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Pricing Patterns of Cellular Phones and Phonecalls: A Segment-Level Analysis

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One expectation of the U.S. Federal Communications Commission (FCC) in the early stages of the cellular communications industry was that the presence of two licensees in each market would ensure competition, and thereby result in declining prices over time for both cellular phones (handsets) and phonécalls. However, industry observers have noted recently that although the price of handsets has declined over time, the price of the phonecalls has not. We investigate this interesting pricing issue by modeling the market interaction between the providers of cellular services and also their interaction with customers using a game theoretic framework.

A critical assumption in the development of our model is that there exist segments of customers with different valuations, usage levels, and price sensitivities for cellular service. Empirically, we provide support for the existence of two customer segments (viz., Business/Professional and Personal) from both secondary data on industry usage and revenue, and primary data collected from a conjoint analysis study of cellular service customers. From the latter source, we also establish that the Business/Professional customers are more sensitive to prices of phonecalls than the Personal segment.

From our analytical model, we characterize the conditions under which *penetration* and *skimming* pricing strategies for the handsets are profit-maximizing from the sellers' standpoint, and derive the corresponding price of phonecalls. One of our main analytical results is that a competitive structure can result in lower prices over time for the handset, but higher prices for the phonécalls, depending on production costs of the handset. We are thus able to provide a theoretical explanation for the observed price patterns for the handset and phonecalls.

(*Cellular Communications; Dynamic Pricing; Customer Segmentation; Repeated Games*)

1. Introduction

An explicit objective of the U.S. Federal Communications Commissions (FCC) when setting the guidelines in the early 1980s for the emerging mobile cellular phone service industry was to foster a market structure that would involve competition in the provision of phone services. The typical structure envisaged was an eventual duopoly, wherein two licenses would be awarded in each cellular market. One license would go to the local telephone company, e.g., the Regional Bell Operating Company (RBOC), and the other to a landline company. This is in constrast to certain other

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utility service markets such as electricity generation and distribution, and cable television, where the industry structure was designed to be one of a regulated monopoly. The rationale underlying the FCC's strategy at that time was that a duopoly would ensure price competition (Busse 1997) and thereby limit the need for regulatory oversight.

Cellular service consists of two components. (a) the phone or the handset, and (b) the service or the ability to make phonecalls. Hence, the pricing of cellular services involves the price of the handset and the price of the phonecall. It was the expectation of the FCC that granting licenses to two firms would induce competition in the pricing of cellular phone services, and therefore, the price of both the handset and the phonecalls would decline over time. However, industry observers have noted that although the price of the handset has declined over time, the price of the cellular phonecalls has largely remained constant (Naik 1994).

In Figure 1 we plot the average wholesale prices for the handset for the period 1985–1992. These data were obtained from a cellular service provider. We note from Figure 1 that over this period, the average wholesale price of the handset declined from over $2,000 in 1985 to around $500 in 1992. That shows a skimming pricing strategy being used by the sellers of the handset. However, we note from Figure 2 that over the period 1986–1993, the average costs to end users of 250 minutes of prime time calling varied from $125 in 1986 to around $118 in 1993. That is, although the price of the handset declined dramatically over time, the price of phonecalls showed no significant decline.

Figure 1 **Average Price ($): Handset**

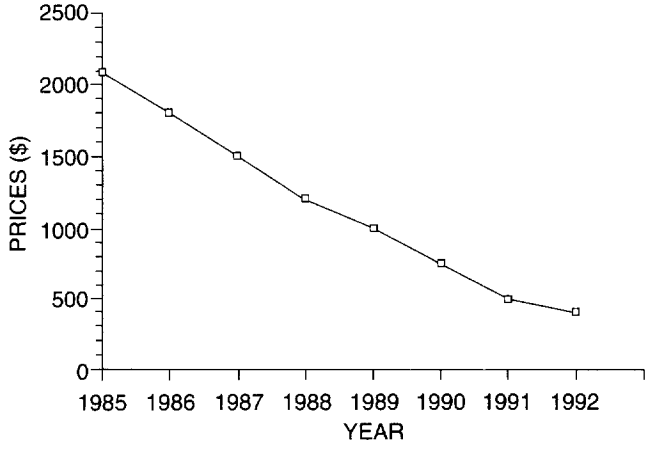
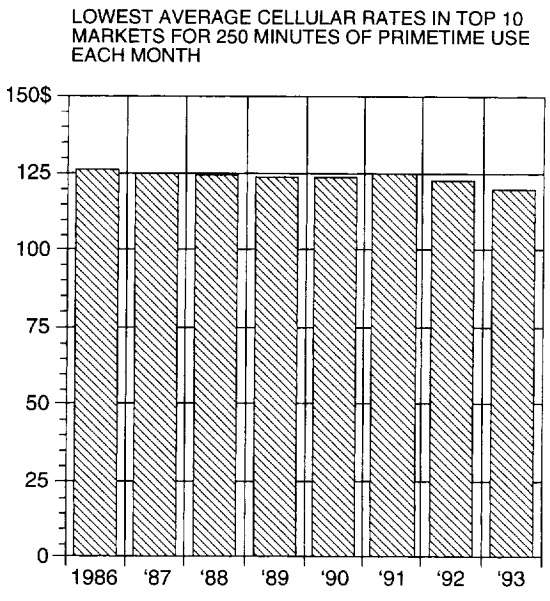


