

**A Strategy for Opening a New Market
and Encroaching on the Lower End of the Existing Market**

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We build on the frameworks of Schmidt and Porteus (2000) and Schmidt and Druehl (2005), which describe alternate ways in which a new product might open a new market and ultimately encroach on an existing market. In the current paper we identify and analyze the scenario where a firm first opens up what we call a “detached” market, by offering a new product that meets a customer need that is very different from (i.e., detached from) the need met by the old established product. For example, cell phones opened up a new market by meeting the customer need for mobility; a need very different from the traditional attribute of reception quality. By meeting an important detached need, a new product can sell at a high price, even though it might be woefully deficient with regard to the traditional performance dimension (the reception / coverage of early cell phones was sorely lacking). A person who is a high-end customer for the old product initially despises the new product as a replacement for the old one, but might simultaneously be one of the first customers for the new product because it fills the detached-market need. Over time, the new product improves along the traditional dimension (e.g., cell-phone reception / coverage has dramatically improved) and eventually it becomes a replacement for the old product, but encroaches from the lower end upward (the first customers to drop their land lines have been lower-end customers such as students and apartment dwellers, while higher-end business customers still have land lines in their offices). We call this the detached-market form of low-end encroachment, and show how it helps explain the conundrum of an expensive “disruptive” innovation. We go on to relate our results to the finding that “willingness to cannibalize” is a key factor in an incumbent firm’s growth and survival, and to the “blue ocean strategy.”

Keywords: Diffusion, Disruptive innovation, Willingness to cannibalize, Blue ocean strategy, Low-end encroachment.

1. INTRODUCTION

Porter (1985), D'Aspremont et al. (1979), DiMingo (1988), Hall (1980) and Karnani (1984) suggest a firm should differentiate its products from competitors by emphasizing alternate performance dimensions. Kim and Mauborgne (2005) suggest firms thereby position themselves within a vast "blue ocean" (instead of a competitive red ocean). However, even if they do open up a new market, differentiated products often do still ultimately encroach on an existing market. (We use the term encroachment to mean that the new product takes sales away from the old product. Cannibalization is a special form of encroachment where both products are sold by the same firm.) Consider several "blue ocean" examples: Southwest Airlines encroaches on the markets of other airlines; [yellow tail] encroaches on the markets of other wines; and early General Motors cars encroached on the market of Ford's Model T.

Given that a new product is introduced with the intent of opening a new market and/or encroaching on an existing market, we suggest it might be useful to more precisely describe the new market, and describe the type of encroachment. For example, for a given new product, how will customer preferences in the new market compare with those in the old? Which of the old product's market segments will first be encroached upon by the new product (a low-end or high-end segment), and which will be the last (if the old product is eventually fully displaced)? The Bass (1969) model and numerous extensions (Mahajan et al. 1995) focus on the rate of diffusion, and segment customers by those who buy due to communication internal or external to the social system – we suggest there might also be other useful ways to describe the diffusion. For example, Southwest Airlines first opened up a fringe market of customers who otherwise would have driven, then attracted vacationers (lower-end customers of competitive airlines) and eventually began encroaching upward into a higher-end market, that of conventional business travel. Schmidt and Porteus (2000), abbreviated SP, call this *low-end encroachment*, because the encroachment begins with a market segment where customer willingness-to-pay is low, and progresses upward to a segment with higher willingness-to-pay. We now further describe this as *fringe-market low-end encroachment*, because the new market that is first opened up (before the low-end encroachment begins) is on the low-end fringe of the old market (e.g., Southwest's low-paying customers who otherwise would have driven).

The other scenario identified by SP is that of *high-end encroachment*, exemplified by a new Pentium microprocessor. It first "steals" the old version's high-end customers (those with highest willingness-to-

pay), and then encroaches downward, with the last to switch being customers with low willingness-to-pay. Schmidt and Druehl (2005), abbreviated SD, further analyze the fringe-market low-end and high-end encroachment diffusion processes.

Herein we extend SP and SD by defining and analyzing a third possible type of encroachment, to describe the manner in which a product such as the cell phone first opens up a new market and then encroaches on the existing market. Early cell-phone prices were as much as \$3,000 (Rogers 2003) and were accompanied by a high initial monthly subscription price for cellular service. An early buyer of a cell-phone subscription may have been a construction foreman who valued the mobility the cell phone offered in going from construction site to construction site – yet this same person may have been a high-end customer for an office land line. Effectively, this construction foreman represents not one customer but two potential customers; one with a strong market need for the high-quality reception offered by a land line (it never drops a call), and one with a very strong “detached” market need for the mobility offered by a cell phone. Our detached-market form of low-end encroachment is able to reconcile why a high-end user of the old product could simultaneously be an early buyer of the new product, in spite of despising the new product’s miserable functionality along the traditional performance dimension (initially, cell phones performed miserably with regard to reception – remember the cell-phone commercial that continually asked “can you hear me now?”). Yet, as the performance of the new product improves along the traditional dimension (e.g., as cell-phone reception and coverage improve), the new product begins to encroach on the old product. In the case of the cell phone, who were the first customers to drop the land line in favor of the cell phone? They were college students and apartment dwellers, who represent lower-end customers (subscriptions for business lines are typically higher priced than for personal lines, providing evidence that business users represent high-end customers). Most higher-end users (i.e., offices) still have land lines (the encroachment has not progressed to the high end, and may never do so). Thus we call the cell-phone scenario one of *detached-market low-end encroachment*.

In detached-market low-end encroachment, the new product’s performance is so dramatically improved on a new or alternate dimension that it first sells not to fringe low-end customers at a low price, but instead to a “detached” market at a high price. High-end customers of the old product initially despise the new product as a replacement for the old because it is de-rated along the traditional performance dimension(s). However, the person who is a high-end customer for the old product could simultaneously

be one of the first buyers of the new product, because it fills a market need that is very different (i.e., detached) from the need that the old product fills. (It is not *necessarily* the case that the new product's first buyers are the same people as the old product's current high-end customer – the first buyers could be other people that have a need that is quite different than the one filled by the old product.) But eventually, over time, as the new product gradually and continuously improves along the traditional performance dimension, it eventually becomes a replacement for the old product. Because lower-end customers of the old product have a lesser need for performance along the traditional dimension, these are the first customers who will consider the new product to be an adequate replacement for the old product. Thus the new product encroaches on the old product from the lower end upward.

Going back to the “blue ocean” analogy of Kim and Mauborgne (2004, 2005), our work (along with that of SP and SD) extends their insights by helping map out the implications of various possible ways of differentiating a new product. One blue ocean might lie at the low-end fringe of the old product market, while another might be “detached,” while a third might lie at the old product's high end. In which of these oceans should the firm plot a course? Our framework, combined with tools from marketing such as conjoint analysis, helps plot the new product's course of diffusion given the new product's attributes, and given customer willingness-to-pay for those attribute(s). Furthermore, if a firm were the only one introducing a product that is detached from the traditional market, our framework suggests such a new product would be able to avoid competition with (and/or cannibalization of) the old product for a longer period of time than if the new product were introduced to compete at the high end of the old product market. In other words, an understanding of the different ways in which a new product might open up a new market and eventually encroach on an existing market will help firms pick the best way to differentiate and position their new products. We further discuss this issue in § 5 of the paper, in the context of Kodak and the digital camera. Similar to cell phones, digital cameras reflect characteristics of the detached-market form of low-end encroachment (early digitals sold at high prices to a new market segment), however Kodak seemingly regrets not having pursued a strategy more akin to fringe-market low-end encroachment. By consciously recognizing various alternative strategies, we argue that a firm will be better prepared to evaluate the feasibility of each and ultimately make a more educated strategic choice.

The works of Christensen (1997), Christensen and Raynor (2003) and Christensen et al. (2004), abbreviated C, CR and CAR, respectively, support our contention that it is useful to identify and categorize various possible types of encroachment. Effectively, they suggest that understanding the nature of encroachment is important to understanding why some firms succeed while others fail. They in effect find that “disruptive” innovations encroach from the low end upward, while “sustaining” innovations encroach from the high end downward. (This mapping between disruptive innovation and low-end encroachment, and between sustaining innovation and high-end encroachment, is based on the trajectory curves of C / CR / CAR, which they state form the basis of their theory. See Druehl and Schmidt 2006, abbreviated DS).

