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The Doubtful Profitability of Foggy Pricing*

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Abstract

This paper studies whether competition may induce firms abandoning deceptive pricing strategies aimed to profit from mistaken choices of consumers. The empirical analysis focuses on the pricing practices of early U.S. cellular firms, both under monopoly and duopoly. Foggy tariff options are those that are dominated by another option or a combination of other tariff options offered by the firm. I also define a measure of fogginess of non-dominated tariffs based on the range of airtime usage for which they are the least expensive option among those available. Results indicate that firms offer more dominated tariff options in a competitive market than under monopoly. While markets are profitable, perhaps because they grow or because firms collude, the use of foggy tactics is not frequent. However, if the market is more mature, or if firms do not cooperate, thus reducing the return to their investment, then they commonly turn to foggy pricing.

Keywords: Nonlinear Pricing; Foggy Strategies; Co-opetition.

JEL Codes: D43, L96, M21

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1 Introduction

People commonly complain about having to make choices among several tariff options when they, for instance, subscribe to a cellular telephone service. The importance of these deliberation costs has created some business opportunities, and thus the large number of options in many service and public utility industries has turned popular some web sites —such as *lowermybills.com*— where consumers can compare the monthly dollar cost of the service that they intend to use if they subscribe to any of the companies that offer it in a particular local market.

More tariff options open the possibility for firms to take advantage of any bounded rationality issue that makes the comparison among options difficult for consumers. But having numerous tariff options to choose from should not be questioned because in principle, consumers could potentially benefit from a wider selection of subscription choices. However, it is a very generalized idea that firms use this multitude of tariff options to benefits from consumers' mistakes.[1] This belief has recently led the *UK Office of Fair Trading* to launch an investigation on the benefits of limiting the number of tariff options that firms may offer to their customers. There is a similar undergoing investigation by the regulatory authorities of India as well. Why should regulatory bodies aim to restrict the choices of consumers? Shouldn't they be given the chance to learn which companies take advantage of their mistakes in an unfair manner? Why will the market not be able to self-correct the existing strategies of deception? Being these normative questions quite important, they should be preceded by a more modest one: Do firms really benefit from offering tariffs explicitly designed to induce mistaken choices among consumers? The goal of this paper is to provide with some empirical evidence that help us figure out the answer to this question.

There is a growing behavioral literature claiming that consumers commonly make wrong choices when they are given several alternatives to choose from. Wrong choices lead consumer to regret their previous decisions when the cost of use of the good or service is not minimized under the chosen alternative. For instance, using cross-section information, Della Vigna and Malmendier (2003) and (2004) conclude that individuals tend to overestimate the number of future visits to the gym when signing up for membership to a health club. These authors suggest a model of hyperbolic discounting to explain such mistakes. Other plausible explanations may include bounded rationality or reputation in social networks.

These problems are very similar to those faced by customers in many telecommunications services.[2] Users of these services are normally required to choose among a set of tariff options ahead of their consumption decision . Their *ex ante* choice will be *ex post* correct or not depending on the intensity of the use of the

[1] See for instance the *Leader* and *Britain* sections of *The Economist*, April 10th-16th, 2004.

[2] Indeed, many of the empirical questions put forward by the bounded rationality literature was empirically addressed in many Bell Labs working papers over twenty years ago.

service. Miravete (2002) and Miravete and Palacios-Huerta (2004) make use of detailed individual data regarding local telephone use and tariff choice to show that while consumers make mistakes (in a cross-section of data), these mistakes are not systematic. Actually, the evidence reported in these papers indicate that consumers actively engage in switching tariff options aiming to minimize the monthly bill of their local telephone service, even though the potential gains from switching are quite limited.

If consumers make mistakes in choosing among optional tariffs, firms could, in principle, take advantage of such behavior when designing these options. How? Firms may not provide a clear description of the features of the options hoping for consumers to subscribe to a tariff different from the least expensive one for the realized service usage. The ambiguity of the features of the tariff option that consumers face (as the incompleteness of any contract) defines the fogginess of the strategy employed by firms. This is an argument much popularized by Brandenburger and Nalebuff (1996, §7) and recently revisited by Liebman and Zeckhauser (2004) in the context of tariff design. However, the hypotheses that firms offer "many" tariff options in order to get consumers confused is based only on circumstantial evidence and, regardless of the popularity of this opinion, it has never been empirically evaluated.

The goal of this paper is to provide with a first evaluation of whether firms appear to successfully engage in foggy pricing strategies aimed at confusing consumers; document whether these strategies are more likely to happen in monopolistic rather than in competitive markets; determine whether foggy strategies are just the result of phasing out old tariff options offered previously to consumers; and last but not least, establish whether firms engagement in foggy pricing could be explained by the low expected return of adding another non-dominated pricing strategy instead. The analysis carried out in this paper is also complementary of those mentioned above in the sense that while all those studies made use of individual consumer demand data, the present work is based on tariff information identifying the pricing strategy of the agents on the supply side of the market.

Little is known about how firms decide upon their pricing tactics. Recently, the work of Seim and Viard (2004) has analyzed how entry of new firms affects the number of tariff options offered by the incumbents. In this paper I, address the correlation among observable market characteristics and the number of tariff options offered by cellular telephone companies as well, but in addition I also analyze the characteristics of the tariff options offered regarding their fogginess.

The definition of foggy strategy is in itself quite ambiguous. In what matters most for this paper Brandenburger and Nalebuff (1996) claim that firms use foggy strategies for a variety of reasons aiming to conform the perceptions of their customers, as well as competitors in order to hide information and profit from it. These authors claim that firms hide information when, for instance, they introduce a new product at a very low price to induce consumers switching standard or simply develop a taste for the product in order to profit from later sales at higher prices. Brandenburger and Nalebuff (1996, §7.3) explicitly mention

the complexity of telephone tariffs as one of the examples where firms may use these tactics to profit from consumers hoping that they do not choose the least expensive tariff option for their consumption. Complexity is a defining feature of the fogginess of the pricing strategy because it makes more difficult for consumers to compare the cost of the service across different providers. It also serves as a way to avoid fierce competition as it is difficult for competitors to identify the profile of consumers that they should target with lower price offers. Brandenburger and Nalebuff (1996) argue that this same complexity, by softening competition may serve as a way to induce firms to cooperate while competing only superficially (co-opetition).

An obvious criticism to foggy tactics is that they may conform at best, a short run strategy. Consumers will eventually learn how to minimize the expense necessary to enjoy the service according to their preferences and competition may end up "lifting the fog" when other firms introduce attractive, simple, and less expensive tariffs. This was the case of the failed "Value Pricing" initiative of American Airlines or the successful "Ten Cents a Minute" campaign of Sprint, both conducted in the early 1990s.

Therefore, the question posed at the beginning of this section could be qualified as follows: Is foggy pricing still a profitable strategy even in the short run? The answer will certainly be industry specific. It is difficult to give a single answer that conforms appropriately the institutional features and business practices of airlines, telephone, entertainment, and computer industry, just to mention a few that employ these tactics. The contribution of this paper consists of addressing the issue of fogginess from an empirical perspective for the first time, thus precisely stating what we should understand by foggy pricing strategy and suggesting ways to measure it beyond the generic description of complexity in a manner that is useful for the empirical analysis.

In order to carry out this task, I will study the pricing strategies of the early U.S. cellular telephone industry. I use a rich data set comprising the tariff information of all cellular telephone companies present in the early U.S, cellular market between 1984 and 1988. There are clear advantages of studying this case:

1. Complexity of telecommunications tariffs is related not only to the number of tariff options offered by telephone carriers, but to the different dimensions of pricing considered such as peak, shoulder, off-peak, distance, identity of the called party, network terminating the call (mobile-to-mobile *vs.* mobile-to-fixed line), roaming charges, rollover minutes of unused allowance, *et cetera*. One obvious advantage of the tariffs offered in the early U.S. cellular industry is that they only screen consumers with respect to three dimensions: pricing of peak and off-peak airtime usage plus a monthly allowance of free minutes associated to the payment of a monthly fixed fee. These relatively simple pricing schemes allows me to define concise measures of what is a foggy tariff option, and to measure the degree of fogginess of a tariff.

2. The available data do not contain a representative average price of consumption for every nonlinear tariff offered, but rather the whole tariff information necessary to compute the monthly bill for any

profile of consumer. This information, together with a measure of market penetration, allows me to evaluate the expected profits associated to price discrimination for each firm in the sample. I will make use of this estimate to evaluate whether the use of foggy pricing is determined by the return to further price discrimination offering non-foggy options.

3. Following the rules set up by the Federal Communications Commission (*FCC*), two firms were allowed to compete in the early U.S. cellular market in each of the 305 metropolitan areas (*SMSA*). However, a miscalculation in the procedure to evaluate the awarding of the second *nonwireline* license led to a temporary monopoly in many of the largest markets. This is a remarkable feature of this industry because entry of the second cellular carrier is, contrary to Seim and Viard (2004), pretty much exogenous, since it depends on a court decision rather than on pricing of the incumbent firm. The existence of two differentiated market structures allows me to study the different pricing behavior and the inclination of firms to use foggy strategies in monopolistic and duopolistic market structures, respectively.

4. Data include a panel with many demand and cost indicators for each market and firms of this industry. Cross-section variation allows me to identify the effect of market characteristics and firm identity in the design of pricing strategies while the added time variation of the panel allows me to address issues such as learning and most importantly to control for the phasing out of previous tariff options.

The first and most important task is to define what characterizes a tariff option as foggy. The relative simplicity of the pricing strategies offered by the early cellular carriers turns the following practical definition also into one that does not ignore any relevant feature of the tariffs: A foggy tariff option is dominated by one or by a combination of the other tariff options offered by the firm. If consumers subscribe to a foggy tariff option, they could always reduce their expenses by switching to a different tariff option. In order to determine whether a tariff option is dominated or not, I evaluate the offered tariffs of each firm in each market and time over all possible combinations of peak and off-peak consumption adding up to a total of 1,000 minutes of airtime usage.[3] Tariffs include a monthly fixed fee as well as an allowance of peak and off-peak minutes plus a differentiated charge for peak and off-peak minutes. At this time, firms do not offer any other type of volume discounts.

Table 1 shows some of the general features of the pricing in the early cellular market. First, firms offered only few tariff options. Indeed, in monopolistic markets, almost half of the firms only offered a single tariff option, quite differently from nowadays. The transition from monopoly to duopoly clearly increase the alternatives for consumers to choose from. One third of the firms offered three options being two and four alternatives almost as popular. The increase in options available to consumers could be interpreted

[3] At this early market, airtime consumption exceeding 1,000 minutes was rare. Hausman (2002) reports that the average cellular telephone airtime usage in the U.S. first reached 160 minutes per month in 1994.

