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ABSTRACT

The Doubtful Profitability of Foggy Pricing*

A particular tariff option is said to be foggy when another option or a combination of other tariff options offered by the same firm is always less expensive regardless of the usage profile of any customer. Alternatively, tariff fogginess may refer to the whole set of tariff options and it is related to the low likelihood that a particular tariff option ends up being the least expensive one among those of a menu of tariff plans for an arbitrary distribution of usage patterns. This paper takes advantage of the exogenous entry of a second carrier in the early U.S. cellular telephone industry. It shows that competition induces firms to introduce mostly non-foggy options, thus abandoning deceptive pricing strategies (fog lifting) aimed to profit from mistaken choices of consumers rather than softening competition through the use of foggy tactics (co-opetition). Results indicate that tariff fogginess is less severe with the entry of a second firm in the industry according to either definition of foggy pricing. Thus competition alone, and in particular the tactics of entrants, appears to correct deceptive pricing strategies, although such correction does not necessarily occur immediately after the entry of a competitor but rather in the long run. Results are robust to the existence of individual uncertainty regarding future telephone usage when consumers sign up for a particular tariff plan.

JEL Classification: D43, L96 and M21
Keywords: co-opetition, fog-lifting, foggy strategies, nonlinear pricing and phasing-out

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Submitted 26 April 2007

1 Introduction

People commonly complain about having to make choices among "too many" options. In addition to costs associated to this complex decision process, committing to a particular contract option ahead of consumption decision opens the possibility of making mistakes that may result in substantial excess payments. The latest uproar in the United States regarding an exuberance of choices has to do with the enrollment in the 2003 Medicare prescription drug benefit plans for the elderly that came into effect in January of 2006. The popular list of complaints includes choosing among retirement plans, health care providers and programs, loans and mortgages, options for home, car, and life insurance among others. This open ended list also includes more mundane decisions such as tariff options for utilities or cable, as well as the topic of this paper: dealing with multiple tariff choices in the subscription to cellular telephone service. Deliberation costs are not to be ignored as they are at the basis of this generalized state of public opinion. These psychological costs have also opened the door to important business opportunities: internet search engines have facilitated not only the systematic comparison of prices across stores, but also among numerous nonlinear tariff options of many services and public utilities.[1] In the present work, instead of dealing with consumer behavior, I will exclusively focus on the supply side of the problem, which has, so far, attracted almost no attention at all.

If consumers can make mistakes in choosing among optional tariffs, firms offering these tariffs could, in principle, take advantage of such mistakes when designing different tariff options. Firms can do so by not providing a clear description of options' features hoping that consumers subscribe to a tariff plan different from the one that minimizes the expense for their realized service usage.[2] Unless the market corrects the use of deceptive tactics, policy makers may feel compelled to intervene in order to avoid their use as long has there exists a generalized perception that consumers make systematic mistakes when choosing among contract options.[3] While numerous tariff options may allow firms to take better advantage of any bounded rationality issue that may affect consumers' comparisons among different options, having numerous tariff options to choose from, however, should not be questioned *per se* as consumers could

[1] For instance, at *lowermybills.com* 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. Ellison and Ellison (2004) document how search engines turn demand very price-sensitive and how retailers engage in practices to frustrate consumer search to avoid the effect of intense competition.

[2] The strategic value of hidden terms and the ambiguity of the features of the tariff options that consumers face 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 when customers have limited understanding of the tariff.

[3] See for instance the *Leader* and *Britain* sections of *The Economist*, April 10th 2004. This suspicion has long attracted the attention the *UK Office of Fair Trading*, who investigated the benefits of limiting the number of tariff options that firms may offer to their customers. For instance, see the UK Office of Fair Trading report No. 194 on "Consumer Detriment under Conditions of Imperfect Information," No. 168 regarding the health insurance industry, No. 255 on financial services, or the 2003 British Academy Keynes Lecture on "Economics for Consumer Policy" by the Chairman, John Vickers. There are similar undergoing investigations by the regulatory authorities of India, Perú, and other countries.

potentially benefit from a wider selection of subscription choices. These conflicting views lead to some important questions: Why should regulatory bodies aim at restricting the choices of consumers? Should individuals simply not be given a 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? The present work addresses this latter empirical question. The answer has important policy implications. If competition alone induces abandoning deceptive strategies, then favoring the entry of firms and ensuring that they do not collude will eventually eliminate the fogginess of tariffs. In addition, such a policy will bring the market equilibrium closer to the efficient solution.

But what is tariff fogginess? How can we rationalize that competition induces more or less fogginess among the menus of tariff options offered to consumers? The definition of *foggy strategy* is in itself quite ambiguous as it normally involves the fine print of contracts and generally, an unspecified measure of complexity of nonlinear functions. For the purpose of the present study a practical measure is needed, and thus, a particular tariff option is said to be *foggy* when another option or a combination of other tariff options offered by the same firm is always less expensive regardless of the usage profile of any customer. It could also be said that this *foggy* option is dominated by another or a combination of other tariff options. Alternatively, tariff fogginess may be referred to the whole set of tariff options. I employ two different measures of foggines of the menu of tariffs. The first is just the proportion of dominated to non-dominated tariff options. The second exclusively focuses on the non-dominated options and I present a measure of fogginess related to the low likelihood that a particular tariff option ends up being the least expensive one among those of a menu of tariff plans for an arbitrary distribution of usage patterns. Since the data contains the complete tariff structure of all firms competing in the top hundred cellular markets in the U.S., all these intuitive measures of fogginess can be computed easily. It is also only within the framework of these definitions that the conclusions of this study apply. I cannot account for the possibility that firms engaged in other more subtle deceptive strategies beyond the design of nonlinear tariff options.

Economists have not said much about the strategic value of using deceptive strategies. Only recently Gabaix and Laibson (2006) have shown that tactics that conceal information from consumers can only be profitable if these consumers are myopic. Moreover, from a purely empirical perspective, there is no clear indication of whether more competitive regimes would favor the use of deceptive strategies rather than inducing their disappearance. Brandenburger and Nalebuff (1996, §7) claim that firms use foggy strategies for a variety of reasons, one of which is to conform the perceptions of both their customers and competitors. In doing so, firms hide information and increases profits as a result. These authors claim that firms hide information when, for instance, they introduce a new product at a very low price to induce consumers to switch standards or simply develop a taste for the product, allowing the firm 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 in which firms could use these tactics to profit from consumers

who do not choose the least expensive tariff option for their telephone usage. Complexity is a defining feature of the fogginess of the pricing strategy because it makes it 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. An increase in tariff fogginess across both firms when a second firm enters the market would be consistent with this view of complexity as a way to soften competition and collude while giving the appearance of an aggressive competitive environment with a multitude of choices for consumers — an environment that Brandenburger and Nalebuff (1996) call *co-opetition*.

An obvious criticism of this idea of foggy tactics is that they may conform, at best, a short run strategy. Seim and Viard (2005) document that entry of new firms leads to an immediate increase in tariff options offered by incumbent cellular carriers after the 1996 Telecommunications Act. Their study does not distinguish, however, whether the newly introduced tariff options were foggy, or if existing tariffs were altered to be made foggy. Miravete (2002) shows that telephone customers switch tariff options in an explicit attempt to reduce their monthly bills while responding to rather limited potential gains. Similarly, Economides, Seim, and Viard (2006, §4.2) notice that after the entry of new firms in the local telephone market, most switching customers realize a gain that amounts to an overall increase in welfare of almost 5%. If we believe, as this evidence appears to support, that consumers will eventually learn how to minimize their expenses for their usage profile, then competition may end up "lifting the fog" when other firms introduce attractive, simple, and less expensive tariffs. This alternative hypothesis —also advanced by Brandenburger and Nalebuff (1996)— includes 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.

The empirical analysis of this paper attempts to elucidate which of these two competing hypotheses, *co-opetition vs. fog lifting*, is more likely to hold in a close-to-ideal framework in which the transition from monopoly to competition is exogenous (and certainly not influenced by the fogginess of the pricing of the monopolist). The data set used in this paper is particularly suited to answer these questions. It consists of all menus of tariff options offered by the telephone carriers of about one hundred cities in the early U.S. cellular industry between 1984 and 1992. While tariffs of that era are relatively simple by today's standards, internet search engines were not available and switching between carriers was quite expensive. Thus, if the entry of a second firm had any effect on the fogginess of the tariff, we should be confident that it is due to competition alone, and not to variations in search or switching costs.

The early U.S. cellular telephone industry is an almost perfect case study because, due to a failure in the process of awarding licenses, many markets operated under a monopoly regime during a significant period of time. Entry always occurred eventually but it depended on independent judicial decisions made market by market, and thus the transition to competition can be considered exogenous. Therefore, we can determine with precision whether competition alone tends to correct any abuse of foggy pricing in which

cellular carriers might have engaged (*fog lifting*) or if, on the contrary as Brandenburger and Nalebuff (1996) argue, competition increased tariff complexity which, by softening competition, served as a way to induce firms to cooperate while competing only superficially (*co-opetition*). Therefore, this paper provides a first evaluation of whether firms appear to successfully engage in foggy pricing strategies aimed at confusing consumers, documents whether these strategies are more likely to happen in monopolistic rather than in competitive markets, and determines whether foggy strategies are just the result of phasing-out old tariff options offered to consumers in previous periods.

Results indicate that competition *lifts the fog*. That is, it induces firms to offer simpler tariffs and reduces the proportion of tariff options that are totally dominated by another plan or combination of tariff plans offered by the same firm. Competition increases the average number of tariffs offered to consumers: it is alone responsible for about 45% of the observed increase in the total number of tariffs offered when markets come to be served by two firms instead of just one. However, competition also increases the number of effective tariff options, *i.e.*, those non-dominated by other tariff plans of the same firm; competition accounts for about 55% of the observed increase in effective tariff after a second firm enters each local market. Furthermore, competition increases dominated options by about 31% less than the increase in non-dominated tariff plans, and non-dominated plans become less complex by about 39% according to the fogginess measure used in this paper. Finally, it should be pointed out that the pricing strategy of the competing firms are essentially the opposite of one another: while the "*wireline* incumbent" offers most of the foggy options and the most complex tariffs, it is the "*nonwireline* entrant" who "lifts the fog" by offering far simpler options. It is the pricing behavior of the entrant carrier that eventually leads to the net effect that pricing strategies are less deceptive under competition. It is therefore unlikely that *foggy pricing* is very profitable when the mere presence of a second competitor turns it unsustainable in the long run. These results are robust to the potential effect of the phasing-out of old tariff plans as well as to the possibility that some of the regressors employed are endogenous. Moreover, results are robust to the presence of individual uncertainty regarding future usage when consumers subscribe to one among many of tariff options that they are offered.

