PRICE DISCRIMINATION, MARKET SEPARATION, AND THE MULTI-PART TARIFF

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Few textbooks in economics pay any explicit attention to multiple rate schedules.1 When the subject is broached, multi-part tariffs are most often regarded as a method of achieving perfect price discrimination. There are an infinite number of rate schedules which allow, in theory, the perfectly discriminating result. The two-part tariff, the sliding price schedule, the multiple-block schedule, and an all-or-nothing price are but a few examples. In each instance, all gains to trade accrue to the seller and the quantity sold corresponds to the price equals marginal cost solution of competition (wealth effects aside). As an explanation of pricing behavior, this formulation is far from satisfactory. Entrepreneurs are not observed to be indifferent among these alternative rate schedules. Which multi-part tariff will the discriminating monopolist select?

An important prerequisite of perfect price discrimination is that the monopolist seller be able to divide consumers into separate markets according to their demands. Such ability is readily assumed in the textbook; in the real world, the requisite knowledge is never free. In this paper I examine the performance of alternative rate structures in the absence of an ex ante mechanism for identifying consumers with different demands. The discriminating monopolist is shown not to be indifferent among all alternative multi-part tariffs. An appropriately selected tariff structure serves as a metering or monitoring device, allowing some degree of ex post discrimination.

The simple analytics of multi-part tariffs are briefly reviewed in Section I. In Section II, several alternative pricing schemes are presented and compared in a simplified framework in which the monopolist is unable to identify consumers with particular demands. A more general stochastic model is presented in Section III. A summary is contained in Section IV.

I. MULTI-PART TARIFFS AND THE PERFECTLY DISCRIMINATING MONOPOLIST

a) A single consumer: Assume that a monopolist has a single customer who makes his purchases competitively. This customer’s demand relationship, \( Q = A(P) \), is assumed to have zero income elasticity so that consumer surplus at any quantity can be calculated as the area under the

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1. For a recent exception, see Hirshleifer (1976), Ch. 11.
demand curve minus total expenditures.\textsuperscript{2} As illustrated in Figure 1, I assume that the firm's marginal cost, \( C \), is constant and equal to average cost.

A simple multi-part tariff schedule is the two-part tariff, whereby the monopolist combines a fixed entry or license fee, \( F \), with a constant per unit charge, \( p \). The quantity purchased will be a function of \( p \) alone, while \( F \) cannot exceed the remaining consumer surplus of the buyer if the customer is not to be driven altogether from the market. The monopolist will maximize profits by assessing a price equal to marginal cost and setting \( F \) equal to the area \( ABC \). Thus the output sold by the monopolist using a two-part tariff is identical to that sold by the competitive seller. All consumer surplus is extracted by the fixed component of the tariff, i.e., all gains from the exchange accrue to the seller who is said, then, to discriminate perfectly against the buyer.\textsuperscript{3}

\textbf{FIGURE 1}

The Multi-part Tariff
Many other multi-part tariffs can extract profits as well as the two-part tariff, but none can do any better. One especially interesting tariff is the "all-or-nothing" scheme in which the seller offers a predetermined amount of the good, $q$, for a lump sum price, $T$. It can be shown that the optimal size of the all-or-nothing package, $Q$, corresponds to the price equals marginal cost solution. The lump sum price will be set equal to the area $OABQ$, and all surplus accrues to the seller.

b) Many identical consumers: The existence of many consumers, even in the case of identical demands, provides an opportunity for buyers to arbitrage many attempted pricing schemes of the would-be discriminator. A two-part tariff, for example, would allow a single consumer, having paid his license fee, to resell the good at a price slightly above $p$ to others willing to pay this premium in order to avoid the lump sum entry fee. As outlined above, the all-or-nothing scheme does preclude arbitrage, but this is only true in the event of identical consumers.

Arbitrage is sometimes limited by contractual prohibitions against resale. When the monopolist’s product is a service or of a personal nature, natural limits are placed upon the ability of consumers to arbitrage the rate differences which result from multi-part pricing schedules. More generally, arbitrage is limited by high transaction costs. In the remaining discussion we will assume that arbitrage is effectively limited, either by contract or transactions costs, so that a more interesting problem faced by the potential discriminator may be emphasized.

c) Non-identical consumers: When his consumers are not identical, the monopolist who wishes to profitably exploit the discriminatory potential of multi-part pricing must be able to separate consumers into different markets according to their demands. Once this separation is complete, perfect discrimination may be achieved by assessing each consumer (or group of consumers) a unique multi-part tariff which extracts all consumer surplus. Any number of tariff structures achieve this goal. A similar problem must be solved when the demand of a single customer is not constant over time. In order to achieve perfect discrimination, the monopolist must identify the customer’s demand in each state of the world.