Table 1: Frequency Distributions of Number of Tariff Options

	All Observations		*Monopoly*		*Duopoly*	
No. Options	Frequency	Rel.Freq.	Frequency	Rel.Freq.	Frequency	Rel.Freq.
1	106	0.1941	43	0.4388	63	0.1406
2	121	0.2216	15	0.1531	106	0.2366
3	181	0.3315	29	0.2959	152	0.3393
4	98	0.1795	8	0.0816	90	0.2009
5	32	0.0586	3	0.0306	29	0.0647
6	8	0.0147			8	0.0179
Mean	2.7308		2.1122		2.8661	
Variance	1.4742		1.3378		1.4048	
Kendall's τ	-0.0461	(1.61)	0.1464	(2.14)	-0.0822	(2.60)
Wireline					-0.2733	(6.09)
Nonwireline					0.1011	(2.25)

Absolute and relative frequency distribution of the number of non-dominated tariff options offered by each active firm. Kendall's τ measures the correlation among the count numbers of effective and foggy options offered by each firm. The corresponding absolute value t-statistics are shown in parentheses.

in different ways. Seim and Viard (2004) would conclude that competition leads to an increase of variety for consumers. Alternatively, we could think that competition induces firms to be more sophisticated in their attempt to extract informational rents to consumers, and thus, they increase their expected profits by better screening among different consumer types. The foggy tactics explanation would conclude that this increase in the number of options is an attempt to benefit from mistaken choices by consumers or to soften competition. But, does the larger number of tariff options offered lead to more fogginess? The measure of association between total and foggy tariff options at the bottom of Table 1 provides with a first piece of evidence against the latest interpretation. Notice that a larger number of tariff options in monopoly goes together with more foggy alternatives. The same is true for the entrant *nonwireline* carrier in the duopolistic markets. However, the incumbent *wireline* carrier drastically redesign its pricing strategy after entry of the competitor to offer less foggy options. The immediate conclusion is that competition appears to discipline firms in limiting the use of deceptive strategies. But of course, this is at odds with the common belief, and further and more detailed analysis is required.

The definition of foggy pricing given above identifies whether a tariff option is dominated or not. Thus, in the empirical analysis of this paper, I do not only study whether firms offer a larger or smaller number of tariff options (complexity) but also whether the offering of some of these options is aimed to induce mistaken choices (deception). However, the analysis of the share of options offered that are dominated can only provide with a partial answer to the question of fogginess. For instance, if one of the options offered by the firms is not dominated only in a very small range of airtime usage, it is likely that it induces consumers to pay higher monthly bills than under some other alternative tariff option. In this paper, I use an analog of the Hirschman-Herfindahl index (*HHI*) defined over the share of minutes for which each tariff option is the least expensive one to account for the degree of fogginess among the non-dominated tariff options.

Evidently, the potential fogginess of a pricing strategy may go beyond whether a particular tariff option is dominated or not, or whether a non-dominated option is actually non-dominated only for a consumption range of say, 153 to 157 peak minutes and 40 to 44 off-peak minutes of usage. For instance, in an experience good markets, such as cellular service has turned out to be, an artificially low introductory pricing to induce subscription may also be considered somewhat a foggy strategy because consumers are not fully aware of the level of future expenses that the current subscription decision may lead to. However, and contrary to the software industry, cellular service has become more and more affordable as its use generalized and technology evolved, and this argument can easily be ignored.

An alternative to foggy pricing that could explain why dominated tariff options are offered to consumers in a moment in time is that such options are currently being phase-out. Thus, consumers who subscribed this option in the past are not automatically switched to one of the new options, but the firm does not intend, neither expect, that new customers subscribe to such option any more. Fortunately the data includes which tariffs were offered in the past, and thus, I can control whether dominated tariffs respond to phasing out of previously offered options or not when conducting the empirical analysis.

Results indicate that firms offer more non-dominated tariff options in a competitive regime than under monopoly, and that indeed, the incumbent *wireline* carrier offer substantially more options than the entrant *nonwireline* operator. The number of tariff options increases with market coverage but decreases with profitability although these effects are only present in the duopoly phase of the markets. Thus, as the market matures, firms appear to offer more options in order to extract additional informational rents and compensate their limited return. Expected profits only decrease marginally the fogginess of the non-dominated strategies offered by monopolist. However, and perhaps this is the most important result of the paper, higher expected profits reduce the share of foggy options offered by competing firms. Therefore, *competition appears to correct deceptive pricing strategies*. Finally, incumbents do not appear to use neither the number of tariff options offered or their fogginess as a strategy to sign up consumers immediately before the *nonwireline* carrier enters the market.

The paper is organized as follows. Section 2 describes the data. Section 3 discusses how three key explanatory variables are constructed from the tariff information: the expected profits per active customer, a measure of market penetration, and the indicator of phasing out of tariff options. As these features are actually determined simultaneously with the design of the tariff, I need to instrument them using exogenous cost and market indicators. Section 4 presents the results of a count data regression model where the number of non-dominated tariff options offered by each firm in each market and time period is explained by market characteristics, and the identity of the owner of the license, as well as the profitability, market coverage, and phasing out indicators. Results are always presented for five alternative specifications of the model distinguishing between monopoly and duopoly markets, and whether entry of the second operator had already been authorized by courts or not to control for the possibility of dynamic pricing. Section

5 estimates a fractional response model to study the determinants of the share of tariff options that are dominated. Section 6 defines a measure of fogginess of the non-dominated options and conducts a similar fractional analysis to explain this feature of the non-dominated tariff options using observable characteristics of the market and the identity of firms plus the profitability, coverage, and phasing-out indicators of Section 3. Section 7 concludes.

2 Pricing in the Early U.S. Cellular Industry

By mid 1980s, the *FCC* granted permission to create 305 non–overlapping cellular markets around *SMSA*s. Concerns about the viability of a fully competitive model led the *FCC* to authorize only two carriers in each market. One of the two cellular licenses –the B block or *wireline* license– was awarded to a local *wireline* carrier, *i.e.*, a company with experience in fixed telephony, while the A block –the *nonwireline* license– was initially awarded by comparative hearing to a carrier other than the local *wireline* incumbent.

Licenses were awarded in ten tiers, from more to less populated markets, beginning in 1984. In general the *wireline* licensee offered the service first and enjoyed a temporary monopoly position until the *nonwireline* carrier entered the market, normally within six months of being awarded the license as required by the *FCC*. However, the administrative review process to award licenses among hundreds of contenders only based on technical issues and investment commitments proved to be far more costly than initially expected. After awarding the first 30 *SMSA* licenses by means of this expensive and time consuming *beauty contest* —there were up to 579 contenders for a single license—, and while the application review of the second tier of 30 markets was on its way, rules were adopted to award the remaining *nonwireline* licenses through lotteries. Court appeals against the administrative award of the *nonwireline* licenses in the earlier tiers, and legal, technical, or managerial difficulties to start operating the lottery-awarded licenses in subsequent tiers led to a situation of temporary monopoly in many of the largest local cellular markets.

In this paper I construct a balanced panel with up to four observations per market, including the tariffs offered to consumers by each firm in the earliest and latest quarter of the monopoly and duopoly phases. Some firms start operating earlier than others, and thus, including more observations of those who are present for a longer period could easily bias the results in favor of the observed behavior of the largest markets where licenses were awarded earlier. Furthermore, tariffs do not change too frequently and these four observations capture most of the pricing behavior of cellular carriers. Descriptive statistics of the variables used in this study are presented in Table 2 distinguishing by market structure.

Tariff data are complemented with market specific demand and cost information as well as an ownership indicator for each firm. The empirical analysis will relate pricing decisions to observable demand characteristics that may condition the distribution of consumers' unobserved heterogeneity that induces firms

Table 2: Descriptive Statistics

	All Observations		*Monopoly*		*Duopoly*	
Variables	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
DUOPOLY	0.8205	0.3841	0.0000	0.0000	1.0000	0.0000
WIRELINE	0.5897	0.4923	1.0000	0.0000	0.5000	0.5006
TIME	13.0641	4.7392	7.9898	4.9461	14.1741	3.8981
NEAREND	0.1227	0.3284	0.6837	0.4674	0.0000	0.0000
MKT-AGE	18.2582	16.7214	13.2143	13.5626	19.3616	17.1520
BUSINESS	32.0924	52.7353	44.9618	67.6731	29.2772	48.5044
COMMUTING	24.7027	3.0556	25.9908	2.8489	24.4210	3.0297
TCELLS	21.0842	22.6944	17.5102	18.0665	21.8661	23.5310
GROWTH	1.1379	1.0350	1.2602	1.0658	1.1112	1.0275
INCOME	26.1772	3.8048	27.9126	3.5988	25.7976	3.7464
EDUCATION	12.5379	0.2534	12.5378	0.2468	12.5379	0.2551
POP-AGE	32.5516	2.9821	32.7449	2.7853	32.5094	3.0248
POPULATION	1.1999	1.5044	1.6217	1.8179	1.1077	1.4124
POVERTY	10.5963	2.8796	11.0020	2.9435	10.5076	2.8611
VARPOVERTY	-109.9628	69.6917	-118.6188	72.6203	-108.0693	68.9734
REGULATED	0.4615	0.4990	0.4490	0.4999	0.4643	0.4993
AMERITECH	0.0916	0.2887	0.1020	0.3043	0.0893	0.2855
BELLATL	0.0623	0.2419	0.0612	0.2410	0.0625	0.2423
BELLSTH	0.1648	0.3714	0.1837	0.3892	0.1607	0.3677
CENTEL	0.0989	0.2988	0.0204	0.1421	0.1161	0.3207
CONTEL	0.1026	0.3037	0.0816	0.2752	0.1071	0.3096
GTE	0.1282	0.3346	0.0612	0.2410	0.1429	0.3503
NYNEX	0.0769	0.2667	0.0612	0.2410	0.0804	0.2721
PACTEL	0.1172	0.3220	0.0816	0.2752	0.1250	0.3311
SWBELL	0.1136	0.3176	0.0612	0.2410	0.1250	0.3311
USWEST	0.1026	0.3037	0.1224	0.3295	0.0982	0.2979
PLANS	3.2143	1.3933	2.6327	1.4530	3.3415	1.3484
EFFPLANS	2.7308	1.2142	2.1122	1.1566	2.8661	1.1853
SHARE-FOGGY	0.1220	0.1834	0.1532	0.2077	0.1151	0.1771
FOGGINESS	0.2878	0.2293	0.1714	0.2111	0.3133	0.2254
LEAD	11.1113	9.1202	10.6248	6.3028	11.2177	9.6297
WAGE	7.0424	1.7816	7.0892	1.5809	7.0321	1.8240
ENERGY	1.6553	0.3479	1.7302	0.3707	1.6389	0.3409
OPERATE	6.3149	1.6022	6.5499	1.5536	6.2635	1.6098
RENT	16.3259	4.8042	16.3340	4.7611	16.3241	4.8189
PRIME	8.7891	1.0775	9.9751	1.1735	8.5297	0.8608
ENG-COSTS	0.4879	0.5513	1.3138	0.4012	0.3073	0.3916
CRIME	65.0901	19.5310	67.0501	19.5573	64.6613	19.5208
SVCRIMES	0.1028	0.0319	0.1092	0.0327	0.1014	0.0315
DENSITY	14.3176	13.9338	15.0064	13.2810	14.1669	14.0824
TEMPERATURE	66.3322	14.0953	55.9322	12.8809	68.6072	13.3165
RAIN	3.6858	1.8189	3.2323	1.9256	3.7850	1.7816
NORTH	37.2120	5.0816	36.3747	5.0473	37.3951	5.0763
WEST	-90.2946	15.5440	-91.4072	15.5796	-90.0513	15.5431
MULTIMARKET	3.5018	2.7496	3.6735	3.0487	3.4643	2.6820
BELLBELL	0.1026	0.3037	0.0000	0.0000	0.1250	0.3311
INDBELL	0.0586	0.2351	0.0000	0.0000	0.0714	0.2578
BELLIND	0.5824	0.4936	0.8367	0.3715	0.5268	0.4998
INDIND	0.2564	0.4371	0.1633	0.3715	0.2768	0.4479
PROFITS	155.6150	41.0900	86.9119	14.3231	170.6438	27.4376
COVERAGE	0.8029	0.2224	0.5556	0.2231	0.8570	0.1820
PHS/PLI	0.0305	0.1615	0.1667	0.3501	0.0007	0.0157
Observations	546.0000	0.0000	98.0000	0.0000	448.0000	0.0000

All variables defined in the text.

to offer a different number of tariff options as screening device to increase profits by extracting consumers' informational rents. Cost variables and other market specific information will be used to instrument for the endogenous expected profits, coverage and phasing-out of tariff options. All money valued magnitudes are expressed in dollars of July 1986. Data definitions and sources are the following:

- Tariff information is reported by *Cellular Price and Marketing Letter*, Information Enterprises, various issues, 1984–1988.

