only retailer C has to decide whether to provide product information. As a result, there are two possible outcomes in this stage: (i) both offer product information, or (ii) retailer E alone offers product information. Retailer C's information service strategy would depend on its profit function in each situation. Given that retailer E provides product information, if retailer C provides product information, its profit would be $E\pi_{C1} = E\pi_{C2}$ (shown in Table 2). If it doesn't provide product information, its profit would be $E\pi_{C3}$. Therefore, given that retailer E provides product information, for retailer C to provide product information, we should have $E\pi_{C1} \geq E\pi_{C3}$, i.e.,

$$(1-\beta)(R-r) \geq V_C \tag{2.5}$$

In sum, if $(1-\beta)(R-r) \geq V_C$ and $R - R_D < K_C$, the competition is in case 1. If $(1-\beta)(R-r) \geq V_C$ and $R - R_D \geq K_C$, the competition is in case 2. If $(1-\beta)(R-r) < V_C$, only retailer E provides product information, and the competition is in case 3.

2.3.4 Stage 1: The Manufacturer's Choice of Distribution Structure

The manufacturer chooses a distribution structure that maximizes its profits. The manufacturer's profits consist of two parts: wholesale price and the fixed fee. After the channel structure is chosen, the manufacturer needs to choose a wholesale price and a fixed fee to maximize its profits. If only one retailer is chosen, as discussed earlier, the manufacturer can easily appropriate the total channel profits. However, when both the retailers are chosen, the competition is asymmetric; different retailers have different revenues and different costs of providing information service. Therefore, the manufacturer may not be able to appropriate all the channel profits. The manufacturer's profits and the structure of the two-part tariff when it chooses both the retailers are as follows:

Proposition 2.2 *The manufacturer's profit and its profit-maximizing price and fixed* *fee when it chooses both the channels are:*

$$\begin{cases} \pi_M^{both} = U_C - K_C + \dfrac{\beta g + \upsilon_C}{(1-\beta)^2}(1-2\beta) - 2\upsilon_C \\ P_M = (U_C - K_C) - (\beta g + \upsilon_C)/(1-\beta)^2 \\ W = \dfrac{\beta}{1-\beta}(g + \upsilon_C) \end{cases} \tag{2.6}$$

It is clear that the manufacturer will choose both the retailers when adding the electronic channel in addition to selling through the physical channel increases its profits, i.e., when $\pi_M^{both} > \pi_M^C$. From equations (2.1) and (2.6) and table 1, we have the following proposition:

Proposition 2.3 *The manufacturer will choose both the retailers if* $\beta < 0.5$ *and one of the following conditions holds:*

$$\begin{aligned} &\text{(A) } R - R_D < K_C - \frac{\beta V_C}{1-2\beta} \text{ and } R - r \geq \frac{V_C}{1-\beta} \\ &\text{(B) } R - r < V_C + K_C \frac{\beta(1-2\beta)}{(1-\beta)^2} \text{ and } V_C \leq R - r < \frac{V_C}{1-\beta} \\ &\text{(C) } R - r < V_C \end{aligned} \tag{2.7}$$

These conditions are shown in Figure 2.2. They are discussed in the following section.

2.4 Analysis of the Equilibrium

The manufacturer has two choices for its vertical structure: to choose retailer C only, or to choose both the retailers. In this section we discuss the forces that influence the manufacturer's distribution strategy. The electronic channel has advantages and disadvantages compared with the physical channel. Consumers may have a higher willingness to pay in the electronic channel than in the physical channel, as they incur a lower search cost in the electronic channel. On the other hand, the electronic channel can only provide information about the digital characteristics. This may decrease consumers' willingness to pay in the electronic channel. When choosing the distribution structure, the manufacturer needs to consider the value of information about digital characteristics ($R_D - r$), the value of information about physical characteristics ($R - R_D$), search cost (K_C), and the proportion of multi-channel consumers (β). If both the channels are chosen, these parameters have two effects on the manufacturer's profits. First, as indicated above, they influence the manufacturer's profits by influencing consumers' willingness to pay in each channel. Second, they determine the manufacturer's profits by influencing the price competition between the two channels, which determines the retailers' profits and thereby the price that the manufacturer can charge the retailers. Next, we examine the price competition between the two retailers when both the channels are chosen.

2.4.1 Price Competition Between the Two Channels

Lemma 2.1 *As the electronic retailer's price premium (g) increases, the manufacturer is more likely to sell through both the channels.*

It is clear that the manufacturer adds the electronic channel, in addition to selling through the physical channel, when the addition of a new retail channel increases its profits. Intuitively, the manufacturer would add the electronic retailer when some consumers are willing to pay a higher price in the electronic channel compared with what they pay in the physical channel when the manufacturer sells only through the physical retailer.[13] This may happen when the subgame is in case 1 or in case 3.

When only retailer C is chosen, it charges the monopoly price. When both the channels are chosen, the two retailers compete for the multi-channel consumers, although retailer C still has monopoly over the physical-channel consumers. In the equilibrium price distributions, for any price p, $F(p)$ is the probability that the retailer charges a price equal to or lower than p. From $F_C(p)$ and $F_E(p)$ in Proposition 2.1, it is straightforward that as g, retailer E's price premium over retailer C, increases, both $F_C(p)$ and $F_E(p)$ decrease. This implies that when retailer E has a large price premium over retailer C, both retailers are less likely to engage in price competition, i.e., they are more likely to charge higher prices.

The intuition for this result is that when retailer E has a large price premium over retailer C (i.e., the electronic channel's advantage in search cost is much larger than its disadvantage in the information service level), retailer C has to lower its price significantly to attract the multi-channel consumers. However, because retailer C cannot discriminate between the two types of consumers, it ends up charging a much reduced price to the physical-channel consumers, which may reduce its total profits. For retailer C, the higher the electronic retailer's price premium, the

[13] This model focuses on the demand side variables that are influenced by IT. The results of the model are about the impact of the nature of product information, and consumers' willingness to purchase from the electronic channel, on retail competition and on the manufacturer's distribution strategy, other things being equal.

greater the decrease in its revenue from selling to its physical-channel consumers, when it competes for the multi-channel consumers. This lowers the physical retailer's incentive to compete for the multi-channel consumers. If retailer C has less incentive to engage in price competition, retailer E of course would be more likely to charge higher prices to the multi-channel consumers. Therefore, price competition is reduced when retailer E has a significant price premium over retailer C. This increases channel profits, and the manufacturer's profits from choosing both the retailers are higher than when only retailer C is chosen. Therefore, when retailer E's price premium is such that retailer C would rather largely concentrate on the physical-channel consumers where it has a monopoly, and retailer E charges a high price to the multi-channel consumers, the manufacturer is more likely to choose both the channels instead of selling through retailer C only.

Type of Products and the Value of Product Information

Result 2.1 *When the value of product information is high, as the value of information about digital characteristics increases, the manufacturer is more likely to sell through both the channels.*

This result is illustrated using Figure 2.2. The X-axis represents the value of information about physical characteristics, $R - R_D$, and the Y-axis represents the value of information about digital characteristics, $R_D - r$. Any point on this graph represents a specific product category. If the point moves rightward, the value of information about physical characteristics increases; if the point moves upward, the value of information about digital characteristics increases; and if the point moves

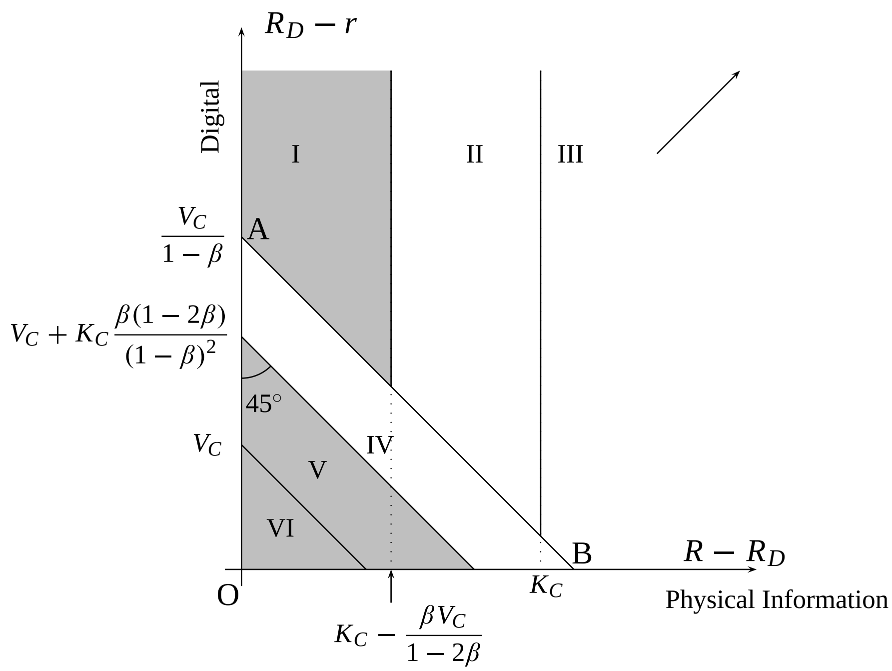

Figure 2.2: Channel Choice

diagonally from bottom left, the value of full information increases. The shaded regions represent conditions under which the manufacturer will sell through both the channels.

In the regions above the line AB that includes regions I, II, and III, the value of full information is high.[14] Specifically, in region I the value of full information is high, however, the product characteristics are primarily digital in nature. In this region, if both the retailers are chosen, both provide product information and there is no free riding. Here retailer E has a significant price premium as it can provide

[14]From Figure 2.2, it is clear that for any point above the line AB, the value of full information ($R - r = (R - R_D) + (R_D - r)$) is greater than $V_C/(1-\beta)$. For any point below the line AB, $R - r < V_C/(1-\beta)$.

a comparable level of product information but has an advantage in search cost. In this region, if the manufacturer chooses both the retailers, retailer C charges the physical-channel consumers close to its monopoly price, and retailer E charges the multi-channel consumers a higher price. Therefore, in this region the manufacturer will sell through both the channels. This happens in case 1. The condition set (A) in proposition 2.3 defines this region. Products such as branded desktop computers are an example of products in this region.

In region II product information is very valuable but information is increasingly about physical characteristics as $R - R_D$ increases. In this region the electronic retailer's advantage in search cost is comparable to its disadvantage in the provision of product information. If the manufacturer chooses both the channels, even though there is no free riding, it will result in aggressive price competition between the two retailers. Therefore, the manufacturer will not choose to sell through both the retailers in this region. This region also falls in case 1.

In region III information about physical characteristics $R - R_D$, is very valuable. In this region every multi-channel consumer visits retailer C first, and retailer E only sells to those consumers who, after visiting retailer C for full information, visit and purchase from retailer E at a lower price. In this case, since retailer E's price premium is negative (0^-), it is clear that price competition between the two retailers would be very severe. Specifically, in this case, retailer E has to charge below $R - K_C$ to induce consumers to free-ride and purchase from retailer E. This would also cause retailer C to charge a lower price and charging its regular/high price, $R - K_C$, has a lower probability. On the other hand, if only retailer C is chosen, it always charges $R - K_C$. As a result, the total channel profits when both retailers are chosen would be lower than when only retailer C is chosen. Therefore, in this region, the manufacturer will only sell through retailer C. This happens in case 2. New brands of perfume are examples of products in this region.

Result 2.2 *When the value of full information is low, the manufacturer will sell through both the channels. When the value of full information is intermediate, the manufacturer will sell through retailer C only.*

This result can also be illustrated using Figure 2.2. In the region OAB the subgame is in case 3. In this region, if the manufacturer were to choose to sell through both the retailers, as suggested by Equation 2.5, retailer C will not provide product information. However, in this region, if the manufacturer were to sell through the physical retailer only, since the physical retailer would be a monopolist, as suggested by Equation 2.1, it may provide product information and charge a higher price. In other words, choosing only retailer C provides the manufacturer the likely benefit of full information. On the other hand, in this region, retailer E has a price premium of K_C. Therefore, in the OAB region, the manufacturer trades off the benefit of full information from retailer C when retailer C is the only retailer chosen, against the benefit from the electronic retailer's price premium when both the retailers are chosen.

In region V and VI product information is not valuable and the manufacturer prefers the benefit of the electronic retailer's price premium over the benefit from the physical retailer's product information. Therefore, in this region the manufacturer sells through both retailers, even though the multi-channel consumers may free-ride by visiting retailer E and then purchasing from retailer C. The condition sets (B & C) in Proposition 2.3 define this region. Products such as music CDs and computer accessories are examples of products in this region.

In region IV product information is moderately valuable. In this region the manufacturer prefers the benefit of the physical retailer's product information when retailer C is the only retailer, over the electronic retailer's price premium of K_C when both the retailers are chosen. Therefore, in this region the manufacturer will sell through retailer C only. Products such as clothing/apparel are examples of products in this region.

In summary, the manufacturer will choose both the channels when retailer E has a high price premium. This happens when full information is very valuable and product information is largely about digital characteristics. This implies that as technology enables the electronic channel to provide improved product information, more and more products will fall into region I, and the manufacturer will be more likely to sell through both channels. The manufacturer will also choose both the channels when full information is not valuable. In both the above situations the manufacturer gets higher profits by making use of the electronic channel's advantage in search cost. A manufacturer will sell only through retailer C, if the product has very valuable physical characteristics, or when product information is only moderately valuable.

2.4.2 The Proportion of Multi-Channel Consumers (β)

Result 2.3 *When β is below a certain value, with an increase in β the manufacturer is more likely to sell through both the channels. When β is above a certain value, with an increase in β, the manufacturer is less likely to sell through both the channels.*

From Equation 2.6, it can be shown that when β, the proportion of multi-channel consumers, is below $\beta^* = g/(3g + 2v_C)$, π_M^{both} increases as β increases. In other words, when there are a small proportion of multi-channel consumers, the manufacturer is more likely to choose both the channels when β increases. But when β is above $g/(3g + 2v_C)$, π_M^{both}decreases as β increases, which means that the manufacturer is less likely to choose both the channels.

