Introduction

This is a paper about pricing strategies. Under most circumstances, a single price is not the revenue maximizing scheme for a seller facing a downward sloping demand. Nonetheless, the seller always faces constraints in the attempt to extract the consumers' surplus.

We describe one type of pricing structure that seems to have efficiency characteristics in extracting surplus. It is what we call multi-tiered pricing. It involves selling only in blocks and sometimes charging different prices for these blocks. We look at the problem in this way because we have some consumption data for individual demanders that seems best explained by this model. These data were generated by the sale of college football season tickets.

In the next section we lay out a structure for analyzing demand among heterogeneous buyers. We then use this framework to discuss two different pricing strategies -- two-part tariffs and multi-tiered pricing. Finally, we analyze the football data.

Demand Curves for Heterogeneous Buyers

Let the demand for a product be made up of heterogeneous buyers. We characterize this heterogeneity by the frequency distribution across the quantity axis. For instance, demanders may be distributed normally with constant variance; this is commonly called homoskedasticity in econometric work. This standard assumption is pictured in every econometrics primer. It means that for a set of linear demand curves, all have the same slope.¹ There are big demanders and small, and they vary about the average so that individual $i$ is always the same distance away from the average individual. Indeed, all individuals are always the same distance away from each other.

Figure 1 shows our graph embodying these assumptions. We draw the population density in inverted fashion beneath the price-quantity space. The average individual's demand is illustrated along side the demand associated with the individuals marking the upper and lower quintiles. The area marked $F_1$ represents the lower 20 percent tail of the normal density. Twenty percent of the buyers have demands that are smaller than $D_1$. Similarly, $F_2$ percent of the buyers have demands between $D_1$ and $D_2$.

In Figure 1 the demand curves run parallel, which we will reference by saying that demanders are homoskedastically distributed. Alternatively, we could assume that the variance collapses to zero as individuals move up their demand curves. (For instance, this occurs if the coefficient of variation is constant.) In this case the demand curves all start at the same exclusion

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¹ We do not usually think much about what this assumption implies in terms of individual consumers. The assumption of normally, homoskedastically distributed individuals does not necessarily imply that all individuals have linear demands with the same slope, but if the slopes are not all the same, some peculiar sampling effect must be operating.

In all events, the precise implication of econometric assumptions is not our worry in this paper. We merely reference the econometric example to help clarify our model.
price and fan out toward the quantity axis. Yet another possibility, and one that we will find interesting later on, is that the demand curves fan out moving away from the quantity axis. This means that the demand curves for large demanders are steeper than for small demanders. In the work to follow we largely ignore the case where individual demands cross. That is, between individuals, a big buyer’s demand is everywhere larger than that of a small buyer.

**Oi’s Two-Part Tariff**

The structure described above is convenient for analyzing various block pricing schemes. For instance, in this framework Oi’s two part tariff problem has the following interpretation. The firm sets an entrance tax or initiation fee and then chooses a unit price. Assuming that resale is prohibited, each demander pays the initiation fee. The front-end fee effectively determines how much of the lower tail of the demand density will be excluded from purchasing the product. As this fee is increased, more and more demanders are left out. Importantly, however, only the marginal demander pays out the entire amount of his consumer surplus. As Oi points out, raising the per unit fee is a way of extracting some of the residual surplus from the buyers with extra-marginal demands.

Figure 2 shows Oi’s model using our graph. The seller’s problem is to choose the right fixed fee and unit price to maximize revenue (i.e., let marginal cost be zero).\(^2\) As the fee and unit price rise, more demanders are excluded. In Figure 2, \(P^*\) is the unit price and the area under \(D_1\) above \(P^*\) is the fixed fee. \(F\) percent of the demanders are served; \(1-F\) are left out. The front end charge and unit price are set so high that all buyers with demands smaller than \(D_1\) are priced out of the market.

The fixed fee is paid by all \(F\) percent of the buyers that participate in the market, so the contribution of the fixed fee to total revenue is the area under \(D_1\) above \(P^*\) times \(FN\) where \(N\) is the population of buyers. Unit sales can be illustrated in our graph by noting the average demand curve of these buyers. It is shown as \(D_2\). This is the demand curve that splits the upper tail of the density marked \(F\). Hence, it is the average of the distribution truncated by the pricing decision of the seller. In this sense, as \(D_1\) moves around because of changes in the fixed fee and unit price, \(D_2\) moves in corresponding fashion. \(Q^*\) is the average consumption at \(P^*\). Thus, \(P^*Q^*FN\) is the revenue derived from unit sales.