- Socioeconomic and demographic data of each market comes from the 1989 *Statistical Abstracts of the United States*; U.S. Department of Commerce, Bureau of the Census, using the *FCC* Cellular Boundary Notices, 1982–1987, available in *The Cellular Market Data Book*, EMCI, Inc. Variables include the number of months since the market started operating, MKT-AGE; thousands of high potential business establishments, BUSINESS;[4] the average commuting time in minutes, COMMUTING; total population of the *SMSA* in millions, POPULATION; average percent growth rate of population during the 1980s, GROWTH; median income in thousand of dollars, INCOME; percentage of households with income below the poverty level, POVERTY; median age of population, POP-AGE; and median number of years of education, EDUCATION. Since screening of consumers has also to do with the dispersion and not only with the levels of these variables, I constructed VARPOVERTY, an approximation to the variance of poverty level assuming that the probability of finding an individual who belongs whose income level is below the poverty line follows a Bernoulli distribution.

- Industry cost indicators for each market are obtained from the Bureau of Labor Statistics; U.S. Department of Energy; *BOMA Experience Exchange Report: Income/Expense Analysis for Office Buildings*, various issues, 1985–1989; and *Cellular Price and Marketing Letter*, Information Enterprises, various issues, 1984–1988; and 1990 U.S. Census. They include the population density of the market (important for the deployment of antennas), DENSITY; the state average electricity rates in dollars per kilowatt/hour, ENERGY; one-period lagged prime lending rate, PRIME; an index of operating expenses per square foot of office space, OPERATE;[5] an index of average monthly rent per square foot of office space in each market, RENT; and an index of average annual wages per employee for the cellular industry, WAGE. All these indicators are market specific. In order to identify demand effects properly I also use the firm specific cost shifter ENG-COSTS, consisting of an engineering estimate of the average cost of production for each firm in the sample.[6]

[4] BUSINESS refers to what it was considered at that time as highly potential customers by cellular industry experts: business service firms, health care, professional, and legal services, contract construction, transportation, finance, insurance, and real state.

[5] These expenses include cleaning, repair and maintenance, administrative costs, utilities, local taxes, security and ground services, office payroll, as well as other leasing expenses associated with running an office.

[6] This indicator was provided by an independent research firm to *Economic and Management Consultants International, Inc.*, the firm who collected the tariff information used in this paper. See Parker (1990).

- Weather and location data is available on the web at http://cdiac.esd.ornl.org, and includes average temperature and precipitation for 1,221 stations in the contiguous continental states plus those of Alaska.[7] Data include the average quarterly temperature in Fahrenheit degrees recorded at the closest station to each market, TEMPERATURE; and the average quarterly precipitation in inches, RAIN.[8] NORTH and WEST indicate the longitude and latitude of the geographical center of each *SMSA* in degrees.

- Crime information is obtained from the *Uniform Crime Report*, FBI, 1984–1988. We include the number of offenses per 100,000 inhabitants, CRIME; number of violent offenses per 1,000 inhabitants while the percent share of violent crimes in each market is denoted by, SVCRIMES.[9]

- Regulation was common in many markets as indicated by Shew (1994). The REGULATED dummy indicates that firms are required to get approval to offer new tariffs. The regulation regime was reported by the Cellular Telephone Industry Association in *State of the Cellular Industry*, 1992.

- Largest shareholder information is available from the *FCC*. We identify the largest carriers: AMERITECH: Ameritech Mobile; BELLATL: Bell Atlantic Mobile; BELLSTH: BellSouth Mobility; CENTEL: Century Cellular; CONTEL: CONTEL Cellular; GTE: GTE Mobilnet; NYNEX: Nynex Mobile; PACTEL: PacTel Mobile Access; SWBELL: South West Bell; and USWEST: US West Cellular.

- Market Players include an indicator of the particular combination firms operating in a particular market as to whether they used to be part of the Bell System or alternative it is an independent firm. Thus we have BELLBELL, BELLIND, INDBELL, and INDIND. In addition, MULTIMARKET indicates the number of *SMSA* in which a particular firm is operating at a given time. In addition I include the NEAREND indicator to identify whether the tariff offered in the last monopoly quarter in which the information was reported falls within the last six months of actual monopoly phase.[10] Both MULTIMARKET and NEAREND are exogenous regressors because which market to enter and when is given by the *FCC* decision or a later court ruling, instead of the will of cellular firms. Finally, DUOPOLY identifies the competition regime and WIRELINE indicates whether a particular observation corresponds to the *wireline* instead of the *nonwireline* carrier.

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[7] See Easterling, D.R., T.R. Karl, EH. Mason, P.Y. Hughes, D.P. Bowman and R.C. Daniels, *United States Historical Climatology Network (U.S. HCN) Monthly Temperature and Precipitation Data*. ORNL/CDIAC-87, NDP-019/R3, 1996. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

[8] Climatology and location effects on the decision to subscribe to fixed local telephony has been documented by Crandall and Waverman (2000) and Riordan (2002, §2).

[9] There has been much speculation about the effect of crime as a driving force to subscription to cellular services. Indeed, cellular carriers at this early stage of the industry actively played this marketing strategy. See Murray (2002, p.212-213). Violent offenses include murder, non-negligent manslaughter, forcible rape, robbery, and aggravated assault. Property offenses include burglary, larceny-theft, motor vehicle theft, and arson.

[10] The indicator can be computed because we always have information of the first tariff offered by the entrant who, according to the terms of the license, should be operating within six months of being awarded such license.

- Endogenous variables include the number of tariff plans, PLANS, how many of them are actually non-dominated, EFFPLANS, the share of total tariffs offered that are indeed dominated, SHARE-FOGGY, and the degree of fogginess of the non-dominated options, FOGGINESS, as constructed in Section 6. Other endogenous variables are constructed, as described in the next section, to identify relevant information upon which firms may condition their decision to offer more or less effective and/or dominated tariff options. These variables are PROFITS — measured in dollars per month per subscriber—, COVERAGE, and the percentage of foggy options that were offered in previous periods, PHS/PLI.

3 Accounting for Profitability, Coverage, and Phasing Out

When firms offer nonlinear tariffs, generally including quantity discounts, they are attempting to take advantage of consumers heterogeneity of valuations to increase their profits. A nonlinear tariff serves as a way to segment the market by giving consumer incentives to self-select into the tariff option of their liking, the one that minimizes billing expenses for their ideal usage pattern. Characterizing the optimal tariff is a complex but well studied problem —see for instance Maskin and Riley (1984) and Wilson (1993)—, and it involves not only determining what is the optimal markup for each possible consumption level but also deciding whether to exclude some consumers (because it is more profitable to serve only to a subset of them), and in practice, how many and which limited number of tariff options will be offered to approximate the ideal fully nonlinear tariff.

All these decisions determine the expected profits of the tariffs offered, as well as the market coverage. These are interesting variables that condition the number and characteristics of the tariff options offered, including their fogginess. In this section I will describe how this information can be recovered from the data. In addition, as both profitability and coverage are endogenous variables, I will instrument them with exogenous market and firm indicators in order to avoid endogeneity bias later when explaining the determinants of the number of options offered and their fogginess as a function of coverage and, most importantly for the goal of this paper, as a function of the expected profits of firms.

3.1 Expected Profits

Expected profits are a non-observable magnitude that drives pricing and investment decisions of firms. This is also the case for monopolists that offer different tariff options to screen among heterogeneous consumers. However, it is possible to obtain an estimate of each monopolist's expectation if we adopt an equilibrium approach, *i.e.*, if we assume that a monopolist is actually maximizing expected profits when he offers a particular nonlinear tariff. If this is the case, the shape of the tariff conveys very valuable information about the monopolist's perceived distribution of the heterogeneity of his consumers.

The fact that the shape and position of a nonlinear tariff carries information that makes possible to recover the distribution of consumer types was first pointed out by Miravete and Röller (2004) in a framework of nonlinear pricing competition in a common agency environment.[11] The idea is quite simple. There are two elements that define any standard problem of nonlinear pricing: the specification of the consumer demand and the distribution of consumer types. In general, a firm with market power solves the following problem:

$$\max_{q(\theta),u(\theta)} \int_{\theta^\circ}^{\overline{\theta}} \{T[q(\theta)] - K - c \cdot q(\theta)\}\, dF(\theta), \tag{1a}$$

$$\dot{u}(\theta) = q(\theta) \geq 0, \tag{1b}$$

$$\dot{q}(\theta) \geq 0, \tag{1c}$$

$$u(\theta) = U[q(\theta), \theta] - T[q(\theta)] \geq 0, \tag{1d}$$

where $U[q, \theta]$ represents the preferences for consumption of an individual of type θ; $u(\theta)$ is the rent of consumer θ; $T[q]$ is the tariff function; K is any fixed cost of production; c is an assumed constant marginal cost of production; and $F(\theta)$ is a well-behaved, twice, continuously differentiable distribution of type θ defined on a compact support $[\underline{\theta}, \overline{\theta}]$. The cutoff type $\theta^\circ \in [\underline{\theta}, \overline{\theta}]$ identifies the consumer that is indifferent between participating in the market or not, and for which the individual rationality constraint (1d) is exactly equal to zero. The other two constraints of the problem, *i.e.*, the incentive compatibility constraint (1b) and the monotonicity of the control function (1c) ensure that the solution of this mechanism design problem exists, and that it is implementable by a well behaved tariff function.

Economic theory has set the conditions leading to well-behaved separating equilibrium of this game, namely the ranking of individual demands of consumers with different types should be independent of the marginal tariff charged —the well-known single-crossing property—, and the distribution of types should be smooth and exclude mass of probability concentrated around specific values of types, *i.e.*, type distributions should be increasing hazard rate.[12] If these two assumptions hold, there is a one-to-one correspondence between the distribution of consumer types and the optimal nonlinear tariff function for any given specification of demand.

Therefore, in principle, I could estimate the parameters that index the distribution of consumer types among a family of distribution provided some specification of demand. With all these elements at hand, it will be possible to obtain the average expected profits of the monopolist using the same distribution that he implicitly assumes when he offers the particular set of tariff options that he is actually offering in

[11] See Miravete and Röller (2004, §3.4) and Appendix 2 for treatment of the monopoly case that better corresponds to the present paper.

