The Doubtful Profitability of Foggy Pricing*

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Abstract

A tariff option is *foggy* when another option or a combination of other tariff options offered by the same firm are always less expensive regardless of the usage profile of any customer. Alternatively, tariff fogginess can also be characterized by the low likelihood that a particular tariff option end up being the least expensive one among those of a menu of tariffs plans for an arbitrary distribution of usage patterns. Taking advantage of the exogenous entry of a second carrier in the early U.S. cellular telephone industry, this paper shows that competition induces firms to abandon deceptive pricing strategies aimed to profit from mistaken choices of consumers (*fog lifting*) rather than inducing competitive firms to soften 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.

Keywords: Nonlinear Pricing; Foggy Strategies; Co-opetition; Fog Lifting; Phasing-out.

JEL Codes: D43, L96, M21

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1 Introduction

People commonly complain about having to make choices among "too many" options. The latest uproar in the United States 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. But the popular list of complains includes choosing among retirement plans; health care providers and programs; loans and mortgages; options for home, car, and life insurance; and more mundane decision 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: search engines on the internet 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; something that has, so far, attracted almost no attention at all.

If consumers may make mistakes in choosing among optional tariffs, firms offering these tariffs could, in principle, take advantage of such mistakes when designing the different tariff options. How? Firms may not provide a clear description of the features of the options hoping for consumers to subscribe to a tariff plan different from the one that minimizes the expense for their realized service usage. Hidden terms and the ambiguity of the features of the tariff options that consumers face defines what I call the fogginess of the strategy employed by firms. This is an argument much popularized by Brandenburger and Nalebuff (1996, §7) and recently revisited by Liebman and Zeckhauser (2004) in the context of tariff design when customers have limited understanding of the tariff.

The definition of foggy strategy is in itself quite ambiguous. In what matters most for this paper Brandenburger and Nalebuff (1996) claim that firms use foggy strategies for a variety of reasons aiming to conform the perceptions of their customers, as well as competitors in order to hide information and profit from it. These authors claim that firms hide information when, for instance, they introduce a new product at a very low price to induce consumers switching standards or simply to develop a taste for the product in order to profit from later sales at higher prices. Brandenburger and Nalebuff (1996, §7.3) explicitly mention the complexity of telephone tariffs as one of the examples where firms may use these tactics to profit from consumers hoping that they do not choose the least expensive tariff option for their consumption. Complexity is a defining feature of the fogginess of the pricing strategy because it makes more difficult for consumers to compare the cost of the service across different providers. It also serves as a way to avoid fierce competition as it is difficult for competitors to identify the profile of consumers that

[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.

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 to 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 lead to an immediate increase in tariff options offered by incumbent cellular carriers after the 1996 Telecommunications Act. Their study does not distinguish, however, whether some of these tariff options where foggy, or if they turned foggy any of the previously existing ones. 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 (2005, §4.2) notice that after the entry of new firms in the local telephone market, most switching customers realize a gain that overall amounts to an in crease 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 will try to elucidate which of these two competing hypotheses, *co-opetition vs. fog lifting*, is more likely to hold in a close-to-ideal framework where the transition from monopoly to competition is exogenous (and certainly not influenced by the fogginess of the pricing of the monopolist), and where because of the comprehensive tariff information available, fogginess can be precisely defined.

But why should this be of any interest? More tariff options open the possibility for firms to take advantage of any bounded rationality issue that may affect consumers' comparisons among different options. This may prompt regulators to screen firms' pricing mechanisms on behalf of "reasoning impaired" customers. But having numerous tariff options to choose from should not be questioned in principle because consumers could potentially benefit from a wider selection of subscription choices. However, it is a very generalized idea that firms use this multitude of tariff options to benefits from consumers' mistakes.[2] This belief has recently led the *UK Office of Fair Trading* to launch an investigation on the benefits of limiting the number of tariff options that firms may offer to their customers. There are similar undergoing investigations by the regulatory authorities of India, Perú, and other countries. Why should regulatory bodies aim to restrict the choices of consumers? Shouldn't individuals simply be given a chance to learn

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

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? If competition alone induces abandoning deceptive strategies favoring the entry of firms and ensuring that they do not collude will eventually eliminate the fogginess of tariffs, and as a plus, will bring the market equilibrium closer to the efficient solution.