Figure 2 **. . . Costs are Still High**



SOURCE: *Cellular Telecommunications Industries Association*

To obtain additional insight as to why the prices of the handsets and phonecalls evolved over time in the manner they did, we examine Figure 3, which plots over time the quarterly average minutes of use per customer. It shows that the average usage across customers has declined over time. There are at least two explanations for this pattern. First, the usage of current customers may itself have declined over time. Alternatively, the customer base may have changed over the time period with new customers exhibiting lower levels of usage and thereby lowering the average usage. In order to examine further the plausibility of these explanations, we plot in Figure 4 the number of subscribers grouped according to usage levels.

Figure 4 clearly shows that while the number of customers with high level of usage (more than 100 minutes per month) have remained fairly stable over the time period, the number of subscribers with low level of usage has increased rapidly over the same period. Hence, the second explanation for the decline in the average usage, i.e., presence of different cus-

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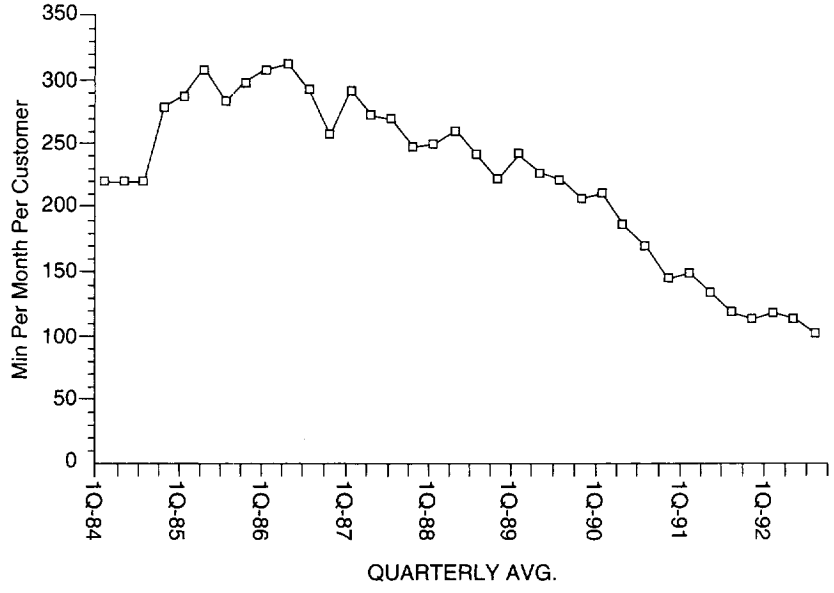
Figure 3 Minutes of Use Per Customer



tomer types, seems to be a more plausible explanation for the observed average quarterly usage over time. Further, Figure 4 also suggests the existence of essentially two broad groups of customers based on usage level. They can be characterized as "heavy" and "light" user segments.

As another piece of evidence to support the existence of two customer segments, we examined the data collected by the market research firm Frost and Sullivan, Inc. (1993). They breakdown the end user market into four major segments: ***Sales and Service, Blue Collar, Business,*** and ***Personal.*** Table 1 summarizes the data for the years 1982–1992. An examination of this table shows that there are essentially only two main segments. The first being a high revenue segment consisting of Businesses and Salespeople, i.e., *Business/Professional,* which generates per capital revenues of about \$900–\$1000 a year to cellular providers. The other segment consists of Blue Collar and Personal end users, i.e., *Personal,* with revenues of \$500–\$600 per year. Hence, there is further empirical support for the existence of two different customer segments with different usage levels and revenues.