The paper is organized as follows. Section 2 describes the data. Section 3 presents the results of a count data regression model in which the number of total and non-dominated tariff options offered by each firm is regressed against market characteristics, the identity of the owner of the license, market coverage, and measures of the underlying spread of the distribution of consumers' heterogeneity. Section 4 studies the determinants of the ratio of dominated to non-dominated tariff options, controlling, among other effects, for the phasing-out of old tariff plans. Section 4 also defines a measure of fogginess of the non-dominated options and conducts a similar econometric analysis to measure how competition simplifies the non-dominated tariff options offered. Section 5 discusses how to instrument for potentially endogenous variables (such as the curvature of the nonlinear tariffs, market coverage, and phasing-out), discusses

the effects of these variables being, for the most part, exogenous, and it presents evidence supporting the view that these results do not depend on the lack of uncertainty among consumers regarding future consumption. Section 6 concludes.

2 Pricing in the Early U.S. Cellular Industry

This paper studies the pricing strategies of numerous cellular telephone carriers in the early U.S. cellular telephone industry. The data set is unique in the sense that it includes a fairly complete description of the nonlinear tariff options offered by each firm over almost a decade. Most importantly, due to the institutional developments surrounding the awarding of licenses, the data allows me to distinguish between monopoly and duopoly regimes, the transition from the former to the latter depending on an exogenous judicial decision in each market. Thus, this data set proves particularly useful to analyzing the effect of competition on pricing behavior of firms and address, such as for instance, the issue of foggy pricing.

Some background information might be needed. By the mid 1980s, the *Federal Communications Commission* (*FCC*) granted permission to create 305 non–overlapping cellular telephone markets around metropolitan areas (*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 these licenses among hundreds of contenders based only 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. Entry of the second firm always happened soon after the independent court decisions in each *SMSA*.

In this paper the data combine two separate databases. Data from 1984 to 1988 were collected by *Economic and Management Consultants International, Inc*. This data set includes periods with both monopoly

Table 1: Frequency Distributions of Number of Tariff Options

	Monopoly		*Early Duopoly*		*Late Duopoly*	
Actual Opt.	Frequency	Rel.Freq.	Frequency	Rel.Freq.	Frequency	Rel.Freq.
1	134	0.3292	70	0.0607	8	0.0548
2	87	0.2138	156	0.1352	10	0.0685
3	68	0.1671	326	0.2825	18	0.1233
4	76	0.1867	317	0.2747	35	0.2397
5	28	0.0688	190	0.1646	73	0.5000
6	14	0.0344	95	0.0823	2	0.0137
Mean/(Var.)	2.5553	(2.1096)	3.5945	(1.7001)	4.1027	(1.4445)
Effective Opt.	Frequency	Rel.Freq.	Frequency	Rel.Freq.	Frequency	Rel.Freq.
1	186	0.4570	97	0.0841	17	0.1164
2	82	0.2015	281	0.2435	8	0.0548
3	114	0.2801	362	0.3137	21	0.1438
4	17	0.0418	265	0.2296	45	0.3082
5	8	0.0197	130	0.1127	53	0.3630
6	0	0.0000	19	0.0165	2	0.0137
Mean/(Var.)	1.9656	(1.0826)	3.0927	(1.4001)	3.7877	(1.7960)

Absolute and relative frequency distribution of the number of actual and non-dominated tariff options offered by each active firm.

and duopoly market configurations.[4] By 1988 this industry was still far from being characterized as mature but at least in all the large markets entry of the second cellular carrier had already happened. While large metropolitan areas had already enjoyed this service for few years, the development of a household-only (instead of a business-based) market laid still ahead.[5] This information is complemented with data collected by Marciano (2000) for year 1992, when all markets were already served by two competing firms.[6] This second data set proves to be critical for the results reported in this paper. The 1984-88 sample captures the short run effects of competition, while including year 1992 adds observations from more mature markets where either competition always existed, or the entry of the second carrier occurred some time ago. Thus, the 1992 sample allows me to identify medium-to-long run effects of competition on pricing.

By today's standards, early cellular carriers offered few tariff options. Table 1 shows that in monopolistic markets, one third of the firms only offered a single tariff option, and another third between 2 and 3 options only. The transition from monopoly to duopoly clearly increased the alternatives available for consumers to choose from. Two thirds of the firms offered 3 or 4 options early in the duopoly phase while in 1992 half of all firms offered 5 options. Competition adds on average between 1 and 1.6 tariff options per

[4] This is the same data set used by Busse (2000) and Parker and Röller (1997) among others.

[5] See Parker (1990).

[6] I am grateful to Arie Beresteanu for sharing this 1992 data with me. In this paper I use the complete data set collected by Marciano (2000) and not only the subsample of markets that she uses in her dissertation.

Table 2: Actual vs. Effective Number of Tariff Options

Monopoly	1	2	3	4	5	6
1	32.92					
2	11.55	9.83				
3	1.23	6.63	2.25			
4	0.00	0.74	16.46	1.47		
5	0.00	0.00	2.70	2.21	1.97	
6	0.00	2.95	0.00	0.49	0.00	0.00
Early Duopoly	**1**	**2**	**3**	**4**	**5**	**6**
1	6.07					
2	1.73	11.79				
3	0.00	8.06	20.19			
4	0.52	4.16	5.89	16.90		
5	0.09	0.26	3.55	3.81	8.75	
6	0.00	0.09	1.73	2.25	2.51	1.65
Late Duopoly	**1**	**2**	**3**	**4**	**5**	**6**
1	5.48					
2	3.75	2.74				
3	0.00	0.68	11.64			
4	1.40	2.05	2.05	18.49		
5	0.68	0.00	0.68	12.33	36.30	
6	0.00	0.00	0.00	0.00	0.00	1.40

Percentage of total plans for each sample. Kendall's τ measures of the correlation among the count numbers of effective and foggy options offered by each firm are: 0.7923 for the monopoly sample, 0.7629 for the early duopoly sample, and 0.8172 for the late duopoly sample. The corresponding t-statistics are (23.87), (36.98), and (14.64), respectively.

firm in the short and long run respectively; and between 1 and 1.8 options when we focus on the effective (non-dominated) tariff options, *i.e.*, those that are the least expensive tariff plans for at least a small fraction of potential consumption profiles. Thus, going from monopoly to duopoly almost quadruples in the long run the effective number of tariff plans that consumers may choose from (from one firm offering an average of 1 option to two firms offering 1.8 each).

The increase in options available to consumers could be interpreted in different ways. Seim and Viard (2005) 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 from consumers. Thus, firms 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. To that end, we must address whether the larger number of tariff options offered lead to more fogginess. The mere description of the frequency distribution of the number of tariff options does not suffice to answer this question.

Tariffs in this early industry are also much simpler than these offered today. A tariff option was normally a two-part tariff with a fixed monthly fee and a fixed rate per minute. Tariff options normally

distinguish between peak (comprising about 13 hours a day at that time) and off-peak marginal rates and sometimes included an allowance of "free" minutes associated to the payment of the fixed monthly fee. Thus, the available combination of monthly fee, marginal rates and usage allowance defines the tariff option completely and accurately. Other value added services such as detailed billing, call waiting, no-answer transfer, call forwarding, three way calling, busy transfer, call restriction, and voice mail were priced independently and rarely bundled together with particular tariff options. This unique feature of the data allows me to analyze whether a particular tariff option is dominated by one or a combination of some other available tariff options. Furthermore, since the data (for the 1984-88 sample) are recorded every time that a firm changes its offering, it is possible for me to trace the history of every tariff option and determine whether a dominated tariff today is simply the result of phasing-out previously effective options.

Perhaps the most extreme version of what constitutes a foggy tariff option is when it is totally dominated by one or a combination of tariff options, *i.e.*, it is always possible for any subscriber to pay less under some other tariff alternative for any usage profile imaginable. The second half of Table 1 reports the frequency distribution of those tariff options that are non-dominated. On average, there are 0.5 foggy options per firm, *i.e.*, one out of two firm offers at least one totally dominated tariff option. This magnitude does not appear to vary substantially when markets go from monopoly to duopoly, but it gets reduced to 0.3 in 1992, once both firms have been present in the market for a significant period of time.

One particular tariff option may be always more expensive than some of the other options offered by the firm. The idea of fogginess is not referred to a particular tariff option but with the total number of tariff options actually offered to cellular telephone customers and that best implements a fully nonlinear tariff. Table 2 documents that the correlation between total and effective number of tariff options is about 75%, and increases to 81% in 1992. While the average number of foggy plans does not appear to change with competition according to Table 1, Table 2 shows that competition has an uneven effect on the percentage of foggy plans offered depending on the total number of tariff options offered. For instance, during the monopoly phase firms offered one foggy option out of two alternatives in 11.55% of occasions. With competition this percentage dropped immediately to 1.73% although later increased to 3.75%. Similarly, situations when one out of four options were foggy went down from 16.46% to 5.89% in the short run and just to 2.05% of cases in the long run. Extremely deceptive menus, with four foggy options out of six total options, disappeared almost immediately, going from 2.95% to 0.09% of cases in the short run. However Table 2 also documents movements in the opposite direction, *i.e.*, increasing the fogginess of the menus of tariffs at least in the short run. This is particularly true for those menus that involve a large number of options. In the long run menus with many options and a large share of foggy alternatives become rare. Thus, the effect of competition on the fogginess of tariffs offered is, at this stage, ambiguous.

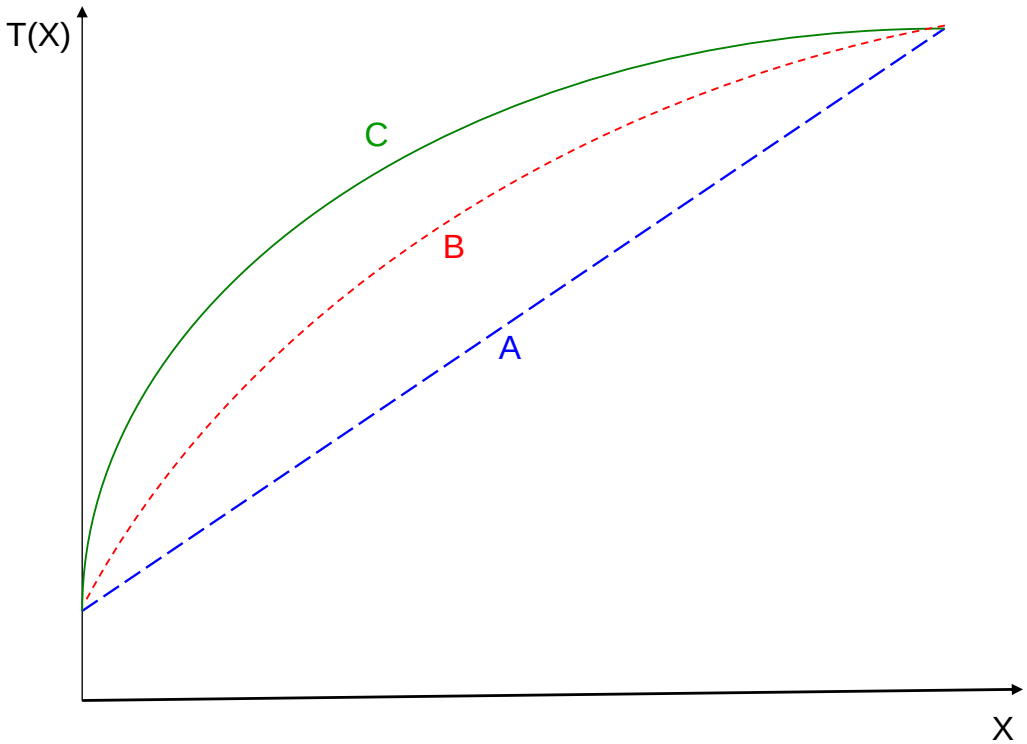
To determine the effect of competition, I conduct a simple econometric analysis in which I control for many observable market characteristics that may induce firms to offer more or fewer tariff options.