[12] On these matters, see for instance Maskin and Riley (1984), Tirole (1989, §3.5), or Wilson (1993, §6).

the market. The evaluation of the expected profit for each firm is obtained through repeated random draws from the estimated distribution of consumer types.

Provided that the single-crossing property of demand and the increasing hazard rate of the distribution holds, Maskin and Riley (1984, §4) show that the optimal equilibrium tariff is a concave function of q, airtime usage in our case, and therefore it can be implemented as the lower envelope of a continuum of self-selecting two-part tariffs. However, firms rarely offer a fully nonlinear tariff option, but rather a menu with few options as Table 1 documents for the early cellular industry.

Firms may have many reasons to offer only a few tariff options. One argument might be the training of sales personnel to make them aware of the many tariffs offered. Another reason might be the substantial marketing research resources needed to optimally design a large number of tariff options that effectively screen consumers. On additional consideration could be the potential negative perception by consumers when facing a large number of options to choose from and that might trigger that they consider simpler options offered by the competitor. But the most important reason is that the foregone profits of offering an additional tariff decreases rapidly with the number of tariff options as shown in full generality by Wilson (1993, §8.3). Thus, recovering the structural parameters characterizing the demand, marginal cost, and the distribution of consumer types needs to be adapted for the case when firms offer only a finite number of tariff options because in such a case, the lower envelope of the offered tariff does not coincide with the general fully nonlinear tariff solution of problem (1a)-(1d).

I assume that firms offer an $(N+1)$-part tariff. Thus, if firms offer a single tariff option, $N=1$, this is two-part tariff consisting of a fixed monthly fee A_1 and a single rate per minute p_1. If a firm offers two options, this leads to a three-part tariff defined by the lower envelope of two two-part tariffs given by (A_1, p_1) and (A_2, p_2) so that $A_1 < A_2$ and $p_1 > p_2$.[13] The solution of this problem will divide the support of consumer types into contiguous compact regions defined by $\theta_1 < \theta_2 < \ldots < \theta_N$ that identify those consumers that would optimally choose each tariff option. More concisely, the objective function (1a) should be written as:

$$\sum_{j=1}^{N} \left\{ A_j \left[F\left(\theta_j\right) - F\left(\theta_{j-1}\right) \right] + \left(p_j - c\right) \int_{\theta_{j-1}}^{\theta_j} q\left(p_j, \theta\right)\, dF\left(\theta\right) \right\}. \tag{2}$$

Maximization with respect to $\{p_j, \theta_j\}$ subject to the constrains: $\theta_1 < \theta_2 < \ldots < \theta_N$ and $p_1 > p_2 > \ldots < p_N$ leads to a set of first order conditions that have to be fulfilled by a firm offering an $(N+1)$-part tariff and that will identify the structural parameters of a parametric model of nonlinear pricing using only

[13] Notice that I am ignoring the allowance of free minutes. There are two reasons for proceeding in this manner. First, single dimensional screening models cannot handle allowances and rather they have to be imposed exogenously as a restriction in the tariff problem. Second, in the present data, the allowance of the tariffs offered by firms rarely belongs to the lower envelope of the menu of tariff options.

the known features of the optional tariffs offered by the firms, *i.e.*, the monthly fixed fee, the rate per minute, and the market coverage. Notice that the market coverage identifies the cutoff type as:

$$\text{COVERAGE}_i = 1 - F_i\left(\theta^{\circ}\right), \tag{3}$$

where i identifies markets, while the fixed monthly fees enter the problem through the incentive compatibility constrains so that:

$$A_j - A_{j-1} = \int_{p_j}^{p_{j-1}} q\left(p, \theta_j\right)\, dp. \tag{4}$$

To solve this nonlinear problem I have to specify both the demand function and a parametric distribution of types. As in Miravete (2004), I assume that individual demands are linear (quadratic utility function):

$$q(p, \theta) = \frac{\theta - p}{\gamma}, \tag{5}$$

while the distribution of θ is assumed to be a Burr type XII with parameter λ:

$$F(\theta) = 1 - \left[1 - \frac{\theta - \underline{\theta}}{\overline{\theta} - \underline{\theta}}\right]^{\frac{1}{\lambda}} \quad ;\ \lambda \geq 0,\ \ \theta \in [\underline{\theta}, \overline{\theta}]. \tag{6}$$

I distinguish and treat separately the peak and off-peak dimension of each tariff. Thus, I use the algorithm described in Miravete (2004) to recover the boundary types $\theta_1 < \theta_2 < \ldots < \theta_N$; the cutoff type θ°; the marginal cost c; the slope of demand γ; and the indexing parameter of the distribution of consumer types λ. This problem is exactly identified if firms offer just a single two-part tariff, and overidentified if they offer two or more options. The procedure to obtain a firm specific estimate of the expected profits is the following. I repeatedly solve this nonlinear problem for every firm-market-time tuple, both for the peak and off-peak tariff over the consumption range 0-1,000 minutes. Once each solution as been found, I simulate the distribution of consumer types according to the estimated firm-market-time specific distribution of types. Then, for each tuple a single expected profit estimate is obtained assuming —as in Hausman (2002)— that peak consumption represents 80% and off-peak 20% of the total airtime usage, respectively. This is the endogenous variable PROFITS that is instrumented in Section 3.4.

3.2 Coverage

The data does not include individual consumption, neither it does include the number of subscribers of each firm. I only know the number of antenna sites used jointly by both operators at each time and across markets. Each cell site accounts for 1,100 to 1,300 subscribers each, depending on the engineering configuration of the

local network and the airtime usage pattern common at that time. This provides with an approximation to the total number of subscribers in each market.[14 , 15]

Once the number of subscribers is approximated I need to determine the size of the potential market. This is problematic, as its magnitude depends on decisions of an unknown number of consumers. Determining the right size of the market share of the outside option is very much present in the recent literature on discrete choice models of demand. Berry (1994) and Berry, Levinsohn, and Pakes (1995) indicate that establishing the right size of non-participating consumers should be decided on an industry by industry basis, accounting for its basic institutional features.

In the case of the early cellular industry, this was a service clearly targeted to business and high income individuals. Cellular telephones were far from popular as they are today. By the end of our sample, there were only 1.6 million subscribers (as compared to the current 140 million according to the *CTIA*'s November 2003 Semi-Anual Data Survey), and telephone sets were still priced over $2,500 (1986 dollars). Thus, I only consider the number of business in an area as potential cellular users and define market penetration as COVERAGE=1,300×TCELLS/BUSINESS. Besides being more realistic, considering the number of businesses in each *SMSA* produces non-negligible ratios, while if I considered the population of the *SMSA*s instead, most of the pricing decisions of firms would consist on excluding the vast majority of potential customers.

3.3 Phasing Out

In addition to profitability and coverage, I need to account for the possibility that current foggy options are the result of previously offered alternatives that are being phased out. Tariff information was recorded every time that a firm offered a differen set of options. Thus, it is possible to account whether a particular dominated tariff option was previously offered as part of the menu of alternatives of each firm in the immediate past. Variable PHS/PLI computes the ratio of current foggy options that were offered immediately before relative to the total number of options of the current tariff.

3.4 Instrumental Regression

Expected PROFITS, market COVERAGE, and the phasing out indicator PHS/PLI are all simultaneously chosen with the menu of tariffs offered to consumers. As they will serve as regressors in our econometric analysis,

[14] The total number of antenna sites in each market is the right measure of capacity because the *FCC* required the *wireline* company to resale access to its competitor without restrictions until the *nonwireline* company was fully operational in order to foster competition and usage of the cellular service. See Vogelsang and Mitchell (1997, p. 207).

[15] Furthermore, Parker and Röller (1997) made use of a small sample where both the antenna and subscription information were available to show that the correlation between these two variables exceeded 90%.

Table 3: Instrumental Regressions

	PROFITS		COVERAGE		PHS/PLI	
CONSTANT	−65.5210	(2.03)	7.2168	(4.00)	4.2906	(3.22)
LEAD	0.3780	(3.21)	0.0160	(2.39)	−0.0054	(0.93)
WAGE	−0.0595	(0.06)	0.1611	(4.74)	−0.0072	(0.25)
ENERGY	−5.7335	(1.51)	−0.2248	(1.44)	−0.0219	(0.14)
OPERATE	1.0408	(0.81)	−0.0712	(1.09)	−0.0220	(0.43)
RENT	1.1386	(3.72)	−0.0504	(2.74)	0.0142	(0.94)
PRIME	4.6495	(2.64)	0.1245	(1.32)	−0.1346	(1.76)
ENG-COSTS	9.8756	(2.29)	−0.1365	(0.72)	0.0046	(0.03)
CRIME	−0.1319	(2.28)	−0.0071	(2.01)	0.0024	(0.74)
SVCRIMES	80.6708	(1.81)	−0.6608	(0.33)	1.4294	(0.94)
DENSITY	0.2178	(2.16)	−0.0047	(1.19)	0.0028	(0.79)
TEMPERATURE	0.2934	(2.06)	0.0053	(0.76)	−0.0045	(0.83)
RAIN	0.1678	(0.15)	−0.0926	(2.08)	−0.0379	(1.15)
NORTH	0.3055	(1.02)	−0.0796	(4.78)	−0.0003	(0.02)
WEST	−0.4196	(3.58)	0.0136	(2.00)	0.0092	(1.94)
REGULATED	0.0029	(0.00)	−0.1050	(0.81)	0.3352	(3.01)
MULTIMARKET	−2.1120	(4.64)	0.1103	(3.65)	0.0854	(2.82)
INDBELL	27.7820	(2.62)	−2.1862	(3.43)	1.7666	(3.12)
BELLIND	7.8229	(1.39)	−2.2840	(6.92)	−0.6283	(2.50)
INDIND	25.0792	(3.12)	−4.5985	(7.64)	1.2037	(2.03)
AMERITECH	−16.6657	(5.02)	−0.0346	(0.13)	0.2038	(1.09)
BELLATL	−7.3201	(1.54)	−0.0998	(0.44)	0.1145	(0.42)
BELLSTH	19.6436	(3.97)	−1.6019	(5.28)	−0.5418	(2.40)
CENTEL	0.0565	(0.01)	2.2744	(7.09)	−1.9829	(4.14)
CONTEL	−17.4414	(3.71)	1.8069	(5.34)	−1.9836	(4.45)
GTE	−12.4823	(1.91)	0.7570	(1.74)	−2.3457	(4.71)
NYNEX	10.9996	(1.94)	−1.0683	(4.51)	0.0547	(0.22)
PACTEL	−15.9193	(3.76)	−1.8094	(6.32)	−0.1459	(0.51)
SWBELL	4.4923	(1.14)	−1.6064	(6.28)	−0.3905	(1.72)
USWEST	20.4119	(3.69)	−1.8539	(7.71)	0.1319	(0.52)
WIRELINE	0.0348	(0.02)	−0.0006	(0.01)	−0.0810	(0.87)
DUOPOLY	96.4559	(21.55)	1.6359	(8.83)	−2.6373	(19.07)
SUMjSHFj					0.1256	(0.80)
SUMjHHFj					−0.0013	(0.05)
$\ln L$	−2399.4096		−352.8408		−480.0861	

The PROFITS equation is estimated by *OLS*, while the COVERAGE and the PHS/PLI equations are estimated by a *Bernoulli Quasi-Maximum Likelihood*. Absolute, heteroskedastic-consistent t-statistics are presented in parentheses.

they need to be instrumented to avoid any endogeneity bias. The optimal nonlinear tariff responds to both demand an cost variables. The usual "demand shifters" include here anything that may affect the distribution of unobservable consumers' valuations as in a nonlinear pricing problem we are concerned about pricing optimally at different consumption levels. Thus, in order to identify these demand shifters that in the end, and through complicated nonlinear relations will determine expected profits, coverage and the phasing out of old tariff options, we need instruments that shift costs but that are uncorrelated with demand shocks. Since in addition the data includes competing firms, it necessary to account for firm specific cost shifters.[16]

[16] Observe that contrary to Bresnahan (1981) and (1987) or Berry et al. (1995), I cannot use the characteristics of the tariff of the competitor in other markets as valid instruments, as the tariff characteristics are indeed endogenous to the analysis.