A pertinent question that arises is: what are the implications of the existence of these two customer segments for pricing of cellular phone sets and services? That is, can the existence of different customer segments be used to explain the pricing patterns identified previously in Figures 1–4? Our objective is to demonstrate that indeed the existence of two such segments of customers can be an explanation for the phenomenon. In order to do so, we also need to relate the differences in usage to differences in price sensitivities of the two segments. We postulate that the two segments will differ in their price sensitivity with the high usage segment, i.e., *Business/Professional,* being more sensitive to prices of phonecalls than the low usage segment, i.e., *Personal.*

Given the preceding discussion about customers and the structure of the market, we develop a game theoretic model to explain the pricing patterns over time in the cellular market for both the handset and phonecalls in a competitive setting.

We proceed to develop a two period game that models the interactions among buyers and sellers and provides the key result that the *introduction of competition in the market for cellular phone services need not result in lower prices for phonecalls,* contrary to the expectations of the FCC at the time the guidelines for the cellular industry were designed. Interestingly, this result of nondeclining prices of cellular calls is empirically documented and analyzed in the study by Parker and Roller (1997). They ascribe *tacit collusive*

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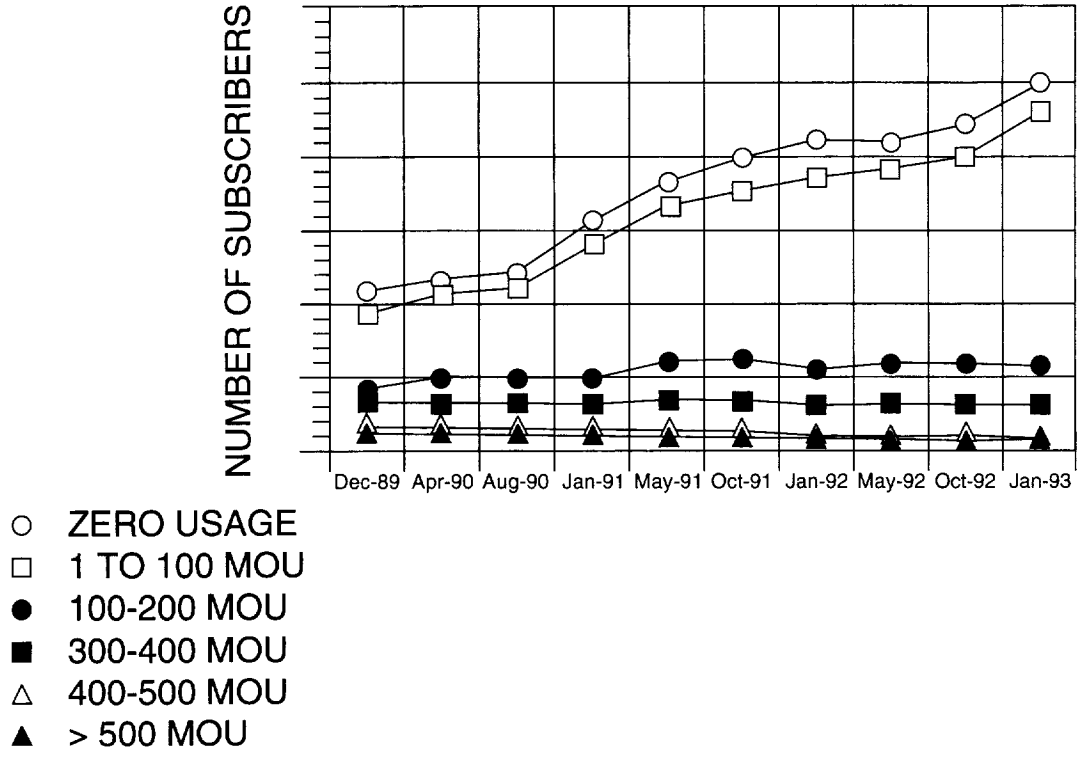
Figure 4 **Number of Cellular Subscribers Per Usage Category**



behavior on the part of providers of cellular services for the prevalence of nondeclining cellular phonecall prices. In contrast to their supply side explanation, our results are driven by demand factors, viz., the existence of different types of customers with different valuations and levels of usage. It is also noteworthy that our results are derived under conditions of noncooperative behavior on the part of cellular providers.

A critical aspect of the modeling framework is the assumption about the price sensitivity of the two segments. Therefore, prior to deriving our key analytical results, we provide in Section 2 below an empirical validation of the assumption that the professional segment is more price sensitive than the personal segment.