However, given some of the examples in C / CR / CAR, their disruptive innovation theory appears incomplete with regard to how a disruptive innovation might open up a new market and encroach on existing market. In particular, we find an anomaly in the work of C / CR / CAR, that of an expensive disruptive innovation. While they categorize as disruptive a number of innovations that started out very expensive relative to the products that they eventually encroached upon (two such examples are the cell phone and the digital camera), the work of Christensen and his co-authors is permeated with discussion that emphasizes the low-cost nature of disruptive innovations: “We normally think of disruptive innovations as being inexpensive” (CR, p. 60). Christensen et al. (2001) refer to disruptive innovations as “cheaper, simpler, and more convenient products” than the ones they eventually displace (p. 82). Adner (2002) also emphasizes the role of price in disruptive innovation, stating on p. 686: “Finally, critical to a disruptive outcome is the price at which the invader offers its product. The attacking firm must have the incentive and ability to offer its technically inferior, yet nonetheless satisfactory product at a sufficiently lower unit price to consumers than its rival...”

Effectively, our work extends that of C / CR / CAR by showing that new-market disruptive innovations come in multiple forms. The more conventional form leads to fringe-market low-end encroachment, where the new product that is de-rated along the traditional performance dimension and sold at a low price (high-end customers despise the new product), but outperforms the existing product along some alternate dimension that fringe lower-end customers appreciate. The bulk of the examples of C / CR / CAR are of this type. Other examples, those typifying the conundrum of an expensive disruptive innovation, are explained by our detached-market low-end encroachment scenario.

Our work also has implications on the findings of Chandy and Tellis (1998) and Govindarajan and Kopalle (2004) who conclude that “willingness to cannibalize” is a key consideration in the successful introduction of innovations by incumbents. Our work suggests there are dramatically different ways that cannibalization can progress, depending on the type of product the firm introduces. What form(s) of cannibalization must a firm be willing to pursue?

A brief description of our modeling framework is as follows. We assume each of two products, one old and one new (such as the land line and cell phone, respectively), has a linear reservation price curve. A reservation price curve is a plot of customer willingness-to-pay, with customers ordered from highest willingness-to-pay to lowest (or lowest to highest). A product’s reservation price curve is determined by the attributes of the product and heterogeneous customer valuations of those individual attributes. Customers with the highest reservation prices for the old product are identified as its high-end customers, and those with lower reservation prices are lower-end. We find the Nash equilibrium outcomes when different firms offer the old and new products, and find the profit-maximizing outcomes when the same firm offers both. In the current paper we focus on the case of opposite-sloping reservation price curves, which leads to the detached-market scenario of low-end encroachment, and fit data from the phone market to our model to illustrate possible market outcomes as diffusion progresses. SP also use a linear reservation price framework but assume both curves are downward-sloping, leading to the other encroachment scenarios discussed herein.

We review related literature in § 2, and in § 3 we develop the opposite-sloping linear reservation price framework. In § 4 we use empirical data from the phone industry to further illustrate the detached-market low-end encroachment scenario, and end in § 5 with a discussion and summary. Proofs are available from the authors in DS.

2. RELATED LITERATURE

Our framework effectively classifies innovations with regard to how they diffuse through the market. See Gatignon et al. (2002) for some other classification schemes. C / CR/ CAR focus on disruptive innovations, while other research examines radical and incremental innovations (e.g., Ettlíe et al. 1984, Dewar and Dutton 1986). Dewar and Dutton (1986) empirically find that radical and incremental innovations differ in nature, while Atuahene-Gima and Ko (2001) find that firms with high market and high entrepreneurial orientations tend to be more successful in innovation. Chandy and Tellis (2000)

examine a broad range of products and find that incumbents do introduce radical innovations, especially recently. As compared to these alternative classifications, we concentrate on how innovations diffuse through the market, and identify some strategic and managerial implications of these diffusion patterns.

Disruptive innovations tend to (but don't necessarily) come from firms not originally serving the disrupted market. Other have examined similar concepts: Foster (1986) discusses the attacker's advantage; Henderson and Clark (1990) examine the entrant's advantage in architectural product changes; Tushman and Anderson (1986) study the entrant's advantage when the new technology is competence destroying (in other words, the established firm's processes must change). Govindarajan and Kopalle (2004) examine the impact of organizational abilities on the introduction of radical and disruptive innovations. They support CR's supposition that a focus on current customers limits a firm's ability to develop a disruptive innovation. In an extensive empirical study of innovation, Sood and Tellis (2005) find that new innovations may attack the existing market from the low or high end, giving qualitative support to our low-end and high-end encroachment scenarios.

We contrast our model with others that lend insight into how disruptive innovations impact the competitive landscape. Adner (2002) models the possible diffusion of one product into a market previously held by a second product, sold by a second firm. While he analyzes firms' decisions regarding whether to pursue diffusion by improving product performance and/or cost, our model focuses on identifying the diffusion pattern as described by the timing of purchases by low-end and high-end customers (we do not make the firms' decisions explicit). Both his model and ours allow for multiple product attributes and multiple customer segments with differing relative preferences for the attributes. However, in his model all customers within a segment have the same willingness-to-pay for a given product, but differ in the minimum performance or net utility a product must offer before being considered for purchase (i.e., differ in purchase thresholds), while in our model, all customers within a segment vary in willingness-to-pay (i.e., reservation price). Adner and Zemsky (2005) identify factors leading to disruption such as performance oversupply and the number of firms using each technology, but do not examine disruption from the perspective of which customers are the first to buy, as we do (in their model, customers in the old product market derive the same utility, net of price, from a new disruptive product as from the old). However, they examine the conditions under which firms choose to innovate, and other related questions that we do not address.

Ghemawat (1991) and Chandy and Tellis (1998) suggest that firms must be willing to cannibalize their own (old) products if they are to become successful with new technologies rather than be displaced. The issues of cannibalization and launch-sequence are examined in Bhattacharya et al. (2003) in a setting where a technology's performance improves over time (as it does in our model), such as with microprocessors. Krishnan and Zhu (2006) propose that a firm might vertically differentiate low-end and high-end products along alternate performance dimensions to mitigate cannibalization. We address cannibalization from the perspective of how the diffusion progresses (from the low end or high end).

3. A MODEL OF DETACHED-MARKET LOW-END ENCROACHMENT

We assume there is a single new product (such as the cell phone) which is introduced into a market with one old product (such as the land line). The products are describable by n product attributes – for phones these might be the three attributes of reception, mobility, and the level of status that the phone offers its owner. We assume customer preferences are heterogeneous, in that customers vary in their willingness-to-pay (i.e., in their part worths) for a product's performance with regard to each attribute. A reservation price is the most a customer is willing to pay for a product, and is assumed to be the sum of a customer's part worths for the individual product attributes. A reservation price curve is a plot of all reservation prices. The notions of part worths and reservation prices are inherent in marketing tools such as conjoint analysis (Green and Srinivasan 1978 and 1990, Dahan and Srinivasan 2000).

We assume the new and old products' reservation price curves are linear and opposite-sloping. For example, this setting can result when there are two attributes and perfectly negatively correlated customers preferences for those attributes, as described in § 3.1. Note, however, that this is not the only situation that yields opposite-sloping curves. In DS we develop hypothetical opposite-sloping curves for the cell-phone / land-line market given a somewhat more complex setting involving the three pertinent attributes of reception, portability, and status.

3.1. Disruptive Innovation May Lead to Opposite-Sloping Linear Reservation Price Curves

The setting of disruptive innovation as described by C / CR/ CAR offers the possibility of opposite-sloping reservation price curves, so we use it to illustrate our framework. Characteristics of a disruptive new-market innovation are that it initially performs poorly along a key dimension valued by mainstream customers, but performs better than the old product along an alternate dimension valued by low-end or

new customers. There are assumed to be two such attributes, the traditional one highly valued by mainstream customers (not highly valued by the new market) and the one highly valued by the new market (not highly valued by the old market).

Starting with the first attribute (the one highly valued by existing customers), and the old product, we order the existing customers in decreasing order of part worths for the primary (first) attribute. We plot the part worths, assuming customers are numerous such that we can consider the plot (which we call a part-worth curve) to be continuous as opposed to consisting of discrete points for each customer. See the left-hand side of the top frame in Figure 1 (the labeling for the x -axis at the bottom suggests the left side applies to the old market). A customer's part worth determines her "type," denoted by θ (again, see the labeling of the x -axis along the bottom). We denote the number of customers in the old-product market by s_1 . The old product's high-end customers are those with the highest part worths for the first product attribute (as will be shown, they also have the highest reservation prices for the old product).