Table 3: Descriptive Statistics

	Monopoly		*Early Duopoly*		*Late Duopoly*	
Variables	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
PLANS	2.5553	1.4525	3.5208	1.3022	4.1027	1.2019
EFFPLANS	1.9656	1.0405	2.9921	1.1248	3.7877	1.3401
SHARE-FOGGY	0.3204	0.4872	0.2154	0.3679	0.1758	0.5294
FOGGINESS	1.0222	1.1396	1.209	0.9665	0.9625	0.8883
TIME	8.6020	3.8022	11.5258	3.8697	30.0000	0.0000
WIRELINE	1.0000	0.0000	0.5079	0.5002	0.5000	0.5017
DUOPOLY	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
YEAR92	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
MKTAGE	15.2629	9.9158	22.7738	13.4865	73.4521	17.3873
COMMUTING	23.5366	2.9511	23.3472	3.5716	22.4481	3.4230
POPULATION	1.7089	2.6555	1.7883	2.6009	1.4317	2.4045
POPAGE	34.767	2.4118	34.4113	1.9336	34.3772	2.1412
EDUCATION	12.9951	0.4487	13.0421	0.4662	13.0178	0.4171
BUSINESS	46.0092	64.9031	43.9701	61.4596	37.0109	58.0771
GROWTH	1.3747	0.9777	0.9286	1.04	1.1548	1.0225
INCOME	38.8741	5.7426	38.378	5.2453	37.0317	4.6572
POVERTY	10.9985	2.8722	10.014	2.609	10.7247	2.8621
σ(POPAGE)	21.8415	0.9325	21.6932	0.9456	21.6956	0.9622
σ(COMMUTING)	16.5690	2.3113	16.4425	2.4253	15.9019	2.4229
σ(EDUCATION)	2.8992	0.2019	2.8469	0.1673	2.8524	0.1826
σ(INCOME)	31.8160	3.1544	30.9637	3.1266	30.4823	2.8728
REGULATED	0.4619	0.4992	0.5278	0.4995	0.5068	0.5017
BELL	0.8280	0.3778	0.5040	0.5002	0.6438	0.4805
DENSITY	16.2987	14.1219	19.1728	16.8967	14.0122	15.7864
MULTIMARKET	4.1450	3.2553	3.1667	2.2000	3.4931	2.9677
LEAD	11.2737	6.6336	9.1782	8.0826	11.7478	10.0892
WAGE	7.2709	1.7977	7.3742	1.9717	7.0904	1.6156
ENERGY	1.7500	0.3814	1.6842	0.3870	1.6210	0.3488
OPERATE	6.5527	1.4615	6.5024	1.6888	6.1349	1.6640
RENT	16.4775	4.4348	15.8282	4.7352	16.0851	4.9165
PRIME	9.8415	0.9076	8.9727	0.9863	8.1918	0.7360
ENG-COSTS	1.2594	0.4142	0.7070	0.4218	0.0960	0.5762
CRIME	6.9635	2.0451	6.3494	1.8149	6.7138	2.0447
SVCRIMES	0.1092	0.0329	0.1095	0.0332	0.1024	0.0355
TEMPERATURE	57.2611	14.7990	57.4245	16.4386	74.2816	16.7467
RAIN	3.1854	1.8478	3.3286	1.6679	3.8669	1.8464
NORTH	36.0174	5.2998	38.3938	4.8650	36.9023	5.2951
WEST	-92.6358	16.7386	-88.8514	14.6065	-91.7775	15.4747
$\mathrm{AP}_{\mathrm{peak}}$	0.0917	0.5396	0.1815	1.3777	0.2275	0.6632
$\mathrm{AP}_{\mathrm{off-peak}}$	0.5923	3.3081	-5.2547	78.6771	0.2905	1.8793
COVERAGE	0.0641	0.0595	0.1021	0.0783	0.0967	0.0630
PHS/PLI	0.3395	0.4464	0.0657	0.2382	0	0.0000
Observations	407		1008		146	

All variables are defined in Appendix A.

Figure 1: Asymmetry of Information and Curvature of Nonlinear Tariff



Observable demographics and other market specific characteristics may be related to the distribution of consumers' willingness to pay in each market, and thus serve as a signal for the cellular carriers to optimally decide on the number and the features of their tariff options. Therefore, tariff data are complemented with market specific demand and cost information for each firm. Descriptive statistics are reported in Table 3 and definition of variables are included in Appendix A.

3 Actual and Effective Number of Tariff Options

In many industries consumer heterogeneity is important. If technology allows to avoid consumer arbitrage, firms can increase their expected profits by offering a nonlinear tariff that optimally discriminates among consumers with different levels of willingness to pay. Optimal nonlinear pricing leads to offering discounts to larger consumers, who in turn face marginal charges closer to marginal costs. Thus, the optimal tariff is an increasing and concave function under very general conditions, and the degree of concavity is intimately linked to the spread of the distribution of consumer types. This result is formally proven by Maskin and Riley (1984) and Wilson (1993). Figure 1 illustrates this point.

Oi (1971) observes that if all consumers are alike a simple two-part tariff such as "Schedule A" of Figure 1 suffices to extract all consumer surplus and achieves the first best solution: the marginal charge should equal marginal cost c and the fixed fee amounts to the size of the identical consumer surplus at c. If consumers are heterogeneous, a different unit price has to be offered to each consumer type in order to extract as much surplus as possible while avoiding arbitrage. As the proportion of high valuation customers increases among the population of active consumers, firms need to charge higher markups for low usage customers in order for the tariff to qualify as an incentive compatible contract that avoids high valuation customers mimicking the behavior of low valuation ones. Thus, "Schedule B" is the optimal tariff when some high valuation consumers are present and "Schedule C" is optimal when the population includes many more high than low valuation customers.[7] There is a large mechanism design literature devoted to finding these optimal discounts for different consumer types. Characterizing the optimal fully nonlinear tariff requires solving a complex variational problem that has attracted much attention among theorists but little among businessmen. In practice firms rarely offer fully nonlinear tariffs, but rather few tariff options that approximate and capture most of the potential gains from discrimination (see Miravete (2007)).

Although the use of few tariff options may be rationalized as a screening problem that takes into account the unobservable costs of commercializing each tariff option, the truth is that little is known about the motivation of firms for offering numerous or few tariff options. The analysis of this section allows to document whether competition, once we control for many other observable variables, indeed induces firms to offer more tariff options. Furthermore, since the data allow to determine whether each tariff option is dominated or not, I will also be able to say something about the nature of this increase in pricing alternatives for consumers following the entry of a second cellular telephone carrier.

The empirical analysis of Table 4 relates the number of tariff plans offered to observable market and firm characteristics. Column A1 of Table 4 presents the results of estimating a Poisson *pseudo maximum likelihood estimation* ($PMLE$) count data model that relates the observed market/firm indicators to the number of tariff options offered by each firm according to the following exponential mean function:[8]

$$E\left[\text{PLANS} \mid \boldsymbol{X}\right] = \exp\left(\boldsymbol{X}'\boldsymbol{\beta}\right) . \tag{1}$$

[7] The connection between the degree of concavity of the optimal tariff and the statistical properties of the distribution of consumer types is analyzed extensively by Miravete (2005).

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

$$\frac{\partial E\left[\text{PLANS} \mid \boldsymbol{X} = \overline{\boldsymbol{X}}\right]}{\partial x_j} = \beta_j \exp\left(\overline{\boldsymbol{X}}'\boldsymbol{\beta}\right) .$$

Similarly, column B1 of Table 4 focuses on the number of effective tariff options only, *i.e.*, those who are the least expensive ones for at least few consumption profiles.[9] The other two columns, A1 and A2 are *PMLE* estimates that control for the potential endogeneity of AP_{peak}, $\text{AP}_{\text{off-peak}}$, and COVERAGE. Since firms can make use of available market characteristics to control for the nature of the distribution of consumers' unobserved heterogeneity. I thus include carriers' characteristics to control for their idiosyncrasy in pricing (or, alternatively, capture the heterogeneity related to the existence of commercialization costs). I include some other features, such as the market coverage and curvature of the tariff to control for the potential effects of existing network externality in pricing as well as for the nature of the distribution of consumer heterogeneity.

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. This is an effect that immediately follows the entry of the second carrier and is common for both competing firms. The expected number of both, actual and effective tariff options, increases by one with duopoly after controlling for observable market and firm heterogeneity. One significant difference between actual and effective tariffs is that only the former tends to decrease over time. Thus, the immediate conclusion of Table 4 is that competition permanently increases the set of relevant choices among consumers, and that time eventually eliminates the excess of dominated tariff plans.

Table 4 also documents some 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, companies from the former BELL system offered on average more options. Secondly, REGULATED firms always offer a larger variety of tariff options. This is consistent with the argument given by Shew (1994) that these firms attempted to circumvent the effects of future regulatory restrictions by initially having as many tariff options approved as possible.[10] It turns out that this threat of future regulation appears also to have triggered an increase in the set of effective choices that consumers faced.

Some of the correlations between number of tariff options and demographics are worth mentioning. In larger markets or in those where population is on average better educated, cellular carriers offered

[9] The variance of a Poisson distribution is identical to the mean. Thus, inference can be seriously compromised if the expected distributions of PLANS and EFFPLANS conditional on $\boldsymbol{X}$ are not equidispersed. The *PMLE* estimation method obtains consistent estimates of $\boldsymbol{\beta}$ based on the Poisson likelihood function, but employs a robust covariance matrix that allows for both overdispersion and the less common underdispersion, which happens to be what characterizes the empirical distribution of both total and effective number of plans in the present sample according to Table 1. The advantages of the robust *PMLE* estimation and the computation of the robust covariance matrix is discussed at length by Cameron and Trivedi (1998, §3.2.3), Gourieroux, Monfort, and Trognon (1984), and Wooldridge (2002, 19.2.2).

