Seagate - Quantum: Encroachment Strategies

Case Supplement

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1. High-end Versus Low-end Encroachment

Consider Intel's continual growth and expansion of its line of microprocessors, as discussed in Schmidt and Wood (1999), for example. As shown in Figure 1, Intel has continually upgraded its product offering, from the 286 model in 1982 to the current P-IV version. Historically, Intel's new product has been a new high-end model. In other words, the new model has superceded the previous model in terms of performance (processing power). The new model is priced at a high level, and initially sells to the "best" customers (where we define the best customers to be those who are willing to pay the most for this type of product). We call this a *high-end encroachment* strategy, since the new product encroaches on the existing market from the high end (the new product is bought by high-end customers, at a high price).

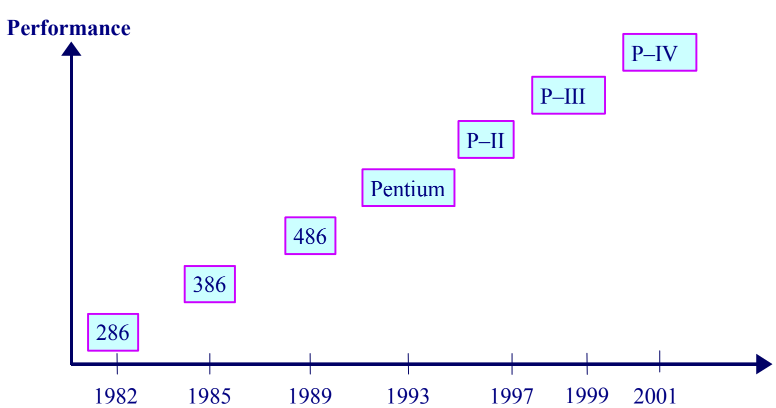

Figure 1. Intel maintained leadership by continual upgrading of microprocessors.

In the late 1990s, Intel modified its strategy to include the Celeron microprocessor. The Celeron did not supercede the current model in terms of performance, but rather sold to lower-end customers who wanted sub-$1000 computers. In other words, it encroached on the low-end of the market, a strategy we refer to as *low-end encroachment*.

Intel's revision of its strategy was, in part, precipitated by studying history. Consider, for example, what happened to the market leaders in the steel industry and the disk drive industry. In the steel industry, integrated mills (the market leaders) watched as new companies such as Chaparral Steel and Nucor built mini-mills. The integrated mills were not particularly concerned, because the mini-mills made low-end, low-margin products such as rebar. As the mini-mills improved their quality and process capability, however, they began moving up in terms of product offering. In our terminology, they were encroaching on the existing market of the integrated mills from the low end. Eventually, they became formidable competitors to the integrated mills.

The hard disk drive industry also provides a classical example of low-end encroachment. Hard disk drives are devices that store digital information and are found inside virtually all computers. (Computers may also have floppy disk drives which write digital data to a portable medium, a floppy disk.) Unlike the microprocessor market, where Intel has sustained a market leadership position from generation to generation, the disk drive market created a new market leader with each generation. As shown in Figure 2, between 1975 and 1990 the computer hard disk drive industry underwent a transition from a standard product size of 14 inches, to 8 inches, to 5.25 inches, and subsequently to 3.5 inches. The *y*-axis of Figure 2 implies disk drive performance grew over time as smaller and smaller drives were developed, however this is an oversimplification in that performance is not so readily expressed along one dimension. Previous buyers measured performance primarily on storage capacity (a new smaller drive initially had less capacity than its predecessor model but grew over time) while initial buyers of a new smaller drive measured performance more based on physical size. Unlike the microprocessor example just presented, there was a new market leader with each generation. Watching the market shifts was like observing the game of musical chairs: Leaders switched from Storage Technologies, to Quantum, to Seagate, to Conner Peripherals, respectively.

