Table 6.1 Ride restrictions and air fares

Variable	*Coefficient*	*t-statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-Statistic*	*Coefficient*	*t-statistic*
Saturday-Night Stay-Over Required	−0.249	−2.50	—	—	−0.408	−4.05	—	—
Saturday-Night Stay- Over x HI	—	—	—	—	0.792	3.39	—	—
Advance Purchase Requirement	—	—	−0.007	−2.16	—	—	−0.023	−5.53
Advance Purchase Requirement x HI	—	—	—	—	—	—	0.098	8.38

If the coefficient on this term is positive, it says that the discount associated with, say, a Saturday night stay-over requirement declines as the level of concentration rises. Stavins' (2001) results are shown in Table 6.1.

The first four columns indicate that passengers do indeed pay different prices depending on the restrictions applied to their rides. These effects are both statistically significant and economically substantial. For example, passengers who accepted the requirement that they not return until after Saturday night paid 25 percent less on average than those who did not accept this restriction even though they were otherwise getting the same flight service.

However, the real issue is how these discounts vary as the extent of competition in the market as measured by *HI* varies. This is where the next four columns become relevant as they show what happens when the term interacting competition or concentration and ride restrictions is included. In both cases, the estimated coefficient on the interaction term is positive. This indicates that while ride restrictions still lead to price reductions, this effect diminishes as the airline route becomes less competitive or has high concentration.

Given the range of *HI* values observed over the twelve routes Stavins (2001) studies, she estimates that in the most competitive markets, a Saturday night stay-over requirement led to a price reduction of about \$253, whereas in the least competitive ones the same restriction led to a price reduction of only \$165. Likewise, an advance purchase requirement was associated with a price reduction of \$111 in the most competitive markets but a cut of only \$41 in the least competitive markets.

Summary

In this chapter, we have extended our analysis of price discrimination to cases in which firms employ more sophisticated, nonlinear pricing schemes. Our focus has been on commonly observed examples of such nonlinear pricing schemes. These are: 1) two-part pricing in which the firm charges a fixed fee plus a price per unit and 2) block pricing in which the firm bundles the quantity being offered with the total charge for that quantity. Both schemes have the same objective, to increase the monopolist's profit either by increasing the surplus on existing sales or by extending sales to new markets, or both.

The most perfect form of price discrimination, first-degree price discrimination or personalized pricing, can only be practiced when the firm can costlessly solve the identification and arbitrage problems. The firm needs to be able to identify the different types of consumers and must also be able to keep them apart. If this is possible, then two-part tariffs and block pricing can, in principle, convert *all* consumer surplus into revenues for the firm. The positive side to this is that the firm supplies the socially efficient level of output to each consumer type. The negative side is that there are potentially severe distributional inequities in that all social surplus takes the form of profit.

If the requirements necessary to practice perfect price discrimination are not met, then the monopoly seller cannot achieve such a large profit. However, the monopolist can employ second-degree price discrimination or menu pricing, another form of nonlinear pricing. Second-degree price discrimination differs from both first- and third-degree in that it relies on the pricing mechanism itself—usually block pricing that exhibits quantity discounts—to induce consumers to *self-select* into groups that reveal their identity or who they are on the demand curve.

The use of a quantity discount to sort or screen consumers must always satisfy an *incentive compatibility* constraint across the different consumer types. This constraint weakens the monopolist's ability to extract consumer surplus. Because the incentive compatibility constraint adversely affects profits, the monopolist may choose to avoid it by refusing to serve low-demand markets, with the result that the low-demand type consumers are clearly worse off. As a consequence, the welfare effects of second-degree price discrimination are not clear. Yet unlike the case of third-degree discrimination (with linear demand curves at least), second-degree pricing strategies do have some positive probability of making things better.

Market power is a necessary requirement for price discrimination. Perfectly competitive firms take the market price as a given and must charge that price to all customers. It is for this reason that we have set our discussion of price discrimination in a monopoly context. Yet while a monopoly framework is convenient, all that is strictly required is a setting of imperfect competition. In this regard, it is noteworthy that the use of price discrimination by firms may also be a means of implementing competition when firms are imperfectly competitive rivals. Price discrimination permits firms with market power to offer price cuts to customers of a rival brand without offering such price cuts to those among its current customers who are not price sensitive. Supporting evidence for this view may be found in many studies, including that by Stavins (2001) on airline competition. Together, this theory and evidence suggest that price discrimination as a tool for inter-firm rivalry can push imperfect competition closer to the competitive ideal.

Problems

1. Many universities allocate financial aid to undergraduate students on the basis of some measure of need. Does this practice reflect charity or price discrimination? If it reflects price discrimination, do you think it lies closer to first-degree discrimination or third-degree discrimination?

2. A food co-op sells a homogenous good called groceries, denoted g. The co-op's cost function is described by: $C(g) = F + cg$; where F denotes fixed cost and c is the constant per unit variable cost. At a meeting of the co-op board, a young economist proposes the following marketing strategy: Set a fixed membership fee M and a price per unit of groceries p_M that members pay. In addition, set a price per unit of groceries p_N higher than p_M at which the co-op will sell groceries to non-members.
   a. What must be true about the demand of different customers for this strategy to work?
   b. What kinds of price discrimination does this strategy employ?

3. At Starbuck's coffee shops, coffee drinkers have the option of sipping their lattes and cappuccinos while surfing the Internet on their laptops. These connections are made via a connection typically provided by a wireless firm such as T-Mobile. Using a credit card, customers can buy Internet time in various packages. A one-hour package currently goes for an average price of \$6. A day pass that is good for any time in the next 24 hours sells for \$10. A seven-day pass sells for about \$40. Briefly describe the pricing tactics reflected in these options.

4. A night-club owner has both student and adult customers. The demand for drinks by a typical student is $Q^S = 18 - 3P$. The demand for drinks by a typical adult is $Q^A = 10 - 2P$. There are equal numbers of students and adults. The marginal cost of each drink is $2.
   a. What price will the club owner set if it is not possible to discriminate between the two groups? What will the total profit be at this price?
   b. If the club owner could separate the groups and practice third-degree price discrimination, what price per drink would be charged to members of each group? What would be the club owner's profit in this case?

5. If the club owner in problem 4 can "card" patrons and determine who among them is a student and who is not and, in turn, can serve each group by offering a cover charge and a number of drink tokens to each group, what will the cover charge and number of tokens be for students? What will be the cover charge and number of tokens given to adults? What is the club owner's profit under this regime?

6. A local phone company has three family plans for its wireless service. Under each of these plans, the family gets two lines (phones) and can make local and long distance (within the United States and Canada) calls for free so long as the total number of minutes used per month does not exceed the plan maximum. The price and maximum minutes per month for each plan are: Plan 1: 500 minutes for $50; Plan 2: 750 minutes for $62.50; and Plan 3: 1000 minutes for $75.00. Assuming that there are equal numbers of consumers in each group and that the value of a marginal minute for each group declines at the rate of $0.0004 per minute used, work out the demand curves consistent with this pricing. What surplus will each consumer group enjoy?

7. Now return to our ski resort owner in the text in which low-demand consumers have an inverse demand of: $P = 12 - Q$, while high-demand consumers have an inverse demand of: $P = 16 - Q$. Marginal cost per lift ride is again $4. Assume that there are N_h high-demand customers and N_l low-demand customers but that the ski resort owner does not know the type of each skier. Show that under these circumstances the firm will only serve low-demand customers, i.e., will only offer both packages if there are at least as many low-demand consumers as high-demand ones. In other words, $\frac{N_h}{N_l} \leq 1$ in order for low-demand consumers to be served.

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7

Product Variety and Quality Under Monopoly

Most firms sell more than one product. Microsoft offers not only an operating system and an Internet browser but also a number of other products, most notably, the word-processing package *Word*, the spreadsheet software *Excel*, and the presentation package *PowerPoint*. High-tech firms such as Apple sell a wide range of computers including a tablet computer, a music player, and a mobile telephone. Major automobile manufacturers such as Toyota offer a bewildering array of mid-range automobiles and a range of higher-end autos under other brand names, such as *Lexus*. Companies such as Comcast offer telephone, television, and Internet services. Fashion designers such as Ralph Lauren offer a broad range of apparel from sportswear to haute couture, for both women and men.

Indeed, even the most cursory examination of consumer markets suggests that the multi-product firm is likely to be the norm rather than the exception. Take a company such as Kellogg's. Is there any flavor, color, or texture of breakfast cereal that they do not market? Or consider Procter & Gamble, a large consumer product company that offers more than a dozen varieties of their *Head and Shoulders* shampoo and even more varieties of their *Crest* toothpaste.