The data set used in this paper is particularly suited to answer this question. It consists of all menus of tariff options offered by the telephone carriers of about a hundred cities in the early U.S. cellular industry between 1984 and 1992. While tariffs of that era are relatively simple for today's standards, search engines on the internet were not available and switching between carriers was indeed 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 happened in the end but it depended on a judicial decision to be 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, it 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 with a first evaluation of whether firms appear to successfully engage in foggy pricing strategies aimed at confusing consumers; document whether these strategies are more likely to happen in monopolistic rather than in competitive markets; and determine 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 reduce the proportion of tariff options that are totally dominated by another plan or combination of tariff plans offered by the same firm. In general 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 become to be served by two firms instead of just one. But competition also increases the number of effective tariff options, *i.e.*, those non-dominated by other tariff plans of the same firm; competition accounts by about 55% of the observed increase in effective tariff after a second firm enters each local market. Furthermore, competition increases dominated options about 31% less than the increase in non-dominated tariff plans, and among non-dominated plans they 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 opposite to each other: while the incumbent *wireline* offers most of the foggy options and the most complex tariffs, it is the *nonwireline* entrant who "lifts the fog" by offering far simpler and less dominated options. It is the pricing behavior of the entrant carrier what

eventually leads to the net effect that under competition pricing strategies are less deceptive. These results are robust to the potential effect of phasing-out of old tariff plans as well as to the possibility that some of the regressors employed are endogenous.

The paper is organized as follows. Section 2 describes the data. Section 3 presents the results of a count data regression model where 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 others by the effect of phasing-out of old tariff plans. This section also defines a measure of fogginess of the non-dominated options and conducts a similar econometric analysis to measure how competition simplify 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 and discusses the effects of these variables being, for the most part, exogenous. Finally, 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. But 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 from an exogenous judicial decision in each market. Thus, this data set proves particularly useful to analyze 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 mid 1980s, the *Federal Communications Commission* (*FCC*) granted permission to create 305 non–overlapping cellular markets around *SMSA*s. Concerns about the viability of a fully competitive model led the *FCC* to authorize only two carriers in each market. One of the two cellular licenses –the B block or *wireline* license– was awarded to a local *wireline* carrier, *i.e.*, a company with experience in fixed telephony, while the A block –the *nonwireline* license– was initially awarded by comparative hearing to a carrier other than the local *wireline* incumbent. Licenses were awarded in ten tiers, from more to less populated markets, beginning in 1984. In general the *wireline* licensee offered the service first and enjoyed a temporary monopoly position until the *nonwireline* carrier entered the market, normally within six months of being awarded the license as required by the *FCC*. However, the administrative review process to award licenses among hundreds of contenders only based

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.

on technical issues and investment commitments proved to be far more costly than initially expected. After awarding the first 30 *SMSA* licenses by means of this expensive and time consuming *beauty contest* —there were up to 579 contenders for a single license—, and while the application review of the second tier of 30 markets was on its way, rules were adopted to award the remaining *nonwireline* licenses through lotteries. Court appeals against the administrative award of the *nonwireline* licenses in the earlier tiers, and legal, technical, or managerial difficulties to start operating the lottery-awarded licenses in subsequent tiers led to a situation of temporary monopoly in many of the largest local cellular markets.

In this paper the data combines two separate databases. Data from 1984 to 1988 was collected by *Economic and Management Consultants International, Inc*. This data set includes periods with both monopoly and duopoly market configurations.[3] By 1988 this industry was still far from being characterized as mature. While large metropolitan areas had enjoyed this service already for few years, the development of a household-only (instead of a business-based) market laid still ahead.[4] This information is complemented with data collected by Marciano (2000) for year 1992, when all markets were already served by two competing firms.[5] This second data set proves to be critical for the results reported in this paper. The 1984-88

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

[4] See Parker (1990).

[5] 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.

sample captures the short run effects of competition but 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.

From today's perspective, 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 right after the entry of the second carrier while in 1992 half of firms offered 5 options. Competition adds on average between 1 and 1.6 tariff options per 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. Thus, going from monopoly to duopoly almost quadruples in the long run the effective number of tariff plans that consumers may choose from.