4. Since the marginal cost solution maximizes the total surplus available to consumers and the producer and since, in this instance, all surplus is captured by the producer, it is not possible for the monopolist to further increase his profits.

5. Writing the inverse demand function as, $P = \bar{A}(Q)$, the customer will elect to accept the all-or-nothing offer so long as $T = qC + \lambda (\int Q \bar{A}(Q) dQ)$, where $qC$ is the lump sum price, $\lambda$ is the marginal cost of the good, and $C$ is the constant cost of providing the good. The firm will select $q$ and $T$ in order to maximize $M = T - qC + \lambda (\int Q \bar{A}(Q) dQ)$. First order conditions require that $\lambda = 1$, $\bar{A}(q) = P = C$, and $T = \int Q \bar{A}(Q) dQ$, the area $OABQ$.

6. For "simple" or "third degree" discrimination, the criterion for separation is price elasticity of demand. For the first degree discrimination implied by multi-part pricing schedules, however, consumers will be separated according to their consumer surplus.
The information necessary for the separation of markets is not, as a rule, costlessly available. The inability to identify a given consumer with his particular demand curve precludes perfect discrimination. This same inability does not, however, destroy the profitability of multi-part rate schedules. Furthermore, when markets cannot be perfectly separated, the monopolist will no longer be indifferent among alternative forms of multi-part tariffs.

II. ALTERNATIVE TARIFF SCHEDULES FOR THE DISCRIMINATING MONOPOLIST

In this section I will compare some alternative pricing strategies of the discriminating monopolist who is unable, *ex ante*, to separate consumers according to their demands. The objective of this section is to demonstrate, in a very simplified framework, that because of the constraints posed by the inability to identify consumers, the monopolist will not be indifferent as to various multi-part pricing policies. In each of the following examples, I assume that there are two consumers, A and B, whose demand relationships, \( A(p) \) and \( B(p) \), are negatively sloped, invariant to income, and such that \( B(p) > A(p) \) at every \( p \). A monopolist, whose marginal costs, \( C \), are constant, knows the relationships \( A(p) \) and \( B(p) \), but he finds it prohibitively expensive to identify consumers A and B prior to the time of sale. His inability to separate markets necessitates uniformity of the tariff schedule. Finally, I shall assume that the monopolist will not find it profitable to price A out of the market.\(^7\)

A. The uniform two-part tariff: The derivation of the optimal uniform two-part tariff as previously formulated by Oi (1971) will be briefly sketched here in order to provide a basis for comparing alternative tariff schedules.\(^8\) The proof, together with those which follow, is a simple exercise in constrained maximization. Profits are

\[
\Pi = 2F + (p - C)[A(p) + B(p)],
\]

where \( p \) is the per unit price and \( F \) is the lump sum charge which cannot exceed \( \int_p^\infty A(p) \)d\( P \). The Lagrangian for constrained profit maximization is

\[
M = 2F + (p - C)[A(p) + B(p)] + \lambda \left[ \int_p^\infty A(p) \right] dP - F.
\]

First order conditions require that

\[
F = \int_p^\infty A(p) \]d\( P \quad \text{and}
\]

\(^7\) In each of the following examples, the monopolist will compare the profits derived from the particular uniform rate schedule to those which could be obtained by perfectly discriminating against \( B \) and foregoing all sales to \( A \).

\(^8\) Oi also considers the case where the demand relationships cross such that the larger buyer obtains the smaller consumer surplus.
(2-4) \[(p - C) = -[B(p) - A(p)]/[A'(p) + B'(p)]\].

Although price exceeds marginal cost, it is less than the price which would be charged by the ordinary monopolist (where \(p^* - C = -[A(p^*) + B(p^*)]/[A'(p^*) + B'(p^*)]\)). The fixed charge is set so as to extract all consumer surplus from consumer A.

A simple diagrammatic illustration of the uniform two-part tariff is contained in Figure 2. Profits will be maximized by setting the variable charge, \(p\), in order to maximize the area \(DD'B - DBE\) and the fixed charge, \(F\), is set equal to the area \(ApD\).