This leads us to the question of exactly how much variety a firm should aim to offer. Indeed Procter & Gamble asked itself the same question when it reexamined its product strategy in the early 1990s. By 1996, the company had reduced its list of products by one-third as compared with 1991. All the evidence suggests, however, that the past decade has seen the company once more expand its product range.

A firm's incentive to offer many varieties of what is essentially the same product—breakfast foods, hair or tooth care—is simple enough to understand. It is a way for the firm to appeal and sell to consumers with very different tastes. Because we as consumers differ in our most preferred color, flavor, or texture, selling successfully to many consumers requires offering something a little different to each of them. Specifically, to induce a consumer to make a purchase the firm must market a product that is reasonably close to the version that the consumer most prefers. When a firm offers a variety of products in response to different consumer tastes, it is adopting a strategy that we refer to as *horizontal product differentiation*.

There are other cases in which consumers agree on the product features that make for a "good" product. For example, all consumers likely agree that a car with antilock brakes is better than one without such a stopping mechanism. Similarly, all probably agree that while a *3 Series* BMW is an attractive car, it pales in comparison to the *7 Series*. Everyone is likely to agree that flying from Boston to San Francisco first class is a better than flying coach. Where consumers differ in these cases is not in what features they consider to be desirable but, instead, in how much a desired feature is worth to them. In other words, consumers differ not in their rankings of product quality but rather in how much they are willing to pay for antilock brakes, a better BMW, or first class airfare. When a firm responds to differences in consumer willingness to pay for quality of a product by offering different qualities of the same product, it is called *vertical product differentiation*.

In this chapter, we analyze the horizontal and vertical product differentiation strategies of a monopoly firm, focusing in particular on how product differentiation may be used by the firm to increase profitability. We also consider the welfare properties of these strategies.

7.1 A SPATIAL APPROACH TO HORIZONTAL PRODUCT DIFFERENTIATION

We begin by considering a market in which consumers agree both on the quality of the product being considered, whether this be breakfast cereal, hair treatment, or an automobile, and on their willingness to pay for this product. However, consumers differ with respect to the specific features of the product that make the product attractive to them: they may differ, for example, in their most preferred taste, color, or location of the product. In other words, all consumers may agree on the quality of and their willingness to pay for a product, perhaps a margherita pizza, if it is sold at a shop close to their home. However, not all consumers are equidistant from the shop. Some are close and some are far away. Given the time and effort required to travel, the willingness to pay of those who live far from the shop will be lower. By contrast, those who live close—and who therefore do not have to incur travel expenses—will be willing to pay a higher price. The fact that a product sold close to home is different from one that is sold far away is a good example of horizontal product differentiation. Such differentiation is characterized by the property that each consumer has his or her own preferred location of the shop or product, namely, one close to the consumer's own address.

When the consumer market is differentiated by geographic location, a firm can vary its product strategy through its choice of where the product is sold. The firm may choose to sell its product only in one central location to which all shoppers must come: high-end designers such as Giorgio Armani or Burberry for example, do this. Alternatively, it may decide to offer the product at many locations spaced throughout the city: McDonald's, Dunkin' Donuts, and Subway are obvious examples. Customers are not indifferent between these alternative strategies. If the firm sells only at one central location, those who do not live in the middle of town have to incur travel costs to come to the store. These costs are greatest for those living farthest from the center. The alternative strategy of selling at many different locations allows more consumers to purchase the good without going too far out of their way.

When geography is taken into account and traveling is costly, consumers are willing to pay more for a product marketed close to their own geographic location. In this case, products are differentiated by the locations at which they are sold. This setting is known as the *spatial model of product differentiation*, pioneered by Hotelling (1929).[1]

[1] Hotelling (1929) was concerned with analyzing competition between two stores whereas we consider here the case in which the stores are owned by the same firm and so act cooperatively.

Before presenting the model formally, there is a very important feature of the model that must be emphasized. It proves convenient to develop the model using a geographic representation that can easily be interpreted. With just a little imagination, however, geographic space can be transformed into a "product" or, more properly "characteristics space." In such a space, each consumer's "location" reflects that consumer's most preferred set of product characteristics such as color, style, or other features. Recall our earlier discussion in Chapter 4 of a soft-drink firm offering a product line differing in terms of sugar content. That example made use of precisely this type of horizontal or spatial differentiation.

Extending the analogy, the travel cost of the geographic model can be interpreted as a psychic or utility cost that the consumer incurs if she must purchase a good whose characteristics are "distant" from her most preferred type. Just as consumers prefer to go to video stores close to their home, so they prefer to buy clothes that are "close" to their individual preferred style, or soft drinks close to their preferred amount of sugar content. In fact, Hotelling suggested just this interpretation in his seminal article:

> Distance, as we have used it for illustration, is only a figurative term for a great congeries of qualities. Instead of sellers of an identical commodity separated geographically we might have considered two . . . cider merchants . . . one selling a sweeter liquid than the other. If consumers of cider are thought of as varying by infinitesimal degrees in the sourness they desire, we have much the same situation as before. The measure of sourness now represents distance, while instead of transportation costs there are degrees of disutility resulting from the consumer getting cider more or less different from what he wants. (Hotelling, 1929, 54)

7.2 MONOPOLY AND HORIZONTAL DIFFERENTIATION

Assume that there is a town spread out along a single road, call it Main Street, that is one mile in length. There are N consumers who live spaced evenly along this road from one end of town to the other. A firm that has a monopoly in, for example, fast food must decide how to serve these consumers at the greatest profit. What this means is that the monopolist must choose the number of retail outlets or shops that it will operate, where these should be located on Main Street, and what prices should be charged. In the product differentiation analogy to drinks of different sweetness, the monopolist has to decide how many different drinks it should offer, what their precise degrees of sweetness should be, and what their prices should be. More generally, what range of products should the monopolist bring to the market and how should they be priced? In what follows we use the geographic interpretation of the model for clarity, but we again emphasize that you should always bear in mind its much wider interpretation.

In this section, we consider cases in which the monopolist does not price discriminate among the consumers that are served.[2] When a consumer travels to a retail outlet in order to buy a product the consumer incurs transport costs. We assume that the transportation cost is t per unit of distance (there-and-back) traveled. Except for their addresses or their locations, consumers are identical to each other. We further assume that in each period each consumer is willing to buy exactly one unit of the product sold by the monopolist provided that the price paid, including transport costs, which we call the *full price*, is less than the reservation price, which we denote by V.

[2] The case in which the monopolist price discriminates is developed in section 7.4.

Suppose that the monopolist decides to operate only a single retail outlet. Then it makes sense to locate this outlet at the center of Main Street. Now consider the monopolist's pricing decision. The essentials of the analysis are illustrated in Figure 7.1. The westernmost resident (residing at the left end of the diagram) has an address of $z = 0$, the easternmost resident has an address of $z = 1$, and the shop is located at $z = 1/2$.

The vertical axis in Figure 7.1 measures the price. A price of V in this diagram is the reservation price for each consumer. The full price that each consumer pays is comprised of two parts. First, there is the price p_1 actually set by the monopolist. Secondly, there is the additional cost consumers incur in getting to the shop (and back home). Measured per unit of distance there and back, the *full price* actually paid by a consumer who lives a distance x from the center of town is the monopolist's price plus the transport cost, or $p_1 + tx$. This full price is indicated by the Y-shaped set of lines in Figure 7.1. It indicates that the full price paid by a consumer at the center of town—one who incurs no transport cost—is just p_1. However, as the branches of the Y indicate, the full price rises steadily above p_1 for consumers both east and west of the town center. So long as distance from the shop is less than x_1, the consumer's reservation price V exceeds the full price $p_1 + tx$ and such a consumer buys the monopolist's product. However, for distances beyond x_1 the full price exceeds V and these consumers do not buy the product. In other words, the monopolist serves all those who live within a distance of x_1 units of the town center.