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 to consumers, and thus, they increase their expected profits by better screening among different consumer types. The foggy tactics explanation would conclude that this increase in the number of options is an attempt to benefit from mistaken choices by consumers or to soften competition. But, does the larger number of tariff options offered lead to more fogginess? The mere description of the frequency distribution of the number of tariff options does not suffice to answer this question.

Tariffs in this early market are also much simpler than today's. 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) is 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

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 (23.87) for the monopoly sample; 0.7629 (36.98) for the early duopoly sample; and 0.8172 (14.64); and where the corresponding absolute value t-statistics are shown in parentheses.

the frequency distribution of those tariff options that are non-dominated. The difference with actual tariff options of the first half of this Table are foggy tariff plans defined in this extreme manner. On average, there are 0.5 foggy options per firm, *i.e.*, one of every other 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.

Evidently, the amount of fogginess is related with the total number of tariff options actually offered to cellular telephone customers Table 2 documents that the correlation between total and effective number of tariff options is about 75%, and increases up 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 actual number of tariff options offered. Thus, 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% and later increased to 3.75%. Similarly, combinations when one out of four options were foggy went down from 16.46% to 5.89% in the short run and only to 2.05% of cases in the long run. Extremely deceptive menus with four foggy out of six total options disappeared almost immediately, going from 2.95% to 0.09% of cases in the short run. But Table 2 also documents movements in the opposite direction, *i.e.*, increasing

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	8.602	3.8022	11.5258	3.8697	30	0.0000
WIRELINE	1	0	0.5079	0.5002	0.5	0.5017
DUOPOLY	0	0	1	0	1	0.0000
YEAR92	0	0	0	0	1	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
AMERITECH	0.0246	0.155	0.1716	0.3772	0.0685	0.2535
BELLATL	0.0614	0.2404	0.1151	0.3193	0.0548	0.2284
BELLSTH	0.2211	0.4155	0.1567	0.3637	0.2329	0.4241
CENTEL	0.0197	0.139	0.0823	0.275	0.137	0.3450
CONTEL	0.0762	0.2656	0.0476	0.2131	0.1096	0.3135
GTE	0.0762	0.2656	0.1498	0.3571	0.1233	0.3299
NYNEX	0.0418	0.2003	0.1022	0.303	0.0411	0.1992
PACTEL	0.1081	0.3109	0.1081	0.3107	0.1096	0.3135
SWBELL	0.0565	0.2312	0.2083	0.4063	0.137	0.3450
USWEST	0.1376	0.3449	0.1101	0.3132	0.1233	0.3299
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
AP_{peak}	0.0917	0.5396	0.1815	1.3777	0.2275	0.6632
$AP_{off-peak}$	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 defined in Appendix A.

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 where I control for many observable market characteristics that may induce firms to offer more or less tariff options. 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 design the features of their tariff options. Therefore, tariff data are complemented with market specific demand and cost information as well as an ownership indicator for each firm. Descriptive statistics are reported in Table 3 and definition of variables are included in Appendix A.