**FIGURE 2**

Uniform Two-part Tariff

\[\text{Diagram}\]

**B. The uniform declining three-part tariff:** The ability of alternative pricing schemes to yield greater profits than the uniform two-part tariff is readily evidenced upon closer examination of Figure 2. Consumer B would be willing to purchase an increased amount at the variable price, \(p\), if by doing so he was allowed to purchase subsequent units at a lower price. Consider, for example, a tariff schedule such that the price \(p\) is charged for the first \(x^*\) units, \(x^* > B(p)\), and a price equal to marginal cost is assessed for units beyond \(x^*\). Consumer B will expand his purchases to \(OQ_b^*\) so long as \([x^* - B(p)](p - C) < D'E'B'\). Profits to the firm increase by \([x^* - B(p)](p - C)\) over those achieved with a uniform
two-part tariff. In fact, as demonstrated in the derivation below, the optimal declining three-part schedule entails a price equal to marginal cost for the last units sold to consumer B.

For the monopolist using a declining three-part tariff, profits are

$$\Pi = 2F + (P_1 - C)[A(P_1) + x] + (P_2 - C)[B(P_2) - x]$$

where $P_1$ is the variable charge for the first $x$ units and $P_2$ the charge for subsequent units. Again, $\int_{P_1}^w A(P) dP \geq F$. Furthermore, consumer B must be induced to consume some units at the lower price, $P_2$. Thus we have the additional constraint that $B$'s consumer surplus at $B(P_2)$, $\int_{P_1}^{P_2} B(P) dP - (P_1 - P_2)x - F$, must equal or exceed the surplus attainable by simply consuming $B(P_1)$, $\int_{P_1}^{P_2} B(P) dP - F$. The monopolist will select, $F$, $x$, $P_1$, and $P_2$ in order to maximize profits. We find that

$$\begin{align*}
(F) & = \int_{P_1}^w A(P) dP, \\
(X) & = \int_{P_1}^{P_2} B(P) dP / (P_1 - P_2), \\
(P_1 - C) & = -[B(P_1) - A(P_1)] / A'(P_1) \quad \text{and} \\
(P_2) & = C.
\end{align*}$$

All remaining surplus is taxed away from $A$ by the fixed charge and $x$ is set so that $B$ is indifferent between purchasing quantity $B(P_1)$ and $B(P_2)$. Profits are increased beyond those which can be obtained by the uniform two-part tariff. Economic efficiency, on the other hand, is not necessarily enhanced. Although consumer $B$ will be induced to purchase a quantity which corresponds to the price equals marginal cost principle, $P_1$ is higher than the price assessed in the uniform two-part tariff, and sales to $A$ are diminished.\(^9\)

A diagrammatic interpretation is contained in Figure 3. $P_2$ is set equal to $C$ and $x$ is fixed so that the areas $DFH$ and $B'GH$ are equal. $P_1$ is then set in order to maximize the area $DD'B'B - DBE$ and the fixed charge is set equal to $AP_1D$. It is worth noting that the profit obtained from $B$ is identical to that which would be achieved if a fixed charge were set equal to $AP_1D + P_1D'B'P_2$ plus a variable charge equal to marginal cost. The

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9. It is possible that an increasing three-part tariff will be more profitable than the diminishing rate schedule. Stated without proof, the optimal increasing three-part schedule requires

$$(a) \quad P_1 - C = -[B(P_1) - A(P_1)] / 2B'(P_1),$$

$$(b) \quad P_2 - C = 2(P_1 - C),$$

$$(c) \quad F = \int_{P_1}^w A(P) dP.$$
three-part tariff has, in essence, extracted a larger lump sum fee from consumer B even in the absence of an ex ante mechanism for identifying consumers with different demands. The ability to achieve this kind of ex post discrimination through the appropriate choice of multiple rate schedules will be clarified by the following example.