When β increases, more consumers may purchase from the electronic channel. However, β also has an impact on price competition. From proposition 1, it is clear that the higher the value of β, the higher the probability that the two retailers will charge a lower price. When β is low, retailer C would rather concentrate on charging a higher price to the physical-channel consumers where it has a monopoly, instead of competing aggressively to sell to the small proportion of multi-channel consumers. Since retailer C does not compete aggressively for the multi-channel consumers, the electronic retailer is able to charge a higher price to these consumers. As a result, multi-channel consumers are more likely to purchase from the electronic channel at a higher price. This increases channel profits. In this circumstance, an increase in β increases the likelihood that both the channels would be chosen. However, when there are a large proportion of multi-channel consumers, the physical retailer cannot ignore these consumers, and the price competition between the channels is more aggressive. That is, when β is high, retailer C will price aggressively to compete for the multi-channel consumers, rather than concentrate on the smaller proportion of physical-channel consumers where it has a monopoly. This price competition will decrease channel profits. In such an environment, the manufacturer is less likely to choose both the channels.

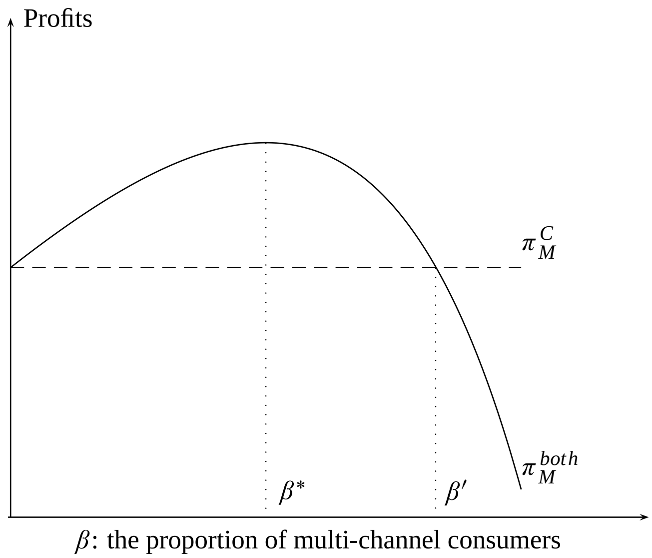

Figure 2.3: Impact of β on Manufacturer's Profits.

This result is illustrated in Figure 2.3. When β is below β^*, π_M^{both} increases with an increase in β, and the manufacturer is likely to sell through both the channels. However, beyond β^*, π_M^{both} decreases with an increase in β, and the manufacturer is less likely to sell through both the retailers. This suggests that though β is expected to increase as Internet technology diffuses further, it is not necessarily beneficial for the manufacturer to always sell through both the channels.

β is the proportion of consumers who are willing to transact through the electronic channel. However, it is likely that there are many electronic retailers for the manufacturer to choose from. In this regard, it is possible that consumers' willingness to transact through the electronic channel differs across different retailers, i.e., each electronic retailer may have a unique β. This difference in the willingness to transact through different electronic retailers may be due to varying levels of trust for different electronic retailers. As there are differences in familiarity and experiences with, and reputation of, different electronic retailers, consumers may have a different willingness to transact through each electronic retailer. For example, in the Book industry, Amazon.com, Textbookx.com, and Bookpool.com may have different levels of β.[15] Therefore, when the manufacturer decides to sell through the electronic channel, the manufacturer may have to choose from electronic retailers with different levels of β. Here it is clear that the manufacturer need not choose the electronic store with the highest β; rather, it should choose the electronic store whose β is equal to β^*.

When the Proportion of Multi-Channel Consumers Is Very High

Result 2.3.1 *When the proportion of multi-channel consumers is very high, the manufacturer will choose to sell through only one channel.*

[15]For the manufacturer, β is the proportion of consumers who are willing to transact through the electronic channel. On the other hand, each electronic retailer has a unique β. These two definitions of β are consistent. β for the manufacturer will be determined after the manufacturer chooses an electronic retailer who has a specific β. For example, assume that a fraction β_0 (β_1) of consumers are willing to purchase from Amazon.com (Bookpool.com). Here both β_0 and β_1 are related to specific stores. If the manufacturer chooses Amazon.com, then β for the manufacturer will be β_0. In other words, a fraction $\beta = \beta_0$ of consumers are willing to purchase from the electronic channel (if the electronic channel is chosen).

When the proportion of multi-channel consumers is very high, if the manufacturer were to choose both the channels, the price competition between the channels would be extremely high. Therefore, as is clear from proposition 2.3, when β is sufficiently high the manufacturer will choose to sell through only one channel. So far we have only compared choosing both the channels with choosing retailer C only. However, when β is close to 1 the manufacturer may weigh the benefits of choosing retailer C only against those of choosing retailer E only.

When retailer E is the only retailer, it will charge R_D, whereas when retailer C is the only retailer, retailer C will charge $R - K_C - V_C$ if $R - r > V_C$, or charge $r - K_C$ otherwise. Therefore, if $R_D > \max(R - K_C - V_C, r - K_C)$, the manufacturer will sell through retailer E only; otherwise, it will sell through retailer C only. The interesting point here is that, for the manufacturer, the distribution problem requires a consideration of both the channels only when some consumers have access to only one channel. If all the consumers can purchase from both the channels, the manufacturer may sell through only one channel.

2.5 Model Extensions

In this section we relax some of the assumptions of the model presented in section two. So far it was assumed that the manufacturer and the two retailers in the physical and the electronic channel are all independent of each other. In section 5.1 we examine the case where the manufacturer considers operating its own electronic store instead of selling through an independent electronic store. In section 5.2 we examine the case where the physical and the electronic stores are jointly owned.

2.5.1 Manufacturer Owns the Electronic Retailer

The Internet makes it easy for a manufacturer to have its own electronic store. Here we examine the scenario where the manufacturer can itself operate as the electronic retailer, i.e., the manufacturer's distribution decision is to sell through retailer C only, or to choose retailer C and its own electronic store, or to sell through retailer C and an independent electronic store. Specifically, we examine the manufacturer's distribution problem where it considers selling through the electronic channel itself, but its own electronic store may have a different β compared with the independent electronic retailer.

Result 2.4 *If the manufacturer's β is close to the independent electronic retailer's β, the manufacturer should itself sell through the electronic channel. If the manufacturer's β is too low, or too high, compared with the independent electronic retailer's β, the manufacturer should sell through the independent electronic retailer in the electronic channel.*

In the original model β is the proportion of multi-channel consumers who are willing to transact through the electronic channel. It is likely that the manufacturer's electronic store can have a different β compared with the independent electronic retailer. In such a situation it is interesting to examine whether the manufacturer should sell through its own electronic store or use an independent electronic retailer.

Figure 2.4 shows the profits of the manufacturer when it itself is the electronic retailer, and when the electronic retailer is independent. It is clear that if the

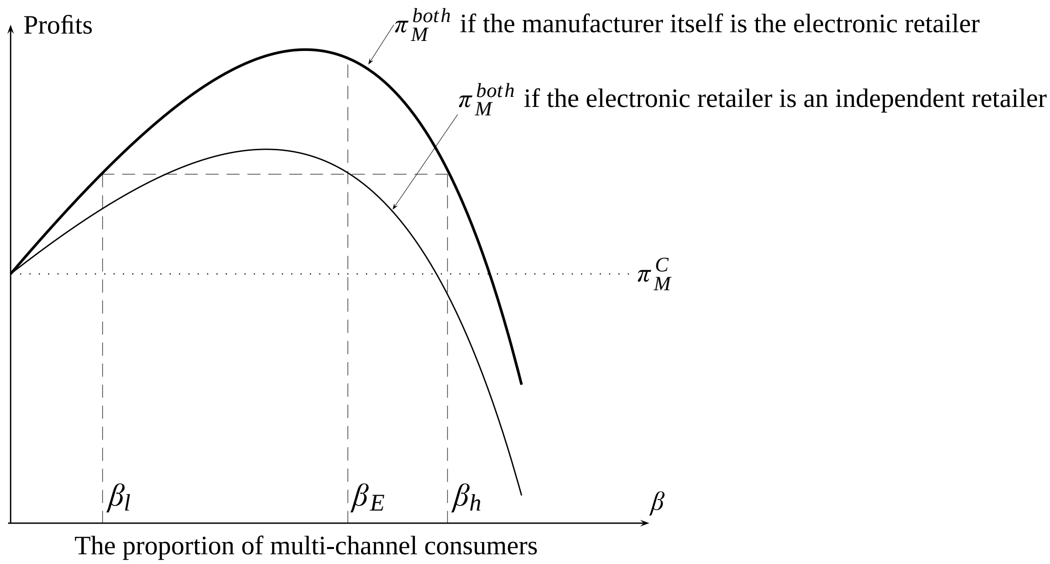

Figure 2.4: Manufacturer's Own Electronic Store

manufacturer and the independent electronic retailer have the same β, the manufacturer's profits are always higher when it itself is the electronic retailer, because it is in a better position to control the price competition across the channels. In other words, given the physical retailer's strategy, a manufacturer-owned electronic retailer would make (e.g., pricing) decisions to maximize the manufacturer's profits, whereas an independent electronic retailer would make decisions to maximize its own profits. Therefore, if the manufacturer's own store and the independent electronic store have the same β, the manufacturer is better off selling through its own electronic store rather than through the independent electronic store.

However, if the manufacturer and the independent electronic retailer have different β, the picture is different. Assume that the independent electronic retailer's β is β_E (please see Figure 2.4). When the manufacturer's β (say β_M) is much lower than the independent electronic retailer's β (i.e., $\beta_M < \beta_l$), a smaller proportion of consumers pay a higher price in the manufacturer's electronic store, compared to the proportion of consumers who are willing to purchase at a higher price from the independent electronic retailer's store. Similarly, when a larger proportion of consumers can purchase at the manufacturer's electronic store, compared to those who are willing to transact through an independent electronic retailer's store (i.e., $\beta_M > \beta_h$), the price competition between the channels is much higher and the manufacturer's profits are lower. Therefore, the manufacturer should itself sell through the electronic channel when its β is close (i.e., $\beta_l < \beta_M < \beta_h$) to the independent electronic retailer's β (β_E), and not when its β is too low or too high compared to the independent retailer's β.

When the manufacturer's β is very high, it is not profitable for the manufacturer to choose both the independent physical retailer and the manufacturer's own electronic store. The manufacturer may choose to sell only through its own electronic store, or sell through an independent physical retailer and an independent electronic retailer with moderate β. However, the manufacturer may also have another alternative, the manufacturer may consider operating its own physical store. For example, Dell is well known for selling directly through the Internet. This implies that Dell.com's β is so high that it has chosen to not sell through independent physical retailers. To serve consumers who may not purchase online, Dell has set up its own stores in large shopping malls [61].

2.5.2 Integrated Retailers

So far it has been assumed that the retailers in the physical and the electronic channel are independent of each other and that they compete with each other. However, the interaction between the two retailers could also be cooperative/complementary. This can happen when the physical and the electronic retailers are jointly owned.[16] In this case there is no price competition between the two retailers.[17] In this environment the higher the β, the higher the channel profits, and the more likely the manufacturer will sell through both the channels.

A manufacturer may also have to choose between two alternatives: (i) two independent retailers in different channels, and (ii) one integrated retailer that operates in both the channels. It is clear that in this situation also the independent electronic retailer's β is likely to be different from the integrated retailer's β.[18] In this case if the integrated retailer's β is too low compared to the independent electronic retailer's β, the manufacturer might not select the integrated retailer even though doing so will reduce free-riding and eliminate inter-channel price competition.

2.6 Discussion of the Model

In this section we discuss two limitations of the model. First, in the model the manufacturer chooses only one retailer in each channel (i.e., the model does not consider

[16]For example, Circuit City owns physical stores as well as operates in the electronic channel through Circuitcity.com. Similarly, Barnes & Noble operates stores in the physical and electronic channels.

[17]Ancarani and Shannkar [4] find that integrated retailers charge higher average prices than independent electronic retailers.

[18]For example, for consumer electronics, Circuitcity.com may have a lower β than Amazon.com.

consumers who can purchase from two or more physical stores), as the emphasis here is on price and service competition across the two channels. In an environment where the manufacturer chooses two or more retailers in one channel, competition exists not only across the two channels but also within each channel. The nature of the competition within the same channel has been studied by Narasimhan [81]. For example, if there are two physical retailers (say, A and B) in the conventional channel, there will be three types of consumers in the physical channel:

1) Consumers who have access to retailer A but not to retailer B

2) Consumers who have access to retailer B but not to retailer A

3) Consumers who have access to both retailer A and retailer B

Therefore, in the physical channel, the retailers will compete for consumers who can purchase from both the retailers. On the other hand, if the electronic channel is introduced, each physical retailer will also compete with the electronic retailer for consumers who can purchase from the electronic retailer and that specific physical retailer. Such an environment may lead to aggressive competition between the retailers in the physical and in the electronic channel. A more involved model may be required to formally analyze this type of environment. However, it is not clear whether such retail competition will benefit the manufacturer as it will reduce retailers' incentive to provide product information, and also reduce channel profits and thus the manufacturer's profits. Therefore, in the physical channel, if the manufacturer chooses many retailers to cover more geographical areas, it may choose physical retailers who are geographically apart from each other, to reduce the price competition within the channel.

The second limitation of the model is the assumption that the physical retailer is able to reach all the consumers. This is largely true as the manufacturer can choose one physical store in each retail market. However, one clear advantage of the electronic retailer is that it can reach consumers who live in very remote and isolated areas. In other words, the physical retailer may only reach a fraction λ_C ($\lambda_C < 1$) of consumers. The remaining (i.e., $1-\lambda_C$) consumers may have no access to the physical retailer. If the manufacturer adds an electronic retailer, the electronic retailer can independently reach a proportion β of the consumers. Thus, if both the channels are chosen, there will be four types of consumers:

1) Consumers who have access only to the physical retailer. We call them physical-channel consumers. The mass of this type of consumers is $\lambda_C(1-\beta)$.

2) Consumers who have access only to the electronic retailer. Let's call them electronic-channel consumers. The mass of this type of consumers is $(1-\lambda_C)\beta$.

3) Consumers who have access to both the retailers. We call them multi-channel consumers. The mass of this type of consumers is $\lambda_C\beta$.

4) Consumers who do not have access to any retailer. The mass of this type of consumers is $(1-\lambda_C)(1-\beta)$.

It may seem that the manufacturer should add the electronic channel because the electronic retailer can reach electronic-channel consumers who do not have access to the physical retailer, and the higher the electronic retailer's ability to reach new consumers, the better. However, this is not the case. The reason is that as the reach of the electronic retailer increases (i.e., as β increases) the proportion of electronic-channel consumers increases (i.e., $(1-\lambda_C)\beta$ increases), but so does the proportion of multi-channel consumers ($\lambda_C \beta$). This means that there are fewer physical-channel consumers (i.e, $\lambda_C(1-\beta)$ decreases). As a result, the physical retailer has more incentive to compete with the electronic retailer for multi-channel consumers. In other words, the electronic retailer's ability to reach more consumers has two effects for the manufacturer.