[10] Regulators were quite uncertain about how to regulate this new industry that was going to be competitive. Thus, they accepted any initial proposal on pricing made by the regulated carrier and promised to revise their decisions in the future depending on the performance of these firms. Regulation was never seriously enforced in this market and eventually its practice faded away. Only incumbent carriers who previously belonged to the old Bell system were subject to regulation.

Table 4: Number of Actual and Effective Tariff Options

	A1		A2		B1		B2	
CONSTANT	−6.2651	(3.30)	−5.6756	(2.96)	−1.1381	(0.71)	−0.5754	(0.35)
TIME	−0.0899	(2.35)	−0.0154	(0.37)	−0.0012	(0.03)	0.0424	(1.09)
TIME^2	0.3829	(2.11)	0.0162	(0.08)	0.0155	(0.09)	−0.2029	(1.13)
WIRELINE	−0.0657	(0.95)	−0.1206	(1.59)	−0.0433	(0.80)	−0.0556	(0.92)
DUOPOLY	0.9966	(9.26)	0.8155	(6.20)	1.0410	(10.97)	0.9669	(8.58)
YEAR92	−0.6246	(0.85)	0.6131	(0.79)	0.4908	(0.76)	1.2503	(1.80)
MKTAGE	0.0107	(1.89)	0.0104	(1.73)	0.0027	(0.59)	0.0025	(0.52)
MKTAGE^2	−0.0012	(2.13)	−0.0011	(1.86)	−0.0002	(0.49)	−0.0002	(0.38)
COMMUTING	0.0357	(1.50)	0.0467	(1.65)	−0.0069	(0.38)	−0.0082	(0.39)
POPULATION	0.1089	(2.83)	0.0706	(1.72)	0.1620	(4.83)	0.1482	(4.14)
POPAGE	0.0787	(4.98)	0.0759	(4.61)	0.0494	(3.59)	0.0512	(3.59)
EDUCATION	0.4303	(3.55)	0.3985	(3.38)	0.1191	(1.21)	0.0818	(0.84)
BUSINESS	−0.0035	(2.51)	−0.0029	(2.16)	−0.0042	(3.72)	−0.0040	(3.56)
GROWTH	−0.2155	(5.48)	−0.1715	(4.23)	−0.0958	(2.95)	−0.0708	(2.13)
INCOME	−0.0413	(2.90)	−0.0329	(2.28)	−0.0345	(3.35)	−0.0287	(2.68)
POVERTY	−0.0702	(3.22)	−0.0689	(3.14)	−0.0961	(5.33)	−0.0956	(5.30)
REGULATED	0.5194	(7.58)	0.3793	(4.39)	0.1729	(3.17)	0.1249	(1.79)
BELL	0.3294	(4.87)	0.3906	(5.55)	0.1323	(2.51)	0.1802	(3.27)
AP_{peak}	0.0897	(2.12)	0.8920	(5.03)	0.1435	(3.19)	0.5254	(3.46)
$\text{AP}_{\text{off-peak}}$	−0.0008	(4.17)	0.0095	(3.95)	0.0004	(3.97)	0.0073	(3.52)
COVERAGE	−0.4364	(2.54)	0.4365	(1.28)	−0.1665	(1.33)	0.3388	(1.31)
v_1			−0.8144	(4.63)			−0.3847	(2.62)
v_2			−0.0106	(4.29)			−0.0071	(3.32)
v_3			−0.9051	(2.35)			−0.5268	(1.78)
Observations	1561		1561		1561		1561	
$-\ln L$	2581.6049		2571.4390		2315.5523		2310.7623	
$DPLRI$	0.1791		0.1892		0.2121		0.2169	
LM	8.3483				21.7166			
$[p-value]$	[0.0393]				[0.0002]			

Marginal effects evaluated at the sample mean of regressors of *Poisson PMLE*. Absolute value, heteroskedastic-robust t-statistics are reported between parentheses. $DPLRI$ is the Poisson-deviance pseudo-R^2 of Cameron and Windmeijer (1996). LM is the regression-based, heteroskedastic-robust, Lagrange multiplier test of endogeneity of Wooldridge (1997). LM is asymptotically distributed as a χ^2_3 distribution under the null hypothesis of exogeneity and p-values are shown between brackets. Model A estimates the determinants of the number of actual tariff options while model B addresses the number of effective (non-dominated) tariff options. Equations labeled A1 and B1 present *Poisson PMLE* estimates while those marked A2 and B2 instrument for potentially endogenous regressors AP_{peak}, $\text{AP}_{\text{off-peak}}$, and COVERAGE.

more tariff options. This result is consistent with the idea that more tariff plans are needed to successfully screen more heterogeneous populations of customers that are more likely to be found in large and educated urban areas. These effects have however a limited practical importance: six more million inhabitants of an *SMSA* are needed for carriers to offer an additional effective tariff option while EDUCATION stops being significant at all when we focus on effective rather than on actual tariffs. Surprisingly, BUSINESS, and INCOME are negatively correlated with the number of actual and effective tariff plans offered, although their negative effect is far smaller than the positive effect of POPULATION and EDUCATION.

The last three regressors may all suffer from endogeneity. In the case of AP_{peak} and $\text{AP}_{\text{off-peak}}$, endogeneity may arise because firms do not only decide on the number of tariff options, but also which tariff options to offer, thus determining the curvature and position of the tariff lower envelope. Alterna-

tively, we could adopt the view that the distribution of consumer heterogeneity is exogenous and firms are simply responding to this heterogeneity when they design the nonlinear tariff. To elucidate which explanation is better supported by the data, I include AP_{peak} and $\text{AP}_{\text{off-peak}}$ as regressors that account for the degree of concavity of the lower envelope of the different tariff options offered. In particular, I fit this lower envelope on a quadratic polynomial on airtime usage over a 0-1000 minute range of potential consumption. Variable AP_{peak} is the equivalent of the Arrow-Pratt measure of risk aversion averaged over the 0-1000 minute interval of airtime usage of the quadratic polynomial that fits the lower envelope of the peak component of the tariff. Variable $\text{AP}_{\text{off-peak}}$ is defined similarly but using the off-peak component of the tariff only.[11]

Network externalities are another potential source of endogeneity, as the demand for telephone services may depend on the number of total subscribers in a market. Since pricing determines the decision to subscribe, the strategy followed by each carrier is partly responsible for the net externality that a new customer may enjoy.[12] This argument is admittedly weak for the early U.S. cellular telephone industry, since the service clearly targeted businesses and high income individuals.[13] Cellular telephones were far less popular than they are today. By the end of our sample, there were only 11 million subscribers (as compared to the current 208 million according to the *CTIA*'s November 2005 Semi-Annual Data Survey). Therefore, the definition of COVERAGE used here accounts not only for residential, but also for potential business customers.[14]

The second and fourth columns of Table 4 repeat the analysis of columns A and B after correcting for endogeneity by the robust *PMLE* method of Wooldridge (1997), which consists of including the prediction errors of the instrumental regressions of AP_{peak}, $\text{AP}_{\text{off-peak}}$, and COVERAGE on the Poisson *PMLE* count data regression.[15] The *LM* tests reported in Table 4 indicate that AP_{peak}, $\text{AP}_{\text{off-peak}}$, and COVERAGE cannot jointly be considered exogenous.

After correcting for endogeneity the sign and conclusions of this section still remain valid: The net effect of competition still adds up to one effective tariff plan, *i.e.*, a 50% increase, respectively, over the

[11] This approach is equivalent to the discrete Arrow-Pratt measure employed by Marciano (2000, §4.2) to account for the curvature of the tariff. Similar results were obtained with the Cobb-Douglas approximation to the lower envelope of the tariff of Busse and Rysman (2005).

[12] Contrary to other countries, cellular telephones in the U.S. are not numbered differently than any other fixed line telephone. Thus, it is not possible for consumers to know whether they are dialing a cellular phone or a fixed one, thus avoiding a separate billing for interconnection and out-of-network termination charges. Therefore, an explicit pricing of these network-driven components was not possible, and only the size of the active customer base is relevant.

[13] Targeting a small group of customers may indeed lead to network externalities through imitation of other members in a small social network.

[14] This variable is approximated as 1,300 maximum customers per antenna site already built, divided by the sum of the number of business considered as high potential customers and the number of (assumed four member) families in each *SMSA*. For a detailed discussion on this definition see Basaluzzo and Miravete (2006, §2).

[15] Instrumental regressions are discussed below in Section 5.

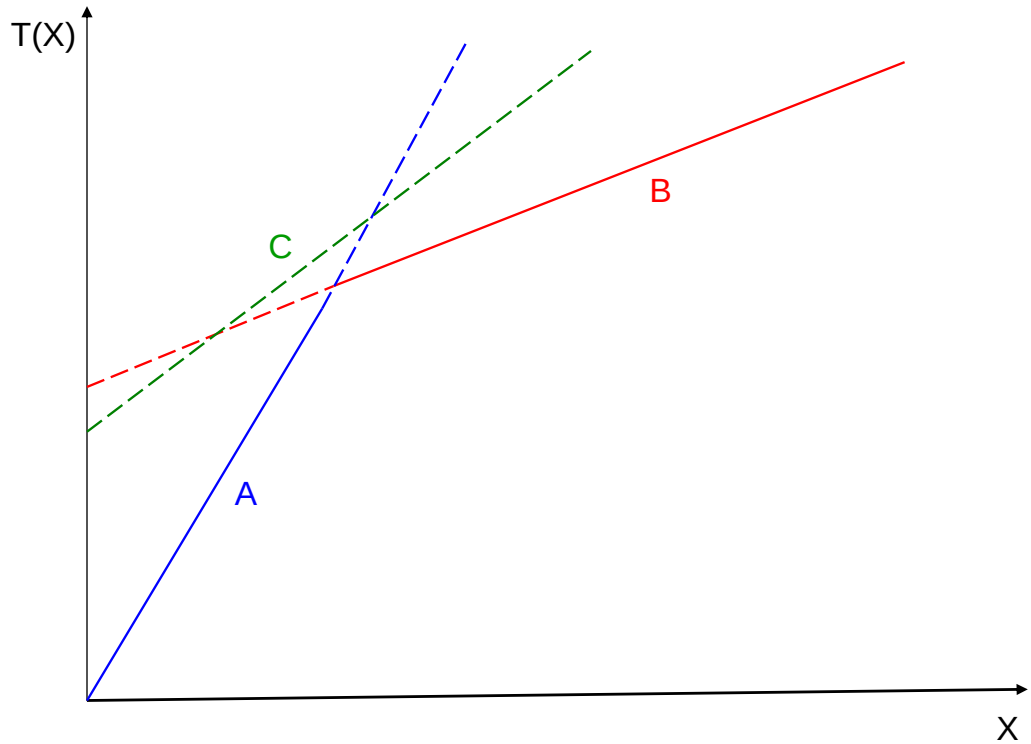
monopoly phase of these markets. This result coincides with the increase of the number of options offered by the incumbent firms with the increase in competition as reported by Seim and Viard (2005). Table 4 also shows that this increase in the number of options is general across all firms in every market (as opposed to only the incumbent), and more interestingly, that it is more pronounced in the case of effective options than for actual tariff plans. Furthermore, the Poisson $PMLE$ estimates of Table 4 confirm the expected result that firms offer more effective options in those large urban markets where a more diverse customer base is more likely to exist.