Revenue maximization can be characterized by two choices: how many buyers to exclude and the optimal ratio of fixed fee to unit sales. Oi discusses the first choice in terms of a picture based on assumptions very similar to ours. In his Figure III he points out that as the number of buyers decreases, fee revenues rise and then fall. At the same time, unit sales are everywhere decreasing. The optimum \(F\) occurs where the rates of change in these two effects are equal. Our graph is not particularly enlightening in depicting this choice. However, it is revealing in the other dimension.

In our Figure 2, \(P^*\) can be found by noting that \(D_2\) represents the revenue potential from unit sales and \(D_1\) from fixed fees. The optimal price occurs where these two margins are equated. Marginal revenue from unit sales can be depicted by drawing a marginal curve to \(D_2\). Let \(D_2\) be expressed as a mapping of price into quantity, \(D(P)\), so that the choice variable is price. Drawn

\(^2\) The exact nature of the solution to revenue maximization in a two-part tariff setting depends on the features of the distribution of buyers and the shape of demand. Assume that the demands are linear and that the distribution is normal and homoskedastic.
this way the marginal revenue curve starts at the quantity intercept of demand and rises at half the rate of the demand curve. This is the curve labeled $MR_2$ in Figure 2.\(^3\)

As price goes up, revenue from fixed fees goes down. The margin of this effect is the quantity distance under $D_1$, or $Q_1$, as shown in Figure 2. For instance, if price increases marginally from $P^*$, the area under $D_1$ above $P^*$ decreases by $Q_1$. $D_1$ is like the marginal cost of unit sales where the whole analysis is simple monopoly problem rotated 90°. Thus, $P^*$ is determined where $MR_2$, the marginal revenue curve for unit sales, intersects $D_1$.

As the seller gropes for the revenue maximum, one of the dynamics can be seen in Figure 2. If the seller starts from the price that maximizes unit sales, that is, where there is no fixed fee, increases in the fixed fee will be accompanied by decreases in the unit price. Intuitively it makes sense that there is a tradeoff between the fixed fee and unit price. Graphically it can be seen by the relation between $D_1$ and $D_2$. When $D_1$ shifts to the right, $D_2$ also shifts right but by less. This causes the intersection of $MR_2$ and $D_1$ to move down implying that the optimal price declines.

In Oi's problem prohibition of resale is crucial because each buyer is allowed to purchase an unlimited amount once the initiation fee is paid. The pricing policy degenerates when resale is possible and where transactions costs prohibit an equilibrium similar to Coase's durable good problem, the single competitive price prevails.

**Multi-tier Pricing**

An alternative pricing strategy to the one analyzed by Oi is to have multiple blocks. Each block entitles the demander to a given quantity for a given block price. This strategy has the advantage that, under many circumstances, there is no requirement that resale be prohibited. In some cases it produces more revenue.

Figure 3 pictures the case of three blocks again assuming linear, homoskedastic demands. If the seller charges $0ab$ for a block of quantity $b$ the frequency distribution inverted below the quantity axis shows that $F_1$ percent of the buyers are excluded from the market. The seller then collects the fee $0ab$ from the rest. The second block adds $c-b$ units, and for this additional quantity the seller can charge the marginal buyer up to $bcd$. The total paid by level II buyers is $0ab+bcd$ for $c$ units. There are $N(1 - F_1 - F_2)$ demanders in the second group where $N$ is the total population.

The major result of this analysis is the fact that the seller cannot charge the marginal buyer more than $bcd$ as the additional price for the second block. This is because the purchase of the first block gives the buyer all the consumer surplus associated with $b$ units. The area above $D_1$ and to the left of $b$ for all demanders is lost to the seller when the offer is made to sell the first block. If the seller charges more than $0ab+bcd$ for the second block, the buyer with demand $D_2$ maximizes consumer surplus by only consuming $b$ units. The most individual $D_2$ will pay for $c-b$ additional units is the area under his demand curve to the right of $b$.