1) The manufacturer can sell to new consumers. This has a positive impact on the manufacturer's profits.

2) The physical retailer competes more aggressively with the electronic retailer for the multi-channel consumers. This has a negative impact on the manufacturer's profits.

The analysis of the impact of β in the original model can also be applied to this new model (where the physical retailer reaches λ_C ($\lambda_C < 1$) of consumers). That is, when β is low, the proportion of multi-channel consumers is also low and the physical retailer focuses on selling to physical-channel consumers, rather than engaging in aggressive price competition with the electronic retailer for multi-channel consumers. Therefore, the first (and the positive) effect dominates when β is low. However, when β is high, the second (and the negative) effect dominates. In this case the price competition between the two channels is very severe and the manufacturer's gain in selling to more new consumers cannot outweigh the decrease in profits from selling to multi-channel consumers and physical-channel consumers at a lower price. In sum, the results in the paper are not influenced by the assumption that the physical retailer can reach all the consumers. In other words, our results also hold when the electronic channel can reach new consumers.

2.7 Conclusion

The Internet is an additional channel for manufacturers to provide information about and sell their products. However, the electronic channel has properties that are different from the physical channel. In this paper we examine how information technology affects a monopoly manufacturer's distribution problem. Specifically, the paper examines how the introduction of the electronic channel, with its reduced search cost and increasing reach but limited capability to provide product information, influences the manufacturer's distribution problem. Despite the reduced search cost and increasing reach, the benefits of selling through both the channels are reduced, and sometimes outweighed, by the free riding and the price competition between the two channels.

The model suggests that a manufacturer would sell through both the channels when the electronic store has a high price premium over the physical store. This can happen when the product information is very valuable and the product information is largely digital in nature, or when the product information is not valuable. This result is consistent with the empirical study by Carlton and Chevalier [18], in which they find that the manufacturers' channel selection decision is influenced by the product category and whether the product is subject to free riding. The model also suggests that when the manufacturer chooses to sell through both the retailers, there is an increase in price competition between the two channels. Therefore, when the manufacturer sells through both the channels, it needs to select an electronic retailer with the optimal reach, rather than selecting the most well-known electronic retailer.

This paper emphasizes the case where the retailers in the physical and the electronic channel are independent retailers who compete with each other. A manufacturer may be interested in using the physical channel and the electronic channel in a complementary manner. This can happen when the physical retailer also owns the electronic retailer. Since the same retailer owns the physical and electronic stores, they will not engage in aggressive price competition with each other, and this can benefit the manufacturer if, as discussed in section 5, the β of the physical retailer's electronic store is not too low compared to the β of the independent electronic retailer.

This study suggests some interesting predictions that can be examined empirically. For example, when product information is valuable and the product category is such that the two channels provide very comparable levels of product information, the product is more likely to be available in both the channels. In this case the price competition between the channels is also expected to be reduced, and the retailers are less likely to engage in frequent promotions. In this environment, the price dispersion in each channel is expected to be low, but the average prices in the two channels may be quite different. Similarly, the price competition between the physical and the electronic retailers would be less severe if product information is not valuable. It would also be interesting to empirically examine the prediction that a manufacturer is more likely to choose only one channel when, for a specific product category, a very large proportion of the potential consumers have access to both the channels.

In this paper we examined a market where the product category is new, there is no competition on the manufacturer's side, and all the consumers need the product information to identify their ideal product. The distribution problem would be different in a more mature market where some consumers have already identified their ideal product (and do not need the product information) and there are competing manufacturers. This is an interesting problem for future research.

Appendix

Proof of Proposition 2.1

To construct the mixed-strategy equilibrium for case 1, we have the following properties:

(1) Each retailer's price distribution (cumulative) is continuous.

(2) No retailer would have a mass point strictly below the highest value in its price distribution.

(3) If retailer E's price distribution (cumulative) has a mass point at $\widetilde{P_E}$, retailer C will charge $\widetilde{P_E} - g$ with zero density. If retailer C has a mass point at $\widetilde{P_C}$, retailer E will charge $\widetilde{P_C} + g$ with zero density.

(4) Retailer E's price distribution is from $\underline{P_E}$ to $R - K_C + g$. Retailer C's price distribution is from $\underline{P_E} - g$ to $R - K_C$.

The proofs for these 4 propositions are essentially the same as the proofs for Propositions 2 to 5 in Narasimhan [81]. From now on, let $\underline{P_E}$ be the lower bound of retailer E's price distribution.

From the propositions above, it can be easily shown that in case 1, retailer C has a mass point at $R - K_C$. Retailer E does not have a mass point in its price distribution. This is also proved in Narasimhan [81]. Thus, when retailer C charges its highest price, it sells only to consumers who purchase only from the physical channel, and when retailer E charges its highest price, it can sell to multi-channel consumers only when retailer C charges $R - K_C$.

We then derive the two retailers' profit functions in case 1. From the above propositions, we know that the support of retailer C's price distribution is $[\underline{P_E} - g, R - K_C]$, and that for retailer E is $[\underline{P_E}, R - K_C + g)$. Here $\underline{P_E}$ and prob($p_C = R - K_C$) are to be determined. Let δ be the probability that retailer C charges $R - K_C$.

In the equilibrium, the physical-channel consumers always purchase from retailer C. The multi-channel consumers will purchase from retailer C if $P_E - P_C > g$, and from retailer E otherwise. If retailer C charges $R - K_C$, it sells only to the physical-channel consumers. On the other hand, retailer C makes the same expected profits if it charges a price in the support of $F_C(p)$. Therefore,

$$E\pi_C(p) = (1-\beta)(R - K_C - P_M) - W - V_C \tag{2.8}$$

$$E\pi_C(p) = [(1-\beta) + \beta(1 - F_E(p+g))](p - P_M) - W - V_C \tag{2.9}$$

Solving the two equations above results in:

$$F_E(p+g) = \frac{1}{\beta}\left[1 - \frac{(1-\beta)(R - K_C - P_M)}{p - P_M}\right]$$

$$\Rightarrow F_E(p) = \frac{1}{\beta}\left[1 - \frac{(1-\beta)(R-K_C-P_M)}{p-g-P_M}\right]$$

Similarly, we have

$$E\pi_E(p) = \beta\delta(R-K_C+g-P_M) - W \tag{2.10}$$

$$E\pi_E(p) = \beta[(1-F_C(p-g))](p-P_M) - W \tag{2.11}$$

Therefore:

$$F_C(p) = 1 - \frac{\delta(R-K_C+g-P_M)}{p+g-P_M}$$

Solving $F_C(p)|_{p=\underline{P_E}-g} = 0$ and $F_E(p)|_{p=\underline{P_E}} = 0$, we get:

$$\begin{cases} \underline{P_E} - g = \delta(R-K_C+g-P_M) - g + P_M \\ \underline{P_E} = (1-\beta)(R-K_C-P_M) + g + P_M \end{cases}$$

$$\begin{aligned} \Rightarrow \delta &= \frac{(1-\beta)(R-K_C-P_M)+g}{R-K_C+g-P_M} \\ &= 1-\beta+\frac{\beta g}{R-K_C+g-P_M} \end{aligned} \tag{2.12}$$

From Equations (2.8)-(2.12), we can easily get the price distribution functions for case 1.

Similarly, we can get the price distribution functions for case 2 and case 3.

■

Proof of Proposition 2.2

From Proposition 2.1 and Equation 2.5, the fixed fee only influences whether retailers will accept the contract. The wholesale price influences retailers' pricing strategy and determines which retailer makes higher profits. Therefore the stages of the game can be modified in the following manner without changing anything:

In stage 1, the manufacturer chooses the distribution strategy and the wholesale price. The manufacturer also promises non-negative profits for retailers. In stage 2 and stage 3, the retailers make service and pricing decisions. In stage 4' the manufacturer charges the fixed fee. The manufacturer's optimal fixed fee is such that one retailer will make zero profits and the other retailer makes non-negative profits. More specifically suppose that before stage 4' the two retailers' profits (after they pay the wholesale price but before they pay the fixed fee) are π'_C and π'_E. Then $W = \min(\pi'_C, \pi'_E)$, and finally $E\pi_C = \pi'_C - W$, $E\pi_E = \pi'_E - W$. Therefore, the manufacturer's profit is $P_M + 2 \cdot \min(\pi'_C, \pi'_E)$. In other words, the manufacturer's ability to extract profits from the two channels is restricted by the less profitable retailer. From equation (2.4), the manufacturer can get all the channel profits only when P_M is such that $P_M = (U_C - K_C) - (\beta g + \upsilon_C)/(1-\beta)^2$ and the two retailers make equal profits. If $P_M < (U_C - K_C) - (\beta g + \upsilon_C)/(1-\beta)^2$, we have $\pi'_C > \pi'_E$, so the manufacturer's profit is:

$$\pi_M^{both} = P_M + 2\pi'_E = 2\beta(1-\beta)(U_C - K_C) + [1 - 2\beta(1-\beta)]P_M \qquad (2.13)$$

On the other hand, if $P_M > (U_C - K_C) - (\beta g + \upsilon_C)/(1-\beta)^2$, we have $\pi'_C < \pi'_E$, so the manufacturer's profit is:

$$\pi_M^{both} = P_M + 2\pi'_C = 2(1-\beta)(U_C - K_C) + (2\beta - 1)P_M - 2\upsilon_C \qquad (2.14)$$

When both channels are chosen, from the equations (2.13) and (2.14), it can be easily shown that when $\beta > 0.5$, the manufacturer's profits increase with P_M. So it will choose P_M as high as possible. The highest wholesale price retailer C can accept is $U_C - K_C - v_C/(1-\beta)$. On the other hand, the highest wholesale price retailer E can accept is $U_C - K_C + g/[\beta(1-\beta)]$. The highest wholesale price the manufacturer can set should be the minimum of these two. As a result, $P_M \leqslant U_C - K_C - v_C/(1-\beta)$, and either retailer C or retailer E makes zero profits. Therefore, if retailer C provides product information, the manufacturer's profits will be P_M as it cannot charge a positive fixed fee, and

$$\pi_M^{both} = P_M \leqslant R - K_C - V_C/(1-\beta) < R - K_C - V_C \qquad (2.15)$$

When $\beta > 0.5$ and retailer C does not provide product information, the manufacturer's profits will be:

$$\pi_M^{both} = P_M \leqslant r - K_C \qquad (2.16)$$

From equations (2.1), (2.5), (2.15), and (2.16), it is clear that as long as $\beta > 0.5$, the manufacturer will not choose both the channels. The intuition is that when a large proportion of consumers have access to both retailers, the price competition will be too severe. As a result, the manufacturer will not choose both channels when $\beta > 0.5$.

From equations (2.13) and (2.14), it can be easily shown that when $\beta \leqslant 0.5$, the manufacturer's profit increases with P_M when $P_M \leqslant P_M^* = (U_C - K_C) - (\beta g +$

$\upsilon_C)/(1-\beta)^2$ and decreases with P_M when $P_M > P_M^*$. As a result, it will choose $P_M^* = (U_C - K_C) - (\beta g + \upsilon_C)/(1-\beta)^2$ to get all the channel profits. In this circumstance, $\pi_M = P_M + 2\pi'_C = P_M + 2\pi'_E$. Therefore,

$$\pi_M^{both} = U_C - K_C + \frac{\beta g + \upsilon_C}{(1-\beta)}(2 - \frac{1}{1-\beta}) - 2\upsilon_C$$

■

Chapter 3

The Impact of IT on Vertical Integration

3.1 Introduction

There is a significant literature in IS examining the coordination capabilities of IT [46, 15]. This literature suggests that by lowering external coordination costs, IT will lead to an overall shift towards more use of markets to coordinate economic activity. Hitt [49] provides empirical evidence that the use of IT is associated with a decrease in vertical integration (VI). Similarly, Dewan et al. [34] and Hitt [49] find that less vertically integrated firms have higher demand for IT capital, implying that these firms invest in more IT to coordinate with external suppliers.

The transaction cost economics (TCE) literature [28, 112] suggests that markets generally have production cost advantages due to specialization, economies of scale, and market-induced efficiency. However, there are costs (e.g., coordination, writing and monitoring contracts, and opportunism) associated with market exchanges. Since IT can reduce some of these costs, IS researchers have argued that IT will lead to greater use of markets [25, 26], and consequently the levels of VI will decrease.

Not withstanding the above observations about VI in some strategy and IS literatures, over the last 25 years, the average level of VI in the economy appears to have increased. Fan and Lang [39], for example, examine multi-segment firms and report that between 1979 and 1997, the average level of VI increased by about 40%. If we examine all the firms in the COMPUSTAT database, the average level of VI has not decreased, but increased in the last 20-30 years. Figure 3.1 plots the level of VI for recent periods for multi-segment firms and for all the firms in the economy. As shown in Figure 3.1, the pattern of increase in the level of vertical integration for multi-segment and all the firms has persisted[1].

Given that the levels of investments in IT have continually increased over the years, the increasing trend in VI is surprising. It is possible that IT is used extensively to reduce internal coordination costs, and not just external coordination costs. Since there is a strong evidence in the IS literature that IT investments are associated with a decrease in VI, it requires us to explore further and explain the possible gaps across different streams of research.

Consider the following two scenarios. In the semiconductor & electronics manufacturing – a dynamic industry – OEMs like Cisco, Ericsson, Nortel Networks,

[1]There is a jump in the level of VI in 1998. This is partially due to SFAS 131, the new segment reporting standard that has lead to an increase in the number of segments reported by many firms [7]. The trend in VI is consistent even if we were to discount the increase in 1998.

