A Multi-Channel Model of Separating Equilibrium in the Face of the Digital Divide

Frederick J. Riggins
Carlson School of Management
University of Minnesota, Minneapolis, MN
friggins@csom.umn.edu
Phone: 612-624-5760
Fax: 612-626-1316

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Abstract

We develop a multi-channel model of separating equilibrium where a seller markets a durable good to high and low type consumers in two different channels – an online Internet storefront and an offline brick-and-mortar store. We show how the digital divide, where high type consumers dominate the online channel and low type consumers dominate the offline channel, artificially segments the marketplace thereby mitigating the classic cannibalization problem. This allows the seller to more efficiently market its goods to each consumer segment. We show conditions under which low type consumers are initially served in the offline channel, but subsequently bridging the divide results in low type consumers not being served in either channel. We also examine the implications of bridging the digital divide when the seller uses delay by engaging in intertemporal price discrimination.

Key Words: Digital divide, economic analysis, electronic commerce, market segmentation, multi-channel marketing, pricing strategy
FREDERICK J. RIGGINS is an Assistant Professor in the Department of Information and Decision Sciences of the Carlson School of Management at the University of Minnesota. His teaching interests include information technology management, information-based goods, e-business strategy, and the economics of information systems. His research focuses on new business models for Internet-based commerce, strategies for implementing interorganizational systems, measuring the value of information systems, and the implications of the digital divide for managers and businesses. He has spoken at many conferences and published in several leading academic journals including Management Science, Journal of Management Information Systems, Communications of the ACM, International Journal of Electronic Commerce, and the Journal of Organizational Computing and Electronic Commerce. He received his Ph.D. from the Graduate School of Industrial Administration at Carnegie Mellon University where he was the winner of the William W. Cooper Doctoral Dissertation Award in Management. Prior to joining the Carlson School he was on the faculty of Georgia Tech and the University of Alberta. Professor Riggins recently was co-chair of a research symposium on the digital divide entitled “The Impact of the Digital Divide on Management and Policy: Determinants and Implications of Unequal Access to Information Technology” hosted at the University of Minnesota.
Introduction

The success of the Internet as a viable channel for commerce depends on achieving a critical mass of users willing to make purchases using the channel. However, examination of the growth in the number of Internet users indicates that adoption has not been uniform across all segments of society, creating what has come to be called the “digital divide.” Much of the debate in the public policy arena concerning the divide examines how to provide online access to those without access to online resources. Empirical studies have investigated the existence of the divide according to several different individual characteristics including income, race, level of education, and age [4, 5]. The findings from a recent Pew Internet and American Life project study [10] show that:

- those with higher incomes are far more likely to be online than lower income individuals causing the report to state “independent of all other factors, having an income above $50,000 annually predicts Internet use”;
- the percentage of whites and Hispanics who have online access is about six to twelve percent higher than African-Americans with similar education;
- 82% of college graduates use the Internet, but only 45% of those with only a high school diploma are online; and
- of non-Internet users, half are over age 50, compared with just 14% being between 18 and 29.1

From this information alone we should expect that vendors that operate both online and offline channels simultaneously would expect to serve a different type of customer in their online store versus those who would typically frequent their physical stores. This should result in a difference in the type of products, quality levels, and price levels offered online versus that offered in offline channels.
From a managerial perspective, the concept of the digital divide encompasses much more than those who do and do not have access to the Internet. For example, the digital divide has been defined as a term that “describes the fact that the world can be divided into people who do and people who don’t have access to – and the capability to use – modern information technology, such as the telephone, television, or the Internet” [15]. Even for those individuals that have access to the Internet, a divide exists between those who make use of many of the more advanced features associated with online commerce, such as online auctions, configuration of personalized shopping sites, product comparison sites, and high bandwidth functionality, versus those who do not make use of such services. For example, in a follow-up study to the one just cited, researchers for the Pew Internet and American Life project found that

- females were more likely to seek online health and religious information, while males were more likely to seek online financial, sports, and political information;

- African-Americans often use the Internet to do school-related research and seek religious information, while Hispanics were more likely to use instant messaging and download music;

- young people are more likely to do instant messaging and download music, while seniors are more likely to gather health and government-provided information; and

- those with higher incomes and college degrees were more likely to access government information, do online banking, and engage in online auctions than other people [11].

Indeed, the earlier Pew Internet report outlines a spectrum of those online and offline as shown in Figure 1 [10]. For example, in 2002 only about 13% of the U.S. population were home broadband users making for a fairly narrow population segment likely to make use of high bandwidth services such as music or video downloads. In addition,
over 40% of those considered to be not online had some experience with the Internet and were classified as either “net evaders,” defined as those who avoid using the Internet but have someone close to them do their online tasks for them, or “net dropouts” who have tried but then discontinued use of the Internet for various reasons. Even of those who were considered to be online, nearly half of them may simply be “intermittent users.”

When considered from this broad vantage point, the digital divide looms much larger and is much more complex than first imagined, especially from the perspective of the providers of online commerce sites and online services. We should expect that managers of these online storefronts would react to the digital divide to form strategies and provide goods and services in ways that will be profit maximizing to the firm, but may not necessarily promote overall welfare and generate benefits to those lacking access – broadly defined. Without an understanding of the impact of the digital divide on the providers of online goods and services, these providers may not create a marketplace that is attractive to those without access. This in turn would lower the perceived benefits of having access to the Internet and engaging in online commerce, thereby mitigating public policy efforts to bridge the digital divide. The success of the Internet as a viable channel for commerce is dependent upon achieving a critical mass of users who are willing to
engage in online commerce. So this paper examines the implications of the digital divide on providers of online goods and services, their potential reaction to the existence of a digital divide, and the subsequent pricing incentives directed at potential users of net-enabled commerce.