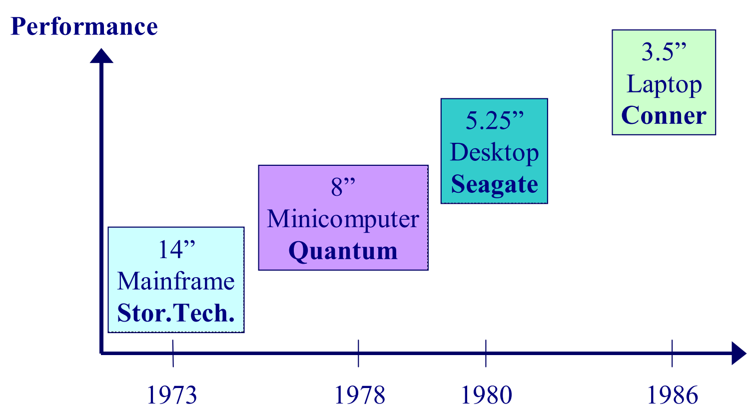

Figure 2. The disk drive market had a new leader every generation.

Per Christensen (1997), the incumbent's loss of market position resulted from its failure to recognize the manner in which the newcomer's smaller sized entry in the marketplace encroached on the mainstream product. The entrant's product did not (initially) appeal to the incumbent's mainstream customers, but rather, appealed to fringe customers who were not buying the incumbent's product anyway. Over time, however, the trajectory of improvements in the smaller drives (namely, increases in storage capacity) led to their acceptance by these same mainstream customers.

In other words, it *seems* that the adage of "listen to your customers" may not always be a good one. However, this adage may indeed be sound if one takes a broader view of who your customer is and what your "customer" is "telling" you: a true market-oriented perspective goes further than simply asking existing customers what they want. Beyond merely asking, it seeks a fuller understanding of latent or unexpressed needs. And beyond looking at existing customers, it looks at future needs of future customers.

Having learned of these instances of successful low-end encroachment in other industries (other examples include the Japanese move from economy cars into luxury cars, and encroachment by hydraulic excavators into the markets held by mechanical excavators), Intel was determined not to let AMD pull off a similar coup in the microprocessor market. Thus Intel countered with its own move: the Celeron. What appears to have made this an appropriate strategy for Intel was a shift in the appetites of many customers, from a desire for computers at the $2,000 price point to a preference for less-powerful sub-$1,000 models. Of course, Intel did not abandon the high-end encroachment strategy, but merely supplemented it with the lower-end Celeron.

2. A Model to Help Understand How New Products Encroach on Old Markets

To better understand the market outcomes under high-end and low-end encroachment, we describe herein a framework from which to think about customer preferences and product positioning.

We begin this section by reviewing the linear reservation price curve framework. We do so by first developing plausible reservation price curves for disk drives. We follow this with an analysis of market outcomes given these reservation price curves. The bulk of our analysis centers on the low-end encroachment example: Since incumbent firms reportedly often fail in the face of a disruptive technology, it is imperative that a firm have a clear understanding of what the potential market outcomes are in this setting. We then briefly discuss market outcomes in the case of high-end encroachment.

2.1. Linear Reservation Price Framework

We illustrate the development of the linear reservation price curve framework by building plausible (but not necessarily factual) curves for computer disk drives. To find a product's reservation price curve, we need to first generate the part-worth curves for each attribute of the product. The case study "Seagate-Quantum: Encroachment Strategies" illustrates plausible part-worth curves for disk drives.

Note how this framework will allow us to model a crucial characteristic of a disruptive technology as identified by Christensen (1997). Namely, it allows us to consider the situation where a new product is quite deficient with regard to the traditional performance criterion (or criteria) of concern to the firm's best existing customers, while offering a significant improvement with regard to a feature (or set of features) that is not of major concern to existing customers. In the case of disk drives, which in the late 1970s were being sold primarily to mainframe and mid-range users, such a new product would be one that is low on capacity but which is of smaller size.