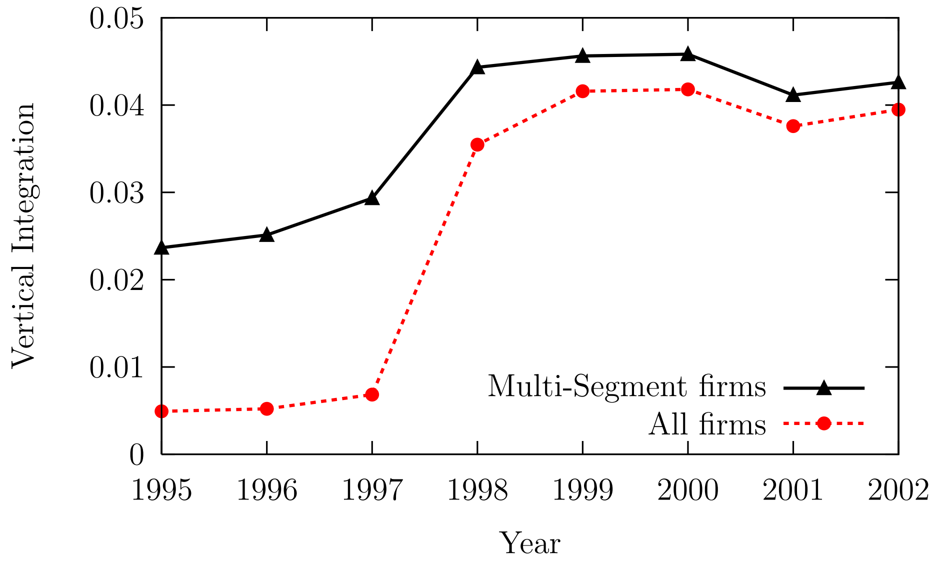

Figure 3.1: Trend in Vertical Integration

3Com, Phillips Electronics, etc., outsource manufacturing to contract manufacturers like Solectron, and use IT to reduce external coordination costs [53]. Generally, the level of VI in this industry is quite low. In contrast, in a stable industry like the petroleum industry, firms such as BP, ChevronTexaco, Shell etc. coordinate production (exploration, drilling, pumping, refining) and distribution (from refineries, to terminals, to roadside gas stations) in large vertically integrated organizations [88]. In this environment, firms use IT to reduce internal coordination costs [114]. Thus, under different competitive environments, IT may reduce coordination costs differently.

The above examples raise the question whether coordination costs can be the basis to make the argument that IT will lead to a decrease in VI. Therefore, the goal of this paper is to examine (a) the impact of firms' competitive environment on how IT affects the level of VI, and (b) how the interaction between IT and the level of VI impacts firms' coordination and production costs.

In this study, we analyze firms included in 1995-1997 InformationWeek 500 and COMPUSTAT. The research makes two important contributions. First, the analysis suggests that the competitive environment moderates the impact of IT on VI — in a more dynamic environment IT is associated with a decrease in VI, and in a more stable environment IT is associated with an increase in VI. Second, the study provides empirical evidence that IT reduces coordination costs. The analysis also suggests that the use of IT to organize production in more vertically integrated firms is associated with an increase in production costs. Given the impact of IT on coordination and production costs (which favor lower levels of VI) the finding that IT is associated with an increase in VI in more stable environments is not consistent with the coordination cost argument about the impact of IT on VI. Therefore, the analysis suggests that there is a need to go beyond efficiency considerations and incorporate strategic reasons for vertical integration

The rest of the chapter is organized as follows. Section 2 presents the theory and the hypotheses. Section 3 discusses the data and the variables, and section 4 presents the empirical analysis. Section 5 concludes with a discussion of the results, and presents directions for future research.

3.2 Theory and Hypotheses

Below we first examine how a firm's competitive environment influences the relationship between IT and VI, and then examine the performance (i.e., the coordination and production cost) implications of the interaction between IT and VI.

3.2.1 Competitive Environment and the Choice of VI level

We assess an environment by the uncertainty in demand and by its competitive stability. Dynamic environments[2] are characterized by uncertainty about, and unpredictability of, customer tastes and preferences, and production and service technologies [77]. Firms can respond to this uncertainty by organizing more activities internally. For example, Walker and Weber [108] found that demand uncertainty increased the likelihood of internal production in automobile manufacturing. Alternatively, firms can choose to reduce their VI level to maintain flexibility, as they require a changing set of assets and capabilities to compete [106, 103]. In contrast to dynamic environments, in stable competitive environments, assets and capabilities are more enduring and operational efficiency and market power are key [38]. Thus, firms can take advantage of stable market conditions by organizing more activities inside the firm [47]. Alternatively, firms can choose to focus on their core competencies and opt for narrow vertical specialization [83]. These arguments suggest that firms in different environmental contexts may make different commitments in specialized assets, and choose different levels of VI.

When demand is very unpredictable, the likelihood of excess specialized capacity without alternative use, or insufficient capacity, increases. D'Aveni and Ilinitch [32], for example, find that in dynamic environments vertically integrated firms are associated with higher risk, as they are less adaptive. Vertically integrated

[2]We use the terms dynamic environment and demand uncertainty interchangeably depending on the grammatical context.

firms have many vertical links between their different units, leading to high interdependence among them. Such interdependence may make it hard to adapt because of the difficulties in changing strategies, abandoning obsolete technologies, or filling unevenly balanced upstream or downstream capacity. In dynamic environments, firms may be better off by reducing their VI, and instead using IT to coordinate with external partners with the necessary assets and capabilities. Folta [41], for example, found technological uncertainty to be associated with a preference for collaboration over acquisition (i.e., vertical integration), as a way of economizing on the cost of committing to a technology with uncertain demand and as a more flexible and faster mechanism to adapt to changes in technology.

Lee [70] discusses how firms in Computer and electronics industries where technologies change rapidly and demand is very unpredictable, use electronic exchanges to collaborate on design. These electronic exchanges allow firms to share product content information to support product changes that reduces cycle time for new product introductions and improves responsiveness. Here contract manufacturers like Solectron provide manufacturing capacity to meet fluctuating demand [53]. Solectron has established a web-enabled extranet that allows information sharing with customers. Thus, OEMs make reduced commitments in manufacturing capacity and instead use IT to coordinate production with Solectron.

Now consider an environment where demand is steady (or increasing), but competitors behave like symmetric oligopolists and sell standardized goods to homogeneous markets (e.g., Petroleum industry). In stable competitive environments firms may have the incentive to perform more activities internally, thereby increasing the level of VI. In this environment, there are fewer threats from substitute products and lower risks of radical change introduced by new competitors, and the competitive dynamics do not involve aggressive competition [43]. Under these conditions, firms can safely gear up to produce more in-house to increase revenue and capture wider value add and margin by integrating vertically [47]. Increasing VI can also increase entry barriers [94], enhance market power (i.e., control input and output prices), offer opportunities for creating one-stop shopping that can increase switching costs [19], and provide experience curve advantages [1]. Hence, in competitively stable markets vertical integration may offer different advantages.

Firms can use IT to organize more activities internally as well as use IT to coordinate more activities with external suppliers. The arguments presented above imply that how IT is used is influenced by the characteristics of the environment. This leads to the following hypotheses:

H1 (a): As demand uncertainty increase, IT is likely to be associated with greater decrease in vertical integration.

H1 (b): As competitive stability increases, IT is likely to be associated with greater increase in vertical integration.

3.2.2 Performance Implications of the Impact of IT on Vertical Integration

IT has implications for the coordination and production cost in the value chain that affect the level of VI chosen by a firm [46]. In this section we examine the impact of IT on coordination and production cost.

Coordination Cost

Coordination cost is the cost of finding suppliers and partners, negotiating and specifying delivery arrangements, monitoring execution of contracts, and taking corrective actions when required. Information technologies such as the Internet and open standards like eXtensible Markup Language (XML) can lower firms' cost of coordinating with members of the value chain [73]. In this regard, IT can reduce coordination costs.

A firm may choose to respond to its environment by increasing its VI. For example, in the context of distribution, John and Weitz [57] found that the likelihood of a direct channel (rather than intermediaries) increases with uncertainty. Nevertheless, coordination of production and information flows is very complex in vertically integrated firms. Subunits in vertically integrated firms have to adapt to demand and other fluctuations by extensively coordinating transfers from one line of business to another. However, information sharing can reduce coordination costs in vertically integrated firms [33]. Brews and Tucci [14] report that IT can reduce coordination costs relating to information gathering, decision making, and compliance monitoring needed when producing internally. Similarly, Lee and Billington [55] suggest that firms can share production plans, capacity, demand and inventory information to coordinate the value chain and substitute information for inventory. In this regard, IT can reduce coordination costs by making information transparent, and enabling production and distribution schedules to be optimized [70]. For example, the adopters of ERP systems, software often used for real-time information sharing and coordination in vertically integrated firms, show superior coordination performance [50]. Also, firms that have IT capabilities to share information have observed superior operational and financial performance [6]. In this regard, the organization of the value chain where a firm performs activities within a more vertically integrated structure reflects managerial choice of using IT-based internal coordination to respond to the environment faced by the firm.

As an alternative to performing more activities internally, a firm may choose to respond to its environment by becoming less vertically integrated. In this context, IT can reduce the cost of coordinating with external suppliers. Clemons and Row [25] and Clemons et al. [26] argue that IT can reduce the cost of exchanging information and the cost of monitoring the performance of other participants in the value chain. IT can also be used to search, identify, and coordinate with external suppliers. Gosain et al. (2004), for example, find that through modular design of interconnected processes and structured data connectivity, IT enabled supply chains provide the flexibility to support changes in orders (offering flexibility) as well as the ability to partner with different supply chain players (partnering flexibility).

Electronic Data Interchange (EDI) systems are examples of technologies used to coordinate with suppliers. EDI systems decrease coordination costs as they are associated with fewer shipment errors and better quality shipments [99], and decrease in delayed payments as well as credit orders [80]. Like the EDI systems in the manufacturing context, firms in the retail industry are increasingly relying on Collaborative Planning, Forecasting, and Replenishment (CPFR) tools [70]. These IT initiatives have reduced coordination costs in the retail industry by lowering inventory levels and by reducing stock outs [68].

Though there may exist differences in coordinating the value chain in different environments, the above arguments suggest that IT can reduce coordination costs whether firms respond to their environment by performing more activities internally (i.e., if they choose less VI) or by coordinating more activities with external partners (i.e., if they choose more VI). These arguments lead to the following hypothesis:

H2: IT is associated with a decrease in coordination cost.

Production Cost

Production cost includes the cost of material and labor involved in producing goods and services. The impact of IT on production cost is contingent on the environment and the level of VI. When demand is very unpredictable, there is a risk of supply failure to the customer (e.g., where there is stock out due to underproduction) or the risk of overproduction for the firm. In response to demand uncertainty, a firm may choose to use IT to perform activities in a more vertically integrated organization, especially when demand uncertainty makes it difficult to coordinate with external suppliers [31]. In this case, managers suffer from "illusion of control" that they can manage the uncertainty by conducting more activities internally.[3]

In environments with significant demand uncertainty if a firm uses IT to perform activities in a more vertically integrated structure, such organization may increase production costs. The argument is that if a firm invests in many specialized assets in uncertain environments, it will often be saddled with assets that are

[3] Illusion of control [67] is the tendency for human beings to believe that they can control or at least influence outcomes which they clearly cannot

not useful when conditions (e.g., consumers' tastes and preferences, technologies) change. Internal production may also lead to a cost disadvantage because of the inability to achieve efficient scale in production [101]. Thus, production costs can increase with VI as the uncertainty of the environment increases. Also, in dynamic environments, if a firm performs more activities internally, the difficulty of organizing production due to unpredictable demand may result in procurement of material at a premium, or shipment through expensive mode (e.g., air shipping). Dynamic demand conditions may also require many change orders that lead to more re-work. Similarly, rush orders may require overtime labor, increasing production costs. Thus, production costs can increase with VI as demand uncertainty increases. However, if firms choose a lower level of VI and instead use IT to coordinate more activities with suppliers with specialized assets necessary for the new environment, then such external coordination can reduce production costs. For example, in the electronics industry, firms use B2B exchanges (e.g., Converge and e2open) to find and coordinate activities with suppliers with specific assets and capabilities [70]. Such IT based coordination with external suppliers avoids risky capital investments and also saves costs associated with change, rework, and exception management that are associated with increase in production costs in more vertically integrated firms.

In competitively stable environments, a firm may use IT to perform more activities inside a vertically integrated organization. If the firm has significant market share, then performing more activities internally can reduce production costs, provided that the firm is able to achieve economies of scale. Internal production can also provide learning and experience curve advantages [1]. However, having in-house captive demand may give rise to agency problems [37] that can raise production costs, since in-house production units often do not have the incentives to be as efficient as market suppliers. Markets enforce discipline and efficiency on suppliers, which may be absent under internal production.

In summary, the above arguments suggest that use of IT to organize production in more vertically integrated firms is likely to be associated with increase in production costs. In contrast, if firms use IT to coordinate more activities with external partners (i.e., if they choose lower level of VI), production costs may fall as firms can benefit from the scale advantage of specialists and also avoid risky capital investments and agency problems that are associated with internal production. The above arguments lead to the following hypothesis:

H3: Use of IT to organize production in more vertically integrated firms is likely to be associated with increase in production costs.

3.3 Data and Variable Measures

3.3.1 Data

This study uses data from multiple sources. Firm level IT spending data from 1995 to 1997 are drawn from InformationWeek 500. This list was compiled annually by Information Week, together with Computer Intelligence (CI), and has been used in prior research in IS [8]. We match the IT spending data for the firms listed in InformationWeek with data from COMPUSTAT. We also use data from the Bureau of Economic Analysis (BEA) to estimate the level of VI.

3.3.2 Variable Measures

IT Spending

Two commonly used measures of IT spending are employed: (i) annual IT budget, and (ii) the ratio of IT budget to sales. The annual IT budget for each firm in InformationWeek 500 was compiled by Information Week from telephone surveys. The sales data was obtained from COMPUSTAT. The annual IT budget and sales data were then adjusted using the price and inflation index from the Bureau of Labor Statistics.

Vertical Integration

Vertical integration refers to the extent to which a firm carries production processes from raw materials to the final product within its boundaries [95]. Three methods have been used in the literature to estimate firms' vertical integration: the ratio of value added to sales, the VIC index by Maddigan [72], and the vertical relatedness index by Fan and Lan [39]. The ratio of value added to sales is not suitable for our cross-industry study since we cannot meaningfully compare VI among firms in different industries. In the value added to sales measure of VI, the firm producing the input will have a higher value added to sales ratio than the firm producing the final output, even though there may exist no difference in the VI levels of the firms [3, 69].[4] Though both Maddigan's, and Fan and Lang's VI measures use the Input-Output table from the Bureau of Economic Analysis (BEA), Maddigan's index ignores the level at which a firm participates in a specific industry. For example, a car manufacturer will report the same value of VI no matter whether its tire factory contributes 1% or 100% of the tires its car factory uses. Accordingly, we employ the index by Fan and Lang [39] as the measure for VI.