In fine-tuning Wal-Mart’s (www.walmart.com) Web site, the retailer giant clearly takes into account the differences between their in-store customers versus their online customers. From the home page, a customer can click on the “Help” link to find the answer to a question pertinent to our study:

*Are the same items available at Walmart.com as in stores? No. Each Wal-Mart store carries an assortment of merchandise that is chosen to serve that store’s particular customers. Walmart.com is no different from your local Wal-Mart store in this respect ... Walmart.com carries a wide assortment of the products our online customers want most, all at Wal-Mart's famous Every Day Low Prices. To serve you better, we are fine-tuning our merchandise assortment all the time.*

While this page also states that there may be some overlap between the product offerings online and offline, given this statement and the demographic characteristics of the typical online users noted earlier, we should expect that Wal-Mart management would seek to use their online channel to promote higher quality, higher priced items than their physical store. Likewise, a casual perusal of BestBuy’s (www.bestbuy.com) or CompUSA’s (www.compusa.com) Web sites indicates that there are a considerable number of high-priced items available in the online store labeled as “Online Only” or “Delivery Only” that are not available in their corresponding physical stores.

While it would seem that bridging the digital divide is an important goal if online commerce is to grow into a widely accepted form of commerce, bridging the divide may have certain negative consequences that have not been considered. This will be
particularly true if these multi-channel retailers use the digital divide as a market segmentation mechanism that can lessen the problems caused by the classic cannibalization problem. For example, online/offline market segmentation is seen in the market for personal computers where manufacturers simultaneously sell in traditional brick-and-mortar electronics retail stores and through the direct channel via their company Web sites. Products offered on the Web site are typically high-end workstations and servers, while those sold at retail electronic stores are typically slower, low-end processors. In fact, many of the low-end products found in the physical store are not available in the online storefront. Even when a new processor is introduced into the online store, rather than add the new model to its existing product line, the manufacturer will often remove the slowest machine previously offered online – even though the slower model is readily available in the brick-and-mortar store. While there are several reasons for this, including the time difference of moving inventory through the two channels, sellers in multiple channels know that different clientele in each channel requires different quality and pricing levels appropriate for each group. In particular, the seller may remove low end products from its online store to keep the high type online consumer’s attention focused on the more profitable powerful desktop models, rather than cannibalize these sales.

In this paper, we develop an analytical model of a separating equilibrium to examine the pricing and quality levels of a firm that sells in two channels simultaneously – an online channel and an offline channel. Prior analytical modeling has examined the classic cannibalization problem that can exist when high and low type consumers exist in the same shopping channel [6, 9, 14]. In the present analysis, we show how the digital
divide artificially segments the marketplace allowing the seller to more efficiently market its goods to each consumer segment, thereby mitigating the cannibalization problem. Subsequently bridging the divide increases the cannibalization problem, causing the seller to lower the quality of the low quality product in the physical store. We show conditions under which low type consumers are initially served in the offline channel, but subsequently bridging the divide results in low types not being served in either channel. We extend the model to examine the implications of bridging the divide when the seller uses delay by offering product introductions in sequential periods.

The organization of the paper is as follows. In the next section, we review the relevant literature upon which we construct our model. The formal model is developed in the following section, where we examine the seller’s optimal selling strategies in the face of the digital divide and examine the implications of bridging the divide. We then expand the model by examining the use of intertemporal price discrimination with the existence of the digital divide. We conclude by summarizing our findings and suggestions for future research.

**Previous Modeling**

Several researchers have examined pricing strategies of sellers that practice intertemporal price discrimination or that operate in multiple channels simultaneously. Stokey [14] showed how a monopolist could use delay as a way of selling to multiple consumers who have differing reservation prices. Landsberger and Meilijson [6] build on that idea to show that intertemporal price discrimination works when the seller and buyers have different discount rates. Conner [2] illustrates how a firm may spend
aggressively on research and development to create a new version of an old product, and then delay introduction of the new product until the old one is challenged by a competitor. Besanko and Winston [1] model the monopolist’s optimal timing and pricing strategy in the introduction of a new product when consumers are intertemporal utility maximizers versus being myopic. They show that prices are always lower when consumers act rationally as opposed to myopic, which allows the seller to practice intertemporal price discrimination. Similarly, Levinthal and Purohit [7] show how expectation of a future product improvement cannibalizes sales of the current version of the product. They show conditions under which the seller should phase out the old product versus instituting a buy-back policy when the new product is introduced.

Purohit [12] develops a two-period model of a manufacturer that markets its goods in a multi-channel setting. By comparing an automotive rental agency structure versus a dealership structure, he determines the profitability of a manufacturer under three different channel scenarios to best coordinate rental and dealership relationships. Zettelmeyer [16] examines how the size of the Internet affects the firm’s pricing and communications strategies. He shows that when the Internet is relatively small in size, firms will provide more information online and prices will be lower than in conventional channels. However, as the number of users on the Internet increases, the amount of information the firm provides through the Internet channel and the firm’s online pricing policy will eventually become similar to that in the conventional channel.