2. Price Sensitivity of Customer Segments

A critical assumption in the proposed model formulation is that the *Personal* segment is less sensitive to prices of phone calls than the *Professional* segment. In

Table 1 **Customer Segments and Usage Levels**

Segment	Year	Number of Subscribers	Total Revenue	Revenue per Subscriber
		(100)	($ 000)	(in $)
1. Salespeople	1989	1464	1,351,300	923
	1990	2137	1,992,600	933
	1991	3099	2,802,600	904
	1992	4463	3,874,300	868
2. Blue Collar	1989	211	123,200	584
Users	1990	279	164,300	589
	1991	373	209,100	561
	1992	489	257,500	527
3. Business	1989	1453	1,447,200	996
Users	1990	2049	2,060,900	1,006
	1991	2868	2,798,800	976
	1992	3987	3,734,700	937
4. Personal	1989	223	109,700	492
Users	1990	306	151,800	496
	1991	405	206,800	487
	1992	599	282,800	472

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order to test the validity of this assumption, we collected primary data by conducting a conjoint analysis study of cellular phone/services choices. Prior to conducting such an analysis, qualitative research was conducted to determine the relevant attributes and their levels.

Qualitative research involved conducting two focus groups; one with heads of households who subscribe to cellular service for *personal* use and the other with people who have adopted cellular service for *business* purposes. The results *revealed* that the members of the *Personal* segment subscribed to cellular service primarily for safety and security or as a way of communicating with family members. Their use of service was modest at best. Additionally, there was little awareness among these users about price and acquisition cost of cellular service. On the other hand, the *Professionals* viewed cellular service as a vehicle to enhance productivity and increase sales. However, they expressed concern about the *cost/benefit* aspect of the service for their business and their ability to predict monthly charges. Both these concerns involve paying close attention to the price of phonecalls. These results, therefore, suggest a difference in price sensitivity between the two segments.

In order to obtain quantitative estimates of the price sensitivity to phonecall charges for the two segments, we designed and implemented a conjoint study.[1] This technique allows the estimation of subscribers' overall utility functions, which are a composite of the utilities for the various attributes of cellular services. The focus groups helped us identify the relevant attributes and their levels. A complete list of the attributes and their levels is presented in Table 2.[2]

Using a fractional factorial design, the number of attributes and their levels resulted in an orthogonal array of 16 profiles. Our sample consisted of 85 North Americans who were users of cellular service. Based on the primary purpose of usage, participants were classified a priori as business users (i.e., *Professional* segment) and other consumers (i.e., *Personal* segment). This resulted in 66 and 19 users in the *business* and *personal* segments, respectively.

Table 2 Attributes and their Levels

1. Monthly access charge and included minutes	2. Phone Price
\$12.95, zero minutes	Free
\$24.95, 50 minutes	\$29.95
\$44.95, 150 minutes	\$69.95
\$79.95, 300 minutes	\$119.95
3. Rate for addition minutes	4. Contract Term
\$0.25 per minute	1 year
\$0.30 per minute	2 years
\$0.35 per minute	3 years
5. Service/Network Quality	
Provider Ranked #1 on cellular service quality	
Provider Ranked #2 on cellular service quality	

Each respondent was given a deck of 16 cards, where each card represented a service with a unique combination of attributes. They were asked to sort the 16 cards from the *most* to *least* preferred. In addition, we collected demographic data such as income, occupation, marital status, gender, and age of the participants.

Individual level utility functions were estimated for each subscriber and the average part-worths and importance weights assigned to the various attributes are presented in Table 3 for the two segments.

From the results in Table 3, we see that the importance weight attached to phonecall rates is (0.27) for the *Professional* segment compared to only (0.10) for the *Personal* segment, suggesting that the *Professional* segment is more sensitive to rate per additional minute than the *Personal* segment. Therefore our assumption that the Professional segment is more sensitive to prices of phone calls than the Personal segment is consistent with empirical evidence.[3]

[1] The main reason for using a conjoint study is that there has been little variation in cellular phonecall charges almost since inception. Therefore, a time series based regression analysis to determine price elasticity would not be useful.

[2] We did not include *brand name* as an attribute because the participants in this study were from different parts of North America and therefore did not share the same cellular providers. Given that there are only two service providers in each market, we used a rank ordering of these providers in terms of their *service/network* quality to accommodate possible variations in *service* quality.