Table 3 regress PROFITS, COVERAGE, and PHS/PLI on a set of market specific cost variables such as the WAGE index of employees of the cellular industry, the PRIME lending rate in each market, the population DENSITY of a market (affecting the deployment of antennas), and some other common costs of running a business in each *SMSA*. While all these regressors capture common cost shifters, I also include variables that may better capture firm specific effects such as the identity of the owner of the license; the possibility of differentiated levels of efficiency due to accumulated experience captured by LEAD, the number of months separating the entry of the *wireline* and *nonwireline* operators; and a firm specific engineering estimate of the average operating unit costs as appraised by an independent research company, ENG-COSTS.

In addition to these variables, instruments also include market specific variables that might affect subscription decisions, such as geographical location, weather, or crime, as well as to the competition regime that might have arisen among firms who used to belong to the Bell System or that on the contrary were independent, recently created firms.

Two more instruments are included. MULTIMARKET intends to capture the effect on profitability and coverage that the presence in several markets may have. While I am treating each market independently from each other, firms operating in several markets may enjoy some important cost savings as they could perhaps consolidate some activities across markets or establish a softer competition regime with other firms also present in several markets. Finally, REGULATED attempts to capture whether firms that operated in regulated markets behaved significantly different in their pricing behavior. The positive and significant effect on the PHS/PLI regression is in accordance with Shew (1994), who argue that regulated firms initially filed as many tariff options as possible in order to avoid future regulatory review, thus leading to important phasing out of these obsolete tariffs as time passed and as regulation was never really enforced seriously in this duopolistic industry.

The phasing out of certain tariff options are necessarily conditioned by previous choices of how many options to offer and their design. Contrary to current features of the tariffs, such as their degree of fogginess or the number of tariff options, the share of current options that were already offered in the past is, up to certain extent, predetermined by previous pricing decisions. If demand shocks are market specific, as opposed to nationally driven, the characteristics of the tariffs of the competitors in other markets during past periods can also be used as valid instruments according to Hausman, Leonard, and Zona (1994) and Hausman (1996). Thus, the PHS/PLI equation includes the sum of the phasing out and fogginess ratio of competing firms in all other markets where the firm operated in previous periods, SUMjSHFj and SUMjHHFj, respectively.

4 The Number of Effective Tariff Options Offered

I begin the empirical analysis of the tariff data by studying the determinants of the total number of non-dominated strategies. In Table 4 I present the results of estimating a *Poisson pseudo maximum likelihood* ($PMLE$) count data model that relate the observed market/firm indicators plus the instruments of Section 3 to the number of tariff options offered by each firm according to the following exponential mean function:[17]

$$E\left[\text{EFFPLANS}_i \mid \mathbf{x_i}\right] = \exp\left(\mathbf{x_i'}\beta\right) . \tag{7}$$

The variance of a Poisson distribution is identical to the mean. Thus, inference can be seriously compromised when the expected distribution of EFFPLANS conditional on $\mathbf{x}$ is not equidispersed. The $PMLE$ estimation method obtain consistent estimates of β based on the Poisson likelihood function, but employs a robust covariance matrix that allows for overdispersion as well as for the less common underdispersion, which happens to be what characterizes the empirical distribution of effective number of plans in the present sample.[18]

If consumer types are distributed on a compact support, the optimal solution to problem (1a)-(1d) is a concave fully nonlinear tariff implementable by a continuum of self-selecting two-part tariff options. However, either because of commercialization costs, or because of negative induced goodwill effects on the customer base, firms only offer a few tariff options. As incremental profits of offering additional tariff options decrease with the number of options offered, we should expect that firms offer more options when total expected profits are higher. This will occur when the proportion of high valuation consumers is large, which in turn translates into more concave optimal nonlinear tariffs to ensure that the large proportion of high valuation customers do not have incentive to deviate and behave as low valuation customers. Results reported in Table 4 are however inconclusive regarding the effect that expected profits have on the number of non-dominated tariff options offered by firms.

[17] Actually, Table 4 reports the response for an hypothetical market with average characteristics. The same procedure is adopted when presenting results in later sections of this paper. In this case, the marginal effects can be written as:

$$\left.\frac{\partial E\left[\text{EFFPLANS} \mid \mathbf{x}\right]}{\partial x_j}\right|_{\overline{\mathbf{x}}} = \beta_j \exp\left(\overline{\mathbf{x}}'\beta\right) .$$

[18] Compare the mean and variance of the number of non-dominated tariff options in Table 1. For completeness I also estimated a *Gamma-count maximum likelihood* model to confirm that data were indeed underdispersed. I do not report these estimates —which produce very similar marginal effects— because the inference is more robust using the $PMLE$ approach. If the data generating process is not given by a gamma distribution, the estimates of the gamma-count model are not consistent. $PMLE$ will, on the contrary, produce consistent and asymptotically normal estimates regardless of the data generating process as long as the conditional mean function (7) is correctly specified. On the gamma-count model see Cameron and Trivedi (1998, §4.3.4) and Winkelmann (1995). As for the advantages of the robust $PMLE$ estimation and the computation of the robust covariance matrix see Cameron and Trivedi (1998, §3.2.3), Gourieroux, Monfort, and Trognon (1984), and Wooldridge (2002, 19.2.2).

Table 4: Number of Non-Dominated Tariff Options

	I		II		III		IV		V	
CONSTANT	8.7656	(1.33)	8.5860	(1.33)	6.9982	(1.82)	5.3428	(1.55)	5.7627	(1.70)
TIME	0.0357	(1.07)	0.0298	(0.85)	0.0345	(1.88)	0.0428	(2.79)	0.0214	(1.37)
MKT-AGE	−0.0088	(0.56)	−0.0100	(0.66)	−0.0090	(2.02)	−0.0077	(1.93)	−0.0079	(2.04)
COMMUTING	0.0279	(0.38)	0.0254	(0.34)	−0.0331	(1.04)	−0.0564	(2.14)	−0.0315	(1.14)
COVERAGE	−0.0995	(0.17)	−0.0404	(0.07)	0.4110	(1.79)	0.5581	(2.97)	0.3719	(1.96)
POPULATION	0.1554	(2.28)	0.1476	(2.22)	0.1360	(1.57)	0.1336	(2.06)	0.1653	(2.45)
POP-AGE	0.0679	(2.07)	0.0695	(2.13)	0.0276	(1.57)	0.0199	(1.34)	0.0247	(1.67)
EDUCATION	−0.4593	(1.02)	−0.4772	(1.05)	−0.2365	(0.80)	−0.2429	(0.91)	−0.2402	(0.92)
BUSINESS	−0.0030	(1.81)	−0.0030	(1.80)	−0.0000	(0.00)	−0.0001	(0.07)	−0.0007	(0.42)
GROWTH	0.2498	(2.60)	0.2322	(2.26)	0.0370	(0.50)	0.0391	(0.61)	0.0385	(0.61)
INCOME	−0.0176	(0.41)	−0.0106	(0.24)	0.0038	(0.15)	−0.0045	(0.22)	−0.0050	(0.24)
POVERTY	−0.7091	(3.53)	−0.6778	(3.47)	−0.1290	(1.13)	−0.1131	(1.10)	−0.1660	(1.60)
VARPOVERTY	−0.0273	(3.62)	−0.0263	(3.57)	−0.0052	(1.21)	−0.0043	(1.09)	−0.0063	(1.60)
REGULATED	0.1481	(0.91)	0.1747	(1.14)	0.2407	(2.08)	0.2887	(2.87)	0.2357	(2.36)
PROFITS	−0.0107	(1.32)	−0.0109	(1.35)	−0.0117	(2.37)	0.0015	(0.88)	−0.0131	(2.94)
AMERITECH	1.6438	(6.24)	1.5555	(5.08)	0.6847	(3.05)	1.0902	(6.10)	0.7459	(3.76)
BELLATL	1.3131	(4.31)	1.2978	(4.15)	0.7480	(3.31)	0.9048	(4.66)	0.8270	(4.24)
BELLSTH	0.0714	(0.31)	0.0835	(0.38)	0.7709	(3.96)	0.4907	(3.07)	0.6585	(3.79)
CENTEL	1.3475	(2.14)	1.3545	(2.19)	0.6894	(3.23)	0.5077	(2.79)	0.7479	(3.94)
CONTEL	−0.1070	(0.44)	−0.1194	(0.47)	−0.2254	(0.99)	−0.1722	(0.84)	−0.1488	(0.73)
GTE	0.1746	(0.44)	0.2275	(0.60)	−0.0308	(0.16)	0.0635	(0.37)	0.0651	(0.38)
NYNEX	2.6802	(9.09)	2.6462	(8.29)	1.2996	(4.79)	1.3325	(5.64)	1.5350	(6.51)
PACTEL	0.0011	(0.00)	0.0854	(0.18)	−0.1647	(0.87)	−0.0452	(0.26)	−0.1801	(1.04)
SWBELL	0.3182	(0.97)	0.3205	(0.98)	0.5563	(3.06)	0.5064	(3.22)	0.4484	(2.83)
USWEST	1.7348	(4.60)	1.7748	(4.86)	1.4990	(5.35)	1.3384	(6.19)	1.6114	(7.16)
NEAREND	−0.1238	(0.64)							0.3728	(1.41)
WIRELINE									0.1814	(1.95)
DUOPOLY									1.9408	(4.07)
$\ln L$	−132.0972		−132.1245		−732.5380		−875.9198		−872.8985	

Marginal effects evaluated at the sample mean of regressors of *Poisson PMLE*. Absolute value, robust, Eicker-Huber-White t-statistics for unspecified variance matrix are reported between parentheses. Monopoly sample is used to obtain estimates of model I and II; Duopoly for III; and all observations for IV and V.

I consider five different models. Model I and II correspond to the monopoly phase. The only difference between these tow models is that the former includes NEAREND, the indicator that the observation corresponds to the last six months of monopoly phase in a given market either because the *nonwireline* license has been already awarded through lottery, or because courts have ruled in favor of one of the contenders for such license. Model III only uses the data of duopolistic markets. Models IV and V pool the monopoly and duopoly phases although the latter allows for incumbent and competition specific effects.

Table 4 shows that there is a substantial difference between the pricing practices under monopoly and duopoly. Overall, more tariff options are offered in duopoly than in monopoly. There is an additional incumbent effect, thus indicating that this firm reacts to the entry of the competitor by trying to better screen his heterogeneous customer base.