C. Selective two-part tariffs: As an alternative to uniform rate schedules, the monopolist may offer a number of rate schedules allowing consumers to select the schedule of their own choice. In this example, the firm offers two two-part schedules, each consisting of a fixed charge \( F_1 \) and \( F_2 \) and a variable charge \( (P_1 \) and \( P_2 \)). If consumer A is induced to pick Schedule 1 and consumer B, Schedule 2, profits will be

\[
\Pi = F_1 + F_2 + (P_1 - C)A(P_1) + (P_2 - C)B(P_2).
\]

If A is not to be priced out of the market, \( \int_{P_1}^{P_2} A(P) dP \geq F_1 \), and if B is to voluntarily choose Schedule 2, \( \int_{P_2}^{P_1} B(P) dP = F_2 \geq \int_{P_1}^{P_2} B(P) dP - F_1 \). First order conditions for profit maximization require that

10. Also, \( \int_{P}^{P_1} A(P) dP - F_1 \neq \int_{P}^{P_2} A(P) dP - F_2 \) if consumer A is to voluntarily choose Schedule 1; however, this constraint is not found to be binding.
\[ F_1 = \int_{P_1}^{P} A(P) dP, \]
\[ F_2 = F_1 + \int_{P_1}^{P} B(P) dP, \]
\[ (P_1 - C) = -[B(P) - A(P)]/A'(P), \quad \text{and} \]
\[ P_2 = C. \]

The variable prices of these two-part tariffs are identical to those block prices which were assessed as part of the optimal declining three-part rate schedule. Furthermore, the firm’s profits are unaltered, since the integral term in equation (2-12) is the area \( P_1 D B P_2 \) in Figure 3.

As opposed to the uniform two-part tariff, more sophisticated rate schedules allow the monopolist to extract a greater amount of surplus from the buyer with the higher demand curve. While the discriminatory aspects of these rate schedules are explicit when consumers are offered a choice of optimally selected two-part tariffs, the discrimination is also implicit in the essentially identical declining three-part rate schedule. In the absence of \textit{ex ante} mechanisms for separating consumer markets, the block rate schedule allows consumers to identify themselves \textit{ex post}, metering the demands of various consumers in addition to extracting (implicitly) differential fixed charges. This method of metering demand in order to extract consumer surplus works in much the same way as the tie-in sale.\footnote{See Burstein (1960).} A tie-in sale requires the purchaser of the tying good (e.g., copying machines) to purchase his “requirements” of some other good (paper) from the same seller, generally at prices above the competitive level. If the value placed upon the tying good is positively related to the intensity with which it is used, such a tying arrangement simultaneously identifies buyers according to their demands and effectively charges higher valued purchasers a larger price for the tying good. The markets for profitable price discrimination are identified \textit{ex post} through the demand metering attributes of the tied good. Multi-part pricing is simply an alternative form of the tie-in sale. The right to purchase later quantities at a lower (marginal cost) price is tied to the requirement that a fixed charge be paid and earlier units be purchased at a price specified above marginal cost.

\textit{D. Selective all-or-nothing tariffs:} The monopolist, by using still more sophisticated tariffs, can enhance his profits beyond those attainable through the three-part schedule. The all-or-nothing tariff provides a formally convenient (and, perhaps, unrealistic) illustration. In this example, the monopolist devises two “packages” of goods with quantities \( Q_1 \) and \( Q_2 \) and assigns all-or-nothing prices of \( T_1 \) and \( T_2 \) respectively.
Expressing the inverse demand functions as \( \bar{A}(Q) \) and \( \bar{B}(Q) \), the firm's profits will be

\[
\Pi = T_1 + T_2 - C/Q_1 + Q_2/2.
\]

If the firm wishes to induce consumer B to select the second package, then

\[
\int_0^{Q_2} \bar{B}(Q) dQ - T_2 > \int_0^{Q_1} \bar{B}(Q) dQ - T_1.
\]

Furthermore,

\[
\int_0^{Q_1} A(Q) dQ \geq T_1
\]

if consumer A is not to be priced out of the market. The profit maximizing monopolist will select

\[
T_1 = \int_0^{Q_1} \bar{A}(Q) dQ,
\]

\[
T_2 = T_1 + \int_0^{Q_1} \bar{B}(Q) dQ,
\]

\[
\bar{A}(Q_1) - C = \int \bar{B}(Q_1) - C/2,
\]

\[
\bar{B}(Q_2) = C.
\]