How is the distance x_1 determined? Consumers who reside distance x_1 from the shop are just indifferent between buying the product and not buying it at all. For them, the full price $p_1 + tx_1$ is equal to V so we have:

$$p_1 + tx_1 = V \text{ which implies that } x_1 = \frac{V - p_1}{t} \tag{7.1}$$

It is important to note that x_1 is just a fraction. Because the town is one mile long, x_1 is a fraction of a mile and the retail outlet sells to a fraction $2x_1$ of the whole town—because it sells to consumers that fall to the left and to the right of the market center so long as they live no further than x_1 from the shop. Recall that we assume that there are N consumers evenly distributed over Main Street. Accordingly, there are $2x_1N$ consumers who each are willing to buy one unit of the product if it is priced at p_1. By substituting the expression for x_1 from

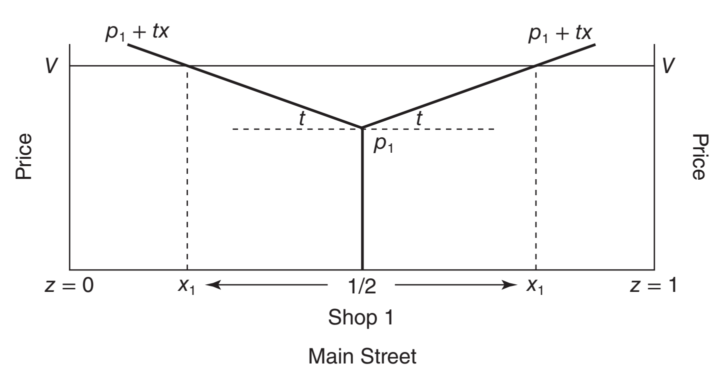

Figure 7.1 The full price of the shop on Main Street
The full price, including transport cost, rises as consumers live farther from the shop.

equation (7.1) into the number of customers served by the monopolist, $2x_1N$ at price p_1, we find that the total demand for the monopolist's product given that it operates just one shop is:

$$Q(p_1, 1) = 2x_1N = \frac{2N}{t}(V - p_1) \tag{7.2}$$

Equation (7.2) tells us something interesting. Even though we have assumed that each consumer buys exactly one unit or none of the monopolist's product, the demand function of equation (7.2) shows that aggregate demand smoothly increases as the monopolist lowers its price. The reason is illustrated in Figure 7.2. When the shop price is reduced from p_1 to p_2 demand increases because *more consumers are willing to buy the product at the lower price*. Now all consumers within distance x_2 of the shop buy the product.

This raises an important question. Suppose that the monopolist wants to sell to every customer in town. What is the *highest* price that the monopolist can set and still be able to sell to all N consumers? The answer must be the price at which the consumers who live furthest from the shop, i.e., those who are half a mile away, are just willing to buy. At any shop price p these consumers pay a full price of $p + t/2$ and so will buy only if $p + t/2 \leq V$. What this tells us is that with a single retail outlet located at the market center, the maximum price that the monopolist can charge and still supply the entire market of N consumers with its one store is $p(N, 1)$ given by:

$$p(N, 1) = V - \frac{t}{2} \tag{7.3}$$

Suppose that the monopolist's marginal production costs are c per unit sold. Suppose also that there are set-up costs of F for each retail outlet. These set-up costs could be associated with the cost of buying a site, commissioning the building, and so on. In the product differentiation analogy, the setup costs might be the costs of designing and marketing the new product. Whatever the framework, the monopolist's profit with a single retail outlet that supplies the entire market is:

$$\pi(N, 1) = N[p(N, 1) - c] - F = N\left(V - \frac{t}{2} - c\right) - F \tag{7.4}$$

We can now confirm that this single shop should indeed be located in the center of town. Very simply, this is the location that makes it possible for the single outlet to supply the

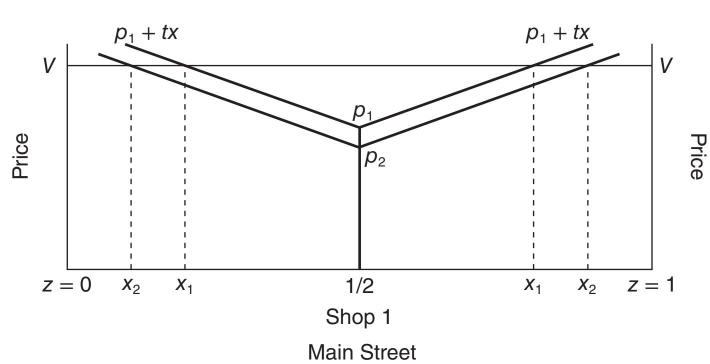

Figure 7.2 Lowering the price at the shop on Main Street
A fall in the shop price brings additional customers from both east and west.

entire market at the highest possible price. To see why, note that at the price $p = V - \frac{t}{2}$, a move a little to the east will not gain any new customers on the east end of town (there are no more to gain) but will lose some of those at the extreme west end of town. In other words, if the firm moves from the center, the only way it can continue to serve the entire town is by cutting its price below $V - \frac{t}{2}$. Only by locating its single outlet at the center can it reach all customers with a price as high as $V - \frac{t}{2}$.

Of course, there is no reason to believe that the monopolist will actually want to operate a single outlet. What happens when there are two, or three, or n outlets along Main Street? As before, we continue to assume that unit cost at each shop is c per unit sold and that the set-up cost for each outlet is F. In other words there are no scope economies from operating multiple outlets. We start by asking what happens if the number of retail outlets is increased to two. Because each segment of the market along Main Street is the same and each shop has the same costs, the monopolist will choose to set the same price at each shop. Moreover the monopolist will want to coordinate the location of these two shops so as to maximize the price charged at a shop while still reaching the entire market. In other words, the same intuition that justifies a central location with one outlet can be used to show that the optimal location strategy with two outlets is to locate one of the two 1/4 mile from the left-hand end and the other 1/4 mile from the right-hand end of Main Street, as in Figure 7.3.[3]

With two retail outlets located as we have just discussed, the maximum distance that any consumer has to travel to a shop is 1/4 mile—much less than the 1/2 mile when there is only one retail outlet. As a result, the highest price that the monopolist can charge and supply the entire market is:

$$p(N, 2) = V - \frac{t}{4} \tag{7.5}$$

which is higher than the price with a single retail outlet. The monopolist's profit is now:

$$\pi(N, 2) = N\left(V - \frac{t}{4} - c\right) - 2F \tag{7.6}$$

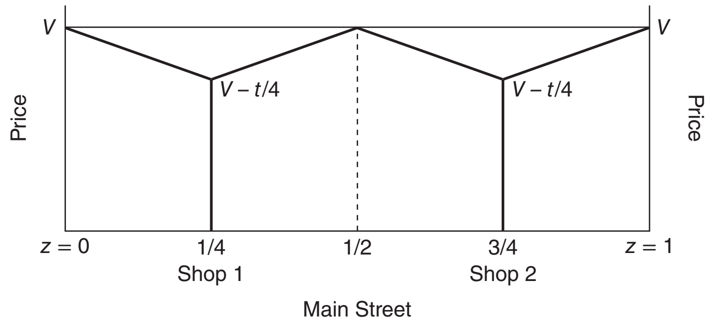

Figure 7.3 Opening two shops on Main Street
The maximum price is higher with two shops than it is with one.

[3] For the interested reader, a formal proof of this result is given in Mathematical Appendix 1 to this chapter.

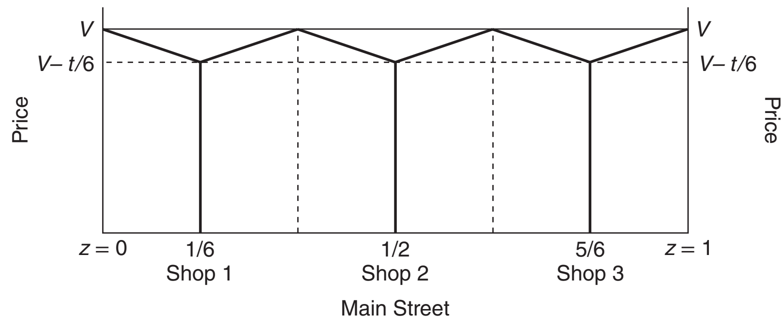

Figure 7.4 Opening three shops on Main Street

Now suppose that the monopolist decides to operate three shops. By exactly the same argument as above, these shops should be located symmetrically at 1/6, 1/2, and 5/6 miles from the left-hand end of the market so that each supplies 1/3 of the market, as illustrated in Figure 7.4. The maximum distance that any consumer has to travel now is 1/6 mile, so the price at each shop (again assuming, of course, that all consumers are to be served) is:

$$p(N, 3) = V - \frac{t}{6} \tag{7.7}$$

While profit is now

$$\pi(N, 3) = N\left(V - \frac{t}{6} - c\right) - 3F \tag{7.8}$$

There is, in fact, a general rule emerging. If the monopolist has n retail outlets to serve the entire market, they will be located symmetrically at distances $1/2n, 3/2n, 5/2n, \ldots, (2i - 1)/2n, \ldots, (2n - 1)/2n$ from the left-hand end of the market. The maximum distance that any consumer has to travel to a shop is $1/2n$ miles, so the price that the monopolist can charge at each shop while supplying the entire market is

$$p(N, n) = V - \frac{t}{2n} \tag{7.9}$$

At this price, its profit is

$$\pi(N, n) = N\left(V - \frac{t}{2n} - c\right) - nF \tag{7.10}$$

Note an important feature of this analysis. As the number of retail outlets n increases, the monopolist's price at each outlet gets closer and closer to the consumer's reservation price V. In other words, by increasing the number of shops, the monopolist is able to charge each consumer a price much closer to the consumer's maximum willingness to pay, V, and thereby appropriate a much greater proportion of consumer surplus.