To assess VI, the following three step process is used. First, we investigate each firm's segment information in COMPUSTAT's Segment database. For each firm, its primary segment (the 4-digit-SIC segment with the highest sales) is identified, and all the other segments are considered as secondary segments. Second, for each secondary segment, we calculate the vertical relatedness between this secondary segment and the primary segment based on the 1997 Input-Output (IO) table from BEA.[5] The value of the vertical relatedness between the two segments is determined by two factors: (i) the dollar value of the secondary segment's output required to produce the primary segment's output, and (ii) the dollar value of the primary segment's output required to produce the secondary segment's output. If the two segments have strong make-buy relationship according to the material flow data in the IO table, they will have a high value of vertical relatedness. Third, based on the calculation from the first two steps, we assess each firm's VI level using the

[4] Here is an example provided by Adelman [3]. Suppose that there are 3 firms in an industry. Assume that the first firm buys nothing and sells its products to firm 2. Firm 2 manufactures using the input from firm 1 and sells to firm 3, a distributor. If each of the 3 firms contributes 1/3 of the total value added by the industry, firm 1 would have a value added-sales ratio of 1, while firm 2 has a ratio of 0.5 and firm 3 has a ratio of 1/3. If firm 2 integrates backwards to absorb firm 1, its new ratio will be 1. But if it integrates forwards to absorb firm 3, the new firm will have a ratio of 2/3.

[5] The table reports for each pair of industries say, i and j, the dollar value of i's output required to produce j's total output, and the dollar value of j's output required to produce i's total output.

following formula:

$$V = \sum_j W_j V_j$$

In the above formula, W_j is the ratio of the jth secondary segment's sales to the total sales of all the secondary segments, and V_j is the vertical relatedness between the jth secondary segment and the primary segment. If a firm's largest secondary segment(s) has (have) very strong vertical relatedness with its primary segment, then the firm will have a high VI index and will be regarded as being highly vertical integrated.

Competitive Environment

Two measures are used for competitive environment: (i) demand uncertainty, and (ii) four-firm concentration ratio. The demand uncertainty measure reflects the instability/variance in industry sales in the industries a firm participates in. For each firm, past five years' data on sales are used to calculate the demand uncertainty for each year. More specifically, demand uncertainty is calculated using the following regression equation:

$$\ln(y_t) = a + bx_t + e_t$$

where y_t is the yearly sales of a particular industry the firm participates in, and x_t is the year. Growth rate is the antilog of the estimate of the regression slope (b). As suggested by Keats and Hitt [63] demand uncertainty is the antilog of the standard error of the regression slope (b).[6]

The four-firm concentration ratio is the sum of the market shares of the top four market share leaders in an industry. A high four-firm concentration ratio implies a stable competitive environment. For example, when an industry has a few well established players, each incumbent knows who their competitors are and how they will behave, thus there is less uncertainty about the nature of the competitive interaction [63].

One advantage of the demand uncertainty and four-firm concentration ratio combination of measures for competitive environment is that they complement each other. As discussed earlier, since demand uncertainty is related to the variance in sales over time, it measures uncertainty on the demand (consumer) side of a firm. Four-firm concentration ratio, on the other hand, is a simple measure of uncertainty on the supply (competition) side of the firm. When calculating the demand uncertainty (or four firm concentration ratio) of a firm that operates in multiple industries, we weight demand uncertainty in each industry with the proportion of the firm's sales from that industry. The two measures of competitive environment are calculated using the COMPUSTAT Segment database.

[6] We also run the analysis with two other alternative measures of demand uncertainty: (i) antilog of the standard error normalized by the sales of that industry - as smaller industries may have more variability, and (ii) antilog of the standard error normalized by the growth rate of the industry - as growing industries may have a higher variability. The results are consistent across these alternative operationalizations.

Performance Measures

We are interested in the impact of firms' VI on coordination and production costs. We use three different measures for coordination cost: (i) Selling, General, & Administrative cost divided by Sales (SGA), (ii) Inventory turnover, i.e., Cost of Goods Sold divided by Average Inventory, and (iii) Receivables turnover, i.e., Sales divided by Average Receivables. SGA reflects the selling and administrative costs incurred to coordinate activities inside the firm and with suppliers and customers, and thus is an aggregate measure of coordination cost [33]. Inventory turnover indicates the efficiency with which a firm converts inventory into sales, thus it reflects the efficiency of coordination with suppliers [49]. Similarly, Receivables turnover reflects the efficiency of coordination with customers [49].

The second performance variable of interest is the production cost. Production cost is measured as the Cost of Goods Sold divided by Sales [33]. The data for all the performance measures is drawn from COMPUSTAT. As this is a cross-industry study and performance varies from industry to industry, we normalize performance (e.g., production cost) by dividing a firm's production cost by the average production cost of all the firms in the same industry.

Industry Capital Intensity

Industry capital intensity is an alternative explanation for the level of VI as firms in capital intensive industries are expected to be more vertically integrated [15]. Thus, Industry Capital Intensity is included as a control variable. This variable is calculated from COMPUSTAT Segment database. For each segment (identified as an SIC/NAICS code) i, we calculate its total assets (AT_i) and its total sales ($SALE_i$) based on the segment data from all the firms that participate in segment i. If a firm participates in n segments, the firm's industry capital intensity is calculated as:

$$CAP = \sum_{i=1}^{n} \frac{s_i}{S} \frac{AT_i}{SALE_i}$$

where s_i is the sales of this firm in segment i and

$$S = \sum_{i=1}^{n} s_i$$

In other words, the Industry Capital Intensity of a firm is the capital intensity of all the industries the firm participates in weighted by its sales in those industries.

The other control variables in the study include Capital Structure - ratio of total liabilities to sales [51], and Debt to Equity ratio [49]. The level of VI and coordination and production costs may also be influenced by the scale of operations and the number of employees involved in operations. So sales and the number of employees are also included as control variables. Similarly, firms with larger market share and firms in growing industries may be more vertically integrated. Thus, market share and industry growth rates are also used as control variables for VI [49]. Also, manufacturing firms may have different levels of VI compared to service, and agriculture and mining firms. Therefore, industry type is also used as a control variable. The level of IT investments may be influenced by the alternative investment opportunities a firm has, so Growth Options - ratio of book vale of assets

Table 3.1: Sample Characteristics

	Minimum	Maximum	Mean	Std.Deviation
IT Budget(in Million Dollars)	0.634	5105.01	228.52	477.8
IT/Sales	0.000	0.374	0.007	0.020
VI(Vertical Integration)	0.000	0.293	0.020	0.044
UNC(Demand Uncertainty)	0.002	0.346	0.040	0.037
FOUR(Four-firm concentration)	0.126	1.000	0.645	0.218
CAP(Capital Intensity)	0.242	70.662	4.403	9.908
MS(Market Share)	0.003	1.000	0.215	0.211
GRR(Growth Rate)	-0.193	0.852	0.087	0.122
DEQ(Debt to Equity)	-138.918	125.298	2.213	10.950
GROP(Growth Options)	0.092	43.252	1.943	2.989
CST(Capital Structure)	0.101	8.966	0.988	1.272
SALES(in Million Dollars)	75.13	168919.00	10530.09	18788.02
EMP(Employees in thousands)	0.57	825.00	47.2066	87.02
COST(Production Cost)	0.008	1.531	0.875	0.308
SGA	0.006	2.703	0.679	0.422
Inv Turns(Inventory Turnover)	0.017	9.580	0.958	0.785

to market vale of the firm [34] - is used as a control variable for IT.[7]

3.4 Empirical Analysis

3.4.1 The Models

We are interested in two research questions: (i) how does the interaction between IT and the competitive environment influence a firm's VI level, and (ii) how does the interaction between IT and VI influence firms' coordination and production costs. Prior studies [34, 49] have shown that OLS estimation will suffer from simultaneity bias since a firm will choose its IT investment given its VI level, and vice-a-versa.

[7]Please refer to the regression models for the set of controls used for a specific regression model.

Hausman tests on our dataset also show that VI and IT budget are endogenous, thus rejecting the OLS formulation in favor of two-stage least squares (2SLS). Therefore, we use a 2-equation model for the first research question as causality may run not only from IT to VI, but also from VI to IT. The model is shown below:

$$
\begin{cases}
\begin{aligned}
VI_i = \; & \alpha_0 + \alpha_1 IT_i + \alpha_2 UNC_i + \alpha_3 IT_i \cdot UNC_i + \alpha_4 FOUR_i \\
& + \alpha_5 IT_i \cdot FOUR_i + \alpha_6 CAP_i + \alpha_7 MS_i + \alpha_8 CST_i \\
& + \alpha_9 DEQ_i + \alpha_{10} Sales_i + \alpha_{11} EMP_i + \alpha_{12} GRR_i \\
& + \alpha_{13} T_{1i} + \alpha_{14} T_{2i} + \alpha_{15} T_{3i} + u_v
\end{aligned} & (VI) \\
\begin{aligned}
IT_i = \; & \gamma_0 + \gamma_1 VI_i + \gamma_2 UNC_i + \gamma_3 FOUR_i + \gamma_4 VI_i \cdot UNC_i \\
& + \gamma_5 VI_i \cdot FOUR_i + \gamma_6 CAP_i + \gamma_7 Sales_i \\
& + \gamma_8 DEQ_i + \gamma_9 CST_i + \gamma_{10} GROP_i + u_z
\end{aligned} & (IT)
\end{cases}
$$

where VI (VI_i), IT (IT_i), demand uncertainty (UNC_i), four-firm concentration ratio ($FOUR_i$), industry capital intensity (CAP_i), market share (MS_i), capital structure (CST_i), debt to equity (DEQ_i), sales ($Sales_i$), the number of employees (EMP_i), growth rate (GRR_i), and growth options ($GROP_i$), represent the characteristic of firm i respectively.[8] We also use three dummy variables to serve as control variables for VI. T_1 is 1 if firm *i* has segment(s) in agriculture or mining industries, T_2 is 1 if firm *i* participates in manufacturing industries, and T_3 is 1 if firm *i* participates in service industries.

[8]Based on the rules widely used in empirical studies, if a variable is a dollar amount (such as IT budget), or number of people (such as number of employees), it appears in logarithmic form. Other variables, such as VI and IT spending such as the ratio of IT budget to sales, are in their original form.

For the second research question, the following model is used:

$$\begin{aligned} PF_i = \ & \beta_0 + \beta\prime_1 IT_i + \beta_2 VI_i + \beta_3 IT_i \cdot VI_i + \beta_4 UNC_i \\ & + \beta_5 FOUR_i + \beta_6 CAP_i + \beta_7 MS_i \qquad\qquad (PF) \\ & + \beta_8 CST_i \ + \beta_9 DEQ_i + \beta_{10} Sales_i + \beta_{11} EMP_i + u_R \end{aligned}$$

where the dependant variable PF is performance (coordination cost or production cost).

The VI, IT, and PF models also use interaction terms. For variables that are involved in the interaction (e.g., IT, UNC, and FOUR in the VI model), we center them by subtracting the mean from each variable. Centering can reduce multi-collinearity among these variables and make the regression coefficients more meaningful. For example, after we center IT, UNC, and FOUR in the VI model, α_1 is the impact of IT when UNC and FOUR are at their average level.

Two-stage least squares method (2SLS) is used to assess each model. Instrumental variables include 2-digit SIC segment and year dummy variables. Each 2-digit SIC industry segment instrument variable takes a value of 1 if the firm participates in this 2-digit industry and 0 otherwise. These exogenous variables capture industry specific effects [110]. We also use 2 year dummy variables, $Y1995$ and $Y1996$. For example, if a data point is for the year 1995, then $Y1995 = 1$. The year dummy variables capture any variances that are related to time, such as IT prices, interest rates, price of oil, level of defense expenditures, etc. [49].

3.4.2 Data Analysis

The VI Model

Table 3.2 presents the 2SLS estimates of the VI model that examines how the competitive environment moderates the impact of IT on VI.[9] In the VI Model, the overall effect of IT on VI is α_1+α_3UNC+α_5FOUR. Here α_1 reflects the effect of IT when demand uncertainty and four-firm concentration ratio are at their average level.[10] α_3 and $\alpha_5$are the interaction effects related to demand uncertainty and four firm concentration ratio respectively.

Table 3.2: The VI Model

(Constant)	-0.143**	(0.061)		CST	-0.007**	(0.003)
IT	-0.001	(0.005)		DEQ	0.000	(0.000)
UNC	-0.103	(0.19)		GRR	-0.017	(0.06)
$IT \cdot UNC$ (α_3)	-0.329**	(0.14)		EMP	-0.037***	(0.007)
$FOUR$	0.057**	(0.025)		$SALES$	0.037***	(0.008)
$IT \cdot FOUR(\alpha_5)$	0.046**	(0.021)		$T1$	0.009	(0.01)
CAP	0.002***	(0.001)		$T2$	-0.021	(0.02)
MS	-0.035	(0.028)		$T3$	-0.004	(0.005)

N: 596; Adjusted R^2: 0.086; F Statistic: 4.730
$Note$: Standard errors are in parenthesis.
$*** - p < 0.01, ** - p < 0.05, * - p < 0.10$

As indicated in Table 3.2, both $\alpha_3$and α_5 are significant. α_3 is negative and significant (at p = 0.016 level), suggesting that IT is associated with greater decrease in VI in more dynamic environments. Thus, H1 (a) is supported. α_5 is positive and significant (at p = 0.030 level), suggesting that IT is associated with greater increase

[9]Please note that though we report the R-square here, the R-square has no natural interpretation (Wooldridge [113]).