Continuing to consider only customers in the old market, we plot their part worths for the new product. Since a characteristic of a disruptive new product is that it is de-rated along the dimension highly valued by existing customers, we assume these customers have much lower part worths for the new product's first attribute, in proportion to their part worths for the old product.

Now consider customers in the new market and their part worths for the second attribute. Refer to the right-hand side of the middle frame in Figure 1. In this case we order the new-market customers in increasing order of part worths. We again denote (potential) customers by type θ and identify the interval over which they reside by s_1 to s . The new-market customers with the highest part worths for the second attribute are denoted as the new product's top-end customers. (We avoid using the term high-end to avoid confusion with the high-end customers of the old market.) We plot their part worths for the new and old products: since the old product does not perform well along this alternate dimension, we assume the part worths for it are much lower, in proportion to the part worths for the new product.

To this point we have discussed the left-hand half of the top frame in Figure 1, and the right-hand half of the middle frame. To complete the frames, we base our reasoning on Christensen (1992a), where he found that preferences for the two dimensions of product performance were negatively correlated across customers. This justifies drawing the downward-sloping part-worth curves shown in the right-hand half of the top frame (the part worth for the first attribute goes down in that graph as the part worth for the

second attribute goes up in the frame below it). Similarly, this justifies drawing the upward-sloping part-worth curves shown in the left-hand half of the middle frame (the part worth for the second attribute goes up in that graph as the part worth for the first attribute goes down in the frame above it). For convenience we assume the part-worth curves of the old and new markets are connected at s_1 and assume the slopes of a product's part-worth curves are the same for customers in $[0, s_1]$ as in $[s_1, s]$.

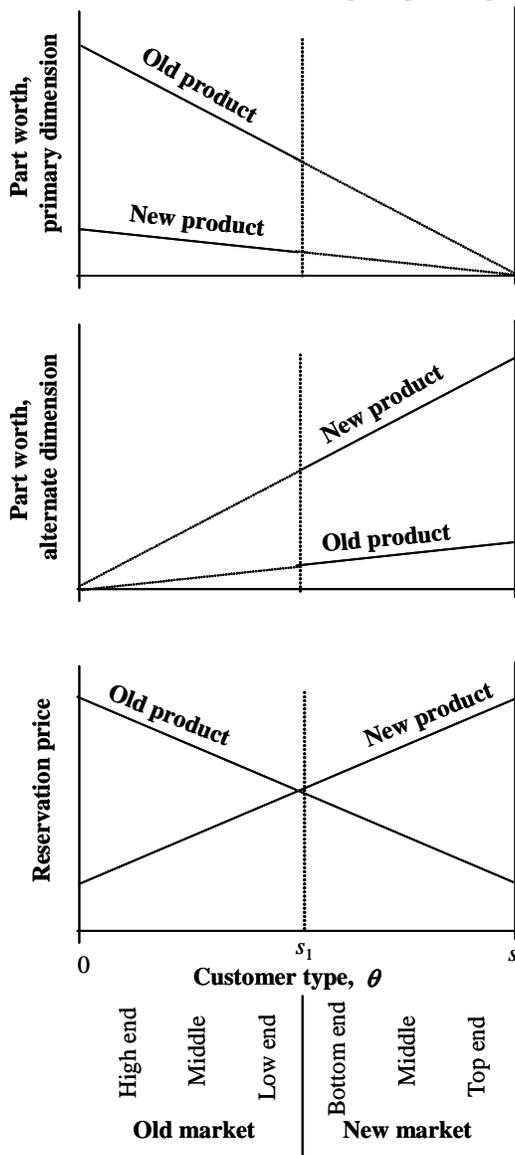


Figure 1. Adding part-worth curves to yield opposite-sloping reservation price curves

Next we add the two part-worth curves to obtain the reservation price curves for the old and new products as shown in the bottom frame of Figure 1. Thus starting from the theory of disruptive innovation, we have qualitatively illustrated how disruptive innovation can result in opposite-sloping

reservation price curves. (The case where both reservation price curves are downward sloping would also be possible if, for example, the slopes of the part-worth curves were shallower in the middle frame – that scenario is analyzed in SP.)

We do not claim that all markets have the potential for opposite-sloping reservation price curves, nor do we claim the curves will be perfectly linear in any market. Our intent is to build a framework that qualitatively describes a possible way in which a new product might open up a new market, and eventually encroach on an existing market. Just as the Bass (1969) model, for example, oversimplifies the customer base in describing it as consisting of “innovators” and “imitators,” our model is a simplified representation of more complex customer preferences, but one that nonetheless offers meaningful insights into a possible way in which diffusion might progress.

3.2. Assumptions and Notation Pertaining to the Reservation Price Curves

In our vernacular the term “customers” includes all potential buyers, not merely those who actually purchase. It is important to recognize that a single person can represent multiple customers if she considers purchasing more than one unit. For example, she may desire multiple phones; one for office use, another for the home, and another for “mobile” use. This person may be looking for different attributes in each of her potential purchases, and thus the three customers that she represents may each have a different willingness-to-pay for a given product.

Similar to Norton and Bass (1987), we assume a customer would like to buy one unit per time period. For example, with phones, this can be interpreted as a monthly subscription. When we refer to “cell phones” and “land lines” we refer to the monthly phone subscription. We assume that at any given time a customer will buy at most one product (but a person may buy multiple products if she represents multiple customers), the one that offers her the most positive surplus, or nothing if both surpluses are negative, where surplus is defined as the difference between her current reservation price and the current selling price. Similar to Adner (2002), we assume that at each point in time, firms consider only current reservation price curves and costs in setting price, and that a customer considers only her current reservation prices and the current sales prices in her purchase decision.

A customer’s part worths, and hence her reservation prices, may vary with time. For example, a part worth may go up because the product quality improves over time, or it may go down because the customer’s expectation rises. Changes in reservation prices over time, along with possible changes in

production costs over time, lead to the diffusion of a new product: a customer that preferred (in terms of surplus) the old product at a previous time may switch to buying the new product or a customer that previously bought nothing may later buy a product.

In Figure 2 we show the (hypothetical but plausible) reservation price curves for cell phones and land lines, circa 1985, as derived in DS. A number of customer segments are loosely identified in Figure 2: from left to right these are the business office through the business mobile segments. See Table 2 for a summary of notation: customer type θ identifies the market segment to which the customer belongs and more specifically, identifies that customer's exact reservation prices. (We assume heterogeneity within each segment such that, for example, the business office customer with the lowest reservation price has "the same" willingness-to-pay as the individual home user with the highest.) Time is denoted by t and a number of parameters are functions of t as they may change over time (e.g., cell-phone reception gets better which enhances reservation price over time). Reservation price, or utility, is a function of both θ and t and is denoted by $u_j(\theta, t)$, where $j \in \{N, B\}$ denotes the product (N and B to be defined shortly).

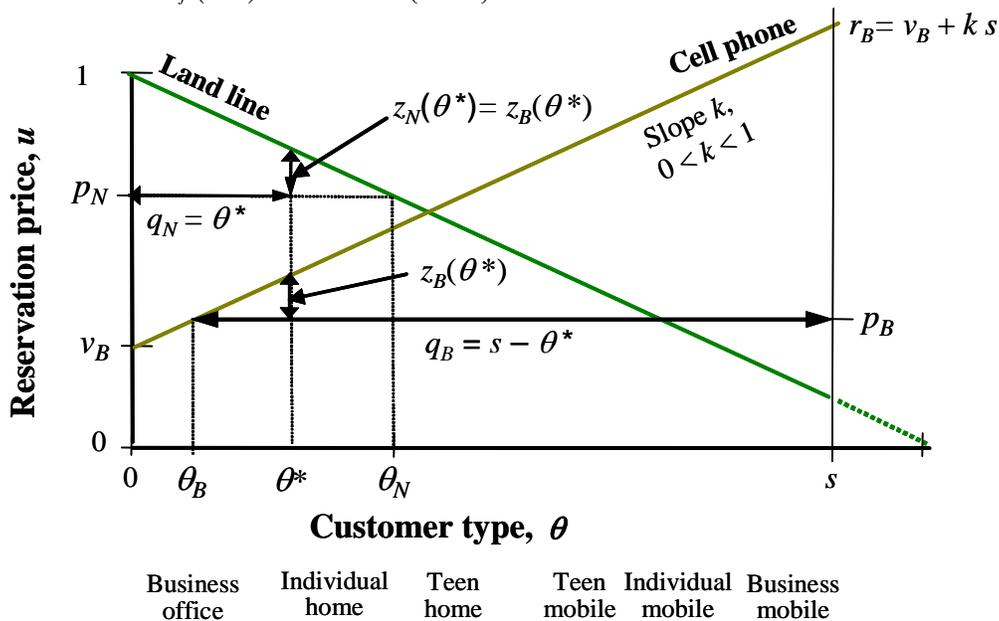


Figure 2. Reservation price curves for the opposite-sloping case (parameters are shown without time dependencies to avoid clutter –curves are assumed to apply circa 1985, but, prices, quantities, and surpluses are not meant to suggest 1985 levels)

Refer in Figure 2 to the reservation price curve labeled “land line,” representing monthly subscription reservation prices. Relative to other customer segments, the business office users with θ close to zero have the highest relative reservation prices for the land line: we assume these users very highly value

reliable reception, which the land line offers. But the business office users have low relative reservation prices for an early cell phone, because of its poor reception.