The moral of the foregoing analysis is clear—especially when we remember to interpret the geographic space of Main Street as a more general product space. Even if no scope economies are present, a monopolist has an incentive to offer many varieties of a good. Doing so allows the monopolist to exploit the wide variety of consumer tastes, charging each consumer a high price because each is being offered a variety that is very close to the consumer's specific most preferred type. It is not surprising, therefore, that we see such extensive product proliferation in real-world markets such as those for cars, soft drinks, toothpastes, hair shampoos, cameras, and so on.[4]

However, there must be some factor limiting this proliferation of varieties or outlets. We do not observe a McDonald's on every street corner, or a personally customized Ford *Focus*, or each person's custom-designed breakfast cereals or soft drinks! We therefore need to think about what constrains the monopolist from adding more and more retail outlets or product variants. Equation (7.10) gives the clue. Admittedly, adding additional retail outlets allows the monopolist to increase its prices. However, the establishment of each additional new shop or new product variant also incurs an additional set-up cost. If, for example, the monopolist decides to operate $n+1$ retail outlets its profit is

$$\pi(N, n+1) = N\left(V - \frac{1}{2(n+1)} - c\right) - (n+1)F \tag{7.11}$$

This additional shop, or variety of drink, or new product variant increases profit if and only if $\pi(N, n+1) > \pi(N, n)$, which requires that:

$$\frac{t}{2n}N - \frac{t}{2(n+1)}N - F > 0$$

This simplifies to:

$$n(n+1) < \frac{tN}{2F} \tag{7.12}$$

Suppose, for example, that there are 5 million consumers in the market so that $N = 5{,}000{,}000$ and that there is a fixed cost $F = \$50{,}000$ associated with each shop. Suppose further that the transport cost $t = \$1$. Hence, $tN/2F = 50$. Then if n is less than or equal to 6, equation (7.12) is satisfied, indicating that it is profitable to add a further shop. However, once the monopolist sets up $n = 7$ shops, equation (7.12) is no longer satisfied, indicating that it is not profitable to add any more shops. (You can easily check that the monopolist should operate exactly 7 shops for any value of $tN/2F$ greater than 42 but less than 56.)

If we ignore the fact that the number of retail outlets n has to be an integer, we can be even more precise about the profit maximizing number of retail outlets (or number of product variants). We show in the Appendix to this chapter that the monopolist maximizes profit as given by equation (7.10) with respect to the number of retail outlets n by setting

$$n^* = \sqrt{\frac{tN}{2F}} \tag{7.13}$$

Equations (7.12) and (7.13) actually have a simple and appealing intuition. The monopolist has to balance the increase in price and revenues that results from increased product variety against the additional setup costs that offering increased variety entails. What this tells us is that we would expect to find greater product variety in markets where there are many consumers (N is large), or where the set-up costs of increasing product variety are low

[4] See Shapiro and Varian (1999) for a similar argument regarding product variety in e-commerce markets.

(F is small), or where consumers have strong and distinct preferences regarding product characteristics (t is large).

The first two conditions should be obvious. It tells us why there are many more retail outlets in Chicago than in Peoria; why we see many franchise outlets of the same fast-food chain but not of a gourmet restaurant; and why we see many more Subway outlets in a city than Marriott hotels. What does the third condition mean? For a given number of shops, n, equation (7.12) tells us that an additional $(n + 1)$ shop will be increasingly desirable the greater that transportation cost t is. Thus, as t increases, so will the monopolist's optimal number of outlets or degree of product variety.

The intuition is that when t is high consumers incur very large costs if they are not offered their most preferred brand. That is, a large value of t implies that consumers are very strongly attached to their preferred product type or location and are unwilling to purchase products that deviate significantly from this type—or travel very far to buy the product—unless they are offered a significant price discount. If the monopolist is to continue to attract consumers while maintaining high prices it must tailor its products more closely to each consumer's unique demand, which requires that it offer a wider range of product variants—or operate more retail outlets.

To summarize, in this kind of market, adding a new shop or a new product variant does not necessarily mean increasing the total supply of the good. Instead, it means replacing some of an existing variety with an alternative variety that more closely matches the specific tastes of some customers. As we have seen, this also allows the firm to charge a higher price. Yet this advantage does not come free. The firm must incur the set-up cost F for each new outlet or product variant.

This raises another important question. Is it actually profitable for the monopolist to serve the entire market? To answer this question we need to identify the condition that determines whether the monopolist will prefer to supply only part of the market rather than the whole market.

If only part of the market is served then each retail outlet is effectively a "stand alone" shop whose market area does not touch that of the remaining outlets, as in Figure 7.5. Again, we use the mathematical appendix to show that the profit-maximizing price when only part of the market is served is $p^* = (V + c)/2$, which does not depend on the number of outlets or product variants the monopolist has. This leads to a simple rule that determines whether or not the entire market is to be served. Suppose that there are n retail outlets. Then we know from equation (7.9) that the price at which the entire market can be served is $p(N, n) = V - t/2n$. Serving the entire market is therefore better than supplying only part of the market provided $p(N, n) > p^*$. In turn, this requires:

$$V - \frac{t}{2n} > \frac{V + c}{2} \Rightarrow V > c + \frac{t}{n} \tag{7.14}$$

We can put this rule another way. What equation (7.14) tells us is that the monopolist's optimal pricing policy can be described as follows:

1. If marginal production cost plus per unit transport cost divided by the number of retail outlets, $c + t/n$, is greater than the consumers' reservation price V, the monopolist should set a price at each shop of $p* = (V + c)/2$ and supply only part of the market.
2. If marginal production plus per unit transport cost divided by the number of retail outlets, $c + t/n$, is less than the consumers' reservation price V, the monopolist should set a price at each shop of $p(N, n) = V - t/2n$ and supply the entire market.

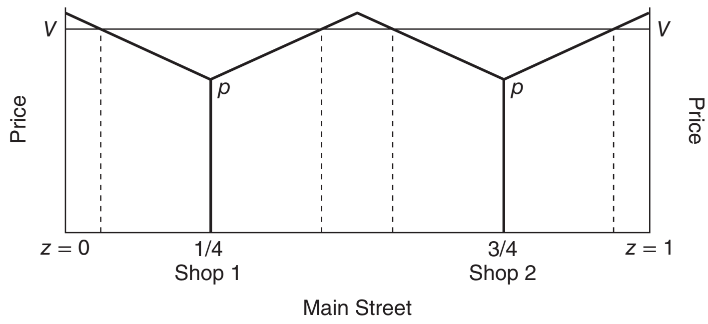

Figure 7.5 Non-competing retail shops on main street

The intuition behind this rule is relatively straightforward. When the consumer reservation price is low relative to production and transportation costs and when there are few outlets, trying to supply the entire market gives the monopolist a very low margin over operating costs and could even lead to selling at a loss. By contrast, when the consumer reservation price is high relative to the cost of production and transportation and there are many outlets, a price that allows the monopolist to supply the entire market offers a reasonable margin over costs. In these latter circumstances, the monopolist will not wish to set a high price that sacrifices any sales. Because the marginal revenue of every unit sold significantly exceeds the production cost, the monopolist will wish to sell all the units it can.

7.3 IS THERE TOO MUCH PRODUCT VARIETY?

Our analysis in the previous section implies that a profit-maximizing firm with market power may have an incentive to create a large number of outlets or product varieties so as to provide each consumer with something close to the consumer's most preferred product and thereby extract a high price. It is easy to think of real-world firms that, while not pure monopolists, have substantial market power and employ this strategy. For instance, automobile manufacturers market many varieties of compact, midsize, and large luxury-class cars. Franchise operations such as McDonald's or Subway grant exclusive geographic rights so as to space their outlets evenly over an area and avoid competition between neighboring franchises. Digital cameras come in a bewildering variety of styles and colors. Soft drink, cereal, and ice cream companies offer a wide array of minimally differentiated goods.