Table 4 also documents other interesting facts. For instance, there are very important firm specific effects, which may indicate that cellular companies, regardless of the characteristics of the markets have a definite corporate strategy that is applied across different geographical areas. Thus, for instance, NYNEX

and USWEST offer around 1.5 more tariff options than the average firm. Firms competing in markets with large cellular penetration offer more non-dominated options perhaps attempting to capture informational rents as a way to increase their return in an environment where most valuable customers are already signed in. Other results indicate that, although slowly, as competitive markets mature the number of tariff options gets reduced.

Two more results are worth being pointed out. First REGULATED firms always offer a larger variety of tariff options. This is consistent with the argument given by Shew (1994) —and mentioned above— that these firms attempted to circumvent the effects of future regulatory restrictions by having as many tariff options approved as possible. It turned out that these more numerous tariff options were non-dominated, as foggy pricing strategies would probably be rejected by the regulator. Finally, it is remarkable that demographics are not significant at all in the regressions using data from the duopoly phase, while few of them are significant in models I and II. This may indicate that the observed average market characteristics have little to do with the distribution of unobservable individual characteristics driving consumption, and ultimately the design of nonlinear tariffs and the number of tariff options that implements it in practice.

5 Proportion of Foggy Tariff Options

The previous section only looked at effective screening, *i.e.*, the number of tariffs that firms offered aiming to distinguish among consumers with different valuations. These options intend to extract as much consumer surplus as possible (informational rents) but do not generate profits out of deception; or at least not completely.

I now consider all tariff options offered by firms, and not only the non-dominated. In this section I attempt to identify the determinants of the share of tariff options that are dominated, *i.e.*, a measure characterizing the intensity in which a firm intends to profit from inducing mistaken choices among his customers. In order to control for the possibility that those dominated options were not exclusively intended to profit from deception, Tables 5 and 6 estimate two specifications of models I-V, including the later the phasing out indicator PHS/PLI.

The estimation of these models has to account for the fact that the endogenous variable is a fraction, *i.e.*, $0 \leq$ SHARE-FOGGY ≤ 0. Since, the endogenous variable can actually take value 0 with positive probability, applying the log-odds ratio is not appropriate. I thus compute the *Bernoulli pseudo maximum likelihood estimator* of Papke and Wooldridge (1996), which as in the case of the $PMLE$ of Section 4 leads

Table 5: Share of Foggy Options

	I		II		III		IV		V	
CONSTANT	−0.1109	(0.72)	−0.1361	(0.76)	−0.7072	(1.14)	−1.1097	(2.00)	−0.8536	(1.54)
TIME	−0.0024	(2.01)	−0.0023	(1.79)	−0.0022	(0.74)	0.0006	(0.25)	−0.0030	(1.06)
MKT-AGE	0.0006	(1.16)	0.0007	(1.47)	0.0003	(0.38)	−0.0000	(0.05)	−0.0001	(0.18)
COMMUTING	−0.0021	(0.79)	−0.0018	(0.68)	0.0088	(1.65)	0.0061	(1.22)	0.0114	(2.36)
COVERAGE	0.0037	(0.37)	0.0010	(0.09)	0.0041	(0.12)	0.0011	(0.03)	−0.0330	(1.15)
POPULATION	−0.0026	(0.85)	−0.0024	(0.80)	−0.0093	(0.60)	−0.0144	(1.16)	−0.0094	(0.69)
POP-AGE	−0.0027	(3.30)	−0.0028	(3.22)	0.0116	(4.47)	0.0075	(2.84)	0.0081	(3.36)
EDUCATION	0.0112	(0.90)	0.0146	(0.97)	0.0027	(0.06)	0.0166	(0.38)	0.0081	(0.19)
BUSINESS	0.0001	(2.07)	0.0001	(1.90)	−0.0001	(0.27)	−0.0000	(0.02)	−0.0001	(0.19)
GROWTH	−0.0054	(1.71)	−0.0041	(1.18)	−0.0058	(0.56)	−0.0023	(0.24)	−0.0021	(0.22)
INCOME	0.0008	(0.64)	0.0004	(0.26)	0.0055	(1.25)	0.0025	(0.53)	0.0029	(0.65)
POVERTY	0.0135	(2.38)	0.0116	(2.02)	0.0459	(2.05)	0.0429	(2.14)	0.0291	(1.57)
VARPOVERTY	0.0005	(2.22)	0.0004	(1.90)	0.0019	(1.98)	0.0016	(1.96)	0.0010	(1.43)
REGULATED	−0.0031	(0.69)	−0.0048	(1.06)	0.0088	(0.52)	0.0128	(0.78)	0.0072	(0.45)
PROFITS	−0.0002	(0.95)	−0.0002	(0.79)	−0.0031	(4.05)	−0.0005	(1.98)	−0.0036	(5.11)
AMERITECH	−0.0103	(0.99)	−0.0053	(0.54)	−0.0596	(1.55)	0.0028	(0.08)	−0.0582	(1.51)
BELLATL	0.0325	(4.25)	0.0334	(4.38)	−0.0146	(0.36)	0.0632	(1.70)	0.0453	(1.19)
BELLSTH	0.0303	(4.92)	0.0286	(4.32)	0.0821	(3.03)	0.0858	(3.46)	0.1148	(4.59)
CENTEL	−0.1309	(4.33)	−0.1363	(4.71)	0.0616	(2.04)	0.0395	(1.22)	0.0823	(2.56)
CONTEL	0.0033	(0.31)	0.0019	(0.17)	−0.0017	(0.06)	−0.0209	(0.63)	−0.0162	(0.52)
GTE	−0.1242	(3.95)	−0.1344	(4.17)	0.0083	(0.30)	0.0130	(0.45)	0.0150	(0.54)
NYNEX	0.0079	(0.77)	0.0103	(1.04)	0.0696	(1.49)	0.0402	(0.90)	0.0867	(1.93)
PACTEL	−0.1443	(4.64)	−0.1541	(4.85)	−0.0493	(1.42)	−0.0384	(1.09)	−0.0594	(1.71)
SWBELL	0.0153	(1.90)	0.0140	(1.65)	0.0797	(2.97)	0.0964	(3.87)	0.0798	(3.22)
USWEST	0.0257	(2.85)	0.0207	(1.92)	0.1299	(3.26)	0.0860	(2.67)	0.1440	(4.22)
NEAREND	0.0062	(1.52)							0.0206	(0.61)
WIRELINE									0.0413	(2.78)
DUOPOLY									0.3515	(4.60)
$\ln L$	−498.7856		−622.7401		−2090.9039		−4132.2132		−3088.6945	

Marginal effects evaluated at the sample mean of regressors of *Bernoulli PMLE*. Absolute value, robust t-statistics are reported between parentheses. Monopoly sample is used to obtain estimates of model I and II; Duopoly for III; and all observations for IV and V.

to consistent and asymptotically normal estimates as long as the following conditional mean function is correctly specified:[19]

$$E\left[\text{SHARE-FOGGY}_i \,|\, \mathbf{x_i}\right] = \Lambda\left(\mathbf{x_i}'\beta\right) . \tag{8}$$

Results show that there are very important differences between market regimes. Thus, for instance, many of the foggy options offered by monopolists were the results of previous pricing decisions. The negative effect of the PHS/PLI indicator in duopoly hints that competition trigger the introduction of foggy tactics to compensate the reduction of profits relative to the monopoly phase. The positive effect of DUOPOLY and WIRELINE in Model V, together with the positive and significant effect of these two variables in Table

[19]The choice of the logistic function $\Lambda\left(\mathbf{x_i}'\beta\right) = \exp\left(\mathbf{x_i}'\beta\right)/[1+\exp\left(\mathbf{x_i}'\beta\right)]$ is arbitrary, and any other function (not necessarily a distribution function) with a range in $(0,1)$ will also serve for the purpose of consistent estimation. Again, the reported results are marginal effects evaluated for a market with average characteristics:

$$\left.\frac{\partial E\left[\text{EFFPLANS} \,|\, \mathbf{x}\right]}{\partial x_j}\right|_{\overline{\mathbf{x}}} = \beta_j \Lambda\left(\overline{\mathbf{x}}'\beta\right)\left[1-\Lambda\left(\overline{\mathbf{x}}'\beta\right)\right].$$

Table 6: Share of Foggy Options & Tariffs Phase-Out

	I		II		III		IV		V	
CONSTANT	−0.1362	(0.84)	−0.1609	(0.86)	−0.7564	(1.22)	−0.7453	(1.35)	−0.8052	(1.46)
TIME	−0.0027	(1.92)	−0.0027	(1.83)	−0.0017	(0.59)	−0.0005	(0.19)	−0.0025	(0.92)
MKT-AGE	0.0005	(0.98)	0.0008	(1.47)	0.0002	(0.27)	−0.0002	(0.29)	−0.0002	(0.25)
COMMUTING	−0.0008	(0.26)	−0.0006	(0.20)	0.0087	(1.67)	0.0088	(1.87)	0.0109	(2.29)
COVERAGE	0.0021	(0.21)	−0.0010	(0.09)	0.0069	(0.20)	−0.0167	(0.56)	−0.0294	(1.00)
POPULATION	−0.0032	(1.19)	−0.0031	(1.08)	−0.0079	(0.51)	−0.0086	(0.60)	−0.0086	(0.62)
POP-AGE	−0.0036	(3.57)	−0.0035	(3.41)	0.0121	(4.47)	0.0095	(3.66)	0.0087	(3.37)
EDUCATION	0.0054	(0.45)	0.0112	(0.79)	0.0054	(0.12)	0.0148	(0.34)	0.0108	(0.25)
BUSINESS	0.0001	(0.94)	0.0001	(1.00)	−0.0001	(0.29)	−0.0000	(0.06)	−0.0001	(0.15)
GROWTH	−0.0058	(1.66)	−0.0035	(0.92)	−0.0078	(0.73)	−0.0070	(0.71)	−0.0042	(0.42)
INCOME	0.0012	(0.93)	0.0004	(0.29)	0.0060	(1.38)	0.0043	(0.98)	0.0034	(0.77)
POVERTY	0.0135	(2.08)	0.0109	(1.65)	0.0463	(2.09)	0.0358	(1.92)	0.0302	(1.65)
VARPOVERTY	0.0005	(1.94)	0.0004	(1.56)	0.0019	(2.00)	0.0013	(1.69)	0.0011	(1.48)
REGULATED	−0.0088	(1.76)	−0.0102	(1.89)	0.0162	(0.91)	0.0244	(1.47)	0.0136	(0.80)
PROFITS	0.0000	(0.10)	0.0000	(0.13)	−0.0032	(4.18)	−0.0031	(4.36)	−0.0037	(5.18)
AMERITECH	−0.0133	(1.27)	−0.0058	(0.57)	−0.0547	(1.43)	−0.0301	(0.85)	−0.0538	(1.41)
BELLATL	0.0303	(3.97)	0.0317	(4.14)	−0.0103	(0.25)	0.0630	(1.66)	0.0500	(1.29)
BELLSTH	0.0283	(4.09)	0.0256	(3.25)	0.0856	(3.20)	0.1196	(4.73)	0.1195	(4.69)
CENTEL	−0.1292	(4.46)	−0.1354	(4.72)	0.0611	(2.03)	0.0735	(2.31)	0.0827	(2.59)
CONTEL	0.0030	(0.28)	0.0008	(0.07)	−0.0040	(0.13)	−0.0170	(0.54)	−0.0167	(0.54)
GTE	−0.1178	(4.59)	−0.1318	(4.91)	0.0034	(0.13)	0.0071	(0.25)	0.0116	(0.41)
NYNEX	0.0021	(0.18)	0.0068	(0.64)	0.0791	(1.63)	0.1004	(2.17)	0.0960	(2.01)
PACTEL	−0.1345	(4.60)	−0.1490	(4.96)	−0.0431	(1.23)	−0.0470	(1.33)	−0.0554	(1.58)
SWBELL	0.0219	(2.82)	0.0180	(2.21)	0.0783	(2.98)	0.0839	(3.35)	0.0794	(3.22)
USWEST	0.0199	(2.13)	0.0130	(1.06)	0.1386	(3.37)	0.1564	(4.27)	0.1544	(4.21)
NEAREND	0.0094	(2.23)							0.0223	(0.66)
WIRELINE									0.0413	(2.78)
DUOPOLY									0.2593	(1.92)
PHS/PLI	0.0891	(2.01)	0.0720	(1.58)	−0.2149	(0.90)	−0.3780	(3.76)	−0.1505	(0.80)
$\ln L$	−628.2678		−746.8265		−2307.6886		−2521.8544		−2862.8126	

Marginal effects evaluated at the sample mean of regressors of *Bernoulli PMLE*. Absolute value, robust t-statistics are reported between parentheses. Monopoly sample is used to obtain estimates of model I and II; Duopoly for III; and all observations for IV and V.