Mason and Milne [8] conduct an empirical study of the cigarette industry to show how the proliferation of brands results in cannibalization of other product lines, leading
firms to reduce the number of brands they sell. They develop a method of identifying the
degree of cannibalization in mature retail markets.

The current analysis is most closely related to Moorthy and Png [9] who develop
a model of separating equilibrium in a single-channel market. They consider a
monopolist that produces a durable product that can be differentiated along some
dimension of “quality.” The monopolist sells to a market that is made up of high and low
type consumers, where high types have a higher valuation for a given level of quality
than low type consumers. In this situation, the seller will produce two versions of the
product to be targeted at the two consumer segments. Because of the lack of information
about a specific consumer’s type, the seller must practice second-degree price
discrimination and price the two products such that the consumers self-select into their
appropriate market segments. The cannibalization problem arises because the seller is
not able to prohibit the high type consumer from buying the low quality good. The
authors show that the optimal solution to the problem is to give high type consumers a
price discount and lower the quality (and corresponding price) of the low quality good to
the point that high type consumers are not interested in that version of the product.
Depending upon the relative consumer valuations of the good, it is possible that the seller
may need to lower the quality of the low quality product to the point that it essentially
doesn’t exist. In that case, the cannibalization problem is so strong that low type
consumers are not served in the marketplace.

This cannibalization problem essentially has two important effects on the market.
First, low type consumer choice is reduced since they receive a lower quality product,
and in fact may not be served at all if the cannibalization potential is high enough.
Second, the seller experiences lower profits since he must contend with the moral hazard problem associated with second-degree price discrimination. To combat the cannibalization problem, the seller may employ intertemporal price discrimination by offering the high quality good at an earlier point in time than the low quality good. By using delay to degrade the low quality good, the seller may be able to mitigate the cannibalization problem if consumers are sufficiently impatient relative to the seller. In the next section, we extend the Moorthy and Png [9] model by allowing the seller to sell in two channels at the same time.

A Multi-Channel Model

We consider the seller’s problem where the seller markets its goods in two channels simultaneously, the online (Internet) channel (I) and an offline (brick-and-mortar) channel (B). The seller sells a durable good that can be differentiated according to some dimension of quality, $q$. There are two types of consumer segments in the market, $h$ and $l$, where $n_h$ is the number of high types and $n_l$ is the number of low types. Further, high type consumers value a given level of quality $q$ at $v_hq$, while low types value the same item at $v_lq$. Let $v_h > v_l > 0$ such that high types value a given level of quality more than low types. Let $v^h_l = v_h/v_l$, $n^h_l = n_h/n_l$ and $R = n^h_l (v^h_l - 1)$ where $R$ is a measure of the degree of cannibalization as shown in [9]. Finally, assume that a consumer buys at most one unit of the durable good and then exits the marketplace.

Due to a favorable online cost structure, we assume that the marginal cost of providing an additional good in the online channel is less than or equal to the marginal cost of an additional good in the offline channel. This cost is the cost of developing and
bringing a product of quality $q$ to market. The cost of developing a product of quality $q$
should not differ regardless of which channel it is sold in, however the costs of bringing
the product to market should differ. First, the transaction costs of delivering a product in
the online channel should be lower than the physical channel. Even more importantly for
this analysis, for a product of a particular quality $q$, other costs such as requirements for
physically packaging, handling, shipping, storing, and securing goods should be higher in
the physical channel as well. In addition, costs for insuring, displaying, and maintaining
qualified sales persons to explain the product should be higher in the physical channel.
Therefore, we assume that the costs of developing and bringing a product to market of
quality $q$ is higher in the physical channel than in the online channel, and that this
difference increases as product quality increases. Therefore, the seller can market the
good in the online channel and/or the offline channel, where the marginal cost of
supplying one unit with quality $q$ is $c_{b}q^{2}$ and $c_{i}q^{2}$ respectively, where $c_{b} \geq c_{i} \geq 0$.

Let $\alpha$ and $\beta$ be the fraction of low and high type consumers, respectively, who
have migrated to the online channel. In the current analysis, we assume that a particular
consumer shops in only one channel and her decision to remain in the offline channel or
migrate to the online channel is independent of the market for the one durable good under
consideration. This assumption simplifies the analysis, however the results would still
hold if we assumed a consumer type has a certain propensity to shop either online versus
offline. Specifically, the general results found in this analysis hold if consumers who
have gone online are less likely to purchase in physical stores than their similar
counterparts who do not have online access. Based on empirical and theoretical grounds,
we assume that a digital divide potentially exists, i.e., $0 \leq \alpha \leq \beta \leq 1$, such that high type consumers migrate to the online channel of commerce faster than low type consumers.