2.1.1. Summing the part-worth curves yields the reservation price curve

By adding the part-worth curves that are depicted in Figures 1 and 2 of the accompanying Case Study, we can determine what each customer will pay for any given disk drive. We call this the customer's *reservation price*, and calculate it as simply the sum of the two part-worths for capacity and physical size. In other industries there may be more than two crucial performance attributes. If so, the part-worth curves would be generated for each level of each attribute, and then, given a specific choice of product to be offered, the part-worths for that product would be summed to yield the product's reservation price curve.

In 1981 a typical 8" disk drive had about 60 MB of capacity. Looking back at Figure 1 of the Case Study, note that the part-worths for 60 MB of capacity ranged linearly from $2,415 for the first customer, down to zero for the 1,275,000th customer. Looking back at Figure 2 of the Case Study, note that the part-worths for the physical size attribute of an 8" drive ranged linearly from $1,085 for the first customer, down to $525 for the 1,275,000th customer. Starting with the first customer, we add her two part worths and find she has a reservation price of $2,415 + $1,085 = $3,500. For the 1,275,000th customer we again add her two part-worths and find she has a reservation price of $0 + $525 = $525. If we similarly add the part-worths for all other customers to get each customer's reservation price for an 8" drive of 60 MB capacity, and then plot all these reservation prices, we get the reservation price curve for an 8" drive of 60MB capacity as shown in Figure 3. (Given that the customers are numerous, we can consider it to effectively be a continuous straight line rather than being comprised of 1,275,000 discrete points.)

Figure 3 shows that the most a customer is willing to pay for this 60 MB 8" drive is $3,500 (i.e., the maximum reservation price is $3,500). The plot further suggests the drive has a total market potential of 1.275 million customers and the 1,275,000th customer is willing to pay $525. In this figure and all similar figures that follow, the unit sales rate is indicated by a vertical line intercepting the *x*-axis (in Figure 3 the sales volume is 150,000 units per year). The area of the shaded rectangle represents the profit associated with the product, while the shaded area plus the rectangular area below it indicates sales dollar volume.

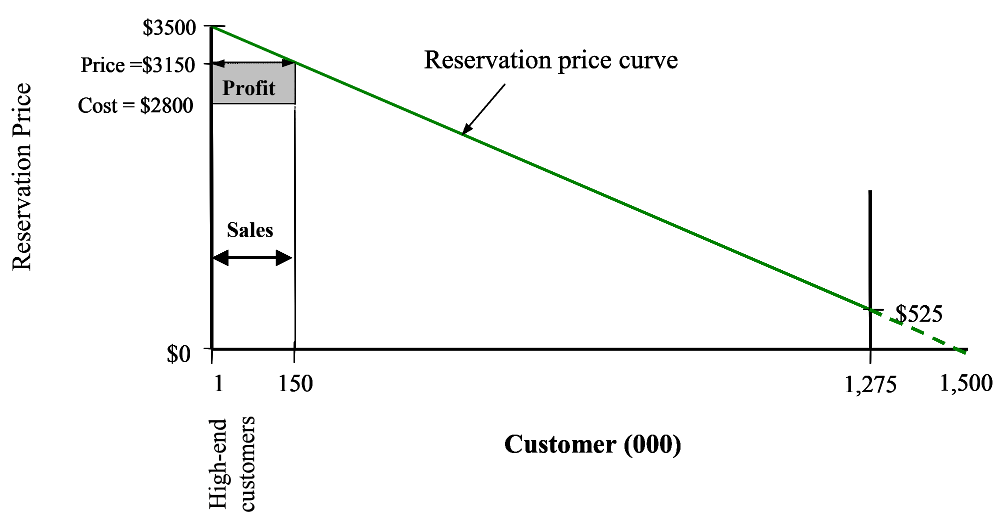

Figure 3. With only the 8" drive, the reservation price curve is the demand curve.

We interpret a "customer" to be an "application" of the product that consumes one unit per year. For example, the 1,275,000th customer in Figure 3 is willing to buy one unit per year at a price of $525. Thus when we derive sales quantities the results are in units sold per year.