[3] In another study for the demand of long distance telephone calls, Heyman, Lazorchak, Sibley, and Taylor (1984) also empirically found that the price elasticities of demand varies with usage levels

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Table 3 Estimated Part-Worths and Attribute Importances

	Average Part-Worths		Importance Weights (in %)	
	Personal	Professional	Personal	Professional
Monthly Access Charges			45	15
$12.95	–	–		
$24.95	−.921	−.065		
$44.95	−3.406	−1.787		
$79.95	−5.677	−1.678		
Rates for additional minute			10	27
0.25	–	–		
0.30	−.628	−1.131		
0.35	−1.319	−3.107		
Phone Price			25	25
Free	–	–		
$29.95	−1.174	−1.196		
$69.95	−3.138	−2.23		
$119.95	−3.142	−2.949		
Contract term			15	23
1 year	–	–		
2 years	−1.181	−.155		
3 years	−1.864	−2.653		
Service/Network Quality			5	10
Rank 1	–	–		
Rank 2	−.664	−1.225		

(Note: '–' denotes the levels that were used as the base levels in analyzing conjoint data.)

Having empirically validated our main assumption that the heavy user segment is more price sensitive than the light user segment, we now proceed to provide an analytical explanation for the observed price patterns in the cellular market based on a two-period, game theoretic model formulation of the interaction between sellers and customers.

with the *high usage* segment being more price elastic (0.31) than the *light user* (0.16).

3. Analytical Model Formulation

A. Customer Optimization Problem

Based on the empirical analysis presented in the previous section, we assume the existence of two customer segments as follows: (a) *Business/Professional* segment 'h' who place a high valuation on each phonecall because of the potentially high revenue R_h each call can generate; and (b) *Personal* segment 'l' such as household users, who place a lower valuation on each phonecall because of the low revenue potential. Customers in each segment maximize their utility derived from subscribing to cellular services. The highest price a consumer is willing to pay for the handset, known as his/her reservation price, depends on the consumer's expectations about the time path of the product's price. S/he discount future streams of utilities by a periodic discount rate of r_c.

We model the market interaction between the providers of cellular services and their customers as a two-period game, where the second period is repeated indefinitely as in a supergame. If the second period is a one shot game, the profits are discounted by $1/(1 + r_c)$, while if the second period repeats itself indefinitely, the profits are an annuity that is discounted by $1/r_c$. Thus, the consumer's utility maximization problem is as follows:

$$\operatorname*{Max}_{x_{ij}} \pi_i = x_{i1}(R_i - c_1) - P_1L_1 + (1/r_c)x_{i2}(R_i - c_2) - (1/(1 + r_c))P_2L_2, \quad (1)$$

where:

c_j = price-per-minute for a phonecall in period $j = 1, 2$,

x_{ij} = is the usage (in minutes) of segment $i = h, l$ in period $j = 1, 2$,

P_j = price of the handset (cellular phone) and in period $j = 1, 2$,

$$L_1 = \begin{cases} 0 & \text{if } x_{i1} = 0 \\ 1 & \text{if } x_{i1} > 0. \end{cases} \quad (2)$$

and

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$$L_2 = \begin{cases} 0 & \text{if } L_1 = 1 \text{ or } L_1 = 0 \text{ and } x_{i2} = 0, \\ 1 & \text{otherwise.} \end{cases} \quad (3)$$

We note from the formulation of the customer's decision problem that there are two price components: a fixed component in the price of the handset (P_j) and a variable component, the price-per-minute (c_j). There is an additional fixed price component that applies in the case of cellular service, viz., the monthly access charge. In our analysis, as we are already making a distinction between the fixed and variable components of price, this additional distinction could be incorporated as follows.

Let M be the monthly charge and let Q_j be the new price defined as:

$$Q_j = P_j + 12M/r_c \quad \text{for } j = 1,2.$$

Thus, the monthly charges can be translated into yearly charges and could be thought of as an annuity whose discounted value is $12M/r_c$.[4] The rest of our analysis can, therefore, continue as is, *mutatis mutandis*.

The term R_i determines the *revenue* type i gets out of each phonecall. It depends on usage x_i, that is, the more phonecalls s/he makes per day, the less efficient each call is, and so R_i is decreasing in x_i. In addition, for each x_i, we have

$$R_h(x) > R_l(x). \quad (4)$$

We assume for the rest of the analysis a specific revenue function R_i $(i = h, l)$ as follows:

$$R_h(x) = \alpha x^{-a}, \quad (5)$$

$$R_l(x) = \beta x^{-b}, \quad (6)$$

where $a < b$ and $\alpha > \beta$.