Table 2. Summary of Notation (in order as defined in the text)

$\theta =$	Customer type (indicates willingness-to-pay for the product).
$t =$	Time: t_0 denotes time of introduction of the new product.
$u_j(\theta, t) =$	Reservation price (or utility) of customer θ for product j at time t : $u_j(\theta, t) = v_j(t) + k_j(t)\theta$.
$s(t) =$	Number of customers (potential buyers) at time t .
Product N =	Product with niche appeal (its reservation price curve has the steeper slope).
Product B =	Product with broad appeal (its reservation price curve has the shallower slope).
$k_j(t) =$	Slope of reservation price curve for product j at time t , $j \in \{N, B\}$.
$k(t) =$	Breadth factor. Relative slopes of res. price curves at time t : $k(t) = k_B(t)/k_N(t) = k_B(t)$.
$v_j(t) =$	y-axis intercept of reservation price curve for product j , $j \in \{N, B\}$, at time t .
$r_B(t) =$	Maximum reservation price for product B at time t : $r_B(t) = v_B(t) + k(t)s(t)$.
$c_j(t) =$	Unit production cost of product j at time t , $j \in \{N, B\}$
$m_j(t) =$	Depth (maximum plausible markup depth) for product j at time t , $j \in \{N, B\}$: $m_N(t) = 1 - c_N(t)$, $m_B(t) = r_B(t) - c_B(t)$.
$m(t) =$	Depth ratio at time t : $m(t) = m_j(t)/m_J(t)$, where j is the new product (and J the old).
$p_j(t) =$	Sales price of product j at time t , $j \in \{N, B\}$.
$z_j(\theta, t) =$	Surplus for product j of customer type θ at time t , $j \in \{N, B\}$.
$\theta_j(t) =$	Customer type indifferent between buying product j and nothing at time t , $j \in \{N, B\}$.
$\theta^*(t) =$	Customer type indifferent between buying product N or B at time t , if such customer exists.
$q_j(t) =$	Rate of sales for product j at time t , $j \in \{N, B\}$.
$\pi_j(t) =$	Rate of profit derived from product j at time t , $j \in \{N, B\}$.
$S_j^i(t) =$	Ratio of market share for product j to that of J at time t , given market type i , $i \in (D, M, B)$, where D denotes duopoly, M detached monopoly, and B benign duopoly: $S_j^i(t) = q_j(t)/q_J(t)$.
$d =$	Coefficient of depth. Magnitude of change in depth ratio $m(t)$ per unit time.
$b =$	Coefficient of breadth. Magnitude of change in breadth factor $k(t)$ per unit time.
$\sigma =$	S-coefficient. Degree of non-linearity in change in $m(t)$ and $k(t)$ over time.

Conversely, the business mobile users (e.g., construction managers traveling from site to site) with θ close to $s(t)$, where $s(t)$ denotes potential size of the entire market, have the highest reservation prices for a cell phone: they most highly value portability, which the cell phone offers, but have low reservation

prices for the land line because of its poor portability. (Since each person may represent multiple customers, a business office user may be the very same person as a business mobile customer.)

Customers with θ close to zero (the business office users) are the high-end customers for the old product. Customers with θ close to $s(t)$ are willing to pay a lot for the new product, but are “detached” from high-end customers for the current product in that their preferences are very different. (Also, in Figure 2 these two sets of customers are detached in the sense that they are on the opposite ends of the x -axis.) This confirms the basic intuition behind the notion of opposite-sloping reservation price curves: different market segments (customer types) have vastly different evaluations of the old and new products.

In Figure 2 we show additional market segments: the individual home segment is much like the business office segment except that willingness-to-pay for land lines isn’t quite as strong as for business users, and the teen home segment has even less willingness-to-pay (these are second lines in homes for which willingness-to-pay is typically less than for the primary line). Similar intuition explains the lower reservation prices of the individual mobile and teen mobile segments with regard to cell phones, as compared to business mobile users. In DS we show why reservation prices for cell phones of individual home and teen home users are higher than for business office users (and why the reservation prices for land lines of individual mobile and teen mobile users are higher than for business mobile users): this result stems from consideration of all three attributes (reception, portability, and status).

The slopes of the reservation price curves are denoted by $k_B(t)$ and $k_N(t)$: we label the product whose reservation price curve has a shallower slope as product B, for broad appeal, such that $|k_B(t)| \leq |k_N(t)|$ (a shallower slope indicates the product appeals similarly across a broader set of customers as compared to a steeper slope), and we label the product with the steeper slope as product N, for niche appeal. Either the old or new product can be product B, and we make no assumptions as to whether one reservation price curve lies above the other or whether they cross.

Let $v_j(t)$ denote the reservation price that a customer of type $\theta = 0$ holds for product j , $j \in \{N, B\}$. We normalize reservation prices such that $v_N(t) = 1$ is the maximum reservation price for product N, and normalize the slopes of the reservation price curves such that $k_N(t) = -1$, suggesting $0 < k_B(t) \leq 1$. Define $k(t) := -k_B(t)/k_N(t) = k_B(t)$, and further define $r_B(t) := v_B(t) + k(t)s(t)$, such that $r_B(t)$ is the maximum reservation price for product B, held by the customer with type $s(t)$. We assume $s(t) \leq \min(1, r_B(t)/k(t))$, indicating all reservation prices are positive. (Our analysis holds if some

reservation prices are negative, but we rule this out to avoid implying that the firm has to “pay” a consumer to take a product.) Thus after normalization, we have $u_N(\theta, t) = 1 - \theta$ and $u_B(\theta, t) = r_B(t) - k(t)(s(t) - \theta)$. The curves in Figure 2 apply to the market at t_0 , the time of cell-phone introduction, where we assume $u_N(\theta, t_0) = 1 - \theta$ and $u_B(\theta, t_0) = 0.314 + 0.9\theta$ (the reservation price curves are derived in DS).

Along with knowledge of each product’s reservation price curve, we assume firms know the normalized product costs $c_j(t)$, $j \in \{N, B\}$, at each time t , and that there are no economies or diseconomies of scale. We assume $1 - 2s(t) < c_N(t) < 1$ and $2v_B(t) - r_B(t) < c_B(t) < r_B(t)$, insuring a product’s monopoly price falls strictly between its minimum and maximum reservation prices.

A product’s maximum reservation price minus its cost is denoted by $m_j(t)$, $j \in \{N, B\}$, and is called its *depth of maximum plausible markup* (or simply its *depth*). That is, $m_N(t) := 1 - c_N(t)$ and $m_B(t) := r_B(t) - c_B(t)$. Actual markup, though, likely differs from depth. Further, define $m(t) = m_j(t)/m_J(t)$ as the *depth ratio* at time t , where j is the new product (and J the old), j and $J \in \{N, B\}$.

Let $p_j(t)$ denote the price of product j at time t , $j \in \{N, B\}$, and let $z_j(\theta, t) := u_j(\theta, t) - p_j(t)$ denote the surplus a customer of type θ holds for product j . Let $\theta_j(t)$ denote the customer who is indifferent between buying product j or nothing: $z_j(\theta_j, t) = 0$. Let $\theta^*(t)$ denote the type of customer who is indifferent between buying product N or B, if such type exists: $z_B(\theta^*, t) = z_N(\theta^*, t)$.

We next derive market outcomes given these opposite-sloping, linear reservation price curves.

3.3. Market Outcomes in Terms of Prices, Quantities, and Profits

For brevity, we omit the time-dependencies in this section (e.g., $c_N(t)$ is abbreviated c_N). In the case of different firms selling the old and new products (i.e., products N and B, but not necessarily respectively), we find the Nash equilibrium prices for each product. If the same firm sells both products, then we find that firm’s profit-maximizing prices. In either case, the prices p_j , $j \in \{N, B\}$, in turn determine the quantities sold, q_j , and the profits derived from the products, $\pi_j = (p_j - c_j)q_j$.