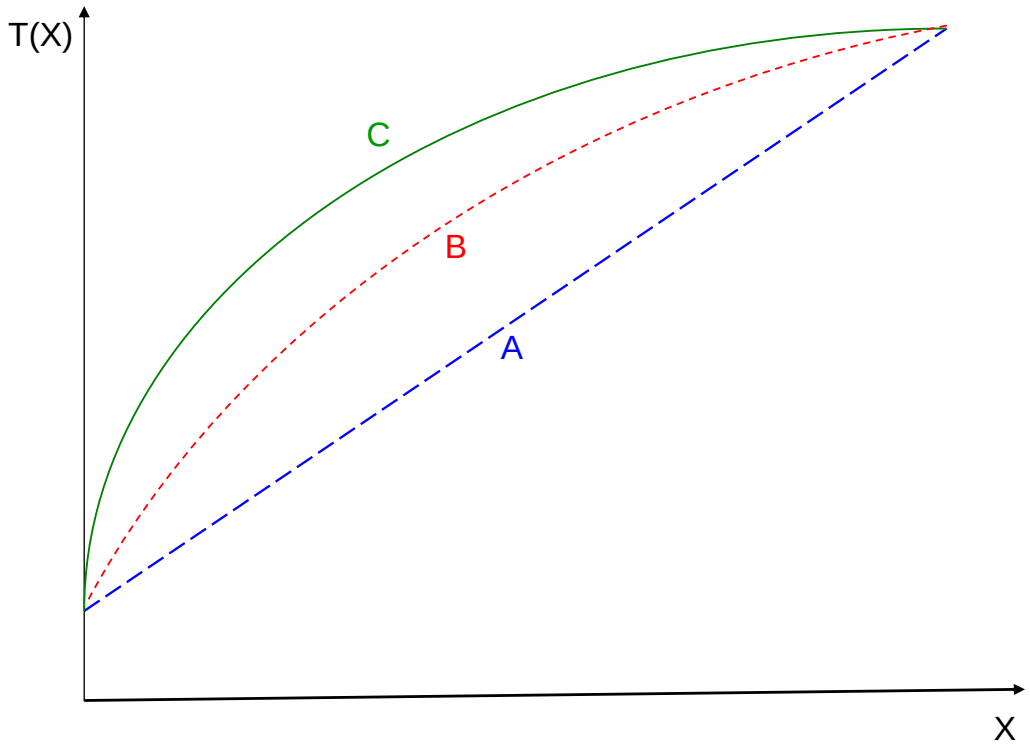
3 Actual and Effective Number of Tariff Options

In many industries consumer heterogeneity is important. If technology allows to avoid consumer arbitrage, firms may increase their expected profits by offering a nonlinear tariff that optimally discriminate among consumers with different willingness to pay. Optimal nonlinear pricing leads to offering discounts to larger consumers so that large customers 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 as shown, among others, by Maskin and Riley (1984) or Wilson (1993).

Figure 1 illustrates this point. As noticed by Oi (1971), if all consumers are alike a simple two-part tariff such as "Schedule A" suffices to extract all consumer surplus and indeed achieving 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, *i.e.*, in this case, that large consumers decide to self-ration their telephone usage. 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" when the population includes many more high than low valuation customers.[6] There is an extensive mechanism design devoted to finding

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

Figure 1: Asymmetry of Information and Curvature of Nonlinear Tariff



these optimal discounts for different consumer types. Characterizing the optimal fully nonlinear tariff requires solving a complex variational problem that has attracted lots of 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 (2006)).

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 more or less 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. But furthermore, since the data allows 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 pricing decisions regarding how many tariff plans to offer to observable market and firm characteristics. Firms may make use of available market characteristics to control for the nature of the distribution of consumers' unobserved heterogeneity. I also include carriers' characteristics to control for their idiosyncrasy in pricing (or alternatively commercialization costs). I also include some other features, such as the market coverage and curvature of the tariff to control for the