The first- and second-order conditions for optimality of Equation (1) yield:

$$a < 1, \quad b < 1, \quad (7)$$

$$x_{hj}^a = \alpha(1 - a)/c_j, \quad (8)$$

$$x_{lj}^b = \beta(1 - b)/c_j. \quad (9)$$

Equations (8) and (9) represent the demand function for the two segments of customers, h and l, i.e., they show how the optimal usage (x_h, x_l) varies with the price-per-minute (c), in period $j = 1, 2$. Since $a < b$ and $\alpha > \beta$ it follows that

$$\alpha(1 - a)/c_j > \beta(1 - b)/c_j, \quad (10)$$

and therefore from Equations (8) and (9) we have

$$x_{hj}^a > x_{lj}^b. \quad (11)$$

Since $a < b$ it also follows that

$$x_{lj}^b > x_{lj}^a. \quad (12)$$

Combining Equations (11) and (12), we have $x_{hj}^a > x_{lj}^a$ and thus $x_{hj} > x_{lj}$, i.e., the optimal usage of the high revenue segment is higher than that of the low revenue segment.

The providers of cellular service have three options for pricing strategies for the handset: (a) *skimming* (whereby the price of the handset is reduced from a high level in period 1 to a low level in period 2); (b) *penetration* (low prices in each period); and (c) *exclusive* (high price in both periods). As a rational consumer that correctly anticipates these strategies, the consumer who buys in the first period and belongs to the *Professional* segment h has two reservation prices for the handset.[5]

If s/he expects the firm to sustain the high price in subsequent periods and s/he buys in the first period $(L_1 = 1, L_2 = 0)$, then her/his reservation price is P_h^*, given by:

$$P_h^* = (1 + 1/r_c)x_h(R_h - c_h). \quad (13)$$

If, on the other hand, s/he expects the firm to lower the price and buys the product in the first period, the reservation price is $\bar{P}_h$, given by:

$$\bar{P}_h = x_h(R_h - c_h) + (1/(1 + r_c))\bar{P}_l, \quad (14)$$

where $\bar{P}_l$ is the reservation price of the *personal* segment that buys the handset in the first period if the prevailing strategy is penetration and buys in the

[4] Please note that this approach makes the assumption that the monthly access charge M is constant over time.

[5] We show that when a high handset price prevails, the corresponding price-per-minute, denoted by c_h, does not depend on the period itself, i.e., it is the same price regardless of whether it is in period 1 or subsequent periods. Similarly for the low price-per-minute c_l.

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second period if the strategy is skimming. It is given by:

$$\bar{P}_l = (1 + 1/r_c)x_l(R_l - c_l). \tag{15}$$

In view of (15), Equation (14) could also be presented as follows:

$$\bar{P}_h = x_h(R_h - c_h) + (1/r_c)x_l(R_l - c_l).$$

It is relatively straightforward to show that the reservation price of the handset of the high revenue segment is higher than the reservation price of the low revenue segment.

Let N_i be the number of customers in segment i, and assume initially that there is only one seller.[6] This provider charges a price of $\bar{P}_l$ either in period 1 under penetration strategy or in period 2 under skimming strategy. In both cases, in that period (1 or 2) it gets all the market and so has to choose optimally the price-per-minute c, given that the phone was bought by all customers from both segments. The seller's problem is thus to choose c so as to maximize the profit Π_l from the provision of phonecalls which is given by:

$$\Pi_l = N_h x_h(c - v) + N_l x_l(c - v), \tag{16}$$

where x_h and x_l are given by Equations (8) and (9), and v is the marginal cost of a per-minute phonecall. The first-order condition for optimality is:

$$\partial\Pi_l/\partial c = N_h(x_h'(c - v) + x_h) + N_l(x_l'(c - v) + x_l) = 0, \tag{17}$$

where x_h' and x_l' are given by:

$$x_h' = \frac{\partial x_h}{\partial c} = -\frac{1}{ac}\cdot x_h, \tag{18a}$$

$$x_l' = \frac{\partial x_l}{\partial c} = -\frac{1}{bc}\cdot x_l. \tag{18b}$$

Substituting Equations (18a) and (18b) for x_h' and x_l' in Equation (17) we get after simplification

$$N_h x_h\left(1 - \frac{c - v}{ac}\right) + N_l x_l\left(1 - \frac{c - v}{bc}\right) = 0. \tag{19}$$

[6] We discuss this assumption and how it is relaxed in the next subsection where we model competition.