When some portion of high and low type consumers are located in both channels, i.e., when $0 < \alpha < \beta < 1$, the seller will potentially sell high and low quality versions of the good in both channels resulting in at most four “products” or levels of qualities where we can easily show that the efficient qualities for the four products are

$$ q^*_i = \frac{v_i}{2c_i}, \quad q^*_h = \frac{v_h}{2c_h}, \quad q^*_l = \frac{v_l}{2c_l}, \quad \text{and} \quad q^*_b = \frac{v_l}{2c_b}. $$

In general, we know that

$$ q^*_h \geq q^*_h, \quad q^*_h > q^*_l, \quad q^*_l \geq q^*_b, \quad \text{and} \quad q^*_b > q^*_b. $$

We now turn our attention to situations where the seller introduces all products in the same period and commits to no further product introductions. The seller’s problem is

$$ \max_{q^i, q^h, q^l, q^b, p^i, p^h, p^l, p^b} \alpha n_i \left( p^i - c_i q^i \right)^2 + \beta n_h \left( p^h - c_h q^h \right)^2 \left( 1 - \alpha \right) n_l \left( p^l - c_l q^l \right)^2 + \left( 1 - \beta \right) n_l \left( p^l - c_l q^l \right)^2 $$

subject to:

$$ v_l q^i_i - p^i \geq v_l q^i_h - p^i \quad \text{(2a)} \quad v_l q^i_l - p^i \geq v_l q^i_h - p^i \quad \text{(2b)} $$

$$ v_h q^i_h - p^i \geq v_h q^i_l - p^i \quad \text{(3a)} \quad v_h q^i_h - p^i \geq v_h q^i_l - p^i \quad \text{(3b)} $$

$$ v_l q^i_l \geq p^i \quad \text{(4a)} \quad v_l q^i_l \geq p^i \quad \text{(4b)} $$

$$ v_h q^i_h \geq p^i \quad \text{(5a)} \quad v_h q^i_h \geq p^i \quad \text{(5b)} $$

Here, (2) and (3) are the self-selection constraints and (4) and (5) are the participation constraints that ensure that each consumer type will participate in the market.

As pointed out in [9], because high type consumers value a given level of quality more than low types, the seller cannot extract all of the consumer surplus from both types

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by binding constraints (4) and (5) at the same time, otherwise high type consumers would purchase the low quality good, thereby gaining some positive surplus. Instead, the seller will bind constraint (4) such that

\[ p_i^l = v_l q_i^l \quad \text{and} \quad p_i^b = v_l q_i^b. \]  

(6)

Also, the seller should set the price for the high quality goods so that the high types in each channel are indifferent between the high quality good and the low quality good by making constraint (3) bind and then using (6), such that

\[ p_h^l = v_h q_h^l - (v_h - v_l) q_i^l \quad \text{and} \quad p_h^b = v_h q_h^b - (v_h - v_l) q_i^b. \]  

(7)

Using (6) and (7) in the objective function we can calculate the qualities as

\[ q_i^l = \frac{v_l}{2c_i} \left( 1 - \frac{\beta}{\alpha} R \right) \quad \text{and} \quad q_i^b = \frac{v_l}{2c_b} \left( 1 - \frac{\beta}{1 - \alpha} R \right) \]  

(8)

\[ q_h^l = \frac{v_h}{2c_i} \quad \text{and} \quad q_h^b = \frac{v_h}{2c_b}. \]  

(9)

The seller’s profits are

\[ \Pi = \frac{\alpha n_i v_i^2}{4c_i} \left( 1 - \frac{\beta}{\alpha} R \right)^2 + \frac{\beta n_h v_h^2}{4c_i} + \frac{(1-\alpha)n_i v_i^2}{4c_b} \left( 1 - \frac{\beta}{1 - \alpha} R \right)^2 + \frac{(1-\beta)n_h v_h^2}{4c_b}. \]  

(10)

The four terms in Equation (10) represent the profit from selling to low types online, high types online, low types offline, and high types offline, respectively. This four-product solution is feasible, if and only if \( q_i^l > 0 \), i.e., when \( R < \frac{\alpha}{\beta} \). When \( R \geq \frac{\alpha}{\beta} \), the seller is able to increase profits by lowering the quality of the low quality online product, and does so until the point that it essentially doesn’t exist – the low type consumer is not served in the online market. However, a three-product solution is
feasible where the low type segment is still served in the offline marketplace provided 
$q_l^b > 0$, which occurs as long as $R < \frac{1-\alpha}{1-\beta}$. When $R \geq \frac{1-\alpha}{1-\beta}$, the seller again is able to 
increase profits by lowering the quality of the low quality offline product until the point 
that the low type consumer is not served in either channel, resulting in a two-product 
solution. In terms of selling to the high type consumers, the seller should supply the high 
types their efficient qualities and price them according to (7). In the appropriate regions, 
profits are increased as $q_l^i$ and/or $q_l^b$ go down. The seller’s maximum profits are shown 
in Appendix A.

We now turn our attention to the specifics of the implications of the digital divide. If $0 < \alpha < \beta < 1$, the seller’s strategy can be determined from Equation (A.1) in the 
Appendix. If $R < \frac{\alpha}{\beta}$, the seller will sell both the high and low quality goods in both 
channels. If $\frac{\alpha}{\beta} \leq R < \frac{1-\alpha}{1-\beta}$, the seller can increase profits by serving the low type 
consumer only in the offline channel, while high types will be served in both channels. If 
$R \geq \frac{1-\alpha}{1-\beta}$, the threat of cannibalization is so great that the seller does not serve low type 
consumers in either channel, but still sells to high types in both channels. Specifically, we 
can state the seller’s strategy as stated in Proposition 1.