Table 4: Number of Actual and Effective Tariff Options

	A		A–Inst.		B		B–Inst.	
CONSTANT	−0.4918	(0.33)	0.7651	(0.44)	−0.6315	(0.52)	−0.1856	(0.13)
TIME	−0.0601	(1.66)	−0.0834	(2.11)	0.0039	(0.11)	−0.0286	(0.78)
TIME^2	0.3422	(2.06)	0.4301	(2.39)	0.0692	(0.45)	0.2055	(1.24)
WIRELINE	0.0799	(1.38)	0.1189	(1.86)	0.0102	(0.21)	0.0222	(0.42)
DUOPOLY	0.4903	(5.04)	0.3778	(3.39)	0.6135	(7.02)	0.4941	(5.14)
YEAR92	−0.7501	(1.14)	−0.9758	(1.40)	0.2001	(0.33)	−0.2095	(0.34)
MKTAGE	0.0070	(1.33)	0.0091	(1.62)	0.0011	(0.24)	0.0032	(0.72)
MKTAGE^2	−0.0007	(1.20)	−0.0009	(1.47)	−0.0001	(0.30)	−0.0003	(0.65)
COMMUTING	−0.0653	(2.41)	−0.0980	(2.89)	−0.0360	(1.63)	−0.0571	(2.00)
POPULATION	0.1630	(4.23)	0.1869	(4.31)	0.1437	(4.46)	0.1552	(4.25)
POPAGE	0.0086	(0.51)	0.0050	(0.29)	0.0242	(1.79)	0.0223	(1.68)
EDUCATION	0.2490	(2.62)	0.2356	(2.29)	0.1180	(1.59)	0.1439	(1.80)
BUSINESS	−0.0043	(3.15)	−0.0043	(3.01)	−0.0046	(4.01)	−0.0043	(3.69)
GROWTH	−0.0081	(0.19)	−0.0171	(0.36)	0.0315	(0.91)	0.0104	(0.27)
INCOME	−0.0393	(2.81)	−0.0379	(2.56)	−0.0308	(2.94)	−0.0314	(2.82)
POVERTY	−0.0448	(2.24)	−0.0298	(1.29)	−0.0514	(2.90)	−0.0328	(1.66)
REGULATED	0.4974	(6.40)	0.5516	(6.60)	0.3790	(6.02)	0.4282	(6.33)
AMERITECH	1.0795	(10.20)	1.2410	(8.28)	1.0395	(11.68)	1.2004	(10.00)
BELLATL	1.7553	(12.12)	1.7790	(9.38)	0.8305	(7.13)	0.7597	(4.83)
BELLSTH	0.6100	(6.95)	0.7443	(6.08)	0.2618	(3.11)	0.4007	(3.55)
CENTEL	0.7603	(5.76)	0.8697	(5.65)	0.5603	(5.31)	0.6859	(5.67)
CONTEL	−0.0482	(0.25)	−0.1206	(0.58)	0.0824	(0.55)	0.0389	(0.24)
GTE	0.4519	(3.66)	0.6291	(4.16)	0.3795	(3.73)	0.5565	(4.33)
NYNEX	2.0343	(15.94)	2.2211	(13.55)	1.7568	(16.80)	1.9403	(14.50)
PACTEL	−0.0295	(0.25)	0.0922	(0.69)	0.2010	(2.19)	0.3340	(3.21)
SWBELL	0.6856	(6.97)	0.8864	(5.78)	0.3264	(3.59)	0.5417	(4.03)
USWEST	1.1591	(8.82)	1.3934	(8.07)	0.8964	(7.69)	1.1309	(7.33)
AP_{peak}	0.0265	(0.68)	−0.2445	(1.58)	0.1039	(2.41)	−0.1608	(1.18)
$\text{AP}_{\text{off}-\text{peak}}$	−0.0003	(1.60)	−0.0010	(0.40)	0.0005	(2.59)	−0.0026	(1.22)
COVERAGE	−0.3855	(2.02)	0.0450	(0.14)	0.0772	(0.57)	0.4211	(1.75)
v_1			0.2827	(1.86)			0.2674	(2.02)
v_2			0.0007	(0.25)			0.0032	(1.44)
v_3			−0.6396	(1.76)			−0.5328	(1.96)
Observations	1561		1561		1561		1561	
$-\ln L$	2461.8007		2459.4009		2217.3089		2214.3320	
$DPLRI$	0.2986		0.3010		0.3120		0.3151	
LM	19.0089				9.9613			
$[p-value]$	[0.0003]				[0.0411]			

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 and p-values are shown between brackets. Model A estimates the determinants of the number of actual tariff options while model B address the number of effective (non-dominated) tariff options. Equations labeled A and B present *Poisson PMLE* estimates while those marked "–Inst." instroment for potentially endogenous regressors AP_{peak}, $\text{AP}_{\text{off}-\text{peak}}$, and COVERAGE.

potential effects of existing network externality in pricing as well as for the nature of the distribution of consumer heterogeneity.

Column A 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:[7]

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

Similarly, column B of Table 4 focuses on the number of effective (non-dominated) tariff options only.[8] The other two columns are *PMLE* estimates that control for the potential endogeneity of AP_{peak}, $\text{AP}_{\text{off-peak}}$, and COVERAGE.