4 Analysis of Fogginess

The observed increase of options available in competitive markets does not suffice to conclude that firms are engaging in foggy pricing to take advantage of consumers' deliberation costs. Indeed the observed increase of tariff options appears to correspond to the increase in the number of effective tariff options according to Table 4. 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*. Furthermore, the increase in the number of effective tariffs might be concentrated in some few markets, perhaps because of the nature of competition or because other institutional circumstances, such as regulation. If this were the case, the observed increase in the total number of tariff options would lead to an increase in foggy pricing in some other markets. However, the analysis of the previous section does not conclude that this geographical heterogeneity in the use of foggy tactics exists. It may well be that the larger increase in non-dominated tariff options is common as well as generalized across markets. This section studies whether fogginess of tariffs increases or decreases after the entry of a second carrier in the cellular industry and aims to determine whether such a process is common to all markets rather than specific to a few of them.

The most restrictive definition of *foggy pricing* is perhaps also the most intuitive one. A *foggy tariff option* is totally dominated by another option or a combination of other tariff options for any usage profile possible. If consumers subscribe to a foggy tariff option, they could always reduce their expenses afterwards by switching to a different tariff plan. This situation is depicted in Figure 2. Tariff C is foggy because any consumer will always pay less for the same usage service subscribing to tariff option A if she uses the telephone sparsely or to tariff option B if she is an intensive cellular customer. This is true if consumers are certain about their future usage, an assumption that I will relax in Section 4.1. The tariff of Figure 2 is defined over a single-dimensional usage measure, "X", but in reality it may involve many other dimensions.

Figure 2: Fogginess: Dominated Tariff Option



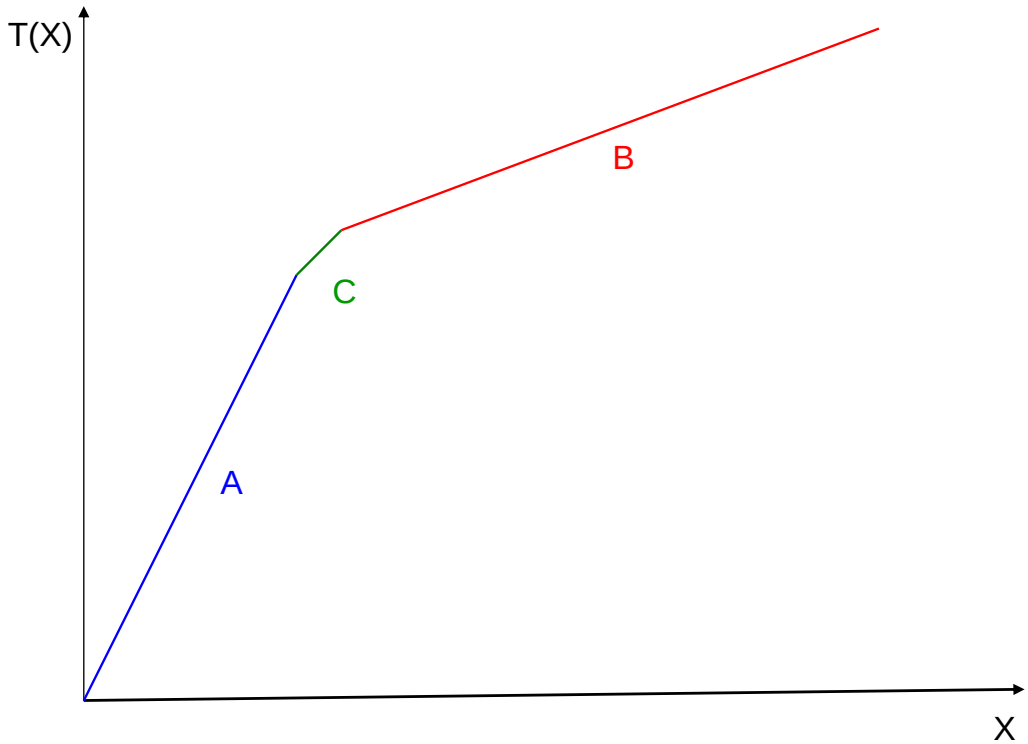
Regarding the econometric application, one obvious advantage of the tariffs offered in the early U.S. cellular industry is that they only screen consumers with respect to three dimensions: pricing of peak and off-peak airtime usage plus a monthly allowance of free minutes associated to the payment of a monthly fixed fee (although far smaller than the bucket tariffs common nowadays). These relatively simple pricing schemes allow me to define precisely what a foggy tariff option is, and to measure the degree of fogginess of a menu of tariff options based on this one or any alternative definition of fogginess. The available data do not contain just a representative average price of consumption for every nonlinear tariff offered, but rather the complete tariff information necessary to compute the monthly bill for any profile of consumer usage.

In order to determine whether a tariff option is dominated or not, I evaluate the offered tariff plans of each firm in each market and time over all possible combinations of peak and off-peak consumption adding up to a maximum of 1000 minutes of airtime usage.[16] A particular tariff option is *foggy* if it is never the least expensive one for at least one of approximately 500,000 potential usage patterns.[17] Once we determine whether a particular tariff is foggy, we can characterize the *fogginess* of a menu tariff plans

[16] Usage patterns do not necessarily need to add to 1000 minutes; I simply exclude the possibility that consumption exceeds 1000 minutes overall. 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.

[17] Billing was metered by the minute at that time.

Figure 3: Fogginess: Non-Dominated Tariff Options



as the ratio of dominated to non-dominated tariff options. Column C1 of Table 5 regresses the following transformation of this ratio on market and firm characteristics:

$$\ln\left(\frac{\text{Number of Dominated Options}}{\text{Number of Non}-\text{Dominated Options}}+0.1\right). \tag{2}$$

This definition of fogginess, based on the existence of fully dominated tariff options, ignores other practices that may make it difficult for consumers to evaluate which tariff option is the least expensive for their usage. Suppose that a firm offers three tariff options, each being the least expensive one for about one third of the combinations when peak and off-peak airtime are used to define usage patterns. For a uniform distribution of usage over the set of potential usage patterns, this tariff is balanced in the sense that it targets low, medium, and high valuation customers similarly. Balanced tariffs like this one do not add any fogginess beyond the multitude of choices that consumers may face, something that was already analyzed in Section 3. The second measure of fogginess that I use in this paper applies only to non-dominated options, and it interprets that a menu of tariff planss is foggy when some of the tariff options are only the least expensive ones for a smaller share of potential usage patterns than some of the other options. Thus, fogginess is synonymous here with asymmetry or inbalance in the menu of options.

Figure 3 illustrates the fogginess of non-dominated tariff options. Tariff option C is the least expensive one for a smaller usage range than any of the other two plans. It might be argued that firms appear to increase the choice set of consumers only with the hope that they do not make accurate predictions of their future usage when subscribing to a particular tariff option. If a consumer chooses an option that is only the least expensive one for a very limited usage range, she will most likely end up paying more for her realized telephone usage (*e.g.*, on the dashed portions of tariff option C in Figure 3) unless she is extremely accurate in predicting her future usage. Again, I will address the effect of consumer uncertainty in Section 4.1. For now, I simply ignore the potential effect of individual uncertainty regarding future usage at the time of subscribing one particular tariff option.

The index of fogginess of non-dominated options thus needs to accommodate potential asymmetries regarding the share of usage patterns for which they are the least expensive option. There is little doubt that a firm is engaging in foggy tactics when it gives consumers the choice among ten different tariff options, none of which are strictly dominated, but some being the least expensive option for only three out of the approximately 500,000 potential usage patterns (in which I evaluate every tariff option of each firm in each market and time). The second proposed fogginess index characterizes this behavior as more foggy than offering only two tariff plans that are the least expensive ones for approximately the same number of usage patterns. To capture the effect of asymmetric menus of tariffs, I define the fogginess index of a non-dominated set of tariff options as:

$$\varphi = n \cdot HHI\,, \tag{3}$$

where n is the number of non-dominated tariff options offered and HHI is the Herfindahl-Hirschman index of concentration defined over the share of usage patterns for which each plan is the least expensive one. Considering only "balanced" tariff schedules in which each plan is the least expensive for the same $1/n$ share of usage patterns, $\varphi = 1$ regardless of n, the number of tariff options offered. Because HHI increases with the asymmetry of the distribution of shares of the least expensive usage patterns of each tariff option according to Tirole (1989, §5.5), the proposed index of fogginess also increases with a less balanced menus of tariffs. Column D1 of Table 5 regresses the following transformation of the fogginess ratio on market and firm characteristics:

$$\ln\left(\varphi + 0.1\right)\,. \tag{4}$$

Table 5 reports the marginal effects of these two measures of fogginess evaluated at the sample mean of regressors while assuming that consumers do not face any uncertainty regarding future telephone usage when they subscribe to a particular tariff plan. In clear contrast with the behavior of the actual and effective number of tariff plans, the incidence of regressors is generally different depending on whether we analyze the ratio of dominated to non-dominated tariff plans or the fogginess index φ. However, competition has the same effect on both measures of fogginess. Entry of the second cellular carrier simplifies tariffs

and makes them less deceptive. This effect is immediate after the entry of the second carrier in regression C1 but in the long run it is particularly strong, as the estimate of YEAR92 indicates in columns C1 and D1. This parameter estimate is by far the largest one for both regressions and implies that, on average, after few years of competition each firm offers 0.4 fewer dominated tariff plans than during the monopoly phase. Furthermore, this reduction of fogginess is mostly evenly distributed across carriers. *Nonwireline* entrants appear to offer slightly more balanced non-dominated tariffs than *wireline* incumbents but this result is not robust to the endogeneity correction. Therefore, regardless of the definition of fogginess used, foggy pricing does not survive competition and fails to serve as a way to soften competition; entry of a second carrier *lifts the fog* and eventually induces far simpler pricing schemes. However, the reduction in fogginess is uneven across markets and results critically depend on the measure of fogginess used. The ratio of dominated to non-dominated options increases with COMMUTING, EDUCATION and BUSINESS POVERTY, and regulation and decreases with POPULATION, GROWTH and INCOME. The behavior of the fogginess index φ is similar although many of these regressors are not significant

When consumers are very similar the optimal nonlinear tariff becomes most likely a simple two-part tariff (as discussed in Figure 1). Thus, the Arrow-Pratt measure of degree of concavity approaches zero. In general, it is in those cases when firms offer more foggy options. Firms make use of more complex and deceptive strategies when adding another effective tariff option to further segment the market leads to a very low increase in expected profits. This result, consistent with the argument put forward in the theoretical model of Yang and Ye (2006), generally survives when the estimation takes into account the potential endogeneity of AP_{peak} and $\text{AP}_{\text{off-peak}}$ among other variables. The third potentially endogenous variable, COVERAGE, has an unclear effect on fogginess and it is not robust to endogeneity correction.