2.1.2. The Market Outcome When There is Only One Product

If there is only one product in the market, then the reservation price curve of Figure 3 effectively represents the product's demand curve for a monopolist. Say each 8" disk drive of 60 MB of capacity costs $2,800 to produce. Many standard economics textbooks show how to find the profit-maximizing sales price in the case of monopolist facing a linear demand curve so we forego the mathematics and present the solution: The firm charges $3,150, such that it sells 150,000 units per year, and makes a profit of $52.5 million (calculated as price minus cost, times units sold).

In Figure 3, note that the "best customers" are defined as those willing to pay the most. Also, note that the profit is indicated by the shaded area and the buying segment is indicated by the diagonal hatching (i.e., buyers are the best customers numbered zero to 150,000).

2.1.3. The Market Outcome When Two Products are Sold by Different Firms

Now assume a new 5.25" disk drive with 10 MB of capacity is introduced into the market by a competitive firm (we later address the case where it is introduced by the same firm). Further assume the production cost for the new drive is $2,100 upon introduction. This product's reservation price curve is calculated in the same manner as that of the 8" drive with 60 MB of capacity, yielding the curve shown in Figure 4, where the most any customer is willing to pay is $2,275, and the price that the 1,275,000th customer is willing to pay is $1,085.

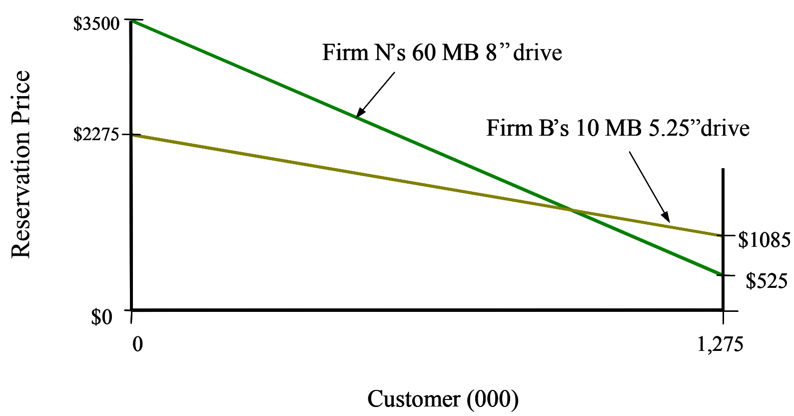

Figure 4. Reservation price curves upon introduction of a new 5.25" drive.

If there are two or more products, then the reservation price curve can no longer be considered to be a demand curve. We address the situation in which there are at most two products, one old and one new. To facilitate the discussion, we call the product whose reservation price curve has a flatter slope product B, because it has relatively *broad appeal*, and the product whose curve has a steeper slope will be called product N, for *niche appeal.* (Consider a range of reservation prices, say between $2,000 and $2,100 in Figure 4. Now consider how broad the set of customers is that holds a reservation price within this range. For product B, the set is broader, while for product N, it is narrower.) Firm's B and N will denote the firms selling products B and N, respectively.

It is important to note that the old product may be product N while the new product is product B, as in Figure 4, or it may be that the old product is B and the new product is N. Furthermore, it should be noted that the reservation price curves may cross, as shown here, or one may lie entirely above the other. The slopes of both curves do, however, need to be of the same sign (we rule out the case where one slope is positive and the other negative).

Let r_N and r_B denote the maximum reservation prices for products N and B, respectively (subscripts denote the product), let c_N and c_B denote the production costs, let p_N and p_B denote the sales prices, and let q_N and q_B denote the sales quantities. Let k denote the ratio of the slope of the reservation price curve of product B to that of product N. Thus by definition, k is a number between zero and one. Finally, let n denote the x-axis intercept of product N's reservation price curve (n effectively represents the number of potential customers who hold positive reservation prices for product N). If the curve does not intercept the x axis, it should be extended to do so to find n (in the example of Figure 3, n = 1.5 million). Note that there is only one n, representing the x-axis intercept for product N (we do not need to use the x-axis intercept for product B in our calculations, as this is accounted for by our use of k and n).