Prices determine the ordering of θ_N , θ_B , and θ^* , and establish the quantities sold, per Lemma 1 below. Note that $\theta_j = \theta_j(p_N, p_B)$ but for simplicity we do not explicitly show the price dependencies. Proof are given in DS.

Lemma 1. Given p_N and p_B , sales quantities q_N and q_B are as follows:

- a) If $\theta_N \leq \theta^* \leq \theta_B$, then $q_N = \theta_N = 1 - p_N \geq 0$, and $q_B = s - \theta_B = (r_B - p_B)/k \geq 0$.
- b) If $\theta_B \leq \theta^* \leq \theta_N$, then $q_N = \theta^* \geq 0$, and $q_B = s - \theta^* \geq 0$.

Two Competitive Firms Sell Products B and N, Respectively

Figure 3 portrays the formal results given in Theorem 1 below. The first possible market outcome is that there are *detached monopolies*, where each product sells at its monopoly price to a segment at one end of the potential market. That is, products N and B sell to customers in the intervals $(0, \theta_N)$ and (θ_B, s) , respectively, where $\theta_N \leq \theta_B$. This result holds when neither product commands wide coverage (when both depths are “low”). Effectively, each firm’s product caters to customers at one end of the potential market, with customers in the “middle” left unserved (the non-buying segment may actually be toward one end, but lies between the two buying segments). The two markets are “detached.”

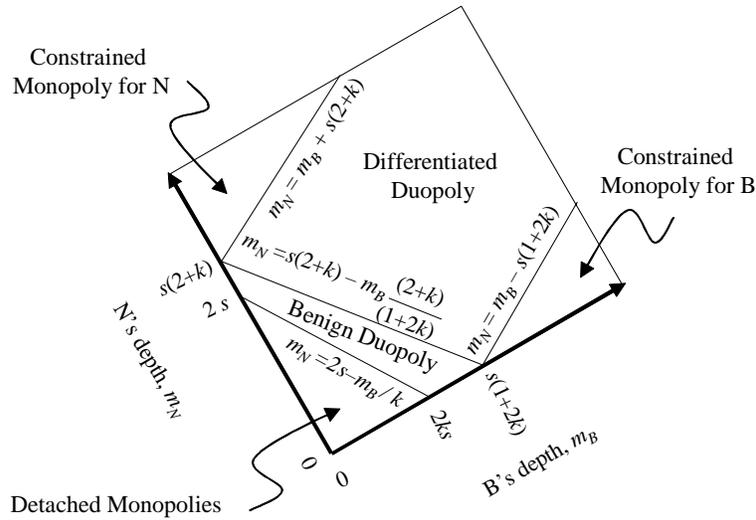


Figure 3. Outcomes when products B and N are sold by different firms (time dependencies omitted)

If we do not find detached monopolies, then the market is covered in one of several possible ways (because we assume a product’s cost is less than its maximum reservation price, there is no chance of only one product having a monopoly on one end of the market with the other end uncovered). Product N covers the market interval $(0, \theta^*)$, while product B covers the remaining segment (θ^*, s) .

If the depth of one product is sufficiently high, while that of the other is sufficiently low, then the one with the sufficiently higher depth can take the entire market. This is a *constrained monopoly* because even though only one product obtains strictly positive sales, that firm is constrained to charging less than

the monopoly price. Product B has a constrained monopoly selling to the entire market when $\theta^* = 0$. Alternately, if $\theta^* = s$, then product N has a constrained monopoly.

Theorem 1. *When reservation price curves are opposite sloping and the two products are sold by different firms, the Nash equilibrium prices, quantities, and profits are as follows:*

	Detached Monopolies	Benign Duopoly
<i>Conditions</i>	$m_N \leq 2s - m_B/k$.	$m_N \geq 2s - m_B/k$ and $m_N \leq s(2+k) - m_B(2+k)/(1+2k)$.
<i>Prices</i>	$p_B = \frac{r_B + c_B}{2}$ and $p_N = \frac{1 + c_N}{2}$.	There is a continuum of equilibria for which prices are: $p_B = r_B - k s + k(1 - p_N)$ and $p_N = 1 - s + (r_B - p_B)/k$, extending over the range: $p_B \in \left[\frac{r_B + c_B}{2}, r_B - ks + k \frac{m_N}{2} \right]$ and $p_N \in \left[\frac{1 + c_N}{2}, 1 - s + \frac{m_B}{2k} \right]$.
<i>Quantities</i>	$q_B = \frac{m_B}{2k}$ and $q_N = \frac{m_N}{2}$.	$q_B = s - \frac{1 - p_N + p_B - r_B + k s}{1+k}$ and $q_N = \frac{1 - p_N + p_B - r_B + k s}{1+k}$.
<i>Profits</i>	$\pi_B = m_B^2 / (4k)$ and $\pi_N = m_N^2 / 4$.	$\pi_B = (p_B - c_B)q_B$ and $\pi_N = (p_N - c_N)q_N$.

	Differentiated Duopoly	Constrained Monopoly for B	Constrained Monopoly for N
<i>Conditions</i>	$m_N \geq m_B - s(1+2k)$ and $m_N \leq m_B + s(2+k)$ and $m_N \geq s(2+k) - m_B \frac{(2+k)}{(1+2k)}$.	$m_N \geq 2s - m_B/k$ and $m_N \leq m_B - s(1+2k)$.	$m_N \geq 2s - m_B/k$ and $m_N \geq m_B + s(2+k)$.
<i>Prices</i>	$p_B = \frac{s(2+k) + r_B + 2c_B - m_N}{3}$ and $p_N = \frac{s(1+2k) + 1 + 2c_N - m_B}{3}$.	$p_B = r_B - ks - m_N$ and $p_N = c_N$.	$p_B = c_B$ and $p_N = 1 - s - m_B$.
<i>Quantities</i>	$q_B = \frac{s(2+k) - m_N + m_B}{3(1+k)}$ and $q_N = \frac{s(1+2k) + m_N - m_B}{3(1+k)}$.	$q_B = s$ and $q_N = 0$.	$q_B = 0$ and $q_N = s$.
<i>Profits</i>	$\pi_B = \frac{[m_B + s(2+k) - m_N]^2}{9(1+k)}$ and $\pi_N = \frac{[m_N - m_B + s(1+2k)]^2}{9(1+k)}$.	$\pi_B = (m_B - m_N - ks)s$ and $\pi_N = 0$.	$\pi_B = 0$ and $\pi_N = (m_N - m_B - s)s$.

Another possibility is that the two products split the covered market (although not necessarily equally) in one of two ways: at θ^* the surpluses are either both zero or they are both positive (and equal). We call the region where they are both positive a *differentiated duopoly*. In this region the depth of each product is relatively large, such that if either firm were a monopolist instead of a duopolist, its market would be relatively large and would extend into the “middle” of the interval $(0, s)$. As monopolists, both firms would sell to customers in the middle, and thus as duopolists both firms are willing to compete somewhat aggressively for these customers in the middle. As a result the two firms price aggressively, to the extent that the customer at θ^* gets a positive surplus.

If the surpluses are both zero at θ^* , we call the outcome a *benign differentiated duopoly* (or benign duopoly for short – the effect of one differentiated product on the other is relatively benign). The product depths are large enough so that if you separately calculate each firm’s monopoly market, the two monopoly markets would overlap only slightly, so in this case firms do not want to aggressively compete for customers in the middle. In the benign duopoly we find a continuum of equilibria. To gain some intuition, consider what would happen if one firm sets price first (as a Stackelberg leader) in this region. Say firm N (the firm selling product N) is the leader – it will price as a monopolist and achieve monopoly sales and profit, while the follower (firm B) will react by setting its price low enough to take the rest of the market but no lower (i.e., it sets price at the lowest reservation price of the remaining customers). This defines one end of the continuum of equilibria, while the other end is set by the analogous outcome achieved when firm B is the leader. Everywhere in between, if one firm sets price, the other firm’s non-aggressive reaction is to simply price low enough to take the rest of the market but no lower. But since we do not define either firm to be a Stackelberg leader, we find the continuum of equilibria.