\( B \) is again induced to purchase a quantity which corresponds to the competitive solution, while the quantity sold to \( A \) may be greater or less than the corresponding purchases induced by the declining three-part tariff or the equivalent two-part tariffs. In terms of Figure 4, \( T_1 \) will be set equal to area \( 0ADQ_1 \) and \( T_2 \) will equal area \( 0ADQ_1 + Q_1EBQ_2 \). Note that beyond \( Q_1 \) all consumer surplus is extracted from \( B \). Assuming it is profitable not to price consumer \( A \) out of the market, no tariff can increase profits beyond those achieved with this pricing scheme. Other tariffs can do just as well, however. For example, a four-part tariff illustrated on Figure 4 sets a fixed charge equal to \( AP_1D \), a variable charge for the first \( Q_1 \) units equal to \( P_1 \), a variable charge for the next \( x^*-Q_1 \) units equal to \( P_2 \), and a charge for remaining units equal to marginal cost. If \( x^* \) is set so that area \( EFG \) equals area \( GBH \), profits and output will be identical to those achieved by alternative all-or-nothing tariffs. The four-part schedule is not unique, however. \( P_2 \) may be increased together with compensating decreases in \( x^* \) without altering profits or output.

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12. Also, \( \int_0^{Q_1} A(Q) dA - T_1 \geq \int_0^{Q_2} A(Q) dA - T_1 \) if \( A \) is to select the first package, but this constraint is not binding.
The calculus of optimal tariff schedules can be generalized to the case of many consumers or, equivalently, to the case of a single consumer whose demand is stochastic. Let a single (or typical) consumer’s demand be $Q = A(P, u)$, where $u$ ranges from minus to plus infinity with a mean of zero and a p.d.f. of $f(u)$. Furthermore, $\partial Q/\partial u > 0$ at all prices. The expected profit derived from a tariff with $n$ blocks and a fixed fee, $F$, is

$$
E(\Pi) = \int_{\theta} f(u) du + \sum_{i=1}^{n-1} \left[ \int_{\theta_i}^{\theta_{i+1}} (P_i - C) A(P, u) f(u) du \right]
$$

$$
+ \sum_{i=1}^{n-1} \left[ (P_i - P_{i+1}) x_i \int_{\theta_i}^{\theta_{i+1}} f(u) du \right] + \int_{\theta_n}^{\infty} (P_n - C) A(P, u) f(u) du,
$$

where the $i^{th}$ block has a price, $P_i$, and a right-hand limit $Q = x_i$. The $\theta_i$'s are given implicitly by

$$
F = \int_{P_i}^{A(0, \theta_i)} A(P, \theta_i) dP \quad \text{and} \quad (P_i - P_{i+1}) x_i = \int_{P_{i+1}}^{P_i} A(P, \theta_i) dP \quad (i = 1, \ldots, n - 1).
$$
In order to solve (3-1) explicitly for optimal values of $F$, $P_i$, and $x$, and to provide a method of comparing alternative tariff schedules, it is necessary to sacrifice some of the problem’s generality. I will assume that the demand relation is linear,

$$Q = \frac{(a + u - P)}{b},$$

and that $u$ is rectangularly distributed with $f(u) = 1/2\phi$. For this example, it can be shown that

$$F = \frac{2}{b} \left[ \frac{(a + \phi - C)}{4n + 1} \right]^2,$$

$$P_i = \frac{[2(n - i) + 1]/(a + \phi - C)}{4n + 1} + C, \quad \text{and}$$

$$E(\Pi)_{max} = \frac{1}{3\phi b} \left[ \frac{(a + \phi - C)}{4n + 1} \right]^3 n(4n + 1)(2n + 1).$$

The first block (at price $P_1$) has a length of $[5(a + \phi - C)]/[b(4n + 1)]$ and each of the succeeding $n - 2$ blocks is $[4(a + \phi - C)]/[b(4n + 1)]$ in length.

As the number of rate blocks, $n$, approaches infinity, $F$ approaches zero and the rate schedule approaches a straight line with a slope equal to one-half that of the demand schedule, or

$$P = \frac{(a + \phi + C - bQ)}{2}.$$

Notice that the marginal price paid when demand is at its greatest level ($u = \phi$) approaches marginal cost. From (3-7) we see that expected profits are strictly increasing although at a decreasing rate, as the number of blocks increases.

$$\Delta E(\Pi)_n = E(\Pi)_n - E(\Pi)_{n-1} = \frac{(a + \phi - C)^3}{(3\phi b)(4n + 1)(4n - 3)^2}.$$

The profit-maximizing monopolist will increase the number of rate blocks so long as this addition to profits is greater than the added cost of administering the more complex tariff schedule. If such costs are not

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13. The following results hold whenever the variance of the distribution is large enough so that it pays the firm to price the customer out of the market for small values of $u$. For this, it is sufficient that $\phi > (a - C)/3$. For $\phi < (a - C)/3$, the explicit results are slightly altered, but this does not effect the tenor of the conclusions regarding changes in the number of rate blocks.
trivial, this is likely to preclude tariffs with large numbers of blocks. The percentage changes in $E(\mathcal{T})$ for adding the 2nd through 10th blocks are recorded in Table 1.