4 indicates that incumbents reacted drastically to the entry of competitors, offering both dominated and non-dominated tariff options.

The negative sign of PROFITS in duopoly appears to confirm this interpretation. Therefore, and perhaps this is the most important result of the paper, foggy tactics appear to be employed when other means of ensuring a "fair return," *i.e.*, , through finer screening of consumers, does not increase profits much. Therefore, the use of foggy tactics will be more common in markets that have reached a certain degree of maturity and competing firms steel business from each other. However, if the market expands and profit expectations are high, the use of foggy tactics vanishes.

There are many other indications of the structural change in the fogginess of the pricing strategies followed by these firms before and after entry of the second operator. Two firms CENTEL and NYNEX embraced foggy tactics as a way to compete against the other carrier, while three important firms who always employed foggy tactics —BELLSTH, SWBELL, and USWEST—, intensified its use in duopoly periods. Only one company,

CONTEL, remained "honest" in both market configurations while BELLATL gave up profiting from deception to face competitors.

Two more signs of this structural change are the positive and significant effect of NEAREND and the loss of significance of REGULATED as we move into a competitive environment. NEAREND is intended to capture any change of pricing behavior triggered by the imminent entry of a competitor. These change of pricing behavior may be justified by dynamic considerations such as to avoid future competition by increasing the captive customer base today with through the use of long term contracts. The positive effect of NEAREND indicates that incumbents turned to foggy tactics to achieve that goal. Similarly, REGULATED monopoly carriers were less likely to offer foggy options as they feared not obtaining the necessary regulatory approval. As time goes on, and the consensus that a competitive markets do not need regulation arises, firms possibly used this gained freedom to offer foggy options more frequently.

Again demographics have very little explanatory power, although the two significant ones may carry some political considerations. It is more likely to encounter the use of foggy pricing in less affluent markets while the average age of the population shows opposite signs depending on the market structure. Foggy pricing was more common in "younger" markets during monopoly while deception in the duopolistic regime is more common among "more senior" markets.

6 The Fogginess of Non-Dominated Tariff Options

Offering a tariff option that is totally dominated by one or a combination of the options offered by the same cellular carrier does not exhaust the possibilities for firms trying to hide information from consumers and thus benefit from their mistaken choices. In this section I focus on non-dominated options again, which are defined as such even if they are the least expensive option for a single combination of peak and off-peak airtime usage pattern. For instance, it is possible that one of the tariff options offered by a firm belongs to the lower envelope of the tariff, say when a consumer talks on the phone exactly 183 peak minutes and 37 off-peak minutes. Evidently this tariff option is foggier than one that belongs to the lower envelope of the tariff for a wide range of airtime usage.

Suppose that a firm offers three tariff options, each being the least expensive one for about one third of the combinations of the peak and off-peak airtime usage. Thus, the tariff clearly targets low, medium, and high valuation customers. Perhaps those with a consumption patterns close to the boundaries of these tariff options may feel regret *ex post* because they did not subscribed to the right tariff option for their realized usage.

We could compute a summary statistic to characterize the degree of fogginess of the menu of tariff options offered by this firm. I will define this index of fogginess as $1 - HHI$, where HHI stands for the

Table 7: Fogginess of Non-Dominated Tariff Options

	I		II		III		IV		V	
CONSTANT	0.2395	(0.46)	0.2005	(0.38)	−0.0327	(0.05)	−0.1806	(0.32)	−0.0512	(0.09)
TIME	0.0064	(2.04)	0.0056	(1.97)	0.0081	(2.61)	0.0085	(3.34)	0.0068	(2.51)
MKT-AGE	−0.0021	(2.10)	−0.0022	(2.14)	−0.0017	(2.31)	−0.0015	(2.34)	−0.0016	(2.42)
COMMUTING	0.0084	(1.61)	0.0086	(1.65)	−0.0072	(1.48)	−0.0085	(2.09)	−0.0058	(1.34)
COVERAGE	−0.0974	(1.94)	−0.0899	(1.83)	0.0562	(1.55)	0.0707	(2.36)	0.0506	(1.59)
POPULATION	0.0032	(0.51)	0.0018	(0.30)	0.0245	(1.36)	0.0146	(1.09)	0.0180	(1.32)
POP-AGE	0.0058	(2.80)	0.0060	(2.89)	−0.0003	(0.09)	−0.0005	(0.16)	−0.0002	(0.05)
EDUCATION	−0.0551	(1.21)	−0.0544	(1.18)	−0.0293	(0.57)	−0.0328	(0.71)	−0.0364	(0.79)
BUSINESS	0.0003	(1.86)	0.0003	(1.92)	0.0005	(1.09)	0.0006	(1.95)	0.0006	(1.72)
GROWTH	0.0164	(1.98)	0.0151	(1.87)	−0.0079	(0.71)	0.0009	(0.10)	0.0013	(0.14)
INCOME	0.0005	(0.12)	0.0005	(0.13)	0.0102	(2.37)	0.0092	(2.48)	0.0094	(2.57)
POVERTY	−0.0344	(1.56)	−0.0327	(1.44)	−0.0359	(2.07)	−0.0307	(1.98)	−0.0369	(2.31)
VARPOVERTY	−0.0011	(1.36)	−0.0011	(1.27)	−0.0015	(2.23)	−0.0012	(2.01)	−0.0014	(2.35)
REGULATED	−0.0140	(0.97)	−0.0101	(0.75)	0.0708	(3.75)	0.0733	(4.57)	0.0678	(4.08)
PROFITS	−0.0016	(2.25)	−0.0016	(2.21)	−0.0011	(1.18)	0.0002	(0.57)	−0.0013	(1.72)
AMERITECH	0.0490	(1.39)	0.0366	(1.14)	−0.0450	(1.02)	0.0093	(0.27)	−0.0220	(0.56)
BELLATL	−0.0860	(1.75)	−0.0932	(1.94)	−0.0586	(1.24)	−0.0737	(1.78)	−0.0792	(1.89)
BELLSTH	0.0661	(1.78)	0.0609	(1.66)	−0.0065	(0.22)	−0.0146	(0.64)	0.0047	(0.18)
CENTEL	0.0579	(0.91)	0.0491	(0.78)	−0.1150	(3.00)	−0.1211	(3.80)	−0.0928	(2.66)
CONTEL	0.0143	(0.25)	0.0009	(0.02)	−0.0509	(1.47)	−0.0489	(1.56)	−0.0459	(1.46)
GTE	0.0871	(2.29)	0.0866	(2.27)	−0.0487	(1.72)	−0.0295	(1.14)	−0.0296	(1.16)
NYNEX	−0.1090	(2.45)	−0.1190	(2.66)	−0.0583	(1.36)	−0.0719	(2.09)	−0.0474	(1.27)
PACTEL	0.0466	(1.14)	0.0526	(1.33)	0.0093	(0.34)	0.0217	(0.93)	0.0065	(0.27)
SWBELL	0.1343	(4.58)	0.1295	(4.35)	−0.0696	(1.98)	−0.0473	(1.49)	−0.0529	(1.69)
USWEST	0.0253	(0.61)	0.0222	(0.53)	−0.0384	(0.82)	−0.0487	(1.35)	−0.0189	(0.47)
NEAREND	−0.0125	(0.73)							0.0113	(0.25)
WIRELINE									−0.0024	(0.16)
DUOPOLY									0.1695	(1.94)
$\ln L$	−56.3999		−49.4201		−249.8279		−317.5256		−287.8041	

Marginal effects evaluated at the sample mean of regressors of *Bernoulli PMLE*. Absolute value, robust t-statistics are reported between parentheses. Monopoly sample is used to obtain estimates of model I and II; Duopoly for III; and all observations for IV and V.

Herfindahl-Hirschman index of concentration defined over the share of airtime usage for which each firm is the least expensive one. In the previous example of the firm with three "balanced" tariff options, this fogginess index would be equal to 0.66.

Suppose now that another firm offers only two tariff options, each being the least expensive one for about 50% of all airtime usage patterns. Now, fewer customers have consumption patterns close to the boundary of these options because there is only one boundary instead of two. In this case the fogginess index equals 0.5. Evidently, if a firm only offers one single option, it is not possible to feel regret *ex post*, and consequently, the fogginess index equals 0.