As this discussion and Theorem 1 suggest, except in the case of detached monopolies, each product encroaches on the low end of the competitive product’s market. That is, each firm would like to extend its market at its low end, but is restrained from doing so by the competitive product. Also note that broad appeal is “good” – product B with broad appeal has an advantage in the sense that it can achieve a constrained monopoly “more easily” than product N. (Compare in Figure 3 the intercept of the boundary to B’s constrained monopoly region on the x -axis, $s(1+2k)$, to the intercept of the boundary of N’s constrained monopoly region on the y -axis, $s(2+k)$, and note that $s(1+2k) < s(2+k)$.) The advantage of broad appeal is also illustrated by the way product B “reaches over” to encroach on product

N earlier. (Compare the intercept of the boundary to the detached monopolies region on the x -axis, $2ks$, with this boundary's intercept on the y -axis, $2s$, and note that $2ks < 2s$.)

The ratio of unit sales of new product j to unit sales of old product J , j and $J \in \{N, B\}$ and $j \neq J$, is denoted by $S_j^M(t)$ in the region of detached monopolies, by $S_j^B(t)$ in the benign duopoly, and by $S_j^D(t)$ in the differentiated duopoly. If the new product is B, from Theorem 1 we find:

$$S_B^M(t) = \frac{q_B(t)}{q_N(t)} = \frac{m(t)}{k(t)} \quad (1)$$

$$S_B^D(t) = \frac{q_B(t)}{q_N(t)} = \frac{s(t)(2+k(t)) + m_N(t)(m(t)-1)}{s(t)(1+2k(t)) - m_N(t)(m(t)-1)} \quad (2)$$

To identify the ratio of market shares in the benign duopoly region, recall that in this region there is a continuum of price equilibria. We assume a product is priced at the midpoint of its continuum (since each reaction function is linear in the other product's price, if one product is priced at its midpoint, so is the other). This yields $p_B(t) = r_B(t) - (k(t)s(t)/2) - (m_B(t) - k(t)m_N(t))/4$ and $p_N(t) = 1 - s(t)/2 + (m_B(t) - k(t)m_N(t))/(4k(t))$ and $q_B(t) = s(t)/2 + (m_B(t) - k(t)m_N(t))/(4k(t))$ and $q_N(t) = s(t) - q_B(t)$. The ratio of market shares is:

$$S_B^B(t) = \frac{q_B(t)}{q_N(t)} = \frac{2k(t)s(t) + m_N(t)(m(t) - k(t))}{2k(t)s(t) - m_N(t)(m(t) - k(t))}. \quad (3)$$

A Monoplist Sells Both Products N and B

When a single firm (a monopolist) offers both the old and new products, both products may be sold in a *joint detached monopoly* with each product taking one end of the potential market (as in the detached monopolies region of the two-firm case), one product may sell to the entire potential market s , or there may be a *joint covered monopoly* where the entire market is covered, with each product selling a strictly positive quantity to a segment at one end. See Theorem 2 below.

As might be expected, in the detached monopoly region both products are sold at their individual monopoly prices. In the joint covered monopoly, the monopolist sets the surplus for the customer of type θ^* equal to zero (every other customer has a strictly positive surplus for the product purchased). Each product is priced above its individual monopoly price – by selling two differentiated products the firm can target each product to one end of the potential market and raise its price as compared to the monopoly

price charged when it is the only product sold. When one product claims the entire market, it is priced at its minimum reservation price.

Theorem 2. *When the reservation price curves are opposite sloping and the two products are sold by the same firm, the monopolist's profit maximizing prices, quantities, and profits are as follows:*

	Monopoly for N	Monopoly for B
<i>Conditions</i>	$m_N \geq 2s - m_B / k$ and $m_N \geq m_B + 2s$.	$m_N \geq 2s - m_B / k$ and $m_N \leq m_B - 2ks$.
<i>Prices</i>	$p_B \geq r_B$ and $p_N = 1 - s$.	$p_B = r_B - ks$ and $p_N \geq 1$.
<i>Quantities</i>	$q_B = 0$ and $q_N = s$.	$q_B = s$ and $q_N = 0$.
<i>Profits</i>	$\pi = \pi_B + \pi_N = (m_N - s)s$.	$\pi = \pi_B + \pi_N = (m_B - ks)s$.

	Joint Detached Monopoly	Joint Covered Monopoly
<i>Conditions</i>	$m_N \leq 2s - m_B / k$.	$m_N \geq 2s - m_B / k$ and $m_N \geq m_B - 2ks$ and $m_N \leq m_B + 2s$.
<i>Prices</i>	$p_B = \frac{r_B + c_B}{2}$ and $p_N = \frac{1 + c_N}{2}$.	$p_N = \frac{2k(1-s) + 1 + c_N + m_B}{2(1+k)}$ and $p_B = \frac{k m_N + (2+k)r_B + k c_B - 2ks}{2(1+k)}$.
<i>Quantities</i>	$q_B = \frac{m_B}{2k}$ and $q_N = \frac{m_N}{2}$.	$q_N = \frac{m_N - m_B + 2ks}{2(1+k)}$ and $q_B = s - \frac{m_N - m_B + 2ks}{2(1+k)}$.
<i>Profits</i>	$\pi = \pi_B + \pi_N = \frac{m_B^2}{4k} + \frac{m_N^2}{4}$.	$\pi = \pi_B + \pi_N = \frac{(m_B - m_N)^2 + 4(k m_N + m_B) - 4k s^2}{4(1+k)}$.

A picture showing the various market regions would be similar to Figure 3 in that the joint detached monopoly region matches that of the detached monopolies. Further, the joint covered monopoly region in Theorem 2 is similar to the differentiated duopoly region in Theorem 1 (Figure 3), and the one-product monopoly regions in Theorem 2 are similar to the one-product constrained monopoly regions in Theorem 1 (Figure 3) except as follows: The joint covered monopoly region abuts the joint detached monopoly

region (there is nothing equivalent to the benign duopoly) and the boundaries between the joint covered monopoly region and one-product monopoly regions are parallel to the boundaries between the differentiated duopoly and the one-product constrained monopoly regions shown in Figure 3, but the x -axis and y -axis intercepts are at $2ks$ and $2s$, respectively.

4. FITTING THE DETACHED-MARKET MODEL TO PHONE DATA

In this section we examine how the cell-phone diffusion/substitution process might be reflected in our framework. Our analysis progresses analogously to the way one would fit empirical data to the Bass (1969) model. In fitting empirical cell-phone data to our model our goal is not to prove that cell phones are going through a detached-market encroachment process of the type we describe (any more than fitting data to the Bass model proves that diffusion occurs due to “innovation and imitation”). Rather, we simply seek to offer a plausible illustration of how such a diffusion process might progress.

Figure 4 shows our empirical data, the number of U.S. subscriptions for cell phones and land lines for 1985 to 2003, obtained from CTIA (2003) and FCC (2005), respectively. Cell-phone size has been reduced, coverage has been greatly enhanced, and cost has come down over time, which in turn change the product depths and breadths. Costs may have fallen over time due to economies of scale and/or learning curve effects (Hatch and Dyer 2004, Macher and Mowery 2003, Schmidt and Wood 1999), for instance. Per our results of the previous section these changes in depths and breadths will impact the market outcomes along with sales prices, quantities, and profits.

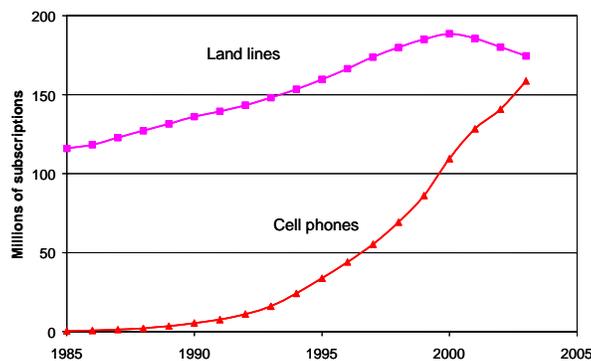


Figure 4. U.S. sales of cell-phone and land-line subscriptions

Assume that at time $t_0 = 0$ a new product B (the cell phone) is introduced into a marketplace involving old product N (the land line). We do not precisely know the phone depths and breadths but proceed by assuming plausible numbers in an attempt to gain insight. We assume the reservation price

curves from Figure 2 (but not the prices and quantities sold shown there) reflect the market at t_0 , with a breadth factor of $k(t_0) = 0.9$, and product depths of $m_N(t_0) = 0.6$ and $m_B(t_0) = 0.005$, such that the depth ratio is $m(t_0) = 0.00833$. We normalize the number of customers to $s(t) = 0.5$ for all t . Note in Figure 3 that these depths would represent a point just inside the detached monopolies region. Given these values, and using the multi-firm results of the previous section we find the market outcome shown in the left frame of Figure 5: sales of land-line subscriptions extend across the business office, individual home, and teen home markets, while cell-phone subscriptions start close to zero. (The width of the rectangle labeled “Sales of land lines” indicates subscription sales volume, and the height of the rectangle reflects sales price, such that the area represents total sales revenue for the product. Similarly for cell phones.)