It is assumed that a customer will buy at most one product. Namely, she will buy a product if it is priced at or below her reservation price, while also providing her with more value than the alternate product. That is, the customer buys the product with the largest positive surplus (where surplus is defined as the difference between reservation price and actual price), or she buys nothing if all surpluses are negative.

With regard to the firm's pricing decision, we assume that each firm sets price to maximize, at a snapshot in time, its current rate of profit generation, given the price of the competitive product. That is, at the snapshot in time, each firm finds its best pricing response to the price set by the other firm, considering only its current rate of profit generation. This is called a Nash equilibrium.

When two different firms sell the two products, the Nash equilibrium prices, quantities, and profits for each firm are given by the equations shown in Table 1 (technically, these equations apply only if certain conditions are met – these conditions are met in this Case Study). To analyze the case is not necessary to understand the underlying mathematical details from which these equations are derived, but if further information is desired, refer to Schmidt and Porteus (2000).

Table 1. Sales prices, quantities, and profits when *different* firms sell the two products.

	Product N	Product B
Prices	$p_N = \dfrac{2(r_N + c_N) - (r_B - c_B) - k\ r_N}{(4-k)}$	$p_B = \dfrac{2(r_B + c_B) - k(r_N - c_N) - k\ r_B}{(4-k)}$
Quantities	$q_N = \dfrac{n[(2-k)(r_N - c_N) - (r_B - c_B)]}{r_N(4-k)(1-k)}$	$q_B = \dfrac{n[(2-k)(r_B - c_B) - k(r_N - c_N)]}{k\ r_N(4-k)(1-k)}$
Profits	$\pi_N = (p_N - c_N)q_N$	$\pi_B = (p_B - c_B)q_B$

2.1.4. The Market Outcome When There are Two Products Sold by the Same Firm

In the case where the same firm sells both the old and the new products, we proceed again to identify the reservation price curves for products N and B, using the same procedure and notation as developed to this point. But instead of finding the Nash equilibrium pricing outcome, we find the monopolist firm's profit maximizing prices. The profit maximizing outcomes for this case (where the same firm sells both products and both products realize positive sales quantities) are given in Table 2 (again, these equations apply only if certain conditions are met, and these conditions are met in the situations where we apply the equations).

Table 2. Sales prices, quantities, and profits when the *same* firm sells the two products.

	Product N	Product B
Prices	$p_N = \dfrac{(r_N + c_N)}{2}$	$p_B = \dfrac{(r_B + c_B)}{2}$
Quantities	$q_N = \dfrac{n[(r_N - c_N) - (r_B - c_B)]}{2r_N(1-k)}$	$q_B = \dfrac{n[(r_B - c_B) - k(r_N - c_N)]}{2k\ r_N(1-k)}$
Profits	$\pi_N = (p_N - c_N)q_N$	$\pi_B = (p_B - c_B)q_B$

2.2. Market Outcome for the Case of High-end Encroachment

To illustrate a the case of high-end encroachment, assume a single firm (a monopolist) offers a version II (V-II) microprocessor. Assume there are 100 million potential customers (see Figure 5), the maximum reservation price is \$800, and production cost is \$400. Again, since there is only a single product, the reservation price curve is equivalent to the demand curve, and standard economics suggests the firm's optimal selling price is \$600, with 25 million units per year sold to high-end customers, resulting in a monopoly profit of \$5 billion per year.