**PROPOSITION 1 (The Product Introduction Quality Choice Proposition).** *If the 
seller chooses to introduce products in one period only, then he will do so in the first 
period, and offer four qualities, $q_h^b$, $q_h^i$, $q_l^b$, and $q_l^i$, if $R < \frac{\alpha}{\beta}$, or offer three qualities, 
$q_h^b$, $q_h^i$, and $q_l^b$, if $\frac{\alpha}{\beta} \leq R < \frac{1-\alpha}{1-\beta}$, or two qualities, $q_h^b$ and $q_l^i$, if $R \geq \frac{1-\alpha}{1-\beta}$.*
The seller’s strategy is readily illustrated in Figure 2, where we show the case where $\beta = .8$, i.e., when 80% of the high type consumers are online. When $R$ is relatively low, the threat of cannibalization is low, allowing the seller to sell to both consumer types in both channels, provided the digital divide is not too great. This is the area labeled as Region A. However, even when $R$ is low, a huge digital divide will result in low types being served only in the offline market, since there would not be enough low type consumers in the online market to make it profitable for the seller to offer a low quality good online. This is Region B, where high types are served in both channels, but the low type consumers are served only in the offline channel. When $R$ is very large, the potential for cannibalization is so large that the seller will sell only to the high type consumers in both channels. This is labeled as Region C. Moorthy and Png [9] show that in the single-channel, one-period case, the seller will sell to both high and low types when $R < 1$, and only to the high type consumers when $R \geq 1$. In Figure 2, this corresponds to the situation where $\alpha = \beta = .8$ where the appropriate strategy is to sell all four quality levels when $R < 1$, and sell only the high quality goods in both channels when $R \geq 1$. However, when $\alpha < \beta$, the digital divide opens up a new opportunity for the low type consumers to be served in the offline channel as shown in Region B. The greater the digital divide, the more Region B dominates the seller’s strategic options.
What is the impact of the digital divide on the seller’s profits? It is easily shown that the seller’s profits increase as $\beta$ increases, i.e., $\frac{\partial \Pi}{\partial \beta} \geq 0$, such that having the high type consumers migrate to the online channel increases the seller’s profits. This is so for two reasons. First, increasing the digital divide further segments the marketplace, thereby lessening the cannibalization problem and increasing profits for the seller. In addition, the seller enjoys the cost advantages of selling to the high type consumers in the more efficient online market. However, bridging the digital divide by bringing more low type consumers into the online channel does not necessarily increase the seller’s profits. This is because the seller benefits by selling to the low type consumers in the cost efficient online channel, but is harmed by the exacerbated cannibalization problem that results from lower segmentation in the market as the high and low type consumers mix in both channels.

Consider Equation (8) for the situation where $\beta$ is considerably large relative to $\alpha$. In that case, the high type consumers dominate the online commerce channel such that the seller is forced to lower the quality, $q_l^i$, of the low quality online good to keep the
high types from cannibalizing sales of the high quality good. In this scenario, it is quite likely that the low types will not be served in the online channel as the seller sets $q^l_i = 0$ and chooses to focus its online marketing efforts on selling the high quality good to the high type consumers. In addition, notice that as $\beta$ increases, the seller is able to raise the level of quality of the low quality good in its brick-and-mortar stores, that is $\frac{\partial q^b_l}{\partial \beta} \geq 0$.

Indeed, in the extreme case where $\alpha$ is some positive value and $\beta \rightarrow 1$, the seller is able to serve its offline low type consumers with an efficient level of quality $q^b_l^\ast$.

Therefore, as more and more high types migrate from traditional brick-and-mortar shopping environments to online shopping, and thereby visit physical stores less frequently, we should expect to see physical stores raise the quality, and by (7) the corresponding price, of their discount merchandise. In this case, we see that the digital divide acts as a mitigating factor for the cannibalization problem that exists when different types of consumers co-exist in the same marketplace. The digital divide lessens, or may in fact eliminate, the cannibalization problem that occurs when high type consumers are tempted to purchase low-end goods due to their higher valuation of quality. We summarize this result in Proposition 2.

**PROPOSITION 2 (The Digital Divide Proposition).** If the seller chooses to introduce products in a single period setting, the digital divide, where $0 \leq \alpha < \beta \leq 1$, segments the market and lessens the cannibalization problem, resulting in higher quality goods at higher prices for low types consumers in the offline channel.

The intuition is quite straightforward. When high type consumers are faster to adopt online shopping, the digital divide naturally segments the market into two channels: the online Internet channel where high quality goods are targeted to the high
type adopters, and the offline brick-and-mortar channel where low quality goods are targeted to low type consumers. When the two consumer types are segmented in this way, the low type consumers are served higher quality goods in the brick-and-mortar store because the seller is not forced to lower quality to avoid the cannibalization problem.