Denote the solution of Equation (19) by c_l (optimal price-per-minute when $\bar{P}_l$ is the price charged for cellular phone).

In much the same way, the provider charges a price of $\bar{P}_h$ or P_h^* either in period 1 (skimming and exclusive strategy) or in period 2 (exclusive strategy). Hence, it will get only the consumers of segment h, and thus its maximization problem is to choose c so as maximize Π_h, given by

$$\Pi_h = N_h x_h(c - v), \tag{20}$$

where x_h is given by Equation (8). It is clear that $\Pi_l > \Pi_h$. The first-order condition for maximization is given by:

$$\partial\Pi_h/\partial c = N_h(x_h'(c - v) + x_h) = 0. \tag{21}$$

Denote the solution of Equation (21) by c_h (optimal price-per-minute when the price charged for cellular phone is $\bar{P}_h$ or P_h^*). Substituting Equation (18a) for x_h' in Equation (21), and solving for c_h we get

$$c_h - v = av/(1 - a). \tag{22}$$

Substituting Equation (22) in Equation (19), we find that the first expression is zero and the second expression reduces to:

$$N_l x_l\left(1 - \frac{av/(1 - a)}{bv/(1 - a)}\right) = N_l x_l\left(1 - \frac{a}{b}\right) > 0,$$

since $b > a$.

Thus, it is evident that $c_h < c_l$, since at c_h, Π_l is still increasing. We, therefore, have proved the following proposition:

PROPOSITION. 1. *The optimal price-per-minute when the price of the handset is P_h' or $\bar{P}_h$ is lower than the optimal price-per-minute when the phone price is $\bar{P}_l$, i.e., $c_h < c_l$.*

B. Sellers Optimization Problem

We now use the results from the analysis of the two customer segments to model the interaction between the sellers and customers using a two-period game formulation. For each period, sellers must choose the price of the handset and the price per phone call. Customers in each segment must decide whether or not to purchase handsets and if so, in which period

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and the usage levels, under the assumption that their expectations of future prices are rational. An equilibrium of the game is one in which customers maximize discounted net income and providers maximize discounted profits.

We model a market in which in the first period there is one firm (called the incumbent) that provides cellular phones and service of phonecalls. In the second period, a new firm enters the market that provides phones and services of phonecalls. Such a structure is consistent with the evolution of markets for cellular services in the United States. For example, in the Chicago area market, *Ameritech Mobile* began providing cellular services in October 1983, where it had a monopoly status for a year until the second entrant, *Cellular One*, started providing services in January 1985. A similar sequential entry pattern also occurred in the New York City area for cellular services (Parker and Roller 1997).

The profits of the incumbent from sales of cellular phones and service of phone calls are given by the following:[7]

$$\Pi^1\ (skimming) = (\bar{P}_h - K)N_h + 0.5(1/(1+r)) \times (\bar{P}_l - K)N_l + \Pi_h + (1/r)\Pi_l, \quad (23)$$

$$\Pi^1\ (penetration) = (\bar{P}_l - K)(N_h + N_l) + \Pi_l + (1/r)\Pi_l. \quad (24)$$

Note that the skimming policy dominates the penetration policy if and only if $K \geq \bar{K}$, where

$$\bar{K} = P_l + ((r+1)/(r+0.5)) \times (\Pi_l - \Pi_h - N_h(\bar{P}_h - \bar{P}_l))/N_l. \quad (25)$$

In the second period, the newcomer also provides phones and the services of phonecalls. In order not to fall into the trap of the Bertrand paradox in which prices fall right away to marginal costs, we model the competition from the second period onwards as a supergame, i.e., a noncooperative game that repeats itself indefinitely. In each period, each firm sets a strategy that maximizes its discounted net cash flows. In such games it is well known that the following trigger strategies sustain any price between marginal costs and the monopoly price, as long the discount rate is less than 1 (Tirole 1988).[8]

(a) The equilibrium of *skimming* or *penetration* strategies, depending on production costs, is supported by the following trigger strategies:

The firm charges $\bar{P}_h$ and c_h in period t if in every period preceding t, both charged $\bar{P}_h$ and c_h. Otherwise, if one charges $\bar{P}_l$ and c_l, it will charge $\bar{P}_l$ and c_l forever, and at any other price it will set both prices at their respective marginal cost forever.