The sometimes overwhelming degree of product variety that we frequently observe raises the question whether the incentive to offer a wide variety of product types is too strong. Does the monopolist provide the degree of product variety that is consistent with maximizing social welfare? Or are the incentives so strong that the monopolist provides too much product variety? To answer this question, we first need to describe the socially optimal degree of product variety. Although the argument can be made in general terms, it is easiest to see the answer for the case in which the entire market is served.

We use the efficiency criterion to determine the optimality of the variety of products offered. This requires that we choose the degree of product variety that maximizes total surplus, which is defined, as usual, as aggregate consumer surplus plus producer profit.

Suppose that there are n retail outlets. With every consumer buying the product, the total consumer valuation placed on the monopolist's production is NV. To calculate aggregate consumer surplus we need to deduct from this valuation the total spending by consumers, which is payment of the product price, $Np(N, n)$ plus payment of the transport costs. Denote aggregate transport cost with n retail outlets as $T(N, n)$. Then aggregate consumer surplus is

$$CS(N, n) = NV - Np(N, n) - T(N, n) \tag{7.15}$$

Aggregate profit is receipt from consumers of the product price minus production costs and set-up costs.[5] In other words, aggregate producer profit is

$$\Pi(N, n) = Np(N, n) - Nc - nF \tag{7.16}$$

Summing these gives total surplus:

$$TS(N, n) = NV - Nc - T(N, n) - nF \tag{7.17}$$

Note that the first two terms of $TS(N, n)$ are independent of the number of retail outlets the firm establishes. In fact, once all N consumers are served, only two factors change as more stores or product varieties are added. One of these is the transport cost incurred by a typical or average consumer. Clearly, as more shops are added, more consumers find themselves closer to a store and this cost falls. That's the good news. The bad news is that adding more shops also incurs the additional setup cost of F per shop. Our question about whether the monopolist provides too many (or too few) shops thus comes down to determining whether it is the good news or the bad news that dominates.

More formally, when all consumers are served, the total surplus is the total value NV, minus the total production cost Nc, minus the total transportation and setup costs. Because the first two terms are fixed independent of the number of shops, maximizing the total surplus is equivalent to minimizing the sum of transportation and setup costs. Does the monopolist's strategy achieve this result?

One feature of the monopoly outcome makes answering this question a little easier. The monopolist always spaces its shops evenly along Main Street no matter how many it operates. That is, a single shop is located at the center, two shops are located at $1/4$ and $3/4$, and so on. This greatly simplifies the calculation of total transportation cost that consumers incur for any number of shops n.

Consider Figure 7.6, which shows both the full price and the transportation cost paid by those consumers buying from a particular outlet, shop i. As before, the top Y-shaped figure shows that a consumer located right next to the store has no transport cost and pays a price of $p = V - \frac{t}{2n}$. As we consider consumers farther from the shop, the branches of the Y show that the full price rises because these consumers incur greater and greater transportation costs. The lower branches in the figure provide a direct measurement of this transportation cost for each such consumer. Again, the transportation cost for a consumer located right next to the store is zero. It rises gradually to $t/2n$—the transportation cost paid by a consumer who lives the maximum distance from the shop. Total transportation cost for the consumers of shop i is the sum of the individual transportation cost of each consumer.

5 Transportation costs are paid by consumers and so do not figure into the profit calculation.

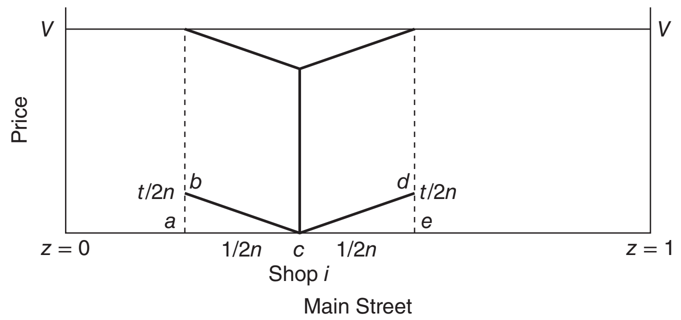

Figure 7.6 Costs of serving customers when there are n shops

This is indicated by the areas of the symmetric triangles *abc* and *cde* in Figure 7.6. Each of these triangles has a height of $t/2n$. Each also has a base $1/2n$. Hence, the area of each is $t/8n^2$. Remember though that the base reflects the fraction of the total N consumers that shop i serves in either direction. This means that to translate this area into actual dollars of transportation costs that the consumers of shop i pay, we have to multiply through by N. The result is that the customers who patronize shop i from the east pay a total transportation cost of $tN/8n^2$ as do those who patronize it from the west. The total transportation costs incurred by all consumers of shop i is therefore the sum of these two amounts, or $tN/4n^2$. If we now multiply this by the number of shops n, we find that the total transportation costs associated with all n shops is simply $T(N,n) = tN/4n$. The same exercise tells us that the total setup costs for all n shops is nF. Accordingly, the aggregate transportation plus setup costs associated with serving all N customers and operating n shops are:

$$C(N,n) = \frac{tN}{4n} + nF \tag{7.18}$$

By the same argument, aggregate transportation plus setup costs with $(n+1)$ shops are

$$C(N,n+1) = \frac{tN}{4(n+1)} + (n+1)F \tag{7.19}$$

Recall that our goal is to minimize this total cost. Therefore, we want to add an additional shop so long as doing so results in a reduction in total costs. Comparison of equations (7.19) and (7.18) indicates that this will be the case, that is, $C(n+1) < C(n)$, if:

$$\frac{tN}{4n} - \frac{tN}{4(n+1)} > F \tag{7.20}$$

Simplification of this inequality tells us that it will be socially beneficial to add one more shop or one more product variant beyond the n existing ones so long as:

$$n(n+1) < \frac{tN}{4F} \tag{7.21}$$

Suppose that, as in our calculation of the profit-maximizing number of retail outlets, we ignore the integer constraint on n. Then we show in Mathematical Appendix 4 that the number of retail outlets maximizes social surplus is, from (7.14):

$$n^o = \sqrt{\frac{tN}{4F}} \tag{7.22}$$

Now compare condition (7.21) or (7.22) with condition (7.12) or (7.13), which describes the situation under which the monopolist finds it profitable to add an additional shop. The denominator of the right-hand-side term is $2F$ in equations (7.12) and (7.13) while it is $4F$ in (7.21) and (7.22). This means that it is less likely for an additional shop to meet the requirement of equation (7.21) and be socially desirable than it is for it to meet the requirement of equation (7.12) and enhance the monopolist's profit. In other words, the monopolist has an incentive to expand product variety even when the social gains from doing so have been exhausted. The monopolist chooses too great a degree of product variety. [See Spence (1976).]

Taking the same example that we had earlier in which $t = \$1$, $N = 5{,}000{,}000$, and$F = \$50{,}000$. We then have that $tN/4F = 25$. In this case, equation (7.21) implies that the socially optimal number of shops is five. However, we have already shown that the monopolist would like to operate seven shops or offer seven product varieties in this market.

Casual evidence supports the "too much variety" hypothesis. Look at the myriad of ready-to-eat breakfast cereals offered by the major cereal firms, the multitude of options available on automobiles, and the vast array of finely distinguished perfumes and lipsticks available at department stores around the country. Admittedly, the producers of these goods are not pure monopolists, but they do exercise considerable market power and so they are likely subject to many of the same influences that we have just been considering.

The basic reason why a monopolist offers too much variety is that the firm maximizes profit, not total surplus. When deciding to add another shop, the monopolist balances the additional setup cost against the additional revenues that it can earn from being able to increase prices. However, from the viewpoint of efficiency this additional revenue is not a net gain. It is just a transfer of surplus from consumers to the monopolist. The true social optimum balances the setup cost of an extra shop against the reduction in transportation costs that results. Clearly, this criterion will lead to the establishment of fewer shops than will the criterion used by the monopolist.

Operating additional shops is attractive to a monopolist because this is the easiest way to reach what would otherwise be distant consumers. The monopolist operating just one shop at the center of Main Street can only sell to customers at the eastern and western ends of town by greatly reducing the price *to all customers*. The incentive to operate additional shops is that it permits reaching consumers without so significant a price reduction.

This raises another issue that takes us back to the discussion in Chapters 5 and 6. If somehow the firm could charge a price to distant consumers that they are willing to pay *without* lowering the price to nearby ones, then reaching these distant consumers from just a few shops or with just a few varieties might be more attractive. That is, if the monopolist could price discriminate, the tendency to oversupply variety might be much less strong. We now examine this possibility.