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 follows immediately the entry of the second carrier and that it is common for both competing firms. The expected number of actual tariff options increases by 0.5 with duopoly while the average number of non-dominated options increases by 0.7 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, NYNEX offers about 2 more options than the average firm in the sample. 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

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

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

[8] 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).

tariff options approved as possible.[9] It turns out that this threat of future regulation appears also to have triggered a increase in the set of effective choices that consumer faced.

Some of the correlations between number of tariff options and demographics are worth mentioning. Thus, in larger markets or in those where population is on average better educated, cellular carriers offered 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: four more years of average education or six more million inhabitants of an *SMSA* are needed for carriers to offer an additional tariff option. Surprisingly, COMMUTING, 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 $AP_{off-peak}$ 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. Alternatively we could adopt the view that the distribution of consumer heterogeneity is endogenous and that firms are simply responding to this heterogeneity when the design the nonlinear tariff. To elucidate which explanation is better supported by the data, I include AP_{peak} and $AP_{off-peak}$ 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 0-1,000 minutes range of potential consumption. AP_{peak} is the equivalent of the Arrow-Pratt measure of risk aversion averaged over the 0-1,000 minutes interval of airtime usage of the quadratic polynomial that fits the lower envelope of the peak component of the tariff. $AP_{off-peak}$ is defined similarly but using the off-peak component of the tariff only.[10]

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. Thus, 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.[11] This argument is admittedly weak for the early U.S. cellular telephone industry.

[9] Regulators were quite uncertain about how to regulate this new industry that in addition 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 belong to the old Bell system were subject to regulation.

[10] This approach is equivalent to the discrete Arrow-Pratt measured 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).

[11] 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.

This was a service clearly targeted to business and high income individuals.[12] 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.[13]

The second and third column of Table 4 repeat the analysis of columns A and B after correcting for endogeneity by the robust *PMLE* method of Wooldridge (1997) consisting 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.[14] The *LM* tests reported in Table 4 indicate that AP_{peak}, $\text{AP}_{\text{off-peak}}$, and COVERAGE cannot jointly be considered exogenous. While v_1 and v_3 are significant in the equation of the effective number of options, they are only marginally significant in the equation of the actual number of plans. Some estimates, such as those of EDUCATION, AP_{peak}, $\text{AP}_{\text{off-peak}}$, and COVERAGE are no longer significant after correcting for endogeneity and the magnitude of the rest of parameters changes slightly.

Still, after correcting for endogeneity the sign and conclusions of this section still remains valid: The net effect of competition is to add 0.4 actual and 0.5 effective tariff plans, *i.e.*, a 16% and 25% increase, respectively, over the monopoly phase of these markets. This result coincides with the increase of options with the increase in competition reported by Seim and Viard (2005). But in addition this section also documents 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 indicate that firms offer more options in those large urban markets where a more diverse customer base is more likely to exists.

4 Analysis of Fogginess

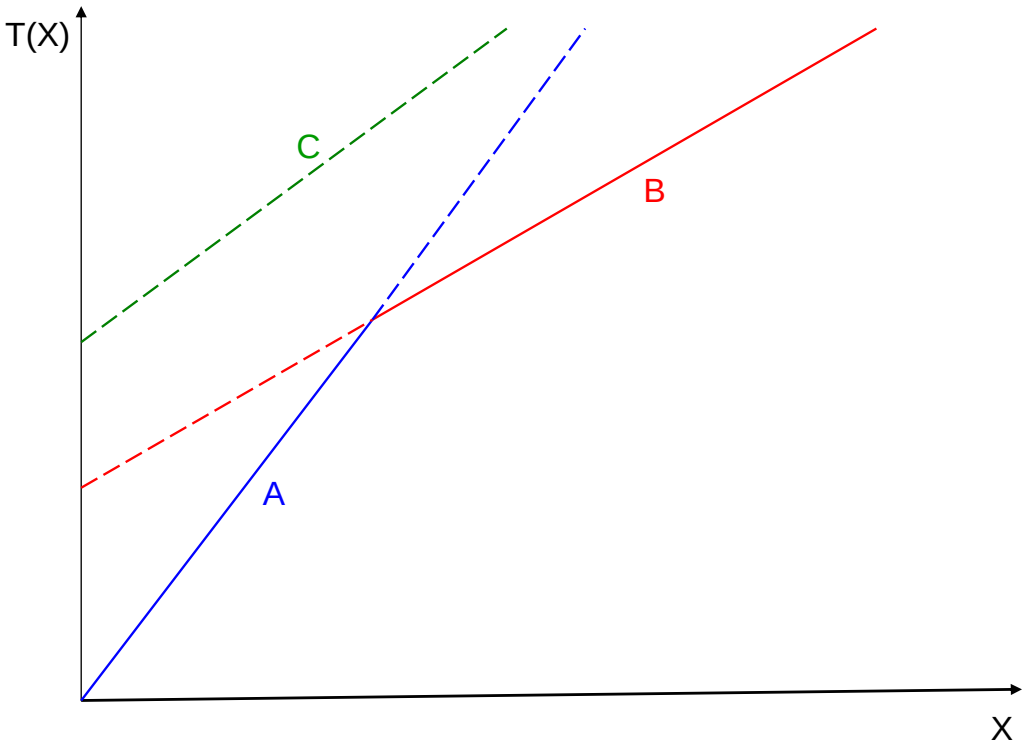
The observed increase of options available in competitive markets does not suffice to conclude that firms are engaging in foggy pricing to take advantage of consumers' deliberation costs. Complexity of telecommunications tariffs is related not only to the number of tariff options offered by telephone 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,