[10]Since the three variables (IT, UNC, and FOUR) are centered in this model, their means, after centering, are zero.

in VI in more stable competitive environments. Thus, H1 (b) is also supported. The moderating role of competitive environment on the impact of IT on VI is illustrated in Figures 3.2 and 3.3. To make the illustrations simple, when studying the impact of demand uncertainty we let four-firm concentration ratio to be at its average level, and vice a versa. We probe the impacts using the procedure in Cohen et. al ([29], pp. 273) and report the significance of the simple slopes (α_1+α_3UNC and α_1+α_5FOUR) at selected points.[11]

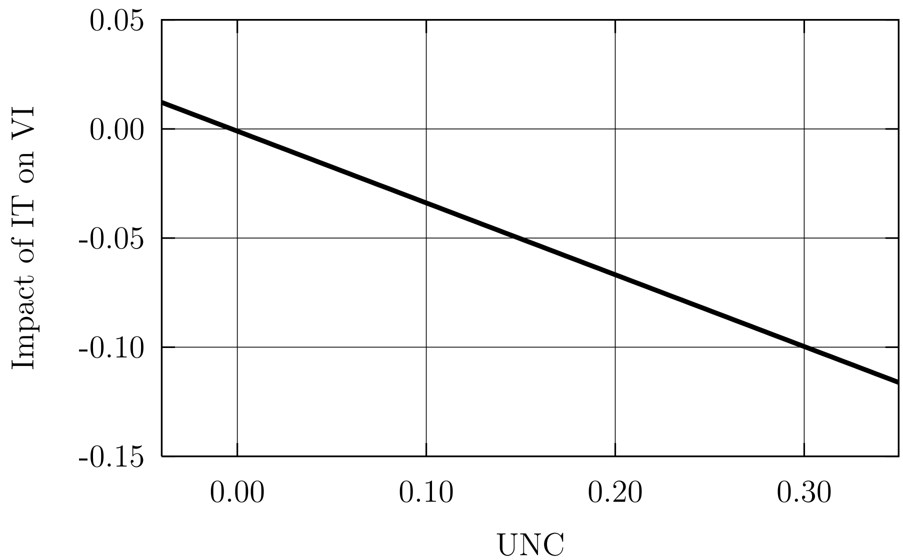

Figure 3.2: Moderating Role of Demand Uncertainty

As shown in Figure 3.2, when demand uncertainty is below -0.01,[12] IT has a positive impact on VI. This impact is significant (at p = 0.06) when demand uncertainty is -0.04. This suggests when demand uncertainty is very low firms use IT

[11]The procedure specifies the standard error of the simple slope at each point so that its significance can be calculated.

[12]After centering, the range of demand uncertainty is from -0.04 to 0.35. More than 56% of the firms have demand uncertainty below -0.01.

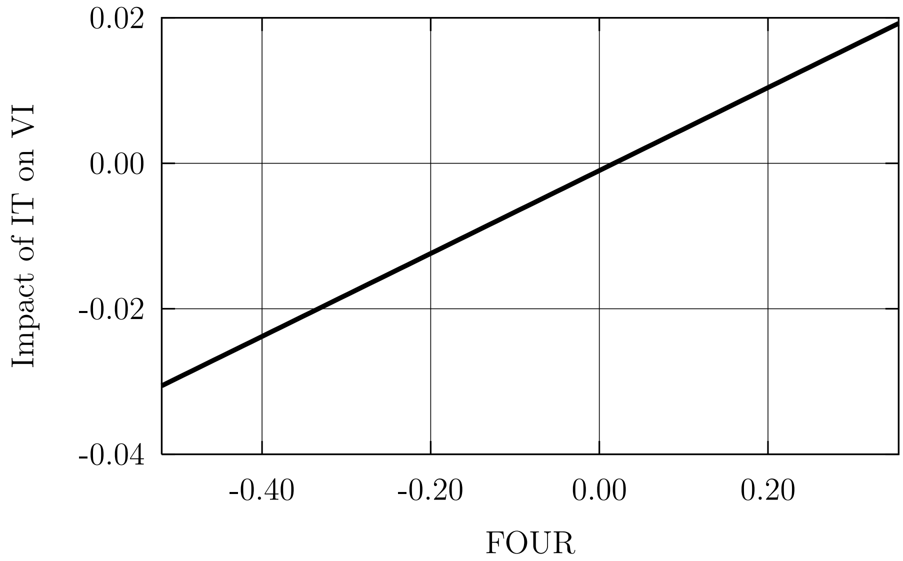

Figure 3.3: Moderating Role of Four-firm Concentration Ratio

to become more vertically integrated. However, as demand uncertainty increases, the impact of IT becomes negative. When demand uncertainty is at its average level (i.e., zero), firms use IT to become less vertically integrated. The overall impact of IT is negative and significant (at p = 0.04 level) when demand uncertainty is 0.07. In sum, the analysis suggests that as demand uncertainty increases, IT is associated with a decrease in VI.

Figure 3.3 shows how four-firm concentration ratio influences the impact of IT on VI. When the four-firm concentration ratio is below average (i.e., below zero), IT has a negative impact on VI. This suggests that firms use IT to become less vertically integrated when the four firm concentration ratio is below the average level. However, when four-firm concentration ratio is above average, firms use IT to become more vertically integrated. This impact is significant at 0.10 level when concentration is at 0.25 and is significant at 0.05 level when concentration is 0.35. This analysis suggests that as four firm concentration ratio increases, IT is associated with an increase in VI.

The IT model

As discussed earlier, IT and VI choices are made simultaneously. In this section we examine how IT investments are influenced by VI, demand uncertainty, and four firm concentration ratio.

Table 3.3: The IT Model

(Constant)	3.573***	(0.611)		CAP	0.033***	(0.01)
VI	-0.656	(2.829)		SALES	1.022***	(0.074)
UNC	1.091	(3.509)		GOP	-0.129***	(0.039)
FOUR	0.551	(0.435)		DEQ	0.007	(0.008)
VI·UNC (γ_4)	-402.703***	(151.611)		CST	0.206***	(0.075)
VI·FOUR (γ_5)	50.472**	(19.762)				

N:575; Adjusted R^2: 0.367; F Statistic:34.246

$Note$: Standard errors are in parenthesis.

$***-p<0.01, **-p<0.05, *-p<0.10$

In the IT model, the impact of demand uncertainty on IT is γ_2+γ_4VI and the impact of four firm concentration ratio on IT is γ_3+γ_5VI. Table 3.3 presents the 2SLS estimates of the IT model. As shown in table 3.3, γ_4 is negative and significant (at p = 0.008 level). This suggests that when demand uncertainty is high, a decrease in VI is associated with increase in IT investments. Similarly, the coefficient of γ_5 is positive and significant (at p = 0.011 level). This indicates that in more stable competitive environments increase in VI is associated with increase in IT investments. We probe the impacts and report the significance of the simple

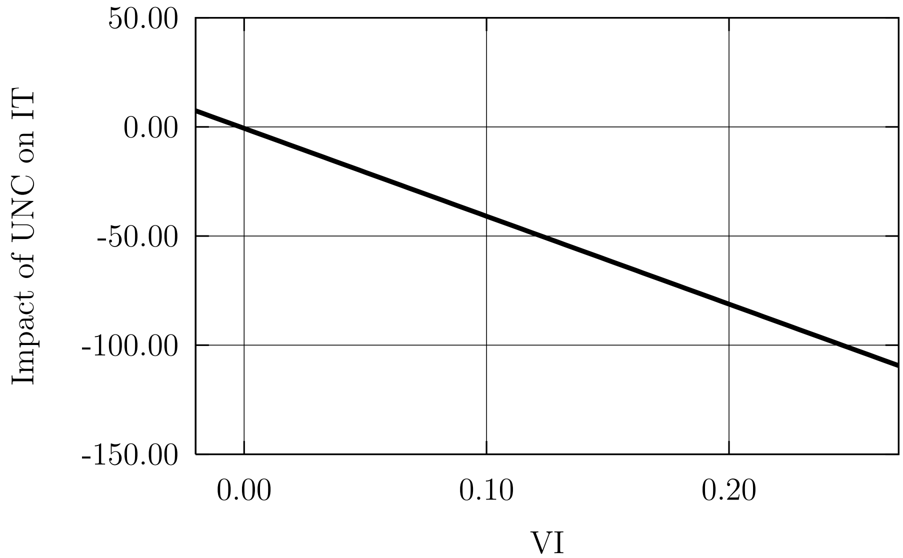

Figure 3.4: Moderating Role of VI (a)

slopes (γ_2+γ_4VI and γ_3+γ_5VI) at selected points.[13]

Figures 3.4 and 3.5 illustrate these results graphically. In figure 3.4, when VI is -0.02, the impact is positive and significant (at p =0.008 level) suggesting that in dynamic environments decrease in VI is associated with increase in IT investments. Similarly, when VI is 0.05, the impact is negative and significant (at p = 0.05 level), suggesting that in dynamic environments increase in VI is associated with decrease in IT investments. Figure 3.5 also yields consistent results. When VI is 0.02, the impact is positive and significant (at p =0.03 level) suggesting that in stable competitive environments increase in VI is associated with increase in IT investments. In summary, the VI and IT model provide results that support H1 (a) and H1 (b).

[13]Here we focus on the moderating role of VI in the impact of demand uncertainty and four firm concentration ratio on IT. We also studied the moderating role of demand uncertainty and four firm concentration ratio in the impact of VI on IT. That analysis also produces very similar results.

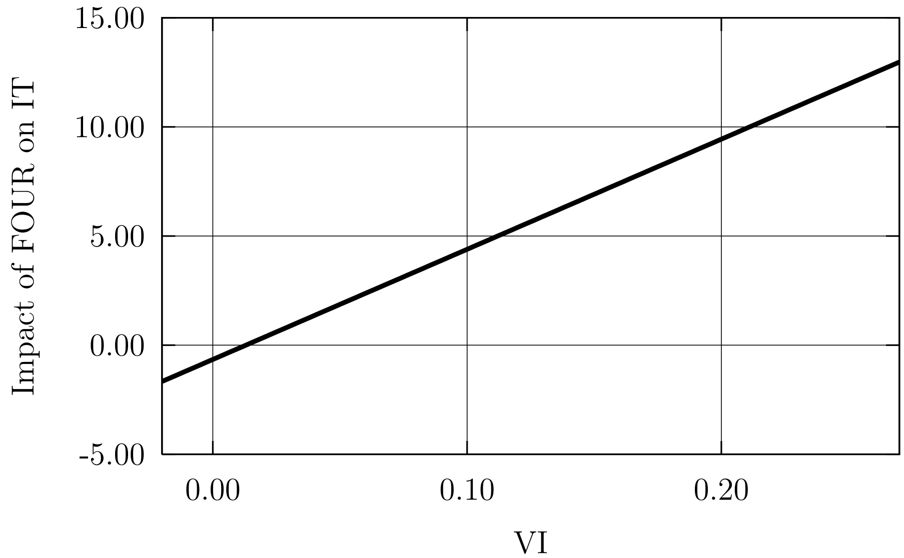

Figure 3.5: Moderating Role of VI (b)

Performance

Table 3.4 shows the 2SLS estimates of the PF model. Since the performance measures are relative to sales, in Table 3.4, the ratio of IT budget to sales is used as the measure for IT. In the above equation, the impact of IT on performance has two parts. The first part, β_1, reflects the 'general' impact of IT when VI is at the average level. The second part, β_3, reflects the impact of IT through its interaction with VI. As the level of VI is an endogenous choice made by a firm, and since this choice is influenced by IT, it is important to consider the impact of the interaction between IT and VI on performance. In this regard β_3 reflects how the use of IT to organize activities in more vertically integrated (i.e., high VI), or less vertically integrated firm (i.e., low VI) affects performance. Thus, $\beta_1+\beta_3$VI is the overall impact of IT on performance.

Table 3.4: Performance Models

	SGA		Inventory Turnover		Receivable Turnover		Production Cost	
(Constant)	1.127***	(0.427)	1.556**	(0.774)	2.178***	(0.361)	0.393	(0.324)
VI	2.896**	(1.204)	0.93	(0.28)	1.03	(1.058)	-0.083	(0.943)
IT (β_1)	-13.696**	(6.557)	45.274***	(17.174)	3.032	(7.994)	-3.648	(5.138)
IT·VI (β_3)	249.917**	(105.013)	-653.008**	(271.661)	32.762	(125.966)	189.506**	(85.058)
UNC	2.365	(1.608)	-6.823**	(2.81)	-1.201	(1.329)	-3.32***	(1.197)
FOUR	-0.854***	(0.29)	0.635	(0.454)	-0.255	(0.213)	0.074	(0.191)
CAP	-0.023***	(0.006)	-0.045***	(0.011)	-0.003	(0.005)	-0.02***	(0.004)
MS	0.963***	(0.286)	-0.61	(0.498)	0.161	(0.232)	0.113	(0.211)
CST	0.062	(0.095)	0.018	(0.061)	-0.084***	(0.028)	0.029	(0.023)
DEQ	0.00	(0.003)	-0.015**	(0.006)	0.005	(0.003)	-0.005*	(0.003)
EMP	0.131**	(0.065)	0.113	(0.117)	0.056	(0.054)	-0.075	(0.052)
SALES	-0.123*	(0.068)	-0.066	(0.125)	-0.171***	(0.058)	0.089	(0.054)
N	471		542		537		598	
Adusted R^2	0.08		0.04		0.07		0.09	
F	4.82***		3***		3.563***		6.16***	

Note: Standard errors are in parenthesis. Key: $* * * - p < 0.01$, $* * -p < 0.05$, $* - p < 0.10$

Coordination Cost SGA: Table 3.4 shows that IT has a negative 'general' impact on SGA (significant at p = 0.031 level), and a positive impact on SGA (significant at p = 0.014 level) through its interaction with VI. This suggests that IT is associated with a decrease in coordination cost when VI is at the average level. However, for firms with higher levels of VI, IT's negative impact on coordination cost weakens. Moreover, for firms that use IT to organize their activities at a very high level of vertical integration, the impact of IT on SGA may be positive. This is consistent with the claim that there are bureaucracy costs associated with highly vertically integrated organizations [33]. Overall, the analysis largely supports hypothesis H2. Figure 3.6 illustrates the total impact of IT on SGA. The figure shows that the overall impact of IT on SGA is influenced by the level of VI. When VI is less than 0.05, IT has negative impact on SGA. This holds for 90% of the firms.[14] However, when VI is higher than 0.05, IT has a positive impact on SGA. This suggests that for firms whose VI is very high, IT may be associated with an increase in coordination costs.

Inventory and Receivables Turnover: The analysis of the impact of IT on inventory turnover is very similar to the analysis for SGA.[15] IT has a positive general impact (significant at p = 0.010 level) on inventory turnover and a negative impact (significant at p = 0.019 level) through its interaction with VI. Therefore, IT can increase inventory turnover for firms with lower level of VI (specifically for firms with VI of 0.06 or less). This analysis also largely supports hypothesis H2. In the analysis of the impact of IT on receivables turnover, the general and the interaction

[14] After centering, VI has a range from -0.02 to 0.27. 90% of the firms have VI less than 0.05

[15] Please note that firms want lower SGA and higher inventory turnover.