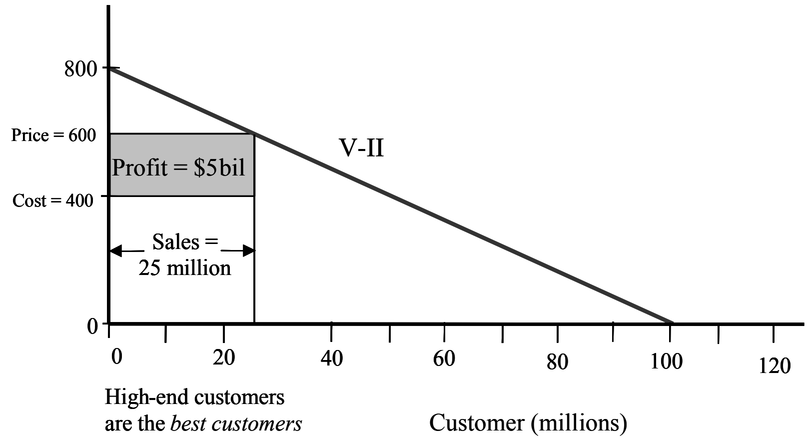

Figure 5. A market with only the V-II microprocessor.

Now assume the same firm introduces a new, faster V-III. A high-end customer who always wants to have the latest and greatest computer is willing to pay a bit more for a faster chip. On the other hand, a low-end customer who was not willing to pay much for a V-II chip probably has little use for a computer of any speed, and thus a V-III chip is of almost no more value than a V-II. Thus we might predict the reservation price curve for the V-III to be shifted upward as compared to the V-II in the manner as shown in Figure 6. Here, we assume the maximum reservation price for the new product is $1,000, and its cost is $550. (These values might represent the situation at, say, one year after the point of introduction of the V-III.)

The new outcome is calculated using the equations given previously in Table 2, and the results are depicted in Figure 6. Many of those high-end customers who would previously have bought the V-II now opt for the V-III instead. Accordingly, we call this a case of *high-end encroachment* (the new product encroaches on the market from the high end). The old V-II is relegated to selling to lower-end customers.

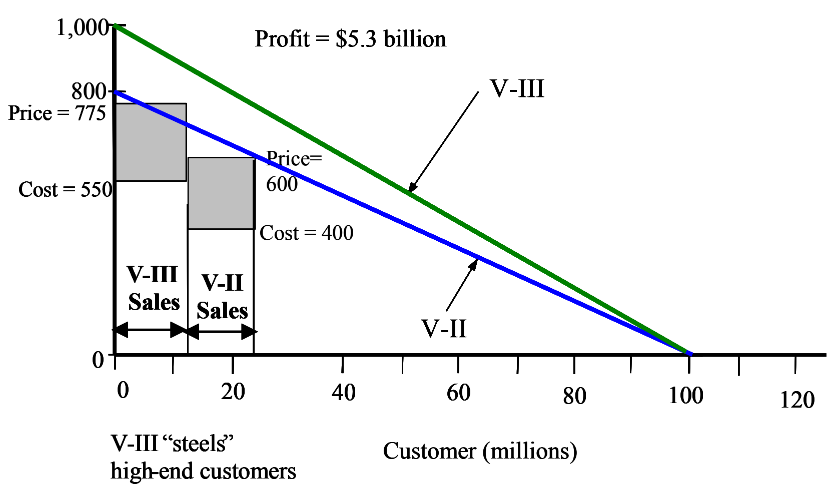

Figure 6. The V-III microprocessor encroaches on the high end of the market.

In this example, we analyze only one pair of reservation price curves and costs. A more thorough analysis would again look at how these change over time, to get a better feel for market outcomes at various points in time.

In the microprocessor example just presented, high-end encroachment resulted from the firm's introduction of its own new product, rather than that of a competitor. Of course, had the competitor introduced the new V-II product, we would still have observed high-end encroachment, but the resulting prices, quantities, and profits would have been quite different. In this case, using Table 1, we find the competitive market results in lower prices, with $p_N = \$594$ and $p_B = \$438$. These lower prices in turn yield higher sales rates of $q_N = 21.88$ million units per year and $q_B = 23.44$ million units per year, albeit lower profits of $\pi_N = \$957$ million per year and $\pi_B = \$879$ million per year.

3. References

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