An alternative interpretation to foggy pricing that could explain why dominated tariff options are offered to consumers at a given time is that such options are currently being phased out. Thus, consumers who subscribed to this option in the past might not be automatically switched to one of the new options, but the firm does not intend nor expect that new customers may subscribe to such option any more. Fortunately the data allow me to identify which tariff options were offered in the past, and thus I can control whether dominated tariffs respond to the phasing out of previously offered options or not. Results indicate that the share of foggy options that were at some point an effective option in the past, PHS/PLI, always have a negative effect on the fogginess of the tariff, *i.e.*, for the largest part, foggy tariffs are not the consequence of past pricing decisions.

Variable PHS/PLI is also endogenous as firms decide which tariffs to phase out and when. Overall, endogeneity of regressors is not serious. Langrange Multiplier tests do not reject the joint exogeneity of AP_{peak}, $\text{AP}_{\text{off-peak}}$, COVERAGE, and PHS/PLI, although after instrumenting some results related to these variables stop being significant. This is the case of regression D2 dealing with the fogginess index of non-dominated options φ. Certainly, the effect of competition on fogginess is now slightly smaller in the

Table 5: Fogginess: Dominated and Non-Dominated Tariff Options

	C1		C2		D1		D2	
CONSTANT	−2.0857	(9.03)	−2.0789	(8.55)	−0.9339	(3.18)	−1.1442	(3.32)
TIME	−0.0276	(4.11)	−0.0162	(2.29)	−0.0230	(3.48)	−0.0178	(2.12)
TIME^2	0.1184	(3.78)	0.0615	(1.86)	0.0994	(3.15)	0.0810	(2.09)
WIRELINE	0.0133	(1.15)	0.0076	(0.61)	0.0364	(2.54)	0.0198	(1.23)
DUOPOLY	−0.0427	(2.81)	−0.0328	(1.50)	−0.0069	(0.40)	−0.0424	(1.52)
YEAR92	−0.4152	(3.35)	−0.2021	(1.55)	−0.4365	(3.28)	−0.3986	(2.53)
MKTAGE	0.0023	(2.67)	0.0022	(2.47)	0.0012	(1.26)	0.0009	(0.81)
MKTAGE^2	−0.0003	(2.95)	−0.0003	(2.73)	−0.0001	(0.70)	−0.0001	(0.51)
COMMUTING	0.0169	(5.13)	0.0204	(5.38)	0.0099	(2.46)	0.0163	(3.11)
POPULATION	−0.0306	(5.27)	−0.0334	(5.19)	0.0043	(0.67)	−0.0083	(1.08)
POPAGE	0.0034	(1.19)	0.0031	(0.98)	0.0035	(0.83)	0.0020	(0.41)
EDUCATION	0.1017	(8.21)	0.1046	(7.19)	0.0767	(4.53)	0.0811	(3.73)
BUSINESS	0.0006	(3.09)	0.0006	(2.87)	−0.0008	(3.39)	−0.0006	(2.34)
GROWTH	−0.0289	(5.16)	−0.0253	(4.30)	−0.0308	(3.64)	−0.0270	(2.94)
INCOME	−0.0047	(2.49)	−0.0049	(2.43)	−0.0029	(1.25)	−0.0020	(0.76)
POVERTY	0.0097	(3.51)	0.0082	(2.83)	0.0053	(1.73)	0.0068	(1.78)
REGULATED	0.0615	(5.63)	0.0563	(3.96)	0.0202	(1.61)	−0.0199	(1.07)
BELL	0.0566	(5.28)	0.0661	(5.87)	0.0339	(2.71)	0.0234	(1.64)
AP_{peak}	−0.0149	(8.45)	0.1098	(4.10)	−0.0128	(5.25)	0.0900	(2.59)
$\text{AP}_{\text{off-peak}}$	−0.0004	(6.71)	0.0008	(1.99)	0.0000	(0.80)	0.0001	(0.18)
COVERAGE	−0.0640	(2.65)	0.0427	(0.88)	−0.0178	(0.63)	−0.0232	(0.33)
PHS/PLI	−0.0400	(8.63)	0.0045	(0.26)	−0.1342	(27.19)	−0.1610	(7.80)
Observations	1561		1561		1561		1561	
$Adj.\ R^2$	0.1883		0.1489		0.2918		0.1422	
LM	5.7315				3.9143			
$[p-value]$	[0.2201]				[0.4177]			

Marginal effects evaluated at the sample mean of regressors. Model C estimates the determinants of the ratio of foggy (dominated) to effective tariff options while model D studies the behavior of a Herfindahl-Hirschman analog measure of fogginess of non-dominated tariff options. Equations labeled C1 and D1 present *OLS* estimates and absolute, heteroskedastic-consistent t-statistics are reported between parentheses. For these models *LM* is the regression-based, heteroskedastic-robust, Lagrange multiplier test of endogeneity of Wooldridge (1995) where joint endogeneity of AP_{peak}, $\text{AP}_{\text{off-peak}}$, COVERAGE, and PHS/PLI is tested. *LM* is asymptotically distributed as a χ^2_4 distribution under the null hypothesis of exogeneity and p-values are shown between brackets. Similarly, estimates of columns marked C2 and D2 are *IV* estimates to account for potential endogeneity of these variables. In this latter case, absolute Wooldridge (1995) *2SLS*, heteroskedastic-consistent t-statistics are reported between parentheses.

long run , but fortunatelly still negative and by far the most important one among the different regressors considered regardless of how we measure fogginess.

4.1 Robustness of Results to Consumers' Uncertainty

Evidently consumers do not choose tariff options and telephone usage simultaneously. Indeed, consumers first choose a tariff option and later decide how much to talk on the phone. Choosing a particular tariff option does not force consumers to commit to any particular level of usage. Thus, the more accurate their predictions are, the more valid are the results of Table 5.

Table 6: Fogginess and Uncertainty: Dominated and Non-Dominated Tariff Options

	DESCRIPTIVE STATISTICS							
	SHARE-FOGGY				FOGGINESS			
	Early Duopoly		*Late Duopoly*		*Early Duopoly*		*Late Duopoly*	
Variables	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
$\sigma = 0.00\mu$	0.1772	(0.3027)	0.1495	(0.4502)	0.5473	(0.4375)	0.4904	(0.4526)
$\sigma = 0.10\mu$	0.5078	(0.5884)	0.5804	(0.5062)	0.6296	(0.4907)	0.6852	(0.4015)
$\sigma = 0.25\mu$	0.4914	(0.5588)	0.5076	(0.5701)	0.6328	(0.4807)	0.6824	(0.4090)
$\sigma = 0.50\mu$	0.4755	(0.5420)	0.5571	(0.5083)	0.6343	(0.4787)	0.6827	(0.4013)
$\sigma = 1.00\mu$	0.4794	(0.5392)	0.5559	(0.5109)	0.6355	(0.4739)	0.6830	(0.3903)
$\sigma = 1.50\mu$	0.4749	(0.5457)	0.5321	(0.5173)	0.6387	(0.4440)	0.6839	(0.3831)
$\sigma = 2.25\mu$	0.4927	(0.5723)	0.5247	(0.5253)	0.6398	(0.4302)	0.6859	(0.3809)
$\sigma = 3.00\mu$	0.5167	(0.5392)	0.5147	(0.5230)	0.6380	(0.4369)	0.6747	(0.3889)
	ESTIMATES							
	C1		C2		D1		D2	
				TIME				
$\sigma = 0.00\mu$	−0.0276	(4.11)	−0.0162	(2.29)	−0.0230	(3.48)	−0.0178	(2.12)
$\sigma = 0.10\mu$	−0.0679	(4.18)	−0.0333	(2.32)	−0.0616	(2.78)	−0.0181	(1.71)
$\sigma = 0.25\mu$	−0.0510	(4.12)	−0.0339	(2.42)	−0.0325	(3.71)	−0.0167	(1.59)
$\sigma = 0.50\mu$	−0.0599	(5.13)	−0.0483	(3.60)	−0.0332	(3.87)	−0.0169	(1.63)
$\sigma = 1.00\mu$	−0.0581	(4.91)	−0.0400	(2.99)	−0.0393	(4.60)	−0.0218	(2.11)
$\sigma = 1.50\mu$	−0.0590	(4.11)	−0.0476	(3.04)	−0.0410	(4.71)	−0.0259	(2.54)
$\sigma = 2.25\mu$	−0.0659	(4.58)	−0.0408	(2.62)	−0.0338	(3.94)	−0.0206	(2.05)
$\sigma = 3.00\mu$	−0.0526	(3.59)	−0.0308	(1.92)	−0.0276	(3.13)	−0.0235	(2.31)
				WIRELINE				
$\sigma = 0.00\mu$	0.0133	(1.15)	0.0076	(0.61)	0.0364	(2.54)	0.0198	(1.23)
$\sigma = 0.10\mu$	0.0510	(1.91)	0.0429	(1.50)	−0.0185	(0.91)	−0.0194	(0.92)
$\sigma = 0.25\mu$	0.0202	(0.76)	0.0223	(0.77)	−0.0204	(1.00)	−0.0225	(1.05)
$\sigma = 0.50\mu$	0.0487	(1.89)	0.0430	(1.54)	0.0071	(0.35)	0.0009	(0.04)
$\sigma = 1.00\mu$	0.0151	(0.57)	0.0189	(0.67)	0.0307	(1.57)	0.0227	(1.08)
$\sigma = 1.50\mu$	−0.0034	(0.13)	−0.0033	(0.11)	0.0111	(0.59)	0.0049	(0.24)
$\sigma = 2.25\mu$	0.0333	(1.21)	0.0330	(1.11)	0.0002	(0.01)	−0.0015	(0.07)
$\sigma = 3.00\mu$	−0.0139	(0.49)	−0.0153	(0.49)	−0.0247	(1.35)	−0.0333	(1.67)
				DUOPOLY				
$\sigma = 0.00\mu$	−0.0427	(2.81)	−0.0328	(1.50)	−0.0069	(0.40)	−0.0424	(1.52)
$\sigma = 0.10\mu$	0.0804	(2.73)	0.0903	(1.93)	0.0382	(1.74)	0.0508	(1.40)
$\sigma = 0.25\mu$	0.0962	(3.34)	0.1301	(2.89)	0.0367	(1.69)	0.0447	(1.31)
$\sigma = 0.50\mu$	0.1229	(4.26)	0.1461	(3.32)	0.0506	(2.36)	0.0563	(1.64)
$\sigma = 1.00\mu$	0.0902	(3.14)	0.1275	(2.92)	0.0873	(4.11)	0.1079	(3.14)
$\sigma = 1.50\mu$	0.0550	(1.66)	0.0935	(1.94)	0.0812	(3.79)	0.1018	(3.07)
$\sigma = 2.25\mu$	0.1050	(3.12)	0.1911	(4.07)	0.0864	(4.04)	0.1192	(3.81)
$\sigma = 3.00\mu$	0.1181	(3.39)	0.1554	(3.22)	0.0690	(3.18)	0.0735	(2.35)
				YEAR92				
$\sigma = 0.00\mu$	−0.4152	(3.35)	−0.2021	(1.55)	−0.4365	(3.28)	−0.3986	(2.53)
$\sigma = 0.10\mu$	−0.7845	(3.20)	−0.3968	(1.46)	−0.5073	(2.84)	−0.2415	(1.18)
$\sigma = 0.25\mu$	−0.7164	(2.95)	−0.3928	(1.47)	−0.4794	(2.74)	−0.2355	(1.18)
$\sigma = 0.50\mu$	−0.8677	(3.71)	−0.6608	(2.55)	−0.4471	(2.59)	−0.2194	(1.10)
$\sigma = 1.00\mu$	−0.7332	(3.14)	−0.4168	(1.63)	−0.4419	(2.56)	−0.1921	(0.97)
$\sigma = 1.50\mu$	−0.8462	(3.22)	−0.6884	(2.39)	−0.4918	(3.79)	−0.2978	(1.53)
$\sigma = 2.25\mu$	−0.8846	(3.30)	−0.4752	(1.65)	−0.4019	(2.38)	−0.2138	(1.12)
$\sigma = 3.00\mu$	−0.7169	(2.65)	−0.4375	(1.47)	−0.4273	(2.47)	−0.4394	(2.27)