7.4 MONOPOLY AND HORIZONTAL DIFFERENTIATION WITH PRICE DISCRIMINATION

In our discussion thus far, we have been assuming that the monopolist does not price discriminate between its customers. This makes sense when customers travel to the shop to purchase the good and so do not reveal their addresses, or who they are to the monopolist. Suppose instead that the monopolist controls delivery of the product, and so knows who is who by their address in the market. What pricing policy might we expect the monopoly firm to adopt?

It should be clear that when the monopolist controls delivery it will charge every consumer the consumer's reservation price V. This is a pricing policy known as *uniform delivered pricing*. A firm adopting such a pricing policy charges all consumers the same prices and absorbs the transportation costs in delivering the product to them. This is discriminatory pricing because even though consumers pay the same price, this price does not reflect the true costs of supplying consumers in different locations. By way of analogy, charging a consumer in San Francisco the same price as a consumer in New York for a product manufactured in New York is just as much discriminatory pricing as charging a different price for this product to two different New York residents.

As in the no-price-discrimination case, we should check whether the monopoly firm actually wants to supply every consumer. Suppose that, as before, the firm operates n retail outlets evenly spaced along Main Street. Then the transportation and production costs that the firm incurs in supplying the consumers located furthest away from a retail outlet are $c + t/2n$. There is profit to be made from such sales provided that:

$$V > c + t/2n \tag{7.23}$$

Notice that this is a weaker condition than equation (7.14) without price discrimination. This is another example of a typical property of price discrimination. It allows the monopolist to serve consumers who might otherwise be left unserved.

Now consider how many shops (or product varieties) the price-discriminating monopolist will choose to operate. Given that the firm is supplying the entire market and is charging every consumer the consumer's reservation price of V, the firm's total revenue is fixed at NV. Total costs are variable production costs, which are fixed at Nc, plus the transport costs that the firm absorbs $T(N, n)$ and the set-up costs nF. These two latter costs are just the total costs $C(N, n)$ from equation (7.18). Thus the profit of the price-discriminating monopolist is:

$$\pi(N, n) = NV - Nc - \left(\frac{tN}{4n} + nF\right) \tag{7.24}$$

How does the monopolist maximize profit in this case? Because the first two terms in (7.24) are fixed, independent of n, profit maximization is achieved by minimizing the costs $C(N, n)$. But this means that *the discriminating monopolist chooses to offer the socially efficient degree of product variety*.

If you recall our discussion of price discrimination in Chapter 5, you should not find this too surprising. We saw in that chapter that a monopolist who engages in first-degree price discrimination extracts all consumer surplus and therefore wants to produce the efficient amount of output. The result just obtained extends that finding to the case of a product differentiated market. In such a market, a firm that can achieve first-degree price discrimination not only produces the socially efficient output but also the socially efficient amount of product variety. With perfect price discrimination the firm expropriates all consumer surplus. As a result, the degree of product variety that maximizes total profit is just the degree of product variety that maximizes total surplus. The incentive to go beyond the socially optimal degree of product variety does not exist.

Price discrimination in a geographic spatial model has a clear interpretation—the monopoly firm incurs the delivery cost and in doing so charges different net prices for the same good. How do we interpret price discrimination in a product characteristics space rather than a geographic one? Alternatively, how can a monopolist control "delivery" of products that are differentiated by characteristics rather than by location? MacLeod, Norman, and Thisse (1988) [See also Borenstein (1985).] provide the analogy:

> In the context of product differentiation, price discrimination arises when the producer begins with a "base product" and then redesigns this product to the customers' specifications. This means that the firm now produces a *band* of horizontally differentiated products ... instead of a single product ... Transport cost is no longer interpreted as a utility loss, but as an additional cost incurred by the firm in adapting its product to the customers' requirements ... (So) long as product design is under the control of the producer— equivalent to the producer controlling transportation—he need not charge the full cost of design change. (1988, pp. 442–3)

Consider, for example, buying a Ford *Taurus*. On the one hand you might choose one of the standard variants. Alternatively, the salesperson might persuade you into taking a different sound system, different wheels, an attractive stripe along the side that makes the car sportier, and so on. Effectively, what the salesperson is doing is making you reveal your actual "address" through the options you choose, with perhaps the intention of also separating you from more of your money.

But how easy is it for firms to offer this type of product customization? After all, customization would seem to imply the sacrifice of economies of scale and so increase costs. You might be surprised to learn that it is becoming easier and less costly by the day. The ability to offer this type of product range is what distinguishes *flexible manufacturing systems*, defined as "production units capable of producing a range of discrete products with a minimum of manual intervention" (US Office of Technology Assessment, 1984, p. 60). We discussed the properties of these types of manufacturing processes in Chapter 4, and they are becoming increasingly common. Companies such as Levi Strauss, Custom Shoe, Italian ceramic tile manufacturers, Ford, Mitsubishi, and Hitachi all operate flexible manufacturing systems. Any of you who regularly use web retailers such as Amazon.com will have noticed that the initial page you see upon entering the site changes over time to reflect your buying habits. You eventually have your very own, customized entry page resulting in your very own, customized prices.[6]

[6] A clear, if brief, expression of the view that e-commerce firms greatly facilitate price discrimination may be found in P. Krugman, "Reckonings: What Price Fairness," *New York Times*, October 4, 2000, p. A16.

7.1 Practice Problem

Henry Shortchap is the only blacksmith in the small village of Chestnut Tree. The village is composed of twenty-one households evenly distributed one-tenth of a mile apart along the main street of the town. Each such household uses at most one unit of smithing services per month. In addition, each household incurs a there-and-back-again transport cost of $0.50 for every tenth of a mile it lives from Shortchap's smithery. The reservation price of each household for such services is $10. Henry's cost of providing smithing services is $2 per unit. However, he can operate only one shop at most. Where should Henry locate his shop and what price should he charge? Suppose instead that Henry could operate a mobile smithy that allowed him to offer his services at his customers' homes. However, it would cost him $0.75 there-and-back-again transport costs for every tenth of a mile he has to move his smithy. Should he switch to this mobile service?

7.5 VERTICAL PRODUCT DIFFERENTIATION

The distinguishing feature of horizontal product differentiation is that consumers do not agree on what is the preferred variety of product. So, if two different varieties are offered at the same price, some consumers are likely to buy one variety and other consumers will buy the other. *Vertical differentiation* is different. In this case, all consumers agree on what is the preferred or best product, the next to best product, and so on. If a high- and a low-quality good are offered at the same price, all consumers will buy the high-quality good. Lower quality goods will find a market only if they are offered at sufficiently lower prices. A Chevrolet costs much less than a Cadillac. No-frills airlines such as JetBlue and Southwest attract customers because their flights are offered at large discounts relative to the larger carriers such as United and American. The Empire Hotel in New York charges much less than the Waldorf Astoria. However, while all consumers agree in their ranking of products from highest to lowest quality, they differ in their willingness to pay for quality. This may occur because consumers have very different incomes or simply because they have different attitudes regarding what quality is worth.

We would like to understand the incentives a monopoly firm has to offer different qualities of a product and the prices that it will charge for them. The analysis we use for this purpose is a simplified one. Nevertheless, it captures much of the flavor of more general treatments.[7]

7.5.1 Price and Quality Choice with Just One Product

We first consider how changes in quality affect consumer demand when the firm offers just one product and each consumer buys at most one unit of the good. This will give us some idea of how quality or product design can be used to enhance a firm's profit. We next examine how the firm might increase its profit by offering more than one quality of a product. The firm knows that there is some feature, or set of features, that can be used to measure the product quality valued by consumers. The firm's ability to choose these features means that it can choose the quality of product as well as its price.

[7] The first and classic treatment of this problem is Mussa and Rosen (1978). Unfortunately, this is also a rather complex analysis.

Suppose, then, that the firm knows that each consumer is willing to pay something extra to get a higher quality product, but the precise amount extra varies across consumers. Some consumers place a high value on quality and will gladly pay a considerable premium for a quality improvement. Others are less concerned with quality and, unless the accompanying price increase is minimal, such consumers do not buy a better quality but higher priced good. In other words, each consumer examines the price and quality of the product and the utility obtained from consuming it. If the consumer places a value on the quality of product offered that is greater than the price being charged, the consumer purchases the good—say a CD player. If not, the consumer simply refrains from buying altogether.