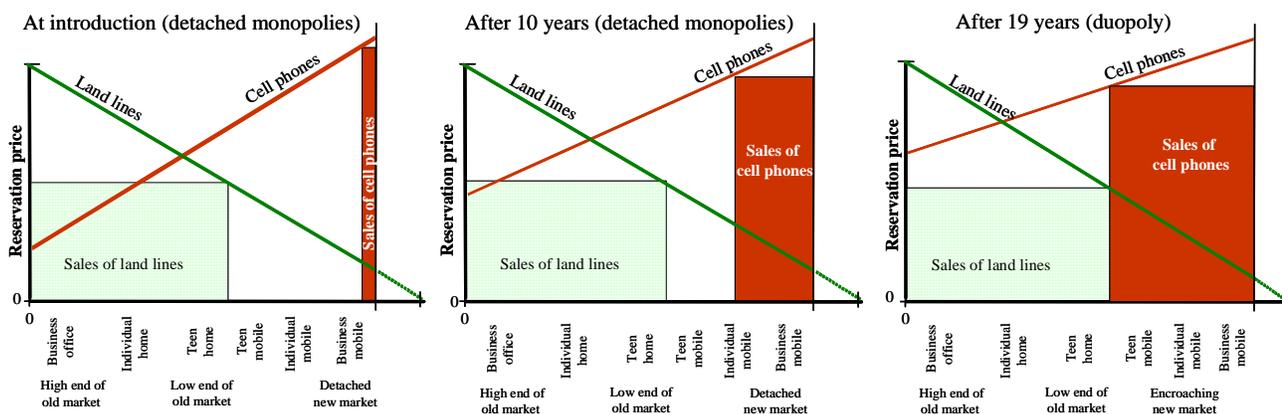


Figure 5. Outcomes as depths and breadths change

These results suggest that upon introduction of cell phones the markets are “detached,” in that initially cell phones and land lines sell at high prices to opposite ends of the market in detached monopolies. There is a wide “blue ocean” between the products in the terminology of Kim and Mauborgne (2004, 2005). The cell phone has not yet encroached on the land line and cell phones are priced significantly higher than land lines.

The middle and right frames of Figure 5 show the market progression over time, 10 years and 19 years after introduction of the cell phone, respectively. These figures were obtained by fitting the empirical data for cells phones to our model. First we qualitatively describe these results as portrayed in the middle and right frames, then we explain how we derive these results from the empirical data.

During their first 10 years, cell phones were upgraded, wireless coverage was enhanced, and costs were reduced, increasing cell-phone depths and breadths (as defined earlier). As a result, the price of cell-

phone subscriptions comes down (as indicated by the diminishing height of the rectangle labeled “sales of cell phones”), and the market expands significantly, as shown in the middle frame of Figure 5. The market for cell phones expands beyond business mobile users to individual mobile users. The market for land lines is unaffected. As shown in the right frame of Figure 5, after 19 years (the 2003 data point) price is further reduced, and the market expands to teen mobile users. Furthermore, at this point cell phones seemingly begin encroaching on the sales of land lines (Figure 4 shows the peak in land-line sales at roughly this time – we proceed under the assumption that the initial point of cell-phone encroachment occurs at roughly this point). But note that the encroachment is from the low end of the land-line market: teen home users (and college students who might have otherwise had land lines in dorm rooms) are the first to adopt the cell phone in favor of the land line. The higher-end user segments (the business office and individual home segments) continue to use the land line. Qualitatively, this description fits the outcome that has been observed to date in the actual market.

As suggested earlier, these market outcomes were obtained by fitting empirical data to our model, analogous to fitting empirical data to the Bass (1969) diffusion model where one finds the best-fit coefficients of innovation and imitation. Instead, we find the best-fit coefficients of depth and breadth, and S-coefficient (all defined shortly). See SD for a similar approach.

The Bass diffusion model fits actual unit sales of a new product to predicted unit sales, ignoring sales of the old product. In contrast, we take into account sales of both products by fitting the logarithms of actual market share ratios to the logarithms of predicted market share ratios. The market share ratio is simply the number of cell-phone subscriptions divided by land-line subscriptions: we use the logarithm because, as Fisher and Pry (1971) show, a plot of the logarithm of the market share ratio versus time is often approximately linear (such a plot is called a substitution curve).

The actual ratios of market shares used are the 19 data points denoted by circles in Figure 6. The market share ratios that are predicted by our model are determined, at any point in time, by the two product depths and the breadth factor $k(t)$.

For simplification, we assume the old product’s depth $m_N(t)$ is constant over time, since land lines have not changed significantly since the introduction of cell phones. We assume changes in depth and breadth are smooth and continuous over time per a logistic (i.e., S-curve) specification, based on empirical evidence that technology improvements follow an S-curve (a technology improves slowly at

first, then more rapidly as the technology becomes better understood, then the rate falls off again because the technology has matured to a point where further improvements are harder to achieve). See Christensen (1992b), for example. Our logistic model specification is $m(t) = m(t_0) + d y(t)$ and $k(t) = k(t_0) + b y(t)$, where $y(t) = a + \beta / (1 + e^{-\sigma(t-\delta)})$, where d denotes the *coefficient of depth* and b denotes the *coefficient of breadth*, representing the change in depth and breadth per unit time, respectively. The S-coefficient σ effectively determines the rates of acceleration (and deceleration) in improvements, δ is the “midpoint” or time about which the curve is symmetric, β is a multiplier that scales (magnifies or shrinks) the y-values and a shifts the curve up (or down).

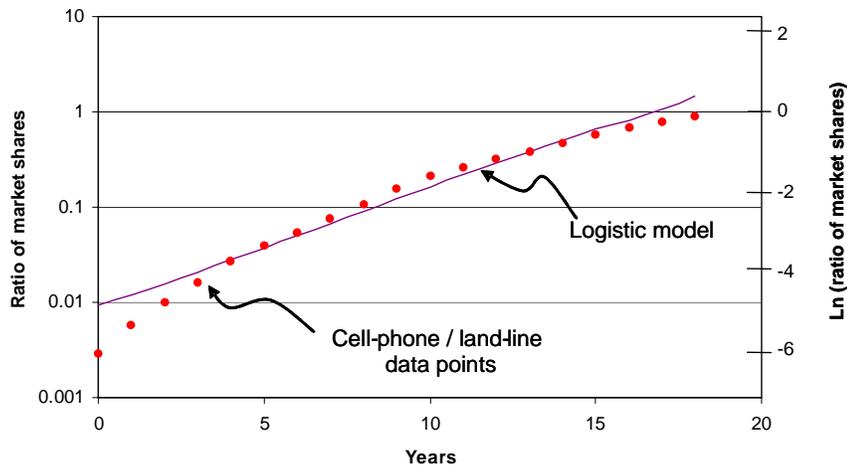


Figure 6. Fitting the model to empirical phone data using substitution curves

When cell phones were introduced the market share ratio started close to zero. When cell-phone and land-line subscriptions are equal the ratio will equal one: we refer to this as the “midpoint” of the substitution process and normalize time to denote the midpoint by $\delta = 0.5$ (from Figure 4 it appears equal sales for the two products will occur at about 20 years, which is normalized to a value of 0.5). We assume the diffusion process is symmetric around this midpoint but do not assume cell phones will eventually totally displace land lines (they may or may not). Note that $y(0) = 0$ and $y(0.5) = 0.5$, yielding $a = -\gamma / (1 - 2\gamma)$ and $\beta = 1 / (1 - 2\gamma)$ where $\gamma = 1 / (1 + e^{\sigma/2})$. This leaves σ , b , and d (the S-, breadth and depth coefficients) as the only unknowns. In reality, we only have two unknowns as the coefficients of depth and breadth are interrelated (if one is specified, the other is determined – given our assumption of symmetry, at $t = 1$ the market would be on the boundary of a transition from a differentiated duopoly to a constrained monopoly for new product B, where $m_N(t) = m_B(t) - s(t)(1 + 2k(t))$, as dictated by

Theorem 1).