To conclude with the description of this index —the endogenous variable to study in Tables 7 and 8—, consider again the case of the firm offering three tariff options. Now, one option is going to be the least expensive for about 57% of airtime usage realizations; the second belongs to the lower envelope in 38% of cases; and the third option is the least expensive for only 5% of airtime usage patterns. Intuitively, this menu of options is less foggy than that of the first example. It is true than those who subscribe to the latter

Table 8: Fogginess of Non-Dominated Tariff Options & Tariff Phase-Out

	I		II		III		IV		V	
CONSTANT	0.1651	(0.32)	0.1543	(0.32)	0.0011	(0.00)	−0.0943	(0.16)	−0.1702	(0.29)
TIME	0.0051	(1.67)	0.0049	(1.91)	0.0076	(2.44)	0.0082	(3.19)	0.0063	(2.30)
MKT-AGE	−0.0021	(2.15)	−0.0021	(2.18)	−0.0016	(2.14)	−0.0016	(2.40)	−0.0015	(2.26)
COMMUTING	0.0073	(1.47)	0.0073	(1.48)	−0.0073	(1.47)	−0.0077	(1.84)	−0.0056	(1.29)
COVERAGE	−0.0751	(1.43)	−0.0724	(1.57)	0.0522	(1.43)	0.0659	(2.17)	0.0457	(1.42)
POPULATION	0.0008	(0.12)	0.0004	(0.07)	0.0234	(1.32)	0.0159	(1.20)	0.0174	(1.29)
POP-AGE	0.0035	(1.64)	0.0034	(1.76)	−0.0008	(0.21)	−0.0002	(0.06)	−0.0008	(0.26)
EDUCATION	−0.0608	(1.35)	−0.0610	(1.35)	−0.0317	(0.63)	−0.0334	(0.72)	−0.0385	(0.84)
BUSINESS	0.0003	(1.95)	0.0003	(2.01)	0.0005	(1.12)	0.0006	(1.89)	0.0006	(1.71)
GROWTH	0.0140	(1.76)	0.0137	(1.86)	−0.0056	(0.50)	0.0002	(0.02)	0.0037	(0.38)
INCOME	0.0018	(0.43)	0.0019	(0.48)	0.0096	(2.20)	0.0095	(2.57)	0.0088	(2.36)
POVERTY	−0.0246	(1.13)	−0.0237	(1.17)	−0.0364	(2.10)	−0.0325	(2.05)	−0.0371	(2.33)
VARPOVERTY	−0.0008	(0.95)	−0.0007	(0.95)	−0.0015	(2.20)	−0.0013	(2.09)	−0.0014	(2.30)
REGULATED	−0.0202	(1.32)	−0.0200	(1.30)	0.0607	(2.95)	0.0749	(4.66)	0.0581	(3.17)
PROFITS	−0.0012	(1.67)	−0.0012	(1.72)	−0.0009	(0.93)	−0.0004	(0.50)	−0.0011	(1.37)
AMERITECH	0.0348	(0.85)	0.0320	(0.96)	−0.0504	(1.12)	0.0016	(0.04)	−0.0272	(0.69)
BELLATL	−0.0873	(1.78)	−0.0884	(1.85)	−0.0635	(1.34)	−0.0735	(1.76)	−0.0849	(2.01)
BELLSTH	0.0725	(2.00)	0.0721	(2.00)	−0.0092	(0.31)	−0.0067	(0.26)	0.0000	(0.00)
CENTEL	0.0551	(0.87)	0.0535	(0.86)	−0.1148	(2.98)	−0.1118	(3.29)	−0.0932	(2.68)
CONTEL	0.0193	(0.35)	0.0177	(0.34)	−0.0468	(1.34)	−0.0489	(1.56)	−0.0425	(1.35)
GTE	0.1218	(2.66)	0.1241	(3.14)	−0.0421	(1.48)	−0.0313	(1.22)	−0.0236	(0.92)
NYNEX	−0.1266	(2.43)	−0.1294	(2.71)	−0.0730	(1.63)	−0.0586	(1.50)	−0.0626	(1.60)
PACTEL	0.0610	(1.49)	0.0628	(1.69)	−0.0013	(0.05)	0.0196	(0.84)	−0.0021	(0.08)
SWBELL	0.1450	(4.93)	0.1450	(4.92)	−0.0680	(1.94)	−0.0495	(1.56)	−0.0518	(1.65)
USWEST	0.0190	(0.45)	0.0180	(0.44)	−0.0508	(1.03)	−0.0340	(0.80)	−0.0340	(0.79)
NEAREND	−0.0025	(0.12)							0.0053	(0.11)
WIRELINE									−0.0029	(0.18)
DUOPOLY									0.3185	(2.20)
PHS/PLI	0.1648	(1.04)	0.1763	(1.48)	0.2790	(1.22)	−0.0833	(0.76)	0.2480	(1.26)
$\ln L$	−44.7108		−43.0886		−247.4934		−294.9987		−313.8073	

Marginal effects evaluated at the sample mean of regressors of *Bernoulli PMLE*. Absolute value, robust t-statistics are reported between parentheses. Monopoly sample is used to obtain estimates of model I and II; Duopoly for III; and all observations for IV and V.

option are more likely to regret it *ex post*, but a wider customer base, subscribing to any of the other two available options has become less "risky." As the HHI increases with the asymmetry of the market shares of airtime usage of each tariff option —Tirole (1989, §5.5)—, the proposed index of fogginess decreases with it. The value of the index of fogginess for this example is 0.5282.

Estimating the results presented in Tables 7 and 8 makes use of the same *Bernoulli pseudo maximum likelihood estimator* of Section 5, as again, the index of fogginess of tariff menus is takes values between 0 and 1.

Results indicate that phasing out of previously offered tariffs does not affect the degree of fogginess of tariffs. The same can be said about many of the demographics, and in this case, also of individual firms. Still, those estimates that are significant also support an important structural change when markets went from monopoly to be served by two competing firms.

Tariffs tend to be foggier as time goes by, although the longer a market has been served by at least one firm induces to a more "balanced" (meaning symmetric) set of options. Monopolist realized high profits by offering less tariff options, and most importantly, as regulation was progressively abandoned, firms engaged in foggier offerings of non-dominated tariffs during the duopoly phase of these markets.

7 Concluding Remarks

This paper has addressed for the first time the determinants of the use of foggy tactics by firms both under monopoly and duopoly market structure. In order to study how firms' deceptive behavior respond to potential profitability I construct three indicators from the available tariff information: the expected profits of price discrimination from the shape and position of the tariffs, the share of dominated strategies in a very wide range of potential airtime usage patterns, and the degree of fogginess from the share of usage time that each tariff option is the least expensive among those offered by each firm.

The most important result is that expected profits have an ambiguous effect on the number of non-dominated tariff options offered; it decreases the share of foggy strategies of firms —particularly in competitive environments—; and it marginally reduces the fogginess of tariffs offered by monopolistic firms. Thus, we should be confident that pursuing the maximization of profits as competition intensifies lead to a gradual disappearing of dominated tariff options.

Should we conclude that the idea of foggy tactics is hollow? No, the evidence presented in this paper corresponds to a particular industry in its infancy when tariffs were relatively simple. Fogginess involves the fine letter of contracts and those issues never stated explicitly in incomplete contracts. There are many ways of hiding information from consumers but not all of them are suitable to be properly codified to conduct a proper econometric analysis. Furthermore, many of these matters are in essence dynamic and they evolve as firms go through phases of cooperation and fierce competition. Let's take again the negative sign of expected profits on the share of foggy tariffs offered. The cellular industry has experimented a tremendous growth since its introduction two decades ago. But what if we were in another more mature industry where entry of another competitor only translates into a business stealing effect? Then an increase in competition will bring expected profits down, and facing limited possibilities to increase the return to their investment, firms, according to the results of Tables 5 and 6, will most likely turn their attention to deceptive strategies.

References

Berry, S. (1994): "Estimating Discrete-Choice Models of Product Differentiation." *RAND Journal of Economics*, 25, 242–262.

Berry, S., J. Levinsohn, and A. Pakes (1995): "Automobile Prices in Market Equilibrium." *Econometrica*, 63, 841–890.

Brandenburger, A. M. and B. J. Nalebuff (1996): *Co-opetition*. New York, NY: Doubleday.

Bresnahan, T. F. (1981): "Departures from Marginal-Cost Pricing in the American Automobile Industry." *Journal of Econometrics*, 17, 201–227.

Bresnahan, T. F. (1987): "Competition and Collusion in the American Automobile Oligopoly: The 1955 Price War." *Journal of Industrial Economics*, 35, 457–482.

Cameron, A. C. and P. K. Trivedi (1998): *Regression Analysis of Count Data*. New York, NY: Cambridge University Press.

Crandall, R. W. and L. Waverman (2000): *Who Pays for "Universal Service"? When Telephone Subsidies Become Transparent*. Washington, DC: Brookings Institution Press.

Della Vigna, S. and U. Malmendier (2003): "Overestimating Self-Control: Evidence from the Health Club Industry." Mimeo, University of California-Berkeley and Stanford University.

Della Vigna, S. and U. Malmendier (2004): "Contract Design and Self-Control: Theory and Evidence." *Quarterly Journal of Economics*, 119, 353–402.

Gourieroux, C., A. Monfort, and A. Trognon (1984): "Pseudo Maximum Likelihood Methods: Applications to Poisson Models." *Econometrica*, 52, 701–720.

Hausman, J. (1996): "Valuation of New Goods under Perfect and Imperfect Competition." In T. F. Bresnahan and R. J. Gordon (eds.): *The Economics of New Goods,* Studies in Income and Wealth, Vol. 58. Chicago, IL: NBER–The University of Chicago Press.

Hausman, J. A. (2002): "Mobile Telephone." In M. Cave, S. K. Majumdar, and I. Vogelsang (eds.): *Handbook of Telecommunications Economics,* Vol. I. Amsterdam, The Netherlands: North-Holland.

Hausman, J. A., G. Leonard, and J. D. Zona (1994): "Competitive Analysis with Differentiated Products." *Annales d'Economie et de Statistique*, 34, 159–180.

Liebman, J. B. and R. J. Zeckhauser (2004): "Schmeduling." Mimeo, Harvard University.

Maskin, E. and J. Riley (1984): "Monopoly with Incomplete Information." *RAND Journal of Economics*, 15, 171–196.

Miravete, E. J. (2002): "Choosing the Wrong Calling Plan? Ignorance and Learning." *American Economic Review*, 93, 297–310.

Miravete, E. J. (2004): "Are All Those Calling Plans Really Necessary? The Limited Gains From Complex Tariffs." Mimeo, University of Pennsylvania.

Miravete, E. J. and I. Palacios-Huerta (2004): "Rational Attention in a Repeated Decision." Mimeo, University of Pennsylvania and Brown University.

Miravete, E. J. and L.-H. Röller (2004): "Competitive Nonlinear Pricing in Duopoly Equilibrium: The Early U.S. Cellular Telephone Industry." Mimeo, University of Pennsylvania and Wissenschaftszentrum Berlin für Sozialforschung (WZB).

Murray, J. B., Jr (2002): *Wireless Nation. The Frenzied Launch of the Cellular Revolution in America*. Cambridge, MA: Perseus Publishing.

Papke, L. E. and J. M. Wooldridge (1996): "Econometric Methods for Fractional Response Variables With an Application to 401(K) Plan Participation Rates." *Journal of Applied Econometrics*, 6, 619–632.

Parker, P. M. (1990): "McCaw versus Pactel: Cellular Pricing (A)." Business Case, INSEAD-CEDEP.

Parker, P. M. and L.-H. Röller (1997): "Collusive Conduct in Duopolies: Multimarket Contact and Cross-Ownership in the Mobile Telephone Industry." *RAND Journal of Economics*, 28, 304–322.

Riordan, M. (2002): "Universal Residential Telephone Services." In M. Cave, S. K. Majumdar, and I. Vogelsang (eds.): *Handbook of Telecommunications Economics,* Vol. I. Amsterdam, The Netherlands: North-Holland.

Seim, K. and V. B. Viard (2004): "The Effect of Entry and Market Structure on Cellular Pricing Tactics." Mimeo, Graduate School of Business, Stanford University.

Shew, W. B. (1994): "Regulation, Competition, and Prices in the U.S. Cellular Telephone Industry." Mimeo, The American Enterprise Institute.

Tirole, J. (1989): *Industrial Organization*. Cambridge, MA: MIT.

Vogelsang, I. and B. M. Mitchell (1997): *Telecommunications Competition: The Last Ten Miles*. Cambridge, MA: AEI–MIT Press.

Wilson, R. B. (1993): *Nonlinear Pricing*. New York, NY: Oxford University Press.

Winkelmann, R. (1995): "Duration Dependence and Dispersion in Count-Data Models." *Journal of Business & Economics Statistics*, 13, 467–474.

Wooldridge, J. M. (2002): *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.