The demand curve facing the monopolist depends on the precise quality of the product marketed. This is reflected in the inverse demand function, denoted by $P = P(Q, z)$, where the market clearing price P depends not only on how much the firm produces Q but also on the quality z of these units. To put it somewhat differently, an increase in quality z raises the market-clearing price for any given quantity, Q. The demand curve shifts out (or up) as product quality z increases.

It is useful to distinguish between two different ways that an increase in quality can shift the inverse demand curve $P(Q, z)$. Each is illustrated in Figure 7.7. To better understand this diagram, note that because consumers vary in terms of their willingness to pay for a good of given quality z, and because each consumer buys at most one unit of the good, the demand curve really reflects a ranking of consumers in terms of their reservation prices for a good of a specific quality z. The reservation price of the consumer most willing to pay for the good is the intercept term. The reservation price of the consumer next most willing to pay is the next point on the demand curve as we move to the right, and so on. In both Figures 7.7(a) and 7.7(b), the initial quantity produced is Q_1 and the initial quality is z_1. The market-clearing price for this quantity–quality combination is P_1. From what we have just said, this price must be the willingness to pay or the reservation price of the Q_1th consumer. At price P_1, this consumer is just indifferent between buying the good and not buying it at all given that it is of quality z_1. This consumer is called the marginal consumer. Consumers to the left—those consumers who also buy the product—are called *infra*marginal consumers.

Figure 7.7(a) shows how the inverse demand curve shifts when there is an increase in quality that raises the willingness to pay of the inframarginal consumers by more than it

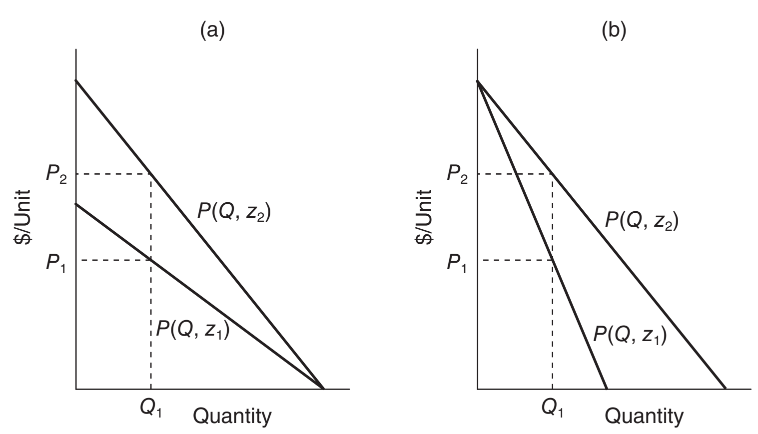

Figure 7.7 Impact of quality on demand

raises the willingness to pay of the marginal consumer. An increase in quality from z_1 to z_2 raises the price at which the quantity Q_1 sells from P_1 to P_2. However, the increase in the reservation price is greatest for consumers who were already purchasing the product so that the demand curve shifts by "sliding along" the price axis. Figure 7.7(b) illustrates the alternative case. Here, the increase in quality from z_1 to z_2 increases the willingness to pay of the Q_1th or marginal consumer by proportionately more than it raises the reservation price of the inframarginal consumers. Once again, this quality increase raises the market price of quantity Q_1 from P_1 to P_2. However, the demand curve now shifts by "sliding along" the quantity axis.[8]

Whether demand is described by Figure 7.7(a) or 7.7(b), we can see that for the monopolist the choice of quality really amounts to a decision as to which demand curve it faces. Increases in quality are attractive because they rotate the demand curve and so increase the firm's revenue at any given price. However, it is normally costly to increase product quality. Therefore what the monopolist has to do is balance the benefits in increased revenue that improved quality generates against the increased costs that increased quality incurs. More precisely, the monopolist choosing quality should think through the profit-maximizing calculus in a way similar to that used when choosing output or price. For any given choice of output, the monopolist should choose the level of quality at which the marginal revenue from increasing quality equals the marginal cost of increasing quality. In other words, the monopolist that controls both quality and quantity of its product has *two* profit maximizing conditions to satisfy. These are:

1. For a given choice of quality, the marginal revenue from the last unit sold should equal the marginal cost of making that unit at that quality;
2. For a given choice of quantity, the marginal revenue from increasing quality of each unit of output should equal the additional (marginal) cost of increasing the quality of that quantity of output.

We illustrate the quality or product design choice by assuming demand is of the type shown in Figure 7.7(a). More specifically, assume that the demand function is given by the equation:

$$P = z(50 - Q) = 50z - zQ \tag{7.25}$$

Equation (7.25) says that regardless of the quality of the product, at a price of zero a total of 50 units will be sold but increased quality causes the demand function to rotate clockwise about the point $Q = 50$.

Let us also keep the example simple by assuming that the cost of improving quality is a sunk design cost so that marginal *production* cost is independent of the quality of the product. A better film or software package may require say, more expensive script or programming, respectively, but the actual costs of showing the film or printing the CD are independent of how good it is. To make matters even simpler, let us further assume that production costs are not only constant but also zero. Design costs, however, rise with the quality level chosen. Specifically, we shall assume that design costs are:

$$F(z) = 5z^2 \tag{7.26}$$

[8] For models based on the case illustrated in Figure 7.7(b), some care must be taken to limit the ultimate size of the market. That is, quality increases cannot indefinitely expand the quantity demanded at a given price.

which implies that the marginal cost of increasing product quality is $10z$ (see Appendix 5).[9] We can now write the firm's profit to be:

$$\pi(Q, z) = P(Q, z)Q - F(z) = z(50 - Q)Q - 5z^2 \tag{7.27}$$

Consider first the profit-maximizing choice of output. This turns out to be very simple in this case. As usual, marginal revenue has the same intercept as the demand function but twice the slope. So with the demand function $P = 50z - zQ$ we know that marginal revenue is $MR = 50z - 2zQ = z(50 - 2Q)$. Equating this with marginal cost gives the profit-maximizing output condition: $z(50 - 2Q) = 0$. Hence, the profit-maximizing output is: $Q^* = 50/2 = 25$.

In this simple example, the monopolist's quantity choice is independent of the quality choice. The profit-maximizing output remains constant at $Q^* = 25$ no matter the choice of quality. Going back to the demand function, the profit-maximizing price is given by $P^* = z(50 - Q^*)$ so that the optimal price is: $P^* = 25z$. Unlike output, the profit-maximizing price ***is*** affected by the choice of quality. Moreover, the quality choice also affects the firm's design costs. A higher quality design z permits the monopolist to raise price and earn more revenue but it also raises the firm's costs. This is the tradeoff that the monopolist must evaluate.

To choose the profit-maximizing quality the monopolist must compare the additional revenue resulting from an increase in z with the increase in design cost that the higher quality requires. Because the quantity sold is constant at $Q^* = 25$, the additional revenue of an increase in quality is just this output level times the difference in price that can be charged following the rise in quality. In our example, we can see from equation (7.20) that the firm's revenue PQ at product quality z when it charges the profit-maximizing price $P^* = 25z$, is:

$$P^*Q^* = 25z25 = 625z \tag{7.28}$$

So, increasing product quality by one "unit" increases revenue by \$625, which is therefore the marginal revenue from increased quality. We know also from equation (7.25) that the marginal cost of increased quality is $10z$. Equating marginal revenue with marginal cost then gives the profit-maximizing quality choice:

$$z^* = 625/10 = 62.5 \tag{7.29}$$

An interesting question that arises in connection with the monopolist's choice of quality is how that choice compares with the socially optimal one. Does the monopolist produce too

[9] For an intuitive understanding, recall that marginal cost is measured at a precise value of z, e.g., we can think of the marginal cost of quality at $z = 2$, or at $z = 8$. Wherever marginal cost is measured however, it is meant to capture *both* the cost increment of increasing quality by a small amount and the cost savings from decreasing quality by a small amount. In principle, the answer to either of these questions should be the same. However, if we consider a one-unit increase in quality, the change in cost is: $5(z + 1)^2 - 5z^2 = 5(2z + 1)$, whereas if we consider a one-unit decrease in quality, the cost savings is: $5z^2 - 5(z - 1)^2 = 5(2z - 1)$. Because we get a slightly different answer depending on whether we measure marginal cost as an increase from raising quality or a decrease from reducing it, and because we want to have just one answer, we simply take the average of the two to get a marginal cost of higher quality $= 5 \times 2z = 10z$.

high or too low a quality of good? Looking at Figure 7.7(a) you might be able to work out that in this case the monopolist's quality choice is too low. The reason is straightforward. An increase in z rotates the demand curve upward and increases the total surplus earned from the 25 units that are always sold. The social optimum requires that quality be increased so long as this gain in total surplus exceeds the extra design cost. However, the monopolist only gets to keep the increase in producer surplus that a quality increase generates. As a result, profit maximization leads the monopoly firm to increase quality only so long as the extra producer surplus covers the additional design cost. Because the producer surplus is less than the total surplus, the monopolist will stop short of producing the socially optimal quality. Of course, the monopolist holds quantity below the optimal amount, too.