Since both skimming and penetration strategies call for low levels of prices in the second period (and subsequent periods as well), it remains to be proven that the newcomer is not better off with high prices in the second period (and therefore by sharing the profits of Π_h rather than Π_l). Comparing Equations (16) and (20), we find that this is not the case since $\Pi_h < \Pi_l$.

(b) The following trigger strategies support an *exclusive* policy (which is worthwhile for the incumbent if $K > \bar{K}$):

The firm charges $\bar{P}_h$ and c_h in period t if in every period preceding t, both firms charged $\bar{P}_h$ and c_h. Otherwise, at any other price it will set both prices at their respective marginal costs forever.

We thus have a game with two equilibria and in order to predict which equilibrium could be expected as a result of the game, we build on a *refinement* of equilibrium that involves the forward induction criterion (Kholberg and Mertens 1986, Cho and Kreps 1987). Let a *Stable Equilibrium* be a Subgame Perfect Nash Equilibrium that satisfies the forward induction criterion discussed in Cho and Kreps (1987). We now apply this criterion to our game.

In the *exclusive* strategy, consider an out of equilibrium move in which the newcomer prices its products at $\bar{P}_l$ and c_l. The incumbent realizes that the newcomer charges these prices because it wishes to share the low revenue market (and not because it wishes to capture

[7] It is clear that the sellers would not charge a price for the handset that is 1) above the reservation price of the *Professional* segment, 2) below the reservation price of the *Personal* segment, and 3) lies in-between the reservation prices of the two segments.

[8] Note that Tirole uses a different discount factor δ, where $\delta = 1/(1+r)$; it follows that $r \leq 1$ if and only if $\delta \geq \frac{1}{2}$.

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the whole market itself). The incumbent concludes that the only reasonable strategy for the newcomer is to charge these prices forever, and thus charges $\bar{P}_l$ and c_l as well. Now, according to Proposition 1, $c_l > c_h$; hence, the price of the phonecall increases although the handset price decreases from $\bar{P}_h$ to $\bar{P}_l$.

We can summarize our discussion in the following proposition:

PROPOSITION 2. *If $r < 1$, the game in which the firms compete in both the handsets as well as the phone service, then the following hold:*

(a) *For a high level of production cost, i.e., $K \geq \bar{K}$, **skimming** is a Stable Equilibrium.*

(b) *For a medium or low level of production cost, i.e., $K < \bar{K}$, **penetration** is a Stable Equilibrium.*

(c) ***Exclusive** policy is not a Stable Equilibrium.*

(d) *The competitive market structure will result in lower prices for cellular phones and higher prices of phonecalls.*

Hence, if production costs exceed a certain level the competitive market structure (where both firms supply both handsets in addition to phonecall services) will result in ***lower*** prices for handsets and, consequently, ***higher*** prices for phonecalls. This result thus provides an explanation for the observed price-paths shown in Figures 1 and 2.

4. Summary and Directions for Future Research

The main contribution of this paper is the development of an analytical model to examine cellular phone and phonecall pricing based on demand side characteristics. We have examined analytically why the FCC's expectation of lower prices over time for both cellular phones and phonecalls under competitive market conditions was not realized in practice. We showed that the competitive market conditions can result in declining prices for the handset, but not for phonecalls. Our explanation rests on the existence of segments of customers with different valuations, usage levels, and price sensitivities for cellular services.

There are a number of potential avenues for further research. The first one involves a more formal empirical analysis of the demand and pricing issues based on usage and prices data pertaining to various cellular markets.

In our analysis of the price of the cellular service, we treated the monthly access charge (M) as a fixed component. Modeling explicitly the time path of the fixed charge (M) would be a useful extension of the model developed here. In addition, considering a menu of call pricing options (i.e., offering different levels of monthly access charges/including minutes) would also offer interesting insights into the seller's pricing decisions.

Another avenue for future research is to examine the implications of tie-in arrangements when buying cellular services. In certain cellular markets in the U.S., it is legal for cellular service providers to require activation of cellular service through a given firm if the end user is to take advantage of an attractive (low) price for the handset. In other markets, such a practice is against the law. The interesting research question is to determine the impact of these tie-in arrangements on the price of cellular phones and phone calls, i.e., do tie-in arrangements reduce or increase the price of phone calls? Also, what are its profit/welfare implications? We leave these issues for future research.

To summarize, the empirical evidence does support our assumptions and the main analytical results. The fact that the price of cellular phonecalls has not declined over time like the price of handsets seems to come as a surprise to many observers of the cellular communication market. We have provided an analytical explanation for the observed price paths based on characteristics of customers in the market.[9]

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