Using this specification we find the best-fit depth and breadth coefficients and S-coefficient that minimize the sum of the squared errors between empirical results and model predictions. We search over values of b , d , and σ to find the coefficients that minimize the sum of the squared errors between the actual logarithms and those given by our model via equations (1) through (3). We find the best-fit coefficients are $b = 0.022$, $d = 3.362$, and $\sigma = 12.4$. Results are plotted in Figure 6. The R^2 is 0.95 ($F = 154.2$) and results are significant at the 0.005 level.

What the model is suggesting is that cell-phone reception is improving such that stationary customers progress to view the cell phone more favorably as compared to land lines. (Note in Figure 5 that the cell-phone's reservation price curve elevates over time.) Figure 5 illustrates detached-market low-end encroachment: first we observe detached monopolies, but eventually cell phones start to encroach on land lines from the low end (teens and college students).

5. MANAGERIAL IMPLICATIONS AND SUMMARY

A key contribution of our work is to delineate the detached-market low-end encroachment strategy, and compare and contrast the strategic implications of this approach with other possible encroachment scenarios identified in SP. These various strategies have dramatically different market outcomes over time.

If a firm chooses the detached-market strategy, then it initially targets a market segment with needs quite different from the existing market. This gives the entrant firm the potential to sell the new product at a high price without necessarily breeding an immediate competitive reaction from the firm selling the old product (or, if the incumbent offers the new product, it avoids immediate cannibalization while simultaneously realizing the potential for charging high prices). This may help explain why many incumbent firms in the land-line market were willing to compete in wireless. However, the high prices might also entice other competitors into this new detached market.

This contrasts with fringe-market low-end encroachment, where initially the firm targets consumers with needs only incrementally different from the existing low-end customers. Because these fringe low-end customers are not willing to pay as much as the firm's most valued high-end customers, the firm offering the old product may more easily concede these customers. However, the margins initially achieved by pursuing this strategy may be relatively lower. This is the more traditional story of

disruptive innovation. Thus a contribution of our work is to distinguish between these noticeably different disruptive scenarios, which allows us to explain the anomaly of an expensive disruptive innovation in the work of C / CR / CAR and Adner (2002).

The detached-market scenario also contrasts dramatically with high-end encroachment. In this case the encroachment on the old product is immediate and dramatic since the new product first “attacks” the high end of the old market, and thus an entrant may face a swift and aggressive response from the incumbent (or if the incumbent is the one introducing the new product, cannibalization will be direct).

A firm’s choice of an encroachment strategy may be limited by technology, as well as by its competitive position. For example, with regard to cell phones, it may not have been technically feasible to produce a low-priced phone that would have encroached as a fringe-market product, so the detached-market scenario may have been the only low-end encroachment alternative. In other cases the fringe-market scenario may be the only low-end alternative. For example, in the 1980s when the 5.25 inch disk drive was introduced it may not have been feasible to make a viable 1.8 inch drive – if such a drive had been introduced back at that point in time it might have opened up an earlier market for primitive PDAs, even before laptop computers became prevalent. The PDA market would have been “detached” from the desktop market (the progression from desktop to laptop to PDA would have skipped the laptop). Further, the rate at which a firm is able to make technological improvements will also impact its strategy, given the implication of our model that diffusion relies on changes in reservation prices and costs over time.

5.1. How the Framework Might Help in Selecting a Strategy: The Example of Kodak

The typical buyer of an early digital camera was an affluent tech-savvy male who bought the camera as an electronic gadget; a computer accessory. Even as digital-camera sales ramped up to 5 million units per year by the year 2000, sales of film-based cameras remained relatively constant at about 20 million units per year. But at that point digital cameras encroached on the lower end of the existing film-camera market, and then moved up-market (digitals first encroached on the point-and-shoot segment with low picture quality and are now moving up to the higher-end SLR segment). Kodak had seemingly been anticipating this since the early 1980s, having invested heavily in digital technology, and in 1995 Kodak followed Apple in introducing a digital camera that worked with a home computer.

Kodak’s first buyers represented a detached-market – tech-savvy males had very different preferences as compared to the film camera mainstream market. Initially, the poor MP rating of the digitals precluded

high-end users of film cameras from discarding their film cameras, particularly in the SLR market.

Kodak seemingly addressed the threat of digitals, but in doing so adopted a strategy quite different from the one upon which the company was built. In the early 1900s, Kodak introduced the Brownie, a camera not for the affluent tech-savvy market, but for the average user. The Brownie opened up a new market at the low-end fringe of the old market, and then improved quality over time to move up-market. A fringe-market strategy with digitals would have involved something like a digital Brownie; a digital that initially sold not to tech-savvy males but to a quite different market segment, such as budget-strapped moms. Over time, the digital Brownie would have again encroached on the existing market from the low end upward, as picture quality improved. While it may not have been technically feasible for the first digitals to have been priced to compete with the lowest end of the film-camera market, Kodak might have used its considerable know-how in digital technology and its extensive R&D budget to produce early digitals that were markedly lower-end than those requiring computer expertise. In fact, as discussed in *Future Image* (2004), Kodak seemingly regrets not having considered an early digital Brownie. The detached-market strategy it actually pursued offered the potential for high prices, but also attracted multiple competitors such as Sony, Canon, and others. With the fringe-market strategy, Kodak would have been carving out a less attractive space in terms of price but possibly one of higher volume (and potentially higher profit).

5.2. “Willingness to Cannibalize” May Not Sufficiently Describe a Necessary Condition for an Incumbent to Maintain Its Position

Chandy and Tellis (1998), along with Govindarajan and Kopalle (2004), find that “willingness to cannibalize” is a key factor in an incumbent firm’s growth and survival. Our framework suggests cannibalization can occur in several ways: cannibalization can be immediate and from the high end (as with a new Pentium microprocessor), or the new product can first open up a new market on the low-end fringe before encroaching on the old product from the low end upward (as with a smaller disk drive), or the new product can first open up a new “detached” market such that there is a rather lengthy delay before the new product encroaches on the old market (as in the case of cell phones encroaching on the land-line market). Thus “willingness to cannibalize” may not be a descriptive enough prescription.

That is, different forms of cannibalization may be called for in different settings. Intel initially relied on a high-end encroachment strategy until it realized that to hold off AMD it needed to be willing to

cannibalize on the low-end fringe by introducing the Celeron. Kodak was willing to eventually cannibalize through the detached-market scenario but apparently unwilling to cannibalize with something more akin to fringe-market low-end encroachment, which in retrospect they seem to regret. More recently Kodak has been fairly successful with lower-end digitals, introducing in 2001 the EasyShare line which redefined ease of use (www.kodak.com) and led to Kodak achieving the highest U.S. market share of 24.9% in 2005 (Dobbin 2006).

5.3. Limitations and Possible Extensions

We make many assumptions that would be interesting to relax in future work. For example, we assume linear reservation price curves – it would be interesting to see if our results hold in the face of other formulations. If we allow a reservation price curve to achieve its minimum (or maximum) somewhere inside the interval $(0, s(t))$, we may find additional forms of encroachment, such as where the new product first sells to a detached market and then encroaches on the high end of the existing market before the market is covered. To more accurately reflect market conditions, it would be interesting to consider multiple firms selling each product and to account for how a person representing multiple customers early in the new product's life may become a single customer or drop out of the market later. Further, our framework assumes the parameters of the new product are given – the next step is to have firms choose the optimal encroachment strategy based on the technological alternatives available to it.

Other limitations of our model are that we consider only the case where two firms each offer a single product or a monopolist offers two products; thus we do not address the issues of product variety and product line extensions. See for example Ramdas (2003). We also do not consider brand competition within a product category as Krishnan et al. (2000) do; instead we focus on the competition between different products that can substitute for one another. Also, further work is needed to link what we have found regarding diffusion to the rich literature surrounding the impact of firm capabilities on the ability of firms to innovate (Cohen and Levinthal 1999, Henderson 2006, Ofek and Sarvary 2003, Schmidt and Porteus 2006, Teece et al. 1997, Wernerfelt 1984) and to consider whether firms rationally decide the type of encroachment process to pursue (Gilbert 2005).

5.4. Summary

The detached-market low-end encroachment strategy that we describe and analyze herein represents a

significant extension to the encroachment framework introduced in SP and SD. This encroachment framework gives firms an insightful way of comparing and contrasting alternative new product introduction strategies, by generically describing the new market segment to which a new product will first sell, and the order in which the old product's market segments will be encroached upon. Our work represents a first step in understanding the implications of these alternate encroachment strategies.

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