**TABLE 1**

<table>
<thead>
<tr>
<th>n</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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</tr>
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<tr>
<td>%Δ$E(\mathcal{T})$</td>
<td>2.88%</td>
<td>.65%</td>
<td>.25%</td>
<td>.12%</td>
<td>.07%</td>
<td>.04%</td>
<td>.03%</td>
<td>.02%</td>
<td>.01%</td>
</tr>
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</table>

Finally, it is possible to examine the social welfare implications of the preceding example. Expected consumer surplus is calculated to be

$$E(CS) = \frac{1}{3b} \left[ \frac{(a + \phi - C)}{4n + 1} \right]^{3} n (4n^2 + 3n + 1)$$

which is decreasing in $n$. If we define welfare as the sum of consumer and producer surplus, then

$$E(W) = \frac{1}{3b} \left[ \frac{(a + \phi - C)}{4n + 1} \right]^{3} n (12n^2 + 9n + 2)$$

which is increasing in $n$. Thus, at least for this constrained example, increasing the number of rate blocks is consistent with both profit and welfare maximization.

**IV. SUMMARY**

In this paper I have described the optimal conditions for several alternative multi-part pricing strategies, having first dropped the assumption of informational perfection which allows the monopolist to identify consumers according to their demands. In this framework the tariff structure is interpreted not only as a revenue generating device, but also as a metering mechanism which causes consumers to identify themselves *ex post*. The metering aspects of the multi-part tariff are similar in nature to those of the more familiar tie-in sale.

In the absence of *ex ante* mechanisms for separating markets for the purpose of perfect price discrimination, the monopolist will not be indifferent among alternative pricing strategies. As a general rule, more complex tariff structures, optimally designed, will generate an increase
in profits. Certainly the entrepreneur will weigh the increased costs of administering and enforcing relatively complex pricing strategies against this “text book” superiority as described in this paper. Nevertheless, explicit consideration of the difficulties involved in separating markets provides a first step toward justifying the concurrent existence and viability of various forms of multiple rate schedules.

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Economic Inquiry
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Volume XV, Number 4  OCTOBER 1977

ARTICLES
How Dead is Keynes? ........................................ James Tobin 459
The Division of Labor in the Firm  ........................................ Richard A. Ippolito 469
An Empirical Model of Price and Output Behavior  ........................................ Louis J. Maccini 493
Why Are Better Seats “Underpriced”? ........................................ Steven N. S. Cheung 513
Sex-Differences in Wages and Employment: A Test of the Specific Capital Hypothesis  ........................................ Elisabeth M. Landes 523
Edwin Chadwick and the Economics of Crime  ........................................ Robert F. Hibbert 539
Assets, Savings and Labor Supply .... James P. Smith 551
Tax-Prices and Voting Behavior: The Case of Local Educational Financing .... Anthony J. Barkume 574
Price Discrimination, Market Separation, and the Multi-Part Tariff .... Michael M. Murphy 587

OTHER CONTRIBUTIONS
The Coase Theorem: A Diagrammatic Presentation ........................................ Alan C. DeSerpa 600
The Effects of Taxation on the Differential Efficiency of Nonprofit Health Insurance ........................................ Ronald J. Vogel 605
Has Electricity Regulation Resulted in Higher Prices? Comment .... Jay Marchand and Robert Sorensen 610
A Test of the Monte Carlo Hypothesis: Comment ........................................ N. E. Savin 613
The Monte Carlo Hypothesis: Reply ........................................ J. Huston McCulloch 618
Conflicting Views on the Effect of Old-Age and Survivors Insurance on Retirement: Comment .... Virginia Reno, Alan Fox, and Lucy B. Mallan 619
Conflicting Views on the Effect of Old-Age and Survivors Insurance on Retirement: Reply to Reno, Fox, and Mallan .... Colin D. Campbell and Rosemary G. Campbell 622
Editor's Note ........................................ 624