Our primary objective however is not to determine whether firms with monopoly power choose to market products of either too low or too much quality. The main point is to show that for such firms the quality choice matters. By carefully choosing product quality jointly with product price, the monopolist can again extract further surplus from the market.

7.2 Practice Problem

Will Barret is the only lawyer in the small country town of Percyville. The weekly demand for his legal services depends on the quality of service he provides as reflected by his inverse demand curve: $P = 4 - Q/z$. Here, P is the price per case; Q is the number of cases or clients; and z is the quality of service Will provides. Will's costs are independent of how many cases he actually takes, but they do rise with quality. More specifically, Will's costs are given by: $C = z^2$.

a. Draw Will's demand curve for a given quality, z. How do increases in z affect the demand curve?
b. Consider the three options: $z = 1$, $z = 2$, and $z = 3$. Derive the profit maximizing output for each of these choices.
c. Compute the market price and profit—net of quality costs—for each of the three choices above. Which quality choice leads to the highest profits?

7.5.2 Offering More than One Product in a Vertically Differentiated Market

Now that we have worked through the basics of how product quality can affect market demand, let's consider a multi-product strategy. To make it simple, suppose that the monopolist knows there are only two different types of consumer, distinguished by their willingness to pay for quality. Each consumer type buys at most one unit of the firm's product per period. In deciding which quality of product to buy, a consumer buys the quality of product yielding the greatest consumer surplus. For consumer type i the consumer surplus obtained from consuming a product of quality z at price p is:

$$V_i = \theta_i(z - \underline{z}_i) - p \quad (i = 1,2) \tag{7.30}$$

In this equation, θ_i is a measure of the value that consumers of type i places on quality and $\underline{z}_i$ is the lower bound on quality below which a consumer of type i chooses not to

Reality Checkpoint

Room Service? We'd like a baby and a bottle of your best champagne!

Although hospitals are always under pressure to rein in costs, they are also always on the lookout for ways to raise quality—at least for those who are willing to pay for it. Offering high-end rooms and service to those who have a taste for such amenities and a willingness to pay for it is a way to attract more revenue from the wealthiest of patients. As a result, the last decade has seen a very healthy splurge in spending on deluxe units. For example, in a growing number of maternity wards, moms-to-be who are willing to pay a little more can get private suites, whirlpool baths, Internet access, and top culinary food. For an extra fee, St. Vincent's Hospital in Indianapolis throws in a massage and the services of a professional photographer. Robert Wood Johnson Hospital in New Jersey allows patients to order from a restaurant-style menu and serves a "high tea" daily at 3:00 p.m. Offering such services reflects a trend that began some years ago as a means to attract customers, especially wealthy ones. Matilda Hospital in Hong Kong is one of a number of hospitals that particularly courts those interested in a luxury hospital stay. Their three-day maternity package includes four-star cuisine meal service with champagne while staying in a beautiful private room with molding-trimmed high ceilings, cherry-finished wood floors, and a balcony overlooking the sea for only $1,800 per night. Likewise, for a mere $2,400 per night, Greenberg 14 South, the elite, penthouse wing of New York Presbyterian/Weill Cornell hospital also offers marble bathrooms, luxuriant beds, and full room service complete with a butler as patients look out through magnificent floor-length windows to a beautiful view of the city and the East River 200 feet below. Talk about vertical differentiation!

Source: See J. Barshay, "Luxury Rooms Are Latest Fads for Private Hospitals in Asia," *Wall Street Journal*, January 26, 2001, p. A1 and P. Davies, "Hospitals Build Deluxe Wings for New Moms," *Wall Street Journal*, February 8, 2005; and N. Bernstein, "Chefs, Butlers, Marble Baths: Chefs Vie for the Affluent," *New York Times*, January 22, 2012, p. A1.

buy the product. We assume that $\theta_1 > \theta_2$. That is, type 1 consumers place a higher value on quality than type 2 consumers, perhaps because type 1 consumers have higher incomes than type 2 consumers or more generally because they have more intense preferences for quality. We also assume that $\underline{z}_1 > \underline{z}_2 = 0$. In other words, type 1 consumers will not buy the monopolist's product unless it is at least of quality $\underline{z}_1$. These are consumers who "wouldn't be seen dead" flying in coach, eating in fast-food joints, or shopping in discount stores. By contrast, type 2 consumers are willing to buy the monopolist's product of any quality provided, of course, that consumer surplus is non-negative. Unfortunately for the firm, while it knows that these different consumer types exist, it has no objective measure by which it can distinguish the different types.

Similar to second-degree price discrimination, the monopolist would like to choose a product line that identifies and separates customers of different types. The monopolist would like to induce type 1 consumers to buy a product of high quality z_1 at a high price while simultaneously inducing type 2 consumers to purchase a product of low quality z_2 at a lower price, which is equal to their willingness to pay. Suppose that the firm is able to produce any quality in the quality range $[\underline{z}, \overline{z}]$. To keep the analysis (reasonably) simple, further assume that the marginal costs of production are constant and identical across all qualities of product, and are set equal to zero.[10] Finally, we make the following important assumption (explained below):

$$\textit{Assumption } 1 : \overline{z} > \frac{\theta_1 \underline{z}_1}{(\theta_1 - \theta_2)}$$

Note that Assumption 1 is most easily satisfied when the difference between θ_1 and θ_2 is relatively large.

Let's look first at a consumer of type 2, a consumer with a low willingness to pay for quality. What the firm will do is charge this consumer a price that is just low enough for the consumer to be willing to purchase the low-quality product. From equation (7.30), and given that $z_2 = 0$, consumer type 2 will buy z_2 if $p_2 \leq \theta_2 z_2$, implying a good 2 price of

$$p_2 = \theta_2 z_2 \tag{7.31}$$

Now consider a consumer of type 1 with a stronger preference for quality. This consumer can, of course, buy the low-quality product. So in pricing the high-quality product, the firm faces the same type of *incentive compatibility constraint* that we met when discussing second-degree price discrimination. (There is also the constraint that type 2 consumers buy the low-quality rather than the high-quality product. See below.) For a type 1 consumer to buy the high-quality product, it is necessary that:

$$\begin{aligned} &\theta_1(z_1 - \underline{z}_1) - p_1 \geq \theta_1(z_2 - \underline{z}_1) - p_2 \\ &\theta_1(z_1 - \underline{z}_1) - p_1 \geq 0 \end{aligned} \tag{7.32}$$

The first expression in (7.32) says that the consumer surplus that a type 1 consumer obtains from buying the high-quality product must be greater than or equal to the consumer surplus that could be obtained if the type 1 consumer bought the low-quality good. The second expression states that the consumer surplus that a type 1 consumer obtains from purchasing the high-quality good must be non-negative.

Substituting $p_2 = \theta_2 z_2$ from (7.31) into the first expression in (7.32) we find that:

$$p_1 \leq \theta_1 z_1 - (\theta_1 - \theta_2) z_2 \tag{7.33}$$

Equation (7.33) says that the maximum price p_1 that can be charged for the high-quality product is $p_1 \leq \theta_1 z_1 - (\theta_1 - \theta_2) z_2$. This price is greater the higher are the values θ_1 and θ_2 that the two types of consumers place on quality, and the higher is the quality differential between z_1 and z_2. That is, quality can be priced more highly when it is valued more highly by all consumers. Further, because the monopolist is effectively competing with itself by offering two products of different qualities, the monopolist has an incentive to increase the quality differential between the products, i.e., to make two goods more differentiated. Doing so weakens the competition between products and allows the firm to increase the price of its high-quality product. Note that when $p_1 \leq \theta_1 z_1 - (\theta_1 - \theta_2) z_2$ the condition that consumers of type 1 receive non-negative surplus when they buy the high-quality good can now be written as $\theta_1(z_1 - \underline{z}_1) - p_1 \geq 0 \Rightarrow (\theta_1 - \theta_2) z_2 - \theta_1 \underline{z}_1 \geq 0$. Given our Assumption

[10] It might be, for example, that the majority of the firm's costs are set-up costs and that crimping higher quality products makes lower quality products. Relaxing this assumption doesn't change much, and having it makes the analysis a bit easier.