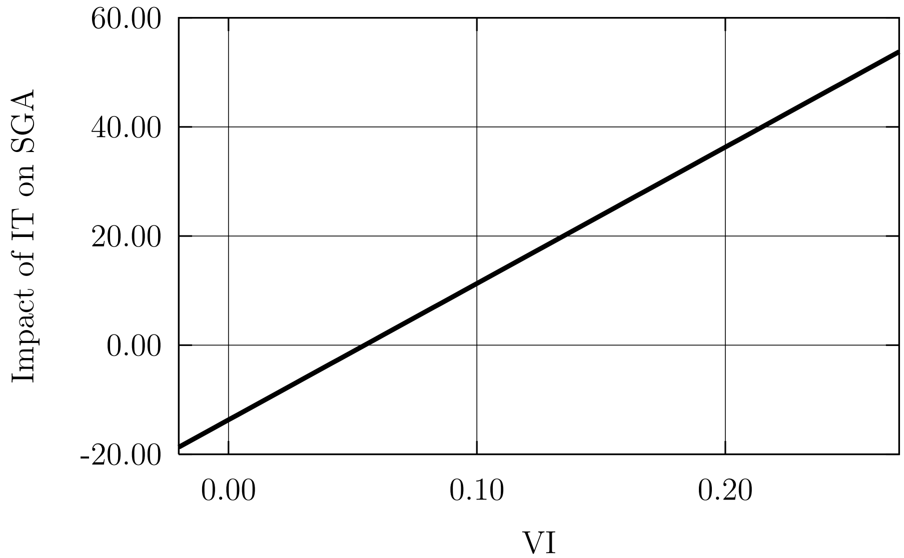

Figure 3.6: Impact of IT on SGA

impact of IT are not significant. Thus, the analysis with receivables turnover does not support hypothesis H2.

Production Cost The impact of IT on production cost also has two components: the general component and the component that is influenced by the chosen level of VI. As shown in Table 3.4, the general impact of IT is not significant, i.e., when VI is at its average level, IT has no impact on production cost. However, the interaction between IT and VI is positive and significant (at p = 0.027 level). This suggests that the use of IT to organize production in more vertically integrated firms may be associated with increase in production costs. Figure 3.7 illustrates the overall impact of IT on production cost. It is clear that for firms with higher levels of VI (i.e., when VI is above 0.02, which is associated with 15% of the firms in the sample), more IT leads to increase in production cost. This finding is consistent with TCE argu-

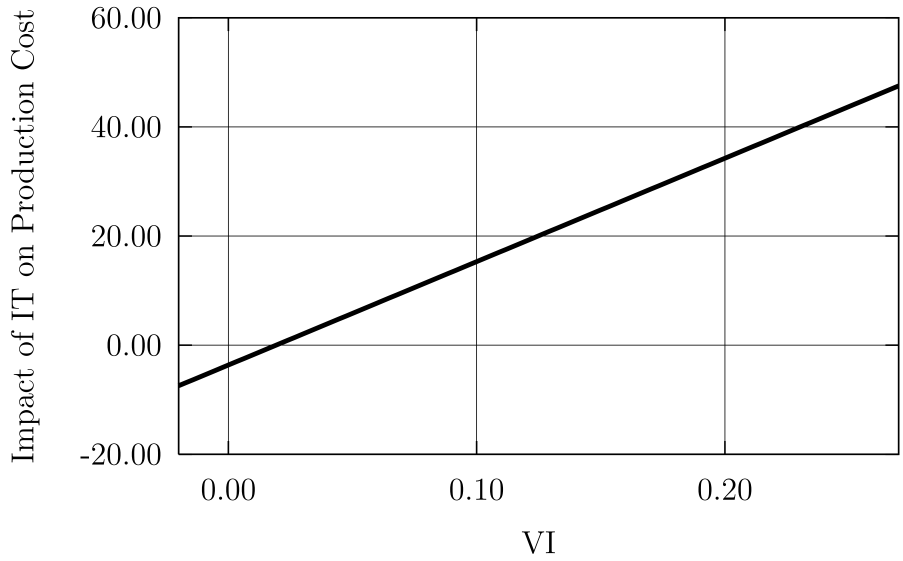

Figure 3.7: Impact of IT on Production Cost

ment that the market has advantage in production cost and that organizing activities inside vertically integrated organizations may lead to increase in production costs [28, 74]. Thus hypothesis H3 is supported by the analysis.

In summary, H2 and H3 suggest that IT decreases (increases) coordination and production costs when firms organize their activities in less (more) vertically integrated structures. Thus IT favors less vertically integrated firms from efficiency (i.e., coordination and production cost) point of view. However, H1 (b) suggests that firms use IT to become more vertically integrated under specific circumstances. This raises the question: why do some firms choose to be more vertically integrated when it can increase coordination and production costs. The implication here is that efficiency considerations, by themselves, do not explain the choice of VI in some circumstances. This issue is explored further in the discussion section.

3.5 Discussion and Conclusion

Before discussing the implications of the findings, it is important to recognize the limitations of this study. The analysis was performed using IT investment data collected by InformationWeek. The Information Week 500 purportedly includes leading users of IT in the US. To that extent the sample is not a purely random sample. However, if we can show the differences in the impact of IT on VI under different competitive environments using this sample, it can actually bolster our claim. Further, this dataset has been used in prior research to examine the economic impact of IT investments [8]. Also, since these firms are leading users of IT, they are likely to make more judicious use of IT that other firms can learn from. The data may also be considered old. However, since the data predates the Internet boom and bust periods, it may be free of the overreactions commonly associated with that period.

The ability to use IT to cost-effectively coordinate with suppliers and business partners has received much attention in the IS literature. This stream of research generally suggests that firms are likely to lower their VI and rely more on markets. The analysis in this paper suggests that though IT may be associated with decrease in VI, the impact of IT on VI is not uniform across all environments. In more dynamic environments IT may be associated with greater decrease in VI as firms try to maintain flexibility by reducing commitments in specialized assets and instead use IT to coordinate more activities with outside partners and specialists. We find that such organization of activities where a firm chooses a lower level of VI may reduce production costs. This is consistent with TCE arguments that vendors may have lower production costs due to economies of scale, specialization and market efficiency. However, interestingly, the analysis suggests that in more stable competitive environments, a firm may use IT to organize more activities inside the firm as there may exist opportunities to increase revenue, and capture value add and margin.

The IS literature suggests that IT is associated with decrease in VI as IT reduces coordination costs. The research presented here suggests that IT reduces coordination and production costs in less vertically integrated firms. Organizing activities in more vertically integrated firm is associated with higher coordination and production costs. Thus we should see a general decrease in VI. Given that for firms in more stable competitive environments, IT is associated with increase in VI, the coordination cost argument that IT will lead to a decrease in VI is not supported in such environments.

The IS literature has so far concentrated on efficiency considerations, such as coordination cost, to examine the impact of IT on VI. However, a key implication of this research is that firms may choose coordination (governance) structures for strategic rather than efficiency reasons [82]. For example, an increasing proportion of the value-add is shifting from manufacturing to service. Firms like IBM and HP are moving from manufacturing to IT services. Firms are pushing downstream to capture this value-add by establishing direct relationships with customers using IT and embedded IT [65]. Direct relationships allow firms to understand customer preferences, build switching costs, and sell more products by cross-selling and up-selling. Fronmueller and Reed [42], for example, find that forward integration is associated with differentiation advantage. Thus, as the service component of the economy increases, and firms integrate into downstream markets for strategic reasons, it is important to look beyond efficiency considerations and take a more integrative approach to study the impact of IT on VI. This strategic perspective is also consistent with the recent call by Santos and Eisenhardt [91] to take a broader look at organizational boundaries.

One strategic motive for VI is to use VI as an entry barrier. A vertically integrated firm can raise costs for competitors by reducing the price of output or by increasing the price of input. Thus, the threat that a large vertically integrated firm can engage in price squeezing, deters entry of less integrated firms. For example, in the petroleum industry discussed earlier, it may be argued that large firms in this environment organize operations in vertically integrated structures, not for efficiency reasons, but to deter entry of specialist players in different markets. Antill and Arnott [5] suggest that with the growth in the depth and liquidity of crude and product markets, the case for vertically integrated operations in the oil industry has become less convincing. They provide an analysis of the barriers to competition and efficiency that vertically integrated "super majors" are able to exploit.

The fashion industry provides another interesting example of the strategic use of VI. In this industry product life cycles are short and differentiation advantages built on product styling can be quickly imitated. Also, low cost global manufacturing has become the norm where producers exploit lower labor costs in developing countries. However, even in this environment some vertically integrated firms (e.g. Zara) have achieved competitive advantage by shifting competition towards speed and timing [89]. In this strategy, vertical integration allows flexible and fast cycle manufacturing with rapid learning about customer demand and preferences, a strategy not available to the more efficient (in terms coordination and production costs) but vertically disaggregated firm [64].

Bibliography

[1] Aaker, D. A.; and Day, G. S. The perils of high-growth markets. *Strategic Management Journal*, 7(5), pp. 409-421, 1986.

[2] Alba, Joseph; Lynch, John; Weitz, Barton; Janiszewski, Chris; Lutz, Richard; Sawyer, Alan; and Wood, Stacy. Interactive Home Shopping: Incentives for Consumers, Retailers, and Manufacturers to Participate in Electronic Marketplaces. *Journal of Marketing*, 61 (July 1997), 38-53.

[3] Adelman, M. A. "Concept of Statistical Measurement of Vertical Integration" in G. J. Stigler (ed.), Business Concentration and Public Policy. Princeton University Press, 1955.

[4] Ancarani, Fabio; and Shankar, Venkatesh. Price Levels and Price Dispersion Within and Across Multiple Retailer Types: Further Evidence and Extension. *Journal of the Academy of Marketing Science*, 32, 2 (2004), 176-187.

[5] Antill, N., and Arnott, R. Creating Value in the Oil Industry. *Journal of Applied Corporate Finance*, 16(1), pp. 18-37, Winter 2004.

[6] Barua, A.; Konana, P.; Whinston, A., B.; and Yin, F. . An Empirical Inves-

tigation of Net-enabled Business Value. *MIS Quarterly*, Vol. 28, No. 4, pp 585-620 December 2004.

[7] Berger, P. and Hann, R. The Impact of SFAS No. 131 on Information and Monitoring. *Journal of Accounting Research*, Vol. 41, No. 2, May 2003, pp. 163-223

[8] Bharadwaj, A.S., Bharadwaj, S. G., and B.R. Konsynski. Information technology effects on firm performance as measured by Tobin's q. *Management Science*, 1999, 45(7), pp. 1008-1024.

[9] Bakos, Y. Reducing Buyer Search Costs: Implications for Electronic Marketplaces. *Management Science*, 43, 12 (1997), 1676-1692.

[10] Bakos, Y.; and Brynjolfsson, E. Bundling Information Goods: Pricing, Profits and Efficiency. *Management Science*, 45, 12 (1999), 1613-1630.

[11] Bakos, Y.; and Brynjolfsson, E. Bundling and Competition on the Internet: Aggregation Strategies for Information Goods. *Marketing Science*, 19, 1 (2000), 63-82.

[12] Balasubramanian, S. Mail versus Mail: A Strategic Analysis of Competition between Direct Marketers and Conventional Retailers. *Marketing Science*, 17, 3 (1998), 181-195.

[13] Benabou, Roland. 1993. Search market equilibrium, bilateral heterogeneity, and repeat purchase. *Journal of Economic Theory*, 60 P.140-158.

[14] Brews, P. J.; and Tucci, C. L. Exploring The Structural Effects of Internet-working. *Strategic Management Journal*, Volume 25, pp. 429-451, 2004

[15] Brynjolfsson, E., Malone, T. W., Gurbaxani, V., Kambil, A. "Does Information Technology Lead to Smaller Firms?," *Management Science* 40(12), December 1994, pp. 1628-1644.

[16] Brynjolfsson, E.; and Smith, M.D. Frictionless Commerce? A Comparison of Internet and Conventional Retailers, *Management Science*, 46, 4 (April 2000), 563-585.

[17] Burdett, Kenneth, and Kenneth Judd. 1983. Equilibrium Price Dispersion. *Econometrica*, 51(4) P.955-969.

[18] Carlton, D.W.; and Chevalier, J.A. Free Riding and Sales Strategies for the Internet. *Journal of Industrial Economics*, 49, 4 (2001), 441-461.

[19] Chen, P., Hitt, L., 2002. Measuring Switching Costs and the Determinants of Customer Retention in Internet-Enabled Businesses: A Study of the Online Brokerage Industry. *Information Systems Research*, 13(3), pp. 255-275.

[20] Chen, Y; Iyer, G.; and Padmanabhan, V. Referral Intermediaries. *Marketing Science*, 21, 4 (Fall 2002), 412-434.

[21] Chiang, W.; Chhajed, D.; Hess, J. D. Direct Marketing, Indirect Profits: A Strategic Analysis of Dual-Channel Supply-Chain Design. *Management Science*, 49, 1 (January 2003), 1-20.

[22] Church, Jeffrey; and Ware, Roger. 2000. Industrial Organization: A Strategic Approach. McGraw-Hill.

[23] Clay, Karen; Krishnan, Ramayya; and Smith, M. D. The Great Experiment: Pricing on the Internet. Lowry, Cherrington, and Watson, eds. 2001. Handbook of Electronic Commerce in Business and Society. CRC Press, New York, 139-152.

[24] Clemons, Eric K.; Gao, Gordon; Hitt, Lorin M. 2004. When Online Reviews Meet Hyperdifferentiation: A Study of the Craft Beer Market. Working Paper in Process. (Extended Abstract).

[25] Clemons, E., and Row, M. C. "Information Technology and Industrial Cooperation: The Changing Economics of Coordination and Ownership," Journal of Management Information Systems, Fall 1992, Volume 9, No. 2, pp. 9-28.

[26] Clemons, E., Reddi, S. P., and Row, M. C. The Impact of Information Technology on the Organization of Economic Activity: The "Move to the Middle" Hypothesis. *Journal of Management Information Systems*, Fall 1993, Volume 10, No. 2, pp. 9-35.

[27] Clemons, Eric K.; Hann, Il-Horn; and Hitt, Lorin M. Price Dispersion and Differentiation in Online Travel: An Empirical Investigation. *Management Science*, 48, 4 (April 2002), 534-550.

[28] Coase, R., The Nature of the Firm. *Econometrica*, Vol. 4, No. 16, Nov., 1937 pp. 386-405.

[29] Cohen, J., Cohen, P., West, S. G., and L. S. Aiken. 2003. Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences, Third Edition. LEA, New Jersey.

[30] Coughlan, Anne T. Competition and Cooperation in Marketing Channel Choice: Theory and Application. *Marketing Science*, 4, 2 (1985), 110-129.

[31] Crocker, K., J.; and Reynolds, K., J. The efficiency of incomplete contracts: an empirical analysis of air force engine procurement. *RAND Journal of Economics*, Spring93, Vol. 24 Issue 1, pp. 126-146.