The situation can be illustrated in Figure 3. The assumption that $\alpha \leq \beta$ means that we need only concern ourselves with the area to the right of line $AB$. Provided that $R < \frac{\alpha}{\beta}$, we can summarize the key points as follows:

- at point $A$, no consumer has migrated to the online channel – the seller sells a high and low quality good in the offline channel only with the maximum cannibalization potential;

- at point $B$, all consumers have migrated to the online channel – the seller sells a high and low quality good in the online channel only with the maximum cannibalization potential;

- along the diagonal from $AB$, there is no digital divide as an equal percentage of high and low types have migrated to the online channel – the seller may sell high and low quality goods in both channels with the maximum cannibalization potential;

- cannibalization potential decreases as we move further from the $AB$ diagonal;

- at point $C$, the markets are perfectly segmented such that there is no cannibalization problem at all – the low types enjoy the efficient quality level in the offline channel and the seller’s profits are maximized;

- the solid/dashed arc beginning at point $A$ is a hypothetical adoption path. Note that the cannibalization potential is minimized at point $D$ for $\alpha^*$ and $\beta^*$;

- the dotted line indicates the hypothetical adoption path where an effort is made to bridge the digital divide. Note that the effort to bridge the digital divide rotates the arc counter-clockwise toward the $AB$ diagonal, thus increasing the cannibalization problem.
Now suppose the seller considers offering less than four different product offerings in the two channels. As shown in Figure 3, if $\alpha = \beta = 0$ ($\alpha = \beta = 1$), the seller sells only in the offline (online) channel. If $\alpha = 0$ and $\beta = 1$, the seller sells only the low quality good in the offline channel and only the high quality good in the online channel with no cannibalization potential. If $\alpha = 0$ and $0 < \beta < 1$, the seller will sell the high quality good in both channels, will not sell any low quality goods online, and will sell a low quality good in the offline channel if $(1-\beta) R < 1$. If $(1-\beta) R \geq 1$, the low type consumer will not be served in either channel.

What happens when the potential for cannibalization is high and an effort is made to bridge the digital divide? Refer to Figure 2 and consider the area where $1 < R < \frac{1-\alpha}{1-b}$, such that the seller pursues the strategy in the right side of Region B by selling to high
types in both channels and to low types offline due to a combination of the cannibalization problem and the digital divide. In this case, a sufficient increase in $\alpha$ will move the seller into Region C where the seller’s strategy is to sell only to the high types in both channels. In other words, bridging the digital divide will force the seller to cease sales of the low quality good in the brick-and-mortar stores because of the cannibalization problem, but will not provide adequate incentives to begin sales of the low quality good in the online channel! This rather surprising result shows that conditions could exist where low type consumers were previously served in one channel, but bridging the digital divide could cause them to be not served in either channel. More formally, we can summarize this result in Proposition 3.

**Proposition 3 (The Low Type Channel Restriction Proposition).** If $1 < R < \frac{1-a}{1-\beta}$, low type consumers will be served in the offline channel only, where $q_i^b > 0$, provided that $0 < \alpha < \beta < 1$. Subsequently increasing $\alpha$ such that $R \geq \frac{1-a}{1-\beta}$ will result in $q_i^b = 0$ such that low type consumers will not be served in either channel.

Naturally the drive to bridge the digital divide is due to the belief that providing Internet access to low type consumers should have certain positive effects on these individuals. In particular, the Internet increases people’s connectivity to information resources, other individuals, ideas and cultures, and new shopping experiences. Theoretically, bridging the digital divide potentially has two diametrically opposed long-term potential impacts on the cannibalization parameter, $R$, that are not taken into account in our model.

First, consider the implications of bridging the divide on the differences in quality valuations, $v_h$ and $v_l$. Having access to the Internet could make low type consumers more
cosmopolitan and aware of more product opportunities in the marketplace, thereby altering their consumer tastes. If having access to the Internet causes $v_l$ to increase, the gap between $v_h$ and $v_l$ could decrease, lowering $v_l^h$ and thereby lowering $R$. We call this long-term change in $R$ the *moderating valuation effect*. Referring back to Figure 2, if $R > 1$, bridging the digital divide could move the seller from Region B to Region C, such that low types are no longer served in either channel. However, over a longer period of time, a reduction in $R$ due to the moderating valuation effect would cause the seller to move leftward back to Region B and begin selling to low types offline, and eventually to Region A where the low types are served in both channels. A long-term increase in $v_l$ lessens the cannibalization problem. Indeed, inspection of Equation (10) reveals that the seller’s profit increases as $v_l$ increases, i.e., $\frac{\partial \Pi}{\partial v_l} \geq 0$.

On a more individual level, having access to the Internet may cause a low type consumer to adopt high type characteristics, essentially causing some low types to become high type consumers. If providing access to the Internet causes $n_l$ to decrease and $n_h$ to increase, the proportion of high types to low types, $n_l^h$, will increase, thereby increasing $R$. We call this long-term change in $R$ the *type transformation effect*. Again, referring to Figure 2, if $R < 1$, bridging the digital divide could move the seller from Region B to Region A such that low types would be served in both channels. However, over a longer period of time, an increase in $R$ due to the transformation of some low type consumers into high type consumers would cause the seller to move to the right back to Region B whereby low types are only served offline, and eventually to Region C where low types are not served in either channel thereby harming the *remaining* low type
consumers. In this case, an increase in $n^h_i$ increases the cannibalization problem. What is the impact of the type transformation effect on the seller’s profit? In Region A, increases in $R$ would tend to lower profits, however, the seller compensates by lowering $q^i$ and $q^h_i$. Likewise, in Region B, the seller compensates for the cannibalization potential by lowering $q^h_i$. However, in Region C the seller avoids the cannibalization problem entirely by not selling a low quality good. Therefore, as shown in Equation (A.1), when $R \geq \frac{1-a}{1-\beta}$, the type transformation effect increases the seller’s profits by providing more high type consumers in the marketplace.