The problem for the seller is to choose the optimal size of the blocks. This effort involves balancing two opposing forces: Making the blocks bigger excludes buyers; making the blocks smaller makes the marginal block prices smaller.\(^4\)

\(^3\) The price intercept of $MR_2$ identifies the unit sales maximizing price.
\(^4\) In principle, the seller defines additional blocks forever. Practically the effect on revenue of additional block decreases at an increasing rate, so when the portion of the distribution of buyers in the last block is less than one percent, lost revenue is much less than this.
Putting aside the question of resale proscription, the seller finds the optimal block sizes by adjusting the relative size of each successive block in the following fashion. In Figure 3 consider the seller's choice of whether or not to delete block 1. The gain in revenue from selling $c$ units as the first block is the area $abde$ times the $F_3 + F_4$ portion of the distribution. The seller is already getting $0ab+bc$ so only $abde$ is gained. The loss in revenue is $0ab$ times $NF_2$ buyers. If the gain from the larger block exceeds the losses from excluding the smaller demanders, the seller discontinues the smaller block. At the margin, this calculation becomes the comparison of the length of the line $ab$ times the area $1-F_1$, the gain from increasing the block size, with the area $0ab$ times the height of the density at $b$, which is the cost of increasing the block size. Visual inspection of Figure 3, suggests revenue could be increased by increasing the size of block 1. The same calculus is applied to block 2, block 3, etc.

Even though Figure 3 is not drawn to depict perfectly the revenue maximizing block structure, it does show a common characteristic of the optimum. Under the assumption of normally distributed demands with identical slopes, the optimal block sizes will decline. They decline in both price and quantity terms. This result is due in part to the normal distribution. The first block is set to knock out the lower tail of demander and the additional units in succeeding blocks need not exclude so many. But the result is also a product of the common slopes of the demand curves. It is interesting to envision what happens when we change these two assumptions.

If the distribution of demand is exponential instead of normal and when the demand curves get steeper for bigger buyers, the revenue maximizing pattern of blocks is just opposite that shown in Figure 3. The blocks get bigger in both quantity and price terms. Of course, the revenue generated from each successive block declines, but the optimal scaling rule outlined above causes the incremental block price (like $bcd$ in Figure 3) and the incremental units (like $c-b$) to increase. One way to express this is to say that the average price per unit in larger blocks goes up; just the opposite is true under the assumptions generating Figure 3.

The benefit of multi-tier pricing is not necessarily in its revenue raising ability compared to two-part tariffs. Under many demand conditions two-part tariffs produce more revenue. However, with multi-tier pricing there need be no restriction on resale. The seller delivers to all comers. The buyers self select themselves into the larger or smaller blocked packages. However, unrestrained purchasing of the blocks creates competitive boundaries on the behavior of the seller in determining the block sizes.

Competition, or more precisely, resale means that all blocks must have the same unit price. Consider what happens in Figure 3 where the price per unit is smaller for the second block than for the first. If unrestrained, speculators will purchase $F_2N$ times $b$ units in blocks of $c$ and undercut the price of the first block offered by the seller. Thus, to meet the competition, the seller cannot offer quantity discounts to larger block purchasers. On the other hand, if the seller raises the per unit charge as block sizes increase, speculators will buy numerous small blocks and resell these to the large demanders. The result is that middle men cannot be excluded, all blocks must have the same unit price.

Of course, this is not what the seller would prefer. In the event that the seller can prevent resale, the per unit price associated with different block sizes will vary optimally, as described above. And in this event, the choice between two-part tariffs and multi-tiered pricing depends on the nature of the distribution of demanders. In the case of normally distributed demand curves two-part tariffs yield more revenue. However, in the event that demand is exponentially distributed and where the demand curves get steeper as individual demands grow, multi-tiered pricing dominates the two-part strategy in revenue generation.
**Pricing**

**Some Data**

We have at our disposal data on a multitier pricing situation. The evidence comes from the pricing of college football games, specifically home season ticket sales by Clemson University. Clemson, like many schools, requires that all season ticket applications be associated with a donation to the athletic booster club. The fee schedule goes as shown in Table 1. Season Tickets cost $100 a piece in round numbers, so the total price for each block is the sum of the contribution and the tickets. This is multi-tiered pricing in our terminology because the number of tickets at each level of contribution is limited. That is, to purchase 14 tickets you would have to be a multiple level member like both a $5000 contributor and a $100 giver as well.

Table 1 shows the unit prices associated with each block. These prices rise. Also shown are the frequencies in each block. The distribution is not normal but rather more like an exponential. Recall that these are the circumstances in which multitier pricing dominates two-part tariffs. However, in order to support increasing prices across blocks, some way has to be found to force big demander to reveal themselves and not to simply purchase numerous small blocks. As can seen from Table 1 the cheapest way to purchase 12 tickets is to contribute 6 times at level I.