Marginal effects evaluated at the sample mean of regressors for samples with alternative definitions of fogginess depending on the dispersion of actual calls relative to the expected telephone usage. Model C estimates the determinants of the ratio of foggy (dominated) to effective tariff options while model D studies the behavior of a Herfindahl-Hirschman analog measure of fogginess of non-dominated tariff options. Equations labeled C1 and D1 present *OLS* estimates and absolute, heteroskedastic-consistent t-statistics are reported between parentheses. Similarly, estimates of columns C2 and D2 are *IV* estimates to account for potential endogeneity of these variables. In this latter case, absolute Wooldridge (1995) *2SLS*, heteroskedastic-consistent t-statistics are reported between parentheses.

In the absence of individual data I decided to evaluate the robustness of the results reported above with respect to the existence of individual uncertainty by means of simulations. For the analysis in Table 5 I first determined which tariff option was the least expensive for each potential usage profiles defined by some 500,000 combinations (i, j) where $i = 0, 1, 2, \ldots$ represented the number of peak minutes a household uses during a month and $j = 0, 1, 2, \ldots$ were the corresponding off-peak minutes of usage. Furthermore, it was assumed that $i + j \leq 1000$. Now, in order to capture the existence of future usage uncertainty among consumers, I have to identify which option leads to the lowest expected tariff payment when the realized consumption profile can be understood as a random draw from a particular bivariate normal distribution centered around (μ_i, μ_j), and s.t. $\mu_i + \mu_j \leq 1000$. Now μ_i and μ_j represent the expected number peak and off-peak number of calls, respectively, that a household makes in a month. Usage in these two dimensions are assumed to be independently distributed according to univariate normal distributions with standard deviations proportional to the mean, *i.e.*, $\sigma_i = \kappa\mu_i$ and $\sigma_j = \kappa\mu_j$. This heteroskedastic assumption captures the documented dispersion of telephone usage for different usage levels (*e.g.*, Miravete (2005, §4)). Therefore, for each of the approximately 500,000 expected usage profiles defined by (μ_i, μ_j) I compute the expected payment under each tariff option by integrating out according to the assumed distributions of usage. In particular I compute the average payment of a particular tariff option over fifty random draws from $N[\mu_i, (\kappa\mu_i)^2]$ for peak usage and another fifty from $N[\mu_j, (\kappa\mu_j)^2]$ for off-peak usage. The process is repeated for each 500,000 potential usage profiles as well as for increasing dispersions of usage as measured by κ.

Table 6 reports the descriptive statistics of the share of dominated tariff as well as the measure φ of fogginess of non-dominated tariffs under increasingly more dispersed usage patterns. As the top of the table shows, fogginess increases initially as the variance of usage goes from zero to a small positive value. However, subsequent increases in the uncertainty of consumers regarding their future usage has an almost negligible effect.

The second half of Table 6 reports the estimates of those variables more relevant to evaluate the importance of competition on the degree of fogginess. The endogenous variables correspond to those of Table 6. While the magnitude of the estimates changes slightly with the dispersion of usage patterns, results from Table 6 mostly confirm the conclusions of Table 5. Thus, the fogginess of pricing is similar for *wireline* and *non-wireline* carriers and the mere pass of time tends to reduce the amount of fogginess. Contrary to results reported in Table 5, duopoly appears to favor fogginess (positive effect of DUOPOLY) but only in the short run because in the long run, the larger and negative effect of YEAR92 compensates the brief increase in fogginess right after the entry of the second carrier. This leads us to conclude that in the long run, competition *lifts the fog* despite consumers being uncertain about their future usage, and thus, potentially prone to make mistakes by choosing tariff options that are not the least expensive for the realized usage

level. Competition thus appears to solve the problem of deceptive pricing by its own, without the need of any regulatory intervention.

The increase in fogginess in the short run and its reduction in the long run can be reconciled with the existing theoretical models. Yang and Ye (2006) show that firms increase the number of tariff option if they engage in business stealing as a way to grow their customer base. This result is documented in Table 4. The increase in the number of tariffs may lead to an increase in fogginess in the present industry since in the early duopoly phase firms had no room to differentiate themselves from each other: they could not even differentiate through coverage of different *SMSA* areas since the *FCC* required the *wireline* company to offer unrestricted resale of its service until the *nonwireline* company was fully operational in order to foster competition and usage of the cellular service (*e.g.*, Vogelsang and Mitchell (1997, p.207)). As time passed, this restriction faded away and firms could differentiate their service areas. Consumer awareness of pricing practices together with this differentiation reduces the return of *foggy* tactics and firms behave closer in line with the competitive nonlinear pricing model of Rochet and Stole (2002) that predicts simple nonlinear pricing as long as the market gets fully covered whenever firms do not face substantially different costs.

5 Instrumental Regressions

The curvature of tariffs, as measured by AP_{peak} and $\text{AP}_{\text{off-peak}}$, market COVERAGE, and the phasing out indicator PHS/PLI are all simultaneously chosen with the menu of tariffs offered to consumers and their other features, such as whether to make one tariff option dominated (or almost dominated, allowing the exception of being the least expensive one for a very small fraction of potential usage patterns). As these variables serve as regressors in our econometric analysis, I instrumented them to avoid the possibility of any endogeneity bias. Table 7 reports the results of these intrumental regressions that I now briefly discuss.

The features of optimal nonlinear tariffs, the coverage that they induce, and the decision of phasing them out respond to both demand and cost variables. In instrumenting these variables I include regressors that condition all these features of pricing but that are independent of the actual implementation of the tariffs. Thus, for instance, in addition to demographics and firm characteristics used in the analysis of the number of tariffs and fogginess, Table 7 regresses AP_{peak}, $\text{AP}_{\text{off-peak}}$, COVERAGE, and PHS/PLI on additional demand variables such as $\sigma(\text{POPAGE})$, $\sigma(\text{COMMUTING})$, $\sigma(\text{EDUCATION})$, and $\sigma(\text{INCOME})$ that attempt to capture within market heterogeneity of consumers (thus affecting the distribution of consumer types) rather than the cross-market heterogeneity identified by market demographics in levels.

The usual "demand shifters" include anything that may affect the distribution of unobservable consumers' valuations. In order to identify these demand shifters (which through complicated nonlinear relations determine the shape of optimal tariffs, coverage, and the phasing out of old tariff options), we