Whether the moderating valuation effect and/or the type transformation effect actually exist is an issue open to debate and empirical study. Longitudinal impacts of Internet access on low type users will be an important area for researchers to examine in the coming years.

**Sequential Product Introductions**

Moorthy and Png [9] extend their original model to examine the possibility that the seller introduces the high and low quality goods in different periods. Specifically, they show that if the consumers are relatively less patient than the seller, the cannibalization problem can be mitigated by offering the high quality good in the first period and the low quality good in the second period. Essentially, the seller uses sequential product introductions to make time another differentiating attribute along with product quality. They also show that when $R$ is particularly large, the low type consumers may be served in an after-market when simultaneous product introductions
would shut the low types out of the market. Our goal is not to duplicate their analysis, but rather to investigate the implications of bridging the digital divide in the multi-channel context. We will consider case when the seller can pre-commit to future actions (for a discussion of the commitment versus no-commitment cases see [9], [13]).

In our case, the seller could choose to introduce products in two different periods by introducing the high quality goods in both channels in the first period in order to reap the profits from the higher-quality goods as soon as possible, followed by the low quality goods in period 2, if it is profitable to do so.\(^3\) Let \(\delta_c \in (0, 1)\) be the consumer’s discount factor of waiting until the second period to make a purchase. When consumers are very patient, \(\delta_c\) will be close to 1, while \(\delta_c\) will be close to 0 if consumers are very impatient. Likewise, let \(\delta_s \in (0, 1)\) be the seller’s discount factor of waiting until the second period for profits from the sale of the low quality goods. Denote \(\delta_c/\delta_s\) by \(\delta^c_s\) and \(\delta_s/\delta_c\) by \(\delta^s_c\).

The seller will now choose qualities \(q^i_h\) and \(q^b_h\) at prices \(p^i_h\) and \(p^b_h\) for release in Period 1, and possibly \(q^i_l\) and \(q^b_l\) at prices \(p^i_l\) and \(p^b_l\) for release in Period 1 or 2, to solve

\[
\max_{q^i_h, q^i_l, q^b_h, q^b_l, p^i_h, p^i_l, p^b_h, p^b_l} \delta_s \alpha n_i \left( p^i_h - c_i q^i_h^2 \right) + \beta n_h \left( p^i_h - c_i q^i_h^2 \right) \\
+ \delta_s (1 - \alpha) n_i \left( p^b_h - c_b q^b_h^2 \right) + (1 - \beta) n_h \left( p^b_h - c_b q^b_h^2 \right)
\]

subject to:

\[
\delta_c \left( v^i_l q^i_l - p^i_l \right) \geq \left( v^i_l q^i_h - p^i_h \right) \tag{12a} \\
\delta_c \left( v^i_l q^i_l - p^i_l \right) \geq \left( v^i_l q^b_h - p^b_h \right) \tag{12b}
\]

\[
\left( v^i_h q^i_h - p^i_h \right) \geq \delta_c \left( v^i_l q^i_l - p^i_l \right) \tag{13a} \\
\left( v^i_h q^b_h - p^b_h \right) \geq \delta_c \left( v^i_l q^b_l - p^b_l \right) \tag{13b}
\]

\[
v^i_l q^i_l \geq p^i_l \tag{14a} \\
v^b_l q^b_l \geq p^b_l \tag{14b}
\]

\[
v^i_h q^i_h \geq p^i_h \tag{15a} \\
v^b_h q^b_h \geq p^b_h \tag{15b}
\]
Proceeding in the same manner as in the previous section, we find that the prices for the four levels of quality are

\[ p^i_l = v_l q^i_l \quad \text{and} \quad p^b_l = v_l q^b_l, \quad (16) \]

\[ p^i_h = v_h q^i_h - \delta_c q^i_l (v_h - v_l) \quad \text{and} \quad p^b_h = v_h q^b_h - \delta_c q^b_l (v_h - v_l). \quad (17) \]

Substituting the four prices into the objective function and maximizing with respect to the four levels of quality, we see that

\[ q^i_l = \frac{v_l}{2c_i} \left( 1 - \frac{\beta}{\alpha} \delta_s^c R \right) \quad \text{and} \quad q^b_l = \frac{v_l}{2c_b} \left( 1 - \frac{1 - \beta}{1 - \alpha} \delta_s^c R \right) \quad (18) \]

\[ q^i_h = \frac{v_h}{2c_i} \quad \text{and} \quad q^b_h = \frac{v_h}{2c_b}. \quad (19) \]

The seller’s profits are shown in Appendix B.

The important point to notice is that when \( \alpha < \beta \), the seller can use time and/or the market segmentation due to the digital divide to mitigate the cannibalization problem, thereby increasing the quality of the low-end good and increasing profits. Unfortunately, the problem for the two-channel case becomes intractable if we try to solve for the specific conditions under which the seller offers products simultaneously or sequentially. However, we can state that market segmentation due to the digital divide has a similar effect on the marketplace as delayed product entry, which makes delaying the offering of the low quality good less attractive to the seller. It could well be the case that allowing the digital divide to exist allows the low type consumers to be served in the marketplace faster by providing the seller the Region B option as shown in the previous section. Without the digital divide, the low type consumers may be forced to wait until a later time period for a product that is suitable for them.
Conclusion

We have shown that efforts to bridge the digital divide may have unforeseen consequences. While we recognize the societal value of bridging the divide, we also recognize certain inefficiencies may result. Specifically, we have shown that the digital divide artificially segments the marketplace into two distinct shopping channels. This allows a seller to efficiently market its goods to different types of consumers – benefiting sellers and buyers. We have shown how bridging the divide can result in lower product quality or even no service for low type consumers when the likelihood of cannibalization of high quality goods is relatively high. The digital divide allows low type consumers to be served in the brick-and-mortar channel when they otherwise might not be served at all.