In football ticket sales the solution is simple. The athletic department bundles quantity and quality in the ticket sales. If an individual wants 10 tickets, and wants them together, he has to give $2000. The ticket grouping, their location in the stadium, parking privileges, and availability of away game and bowl game tickets are all part of the priority afforded larger givers. Even so, these quality inducements to move up the booster club ladder are not perfect, though nearly so. In 1987, there were 186 repeat members spread across all classes of the booster club out of 22,852 total. Most of these repeat block buyers were corporations which might be thought of as consortia of smaller buyers anyway. Also the virtually nonexistent membership in level VI suggests that the self-selection scheme may be breaking down at the highest levels.

Figure 4 shows a plot of the Clemson football demand curves based on our characterization of multitier pricing. The figure denotes the marginal contributions necessary to reach each successive level as well as the exclusion price necessary to drive such a buyer from the market. For instance, the additional contribution necessary to move from level I to level II is $350 shown in the triangle under the level II demand curve and to the right of the level I demand curve. The exclusion price for a level III demander (and the data say that there are 3875 people with demands this large) is $1350. This is found by solving for the slope of line implied by the marginal contribution for level III, which is $450 for 2 tickets, and projecting this back to the price axis. The total area under this curve is $4050.

The total of consumers' surplus for all buyers (demanders not priced out of the market) is between $45 million and $146 million depending on how the frequency distribution of buyers is evaluated. The best guess is around $72 million. This number is virtually identical to an estimate of total consumers' surplus obtained by estimating the demand curve using transportation costs as the price variable. The total revenues under the current scheme are $12 million or one-sixth of the total surplus. Obviously the booster-club price discrimination scheme is not perfect.

When the data presented in Table 1 and Figure 4 are examined closely, it appears that revenue could be increased by cutting out levels I and II. If levels I and II were deleted, level III...

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5 That is, based on the assumptions employed above like linear, non-crossing demands.
6 This research is reported separately.
buyers could be forced to pay around $4000 for their tickets. This times the number of buyers in level III and up yields around $15 million. An additional $2 million could be gained by deleting level IV and charging level V customers another $4000 for their tickets. So the $12 million in current revenues compares to $17 million under best multi-tiered pricing arrangement.

There are several reasons why the athletic department might not adopt what appears to be the revenue maximizing block structure. First, Clemson University is a non-profit organization, which is like saying it is badly managed without saying exactly how. Second, setting the multi-tiered pricing to delete levels I, II, and IV would significantly reduce the number of tickets sold. Out of 50,000 season tickets sold to booster club members in 1987, 25,000 of these were sold to level I and II buyers. Making these demanders stay home might be disadvantageous because fewer fans may make for a less pleasurable experience for the fans who do attend. That is, the demand revealed by level III contributors may only exist because of the substantial presence of level I and II contributors. Moreover, since Clemson University is a state supported institution, numbers of people in attendance at various university events may make political hay.

A final explanation for the apparent shortfall in revenues comes from the way that booster club members are treated over time. Contributions to the booster club entitle the giver to the right to buy season tickets, and once those tickets are assigned, the contributor has them for life as long as the contribution level is maintained. That is, if a football fan gives $1000 today and gets 20 yard line seats, he will get those seats for as long as he gives $1000. The booster club donation forms a long-term contract. Contributors that buy tickets at the minimum contribution level are treated slightly differently, however. They must maintain the minimum contribution level defined by the club. Hence, when the minimum membership level is raised, the long-term contract is altered. From a revenue maximizing standpoint, it may make good sense not to change the minimum contribution level often or dramatically.

In all events it appears that the athletic department is capturing a substantial portion of the potential multi-tiered pricing revenues.

Conclusions

We have looked at pricing data from a very disaggregated source. There are numerous aspects of these numbers that arouse our curiosity but possibly the most interesting of all is whether the seller is setting a price that captures as much of the consumers' surplus as possible. Defining what is the maximum consumers' surplus that can be captured by the seller is part of the problem.

We approached this by describing the pricing structure employed by the seller in the context of the distribution of demand curves that the seller seems to face. We call this structure multitier pricing. There are several things about this pricing strategy that become apparent. When the seller sets the price and size of the first block, the rest of the area under the demand curves for all buyers for that quantity is lost. The same is true for each successive block. This result significantly reduces the revenue potential of mulitiered pricing in claiming all of consumers' surplus. We found that demand picture displayed by the data using this framework for analysis is very close to what we found using more conventional techniques and that the revenue claimed by the pricing agent is not substantially below what might be considered the upper bound.
Table 1: Booster Club Fee Schedule

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<th>Level</th>
<th># of Tickets</th>
<th>Donation</th>
<th>Total Block Price</th>
<th>Unit Price</th>
<th>Buyers</th>
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</table>

Figure 1
Figure 2

Figure 3
Figure 4