[32] D'Aveni, R., and Ilinitch, A. Y. Complex Patters of Vertical Integration in the Forest Products Industry: Systematic and Bankruptcy Risks. *Academy of Management Journal*, 1992, Vol. 35, No. 3, pp. 596-625.

[33] D'Aveni, R. A., and Ravenscraft, D. J. Economies of Integration Versus Bureaucracy Costs: Does Vertical Integration Improve Performance? *Academy of Management Journa*l, 1994, Volume 37, Number 5, pp. 1167-1206.

[34] Dewan, S., Michael, S., Min, C. "Firm Characteristics and Investments in Information Technology: Scale and Scope Effects," Information Systems Research 9(3), September 1998, pp. 219-232.

[35] Dewan, Rajiv; Freimer, Marshall; and Seidmann, Abraham. Organizing Distribution Channels for Information Goods on the Internet. 46, 4 (2000), 483-495.

[36] Dinlersoz, Emin; and Hernandez-Murillo, Ruben. The Diffusion of Electronic Business in the United States, Federal Reserve Bank of St. Louis, January/February 2005, 11-34.

[37] Eisenhardt, K. M., Agency Theory: An Assessment and Review. *Academy of Management Review*, Jan1989, Vol. 14 Issue 1, pp. 57-74

[38] Eisenhardt, K. M., Sull, D. N. Strategy as Simple Rules. *Harvard Business Review*, January 2001, Vol. 79 Issue 1, pp. 106-116.

[39] Fan, J. P. H., and Lang, L. H. P., The Measurement of Relatedness: An Application to Corporate Diversification. *Journal of Business*, 2000, Volume 73, Number 4, pp. 629-660.

[40] Fan, J. P. H., and Goyal, V. K. On the Patterns and Wealth Effects of Vertical Mergers. *Journal of Business*, 2006, Volume 79, Number 2, pp. 877-902.

[41] Folta, T. B. Governance and Uncertainty: The Trade-Off between Administrative Control and Commitment. *Strategic Management Journal*, Volume 19, pp. 1007-1028, 1998.

[42] Fronmueller, M. P., and Reed, R. The Competitive Advantage Potential of Vertical Integration. *International Journal of Management Science*, Vol. 24, No. 6, pp. 715-726, 1996.

[43] Furst, K., and Schmidt, T. Turbulent markets need flexible supply chain Communication. *Production Planning and Control*, 2001, VOL. 12, NO. 5, pp. 525-533

[44] Gu, Bin; Hitt, Lorin M.; and Clemons, Eric K. Does Online Product Information Increase Consumer Demand? An Empirical Investigation (September 2002). http://ssrn.com/abstract=515764

[45] Guay, Louise. Lands' End Improves Online Profitability Via My Virtual Model Technology. *Direct Marketing*, 64, 2 (Jun 2001), 11-11

[46] Gurbaxani, V., and Wang, S. The Impact of Information Systems on Organizations and Markets. *Communications of the ACM*, June 1991, Volume 34, Number 1, pp. 59-75.

[47] Harrigan, K. R. Vertical Integration and Corporate Strategy. *Academy of Management Journal*, 1985, Volume 28, Number 2, pp. 397-425.

[48] Hendershott, T.; and Zhang, J. A Model of Direct and Intermediated Sales. forthcoming in *Journal of Economics and Management Strategy*, 2006.

[49] Hitt, L. Information Technology and Firm Boundaries: Evidence from Panel Data. *Information Systems Research* 10(2), June 1999, pp. 134-149.

[50] Hitt, L., Wu, D. J., and Zhou, X. Investment in Enterprise Resource Planning: Business Impact and Productivity Measures. *Journal of Management Information Systems*, Vol. 19, No. 1, pp. 77-98, Summer 2002.

[51] Hitt, M.A., R.E. Hoskisson, H. Kim. International diversification: Effects on innovation and firm performance in product-diversified firms. *Academy of Management Journal*, 1997, 40(4) pp. 767-798.

[52] Hoffman, W., Keedy, J., and R. Karl. “The unexpected return of B2B,”.McKinsey Quarterly, 2002 Issue 3, pp. 96-105.

[53] Hoyt, D., and Lee, H. “Solectron: From Contract Manufacturer to Global Supply Chain Integrator,” Stanford University Case GS-24, 2001

[54] Hong, W.; Thong, J. Y. L.; and Tam, K. Y. The Effects of Information Format and Shopping Task on Consumers’ Online Shopping Behavior: A Cognitive Fit Perspective. *Journal of Management Information Systems*, 21, 3 (Winter 2005), 149-184.

[55] Lee, H.L., and Billington, C. Managing Supply Chain Inventory - Pitfalls and Opportunities. *Sloan Management Review* (33:3), Spring 1992, pp 65-73

[56] Ingene, Charles A.; and Parry, Mark E. Channel Coordination When Retailers Compete. *Marketing Science*. 14, 4 (1995), 360-377.

[57] John, G., and Weitz, B. A. Forward integration and distribution: An empirical test of transaction cost analysis. *Journal of Law, Economics, and Organization*, 4(2), pp. 337-355, 1988.

[58] Iyer, Ganesh. Coordinating Channels Under Price and Nonprice Competition. *Marketing Science*, 17, 4 (1998), 338-355.

[59] Lynch, John; and Ariely, Dan. Wine Online: Search Costs and Competition on Price, Quality, and Distribution. *Marketing Science*, 19, 1 (2000), 83-103.

[60] Jeuland, Abel; and Shugan, Steven. Managing Channel Profits. *Marketing Science*. 2, 3 (1983), 239-272.

[61] Jackson, Paul. 2004. Sales: Dell's Kiosk at Mall Sees Increase. http://www.journalnow.com.

[62] Jiang, Z.; and Benbasat, I. Virtual Product Experience: Effects of Visual and Functional Control of Products on Perceived Diagnosticity and Flow in Electronic Shopping. *Journal of Management Information Systems*, 21, 3 (Winter 2005), 111-147.

[63] Keats, Barbara W.; Michael A. Hitt. (1988). A Causal Model of Linkages among Environmental Dimensions, Macro Organizational Characteristics, and Performance. *Academy of Management Journal*, 31(3). 570-598.

[64] Kasra, F., Lewis, M., and Machua, J. A. D. Rapid-Fire Fulfillment. *Harvard Business Review*, Vol. 82, Issue 11, pp. 104-110, November 2004.

[65] Konana, P.; and Ray, G. Physical Product Re-Engineering with Embedded Information Technology. forthcoming in the *Communications of the ACM*, 2006

[66] Lal, Rajiv; and Sarvary, Richard. When and How Is the Internet Likely to Decrease Price Competition? *Marketing Science*, 18, 4 (1999) 485-503.

[67] Langer, E. J. (1982). The Illusion of Control. In Kahneman D., Slovic P., & Tversky, A. (Eds.). Judgment Under Uncertainty: Heuristics and Biases. New York: Cambridge University Press

[68] Lee, Ho Geun, Theodore Clark, and Kar Yan Tam. (1999). Research Report. Can EDI Benefit Adopters? *Information Systems Research*, 10(2) 186-195.

[69] Lee H. Y. 1994.Vertical Integration and Technological Innovation. Garland Publishing. New York & London 1994.

[70] Lee, H. L. Aligning Supply Chain Strategies with Product Uncertainties. *California Management Review*, Volume 44, Number 3, Spring 2002, pp. 105-119.

[71] MacMinn, Richard. 1980. Search and Market Equilibrium. *Journal of Political Economy*, 88(2) P.308-327.

[72] Maddigan, R. J. The Measurement of Vertical Integration. *Review of Economics and Statistics*, August 1981, Vol. 63 Issue 3, pp. 328-335.

[73] Malhotra, A., Gosain, S., and El Sawy, O. A Absorptive Capacity Configuration in Supply Chains: Gearing for Partner-Enabled Market Knowledge Creation. *MIS Quarterly*, Mar2005, Vol. 29 Issue 1, pp. 145–187.

[74] Malone, T. W., Yates, J., and Benjamin, R. I., Electronic Markets and Electronic Hierarchies. Communications of the ACM, June 1987, Volume 30, Number 6, pp. 484-497

[75] McGuire, Timothy; and Staelin, Richard. An Industry Equilibrium Analysis of Downstream Vertical Integration. *Marketing Science*, 2, 2 (1983), 161-191.

[76] McMillion, C. W. Merger Madness. *The International Economy*, July/August 1999, pp. 36-39.

[77] Miller, D., and Frisen, P. H. 1983. Strategy-Making and Environment: The Third Link. *Strategic Management Journal*, 4, 221-235.

[78] Mittelstaedt, Robert. Sasquatch, the Abominable Snowman, Free Riders and Other Elusive Beings. *Journal of Macromarketing*, 6, 2 (1986), 25-35.

[79] Moorthy, K. Sridhar. Strategic Decentralization in Channels. *Marketing Science*, 7, 4 (1988), 335-355.

[80] Mukhopadhyay, T.; and Kekre, Sunder . (2002), Strategic and Operational Benefits of Electronic Integration in B2B Procurement Processes. *Management Science*, 48(10) 1301-1313

[81] Narasimhan, Chakravarthi. Competitive Promotional Strategies. *Journal of Business*, 61, 4 (1988), 427-449.

[82] Osegowitsch, T., and Madhok, A. Vertical Integration is dead, or is it? *Business Horizons*, March-April 2003, pp. 25-34.

[83] Prahalad, C. K., Hamel, G., The Core Competence of the Organization. *Harvard Business Review*, May/June 1990, Vol. 8, Issue 3, pp. 79-91.

[84] Raju, Jagmohan; Srinivasan, V.; and Lal, Rajiv. The Effects of Brand Loyalty on Competitive Price Promotional Strategies. *Management Science*, 36, 3 (1990), 276-304

[85] Rangan, V. Kasturi; Menezes, Melvyn; and Maier, E. Channel Selection for New Industrial Products: A Framework, Method, and Application. *Journal of Marketing*, 56 (July 1992), 69-82.

[86] Ratchford, Brian; Lee, Myung-Soo; and Talukdar, Debabrata. The Impact of the Internet on Information Search for Automobiles, *Journal of Marketing Research*, 40, 2 (May 2003), 193-209.

[87] Riggins, F. A Multichannel Model of Separating Equilibrium in the Face of the Digital Divide. *Journal of Management Information Systems*, 21, 2 (Fall 2004), 161-179.

[88] Reinhardt, F., Casadesus-Masanell, R., and Hanson, D. “BP and the Consolidation of the Oil Industry, 1998-2002,” HBS Case, 9-702-012, 2003.

[89] Richardson, J. Vertical Integration and Rapid Response in Fashion Apparel. *Organization Science*, Jul/Aug 1996, Vol. 7 Issue 4, pp. 400-412.

[90] Rob, Rafael. 1985. Equilibrium Price Distributions. Review of Economic Studies, 52(3) P.487-504.

[91] Santos, F. M., and Eisendardt, K. M. Organizational Boundaries and Theories of Organization. *Organization science*, Volume 16, No. 5, September-October 2005, pp. 491-508.

[92] Saunders, Christopher. 2002. Survey: Multi-Channel Buyers Worth Pursuing. http://www.clickz.com.

[93] Scheleur, S.; King, C.; and Shimberg, M. Quarterly Retail E-Commerce Sales, 1st Quarter 2005. US Census Bureau News.

[94] Scherer, F M. Industrial Market Structure and Economic Performance, Boston: Houghtom Miffin Company, 1980.

[95] Singer, Eugene M., Antitrust Economics: Selected Legal Cases and Economic Models (Englewood Cliffs, N. J.: Prentice Hall, 1968)

[96] Singley, Rodger B., and Michael Williams. 1995, Free riding in retail stores: An investigation of its perceived prevalence and costs. *Journal of Marketing Theory & Practice*, 3(2) P.64-74.

[97] Smith, Michael D.; and Brynjolfsson, E. Customer Decision Making at an Internet Shopbot: Brand Still Matters. *The Journal of Industrial Economics*, 49, 4 (2001), 541-558.

[98] Smith, M. D. 2001. The Law of One Price? The Impact of IT-Enabled Markets on Consumer Search and Retailer Pricing. Working Paper.

[99] Srinivasan, Kannan; Kekre, Sunder; and Mukhopadhyay, Tridas (1994). Impact of Electronic Data Interchange Technology on JIT Shipments. *Management Science*. 40(10): 1291-1304.

[100] Stahl, Dale. 1989. Oligopolistic Pricing with Sequential Consumer search. *American Economic Review*, 79(4) P.700-712.

[101] Stigler, G. J. The Organization of Industry, Richard D. Irwin, Homewood, IL, 1968

[102] Telser, Lester. Why Should Manufactures Want Fair Trade? *Journal of Law and Economics*, 3 (October 1960), 86-105.

[103] Thomas, L. G., The Two faces of Competition: Dynamic resourcefulness and the hypercompetitive shift. *Organization Science*, 1996, 7(3), pp. 221-242.

[104] Tirole, Jean. *The Theory of Industrial Organization*, MIT Press. 1988.

[105] Trager, L. Catalogers Find E-tail Success in the Bag. *Interactive Week*, 7, 17 (2000), 28

[106] Tushman, M. L., and Anderson, P. 1986. Technological Discontinuities and Organizational Environments. *Administrative Science Quarterly*, 31: 439-465.

[107] Varian, Hal. 1980. A Model of Sales. American Economic Review, 70 P.651-659.

[108] Walker, G., and Weber, D. A transaction cost approach to make-buy decisions. *Administrative Science Quarterly*, Vol. 29, pp. 337-391, 1984.

[109] Walker, G., and Weber, D. Supplier competition, uncertainty and make-buy decisions. *Academy of Management Journal*, 30, pp. 589-596, 1987..

[110] Wernerfelt, B., and C. A. Montgomery. 1988. Tobin's Q and the importance of focus in firm performance. *American Economic Review*, 78 (March), pp. 246-250

[111] Wernerfelt, Birger. On the Function of Sales Assistance. *Marketing Science*, 13, 1 (1994), 68-82.

[112] Williamson, O. Markets and Hierarchies: Analysis and Antitrust Implications, The Free Press, New York, 1975.

[113] Wooldridge, J. Introductory Econometrics : A Modern Approach, South-Western College Pub, 2002.

[114] Worthen, B. Drilling for Every Drop of Value. *CIO* June 2002

[115] Zettelmeyer, F. Expanding to the Internet: Pricing and Communication Strategies When Firms Compete on Multiple Channels. *Journal of Marketing Research*, 37, (August 2000), 292-308.

Vita

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