Table 7: Instrumental Regressions

	AP_{peak}		$AP_{off-peak}$		COVERAGE		PHS/PLI	
CONSTANT	−13.2623	(2.70)	14.4113	(0.18)	0.7925	(1.16)	1.9357	(0.81)
TIME	−0.0330	(1.95)	−5.7210	(2.51)	0.0255	(3.59)	0.0522	(1.47)
TIME2	0.2093	(1.72)	17.2259	(1.91)	−0.0571	(2.00)	0.2096	(1.49)
NON-WIRELINE	0.1468	(2.21)	−7.5376	(2.41)	0.0150	(1.13)	−0.1124	(2.76)
DUOPOLY	0.1557	(2.81)	−12.3510	(2.85)	0.2368	(14.75)	−0.4526	(5.59)
YEAR92	−0.9114	(1.27)	−33.0835	(0.80)	0.1022	(0.81)	−2.0450	(3.75)
MKTAGE	0.0050	(0.93)	0.0712	(0.23)	−0.0047	(3.64)	−0.0108	(2.54)
MKTAGE2	−0.0004	(0.70)	0.0070	(0.40)	0.0002	(2.04)	0.0004	(1.06)
COMMUTING	−0.1093	(3.05)	7.3935	(2.82)	0.0152	(2.13)	−0.0097	(0.40)
POPULATION	0.0563	(2.52)	−2.6395	(1.85)	−0.0108	(1.52)	−0.1329	(5.15)
POPAGE	−0.1040	(2.84)	−3.9284	(2.35)	0.0613	(8.50)	−0.0139	(0.49)
EDUCATION	0.4766	(2.95)	15.2121	(2.15)	−0.1255	(4.40)	−0.3245	(3.14)
BUSINESS	0.0005	(1.08)	0.0102	(0.34)	−0.0007	(3.87)	0.0018	(2.52)
GROWTH	−0.0327	(2.22)	−0.5755	(0.80)	−0.0332	(4.21)	0.0534	(1.63)
INCOME	0.0220	(1.12)	−1.4308	(1.88)	−0.0021	(0.45)	−0.0342	(2.03)
POVERTY	−0.0021	(0.19)	1.7077	(1.85)	−0.0317	(7.46)	−0.0081	(0.49)
REGULATED	0.3794	(3.27)	−10.4463	(2.53)	0.0121	(0.74)	−0.4991	(10.06)
BELL	0.0510	(1.18)	−7.8326	(2.63)	−0.0347	(2.59)	−0.0906	(2.14)
MULTIMARKET	0.0364	(2.00)	0.0674	(0.09)	−0.0051	(2.47)	−0.0377	(3.42)
σ(POPAGE)	0.3699	(2.84)	5.0552	(1.39)	−0.1279	(8.32)	−0.1250	(1.78)
σ(COMMUTING)	0.1142	(2.52)	−8.5555	(2.59)	−0.0088	(1.07)	−0.0728	(2.60)
σ(EDUCATION)	1.1905	(2.82)	−29.0823	(2.65)	0.1458	(2.35)	−0.3604	(1.47)
σ(INCOME)	−0.0657	(1.70)	0.5771	(0.58)	0.0118	(1.69)	0.1147	(4.08)
LEAD	−0.0071	(2.45)	−0.0625	(0.23)	0.0026	(3.00)	0.0109	(2.77)
WAGE	0.0011	(0.13)	−3.1613	(3.05)	0.0179	(5.26)	0.0159	(1.23)
ENERGY	−0.1311	(2.45)	1.9852	(0.57)	0.0590	(4.24)	−0.1073	(1.90)
OPERATE	0.0586	(1.94)	2.0996	(1.55)	−0.0134	(2.12)	0.0942	(4.16)
RENT	−0.0226	(2.01)	2.5764	(2.87)	0.0039	(1.81)	−0.0046	(0.52)
PRIME	0.0975	(1.44)	−9.8208	(1.90)	0.0136	(1.09)	0.2103	(4.26)
ENG-COSTS	−0.0312	(0.46)	1.5210	(0.30)	0.0328	(1.88)	0.4432	(6.23)
CRIME					0.0218	(4.69)	−0.0180	(1.09)
SVCRIMES					−0.4316	(1.58)	6.8669	(6.78)
DENSITY					−0.0052	(7.14)	0.0003	(0.15)
TEMPERATURE					0.0001	(0.35)	0.0047	(3.22)
RAIN					−0.0102	(3.07)	0.0087	(0.53)
NORTH					−0.0055	(2.90)	0.0024	(0.28)
WEST					0.0048	(8.98)	−0.0102	(4.74)
AVGjSHFj							0.5233	(4.32)
AVGjHHFj							−0.1312	(3.54)
Observations	1561		1561		1561		1561	
$Adj.\ R^2$	0.0479		0.0591		0.4389		0.3210	

OLS estimates. Absolute, heteroskedastic-consistent t-statistics are presented in parentheses.

need instruments that shift costs but that are uncorrelated with demand shocks. Since data also include competing firms, it is necessary to account for firm specific cost shifters.[18] Regressions of Table 7 include a large set of market specific cost variables such as the WAGE index of employees of the cellular industry, the PRIME lending rate in each market, an index of the cost of ENERGY, RENT, and operating costs of running a business (OPERATE). To identify differences in costs among carriers of a same market, I also include variables that may better capture firm specific effects such as the identity of the owner of the license, the possibility of heterogeneous levels of efficiency due to different accumulated experience captured by LEAD, *i.e.*, 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. Finally, the MULTIMARKET indicator intends to capture the effect on profitability and coverage that the presence of a firm in several markets may have. While I am treating markets independently of 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 through multimarket contact.

The population DENSITY of a market affects not only the deployment of antennas, but also how people interact and their need for cellular communication. Thus, this regressor is included mostly to control for the endogeneity of market penetration as measured by COVERAGE. In addition to this variable, available information includes other market specific variables that might affect subscription decisions, such as geographical location, weather, or crime.[19, 20]

The phasing out of certain tariff options is 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 in the menu, 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 cross-market average of the ratio of foggy options that were the result of phasing out, AVGjSHFj, and the fogginess index of non-dominated options corresponding to all competing firms that a particular carrier confronted in all other markets where this carrier operated in previous periods.

[18] Observe that contrary to Bresnahan (1981) and (1987) or Berry, Levinsohn, and Pakes (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.

[19] 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).

[20] 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).

The additional information available provides instruments that lead to a reasonably good fit of the four endogenous variables, in particular in the case of COVERAGE and PHS/PLI. However, as we saw in sections 3 and 4, correcting for endogeneity does not change the basic conclusion of the paper, *i.e.*, that regardless of how we measure it, competition increases the options available to consumers while reducing the fogginess of nonlinear tariffs. Section 4.1 confirmed that all these results are robust to the existence of uncertainty regarding future telephone usage at the time of subscribing to a particular tariff option from the menu offered by competing firms.

6 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. I show that the exogenous entry of a second cellular carrier triggers a 50% increase in the number of effective tariff options offered to customers. This increase is uneven across markets since more tariff options are generally offered in larger urban markets, where it is more likely to encounter heterogeneous consumers. The increase in tariff options is an industry-wide rather than a firm-specific effect and customers of both the *wireline* (incumbent) and *non-wireline* (entrant) carriers enjoy a larger choice of tariff plans.

The paper also suggests two alternative ways to characterize the fogginess of a menu of tariff options. The ratio of dominated to non-dominated tariff plans and the Herfindahl-Hirschman analog index of fogginess behave quite differently across markets. However, regardless of how we measure the tariff fogginess, the effect of competition is unambiguous: tariffs become simpler and less foggy although such result does not happen immediately but rather in the long run once firms can differentiate each other through the area of coverage. This result supports, at least partially, the equilibrium features of the competitive nonlinear tariff model of Rochet and Stole (2002). In addition, I have proven that the simplifying effect of competition is robust to the existence of individual uncertainty regarding future usage at the time of tariff subscription.

Should we conclude that the idea of foggy tactics is hollow? A fair answer is that we should not rule it out in some other environments. The evidence presented in this paper corresponds to a particular industry in its infancy when tariffs were relatively simple. Fogginess involves the fine print 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 easily measured in a manner that it is possible to conduct a proper econometric analysis. This paper just focuses on the number of tariffs and their commonly claimed *foggy* use of dominated or almost dominated options. The importance of the results of this paper is that it accounts for a simplifying effect of competition already with the entry of only a second competitor

and most importantly, that it makes use of an almost ideal data set in which fogginess can be precisely defined and entry occurs exogenously in several local and independent markets. Results clearly favor the interpretation of foggy pricing as a short run strategy. Broadening competition will eventually *lift the fog* and neither policy makers or social scientists will have to worry about the potentially mistaken choices of consumers.

Do the available economic models predict anything different from the reported results? The answer this second rethorical question is also negative. Take for instance the index of fogginess φ. According to standard economic theory models, we could have argued that firms do not attempt to deceive consumers by offering options that are the least expensive ones for only a small range of usage possibilities. A firm may offer a menu of tariff options like the one depicted in Figure 3 without any intention whatsoever of deceiving customers if (1) the distribution of consumer types has relative large mass of probability concentrated around intermediate usage range and (2) commercialization costs are low enough to justify three options but too high to offer four. After a second firm effectively competes, the new equilibrium nonlinear tariff would be much flatter because firms have a much limited ability to extract informational rents when consumers enjoy a better outside option than just not participating in the market. In the limit, the optimal fully nonlinear tariff in a competitive environment is just a two-part tariff (*e.g.*, Armstrong and Vickers (2001) and Rochet and Stole (2002)) as the market gets fully covered and when costs of production are similar. While the market penetration in 1992 is far from full coverage, the present results show that entry of the second firm simplifies tariffs in the direction hinted by these theoretical models of nonlinear pricing competition.

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Appendix

A Definition of Variables and Description of Data Sources

- Tariff information is reported by *Cellular Price and Marketing Letter*, Information Enterprises, various issues, 1984–1988. This information was collected by *Economic and Management Consultants International, Inc.* For year 1992, Marciano (2000) combined information from *Cellular Directions, Inc.*, the *Cellular Telephone Industry Association*, and direct interviews with managers. TIME indicates the number of months since the first monopolist started offering cellular service in the U.S.; WIRELINE identifies the owner of the first cellular license in each market; and DUOPOLY and YEAR92 are two dummy variables that identify whether a market enjoys a competitive regime and the year 1992 observations, respectively. Finally, MKTAGE accounts for the age of each market in months (when service was first offered by any of the two firms in each market).

- Socioeconomic and demographic data of each market come 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.; as well as the 1990 U.S. Decennial Census. Variables include the average commuting time in minutes, COMMUTING; thousands of high potential business establishments, BUSINESS,[21] total population of the *SMSA* in millions, POPULATION, the average percent growth of population in the 1980's, GROWTH, median income in thousands of dollars, INCOME, percentage of households with income below the poverty level, POVERTY, median age of population in years, POPAGE, and median number of years of education, EDUCATION. Variables marked "$\sigma(\cdot)$" indicate the within market standard deviation of the corresponding demographic.

- The REGULATED dummy indicates that firms were 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 whether it belongs to a firm of the former BELL system.

- 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

[21] BUSINESS refers to what 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 estate.

issues, 1984–1988, and 1990 U.S. Census. They include the population density of the market (people per square mile), DENSITY, the number of months each market was served only by the incumbent firm, LEAD, the number of markets in which a firm operates, MULTIMARKET, 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,[22] 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. Finally, ENG-COSTS is an engineering estimate of the average cost of production for each firm in the sample.[23]

- Weather and location data are available on the web at http://cdiac.esd.ornl.org, and include average temperature and precipitation for 1,221 stations in the contiguous continental states plus those of Alaska.[24] 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. 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 1000 inhabitants, CRIMEand the percent share of violent crimes in each market, which is denoted by SVCRIMES.[25]

- 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 4. Other potentially endogenous variables are constructed, as discussed in the text, 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 curvature of the peak and off-peak tariff schedule as defined by $\mathrm{AP}_{\mathrm{peak}}$ and $\mathrm{AP}_{\mathrm{off-peak}}$, the ratio of total to potential subscribers, COVERAGE, and the percentage of dominated tariff options options that were offered in previous periods, PHS/PLI.

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

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

[24] 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.

[25] Violent offenses include murder, non-negligent manslaughter, forcible rape, robbery, and aggravated assault. Property offenses include burglary, larceny-theft, motor vehicle theft, and arson.