We recognize this analysis is exploratory and limited by at least two assumptions. First, we assumed that the cost of providing a good of quality $q$ is different in the two channels and that this difference increases as the quality increases. Empirical research should be done to examine the extent to which firms selling in multiple channels provide different levels of quality for otherwise similar goods. Second, we assumed that consumers shop in only one channel, which eliminates the possibility that those with online access will seek out product and price information online and then purchase offline. However, we have noted that the general results found in this paper will still hold provided those with online access visit physical stores less frequently than before the use of the online channel. Empirical work should examine this issue to see if this is the case. This analysis then provides a starting point for analyzing the way in which sellers that operate both online and offline storefronts may react to the existence of the digital divide and the different consumer segments in each channel. Further analytical
modeling and empirical work is needed to better understand the seller’s response, which would then guide policy makers seeking to encourage open and efficient market mechanisms.

References


Appendix A

For the single period introduction case, in the limit, no four-product solution can have profits greater than

\[
\lim_{q_l \to 0, q_l^b \to 0} \beta n_h \left( v_l q_l^i + v_h \left( \frac{v_h}{2c_i} - q_l^i \right) - \frac{v_h^2}{4c_i} \right) \\
+ \alpha n_l \left( v_l q_l^i - c_i q_l^i \right)^2 \\
+ (1 - \beta) n_h \left( v_l q_l^b + v_h \left( \frac{v_h}{2c_b} - q_l^b \right) - \frac{v_h^2}{4c_b} \right) \\
+ (1 - \alpha) n_l \left( v_l q_l^b - c_b q_l^b \right)^2 \\
= \beta \frac{n_h v_h^2}{4c_i} + (1 - \beta) \frac{n_h v_h^2}{4c_b}
\]

Therefore, the seller’s profit for the single period introduction case is

\[
\Pi \leq \begin{cases} 
\frac{\beta n_h v_h^2}{4c_i} + (1 - \beta) \frac{n_h v_h^2}{4c_b} + \\
\frac{(1 - \alpha) n_l v_l^2}{4c_b} \left( 1 - \frac{1 - \beta}{1 - \alpha} R \right)^2 & \text{if } R < \frac{\alpha}{\beta} \\
\frac{\beta n_h v_h^2}{4c_i} + (1 - \beta) \frac{n_h v_h^2}{4c_b} + \\
\frac{(1 - \alpha) n_l v_l^2}{4c_b} \left( 1 - \frac{1 - \beta}{1 - \alpha} R \right)^2 & \text{if } \frac{\alpha}{\beta} \leq R < \frac{1 - \alpha}{1 - \beta} \\
\frac{\beta n_h v_h^2}{4c_i} + (1 - \beta) \frac{n_h v_h^2}{4c_b} & \text{if } R \geq \frac{1 - \alpha}{1 - \beta},
\end{cases}
\]

(A.1)

Note that profits reduce to the Moorthy and Png [9] case when \(c_b = c_i\) and when \(\alpha = \beta\).
Appendix B

For the sequential introduction formulation

\[
\Pi = \frac{\delta_s an_i v_l^2}{4c_i} \left(1 - \frac{\beta}{\alpha} \delta_s^c R\right)^2 + \frac{\beta n_h v_h^2}{4c_i} + \frac{\delta_s (1 - \alpha) n_i v_l^2}{4c_b} \left(1 - \frac{1 - \beta}{1 - \alpha} \delta_s^c R\right)^2 + \frac{(1 - \beta) n_h v_h^2}{4c_b}
\]  

(B.1)

when \( R < \frac{\delta_s^c \alpha}{\beta} \). More generally, the maximum profits while introducing four products sequentially over two periods are

\[
\Pi \leq \frac{\beta n_h v_h^2}{4c_i} + \frac{(1 - \beta) n_h v_h^2}{4c_b} + \frac{\delta_s (1 - \alpha) n_i v_l^2}{4c_b} \left[1 - \left(\frac{1 - \beta}{1 - \alpha} \delta_s^c R\right)\right]^2 \text{ if } \delta_s^c \frac{\alpha}{\beta} \leq R < \delta_s^c \left(\frac{1 - \alpha}{1 - \beta}\right)
\]

\[
\leq \frac{\beta n_h v_h^2}{4c_i} + \frac{(1 - \beta) n_h v_h^2}{4c_b} \quad \text{if } R \geq \delta_s^c \left(\frac{1 - \alpha}{1 - \beta}\right)
\]

(B.2)
Footnotes

1 For additional information and statistics on the digital divide see [3].


3 The two-period scenario is feasible due to our original assumption that a particular consumer shops in only one channel at a given point in time. Here, the high (low) quality product offered offline does not cannibalize the high (low) quality product offered in the online channel. Relaxing this assumption creates the potential to introduce four levels of quality over four periods. Depending on the values of $\alpha$, $\beta$, and $R$, it is not clear what order the products are introduced.