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

[13] 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).

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

Figure 2: Fogginess: Dominated Tariff Option



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 realities, 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. But he analysis of the previous section does not conclude that this geographical heterogeneity in the use of foggy tactics exists. It may well be that larger increase in non-dominated tariff options is common and it is 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 process is common to all markets rather than specific to few of them.

The most restrictive definition of foggy pricing is perhaps also the most popular 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 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. The tariff of Figure 2 is defined over a single dimensional usage measure, "X" but in reality it may involve many other dimensions such as

peak and off-peak, differentiated charges per call and/or minute of usage, distance, setup, interconnection charges, *et cetera*.

One obvious advantage of the tariffs offered in the early U.S. cellular industry is that they only screen consumers with respect to three dimensions: pricing of peak and off-peak airtime usage plus a monthly allowance of free minutes associated to the payment of a monthly fixed fee (although far smaller than the bucket tariffs common nowadays). These relatively simple pricing schemes allows me to define precisely what a foggy tariff option is, and to measure the degree of fogginess of such menu of tariff options. The available data do not contain 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 1,000 minutes of airtime usage.[15] If a particular tariff option is never the least expensive one for at least one of these these 1,000,000 potential usage patterns.[16] Thus, once we determine whether a particular tariff is foggy, we can characterize the fogginess of a tariff plan as the ratio of dominated to non-dominated tariff options. Thus, column C of Table 5 regresses the following transformation of this ratio on market and firm characteristics:

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

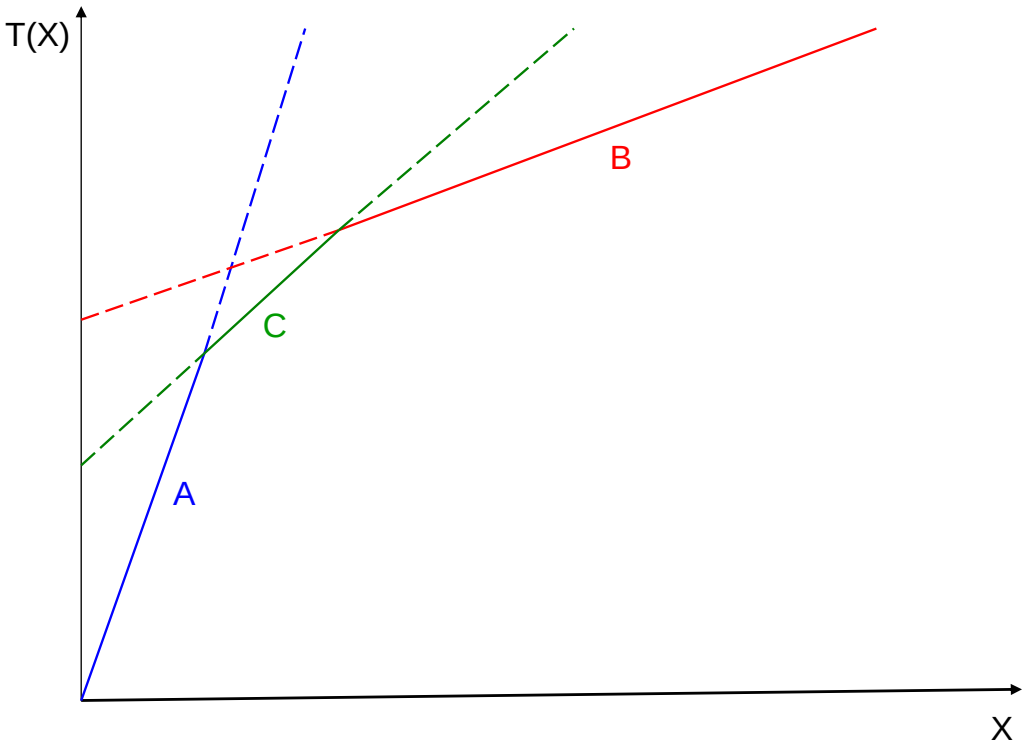
This definition of fogginess based on the existence of fully dominated tariff options ignores other practices that may make difficult for consumers to evaluate which tariff option is the least expensive for their usage. Suppose that a firm offers three tariff options, each being the least expensive one for about one third of the combinations of the peak and off-peak airtime defining the usage patterns. Thus, 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 Section3.

The second measure of fogginess that I will use in this paper, this time applied only to non-dominated options, interprets that a menu of tariff is foggy when some of the tariff options are only the

[15] Usage patterns do not necessarily need to add to 1,000 minutes; I simply exclude the possibility that consumption exceeds 1,000 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.

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

Figure 3: Fogginess: Non-Dominated Tariff Options



least expensive ones for a smaller share of potential usage patterns than some of the other options. Thus, fogginess is synonym here of a asymmetric or unbalanced 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. Thus, 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.

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 is strictly dominated, but some being the least expensive option for only 3 out of the 1,000,000 potential usage patterns in which I evaluate every tariff option of each firm in each market and time. The fogginess index needs to characterize this behavior as more foggy than offering only two tariff plans that are the least expensive ones approximately for the same number of usage patterns. To capture

the effect of asymmetric menus of tariffs I define the fogginess index of 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 where each plan is the least expensive for the same $1/n$ share of usage patterns, $\varphi = 1$ regardless of the number of tariff options offered, n. And since HHI increases with the asymmetry of the distribution of shares of of least expensive usage patterns of each tariff option —Tirole (1989, §5.5)—, the proposed index of fogginess also increases with less balanced menus of tariffs. Therefore, column D 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. In clear contrast with the behavior of the actual and effective number of tariff plans, the incidence of regressors is general different depending 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 simplify tariffs and makes them less deceptive. This effect is immediate after the entry of the second carrier but in the long run it is particularly strong as the estimate of YEAR92indicates. This parameter estimate is by far the largest one for both regressions and it implies that, on average, after few years of competition each firm offers 0.3 fewer tariff plans than under monopoly. Just adding the negative effect of TIME, as the industry matures, leads to the conclusion that in each market there is an average reduction of at least one fully dominated tariff plan relative to the pricing practice of the monopoly stage. Furthermore, this reduction of fogginess is not evenly distributed across carriers and involves the *nonwireline* entrant offering simpler more balanced tariffs with options that are far less frequently dominated thah the *wireline* incumbent. Foggy pricing does not survive competition and instead of serving as a way to soften competition, entry of a second carrier *lifts the fog* and eventually induces to a far simpler pricing schemes in each market.

The reduction in fogginess is uneven across markets although results critically depend on the measure of fogginess used. The ratio of dominated to non-dominated options increases with EDUCATION and BUSINESS and decreases with GROWTH and INCOME. The behavior of the fogginess index φ is economically more interesting. It increases with POPULATION, which could be interpreted as an attempt to better screening the potentially more heterogeneous consumers of large cities. But the fogginess of non-dominated tariffs is significantly lower, thus perhaps minimizing the probability that regulatory authorities object to any of the proposed tariff options.

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

	C		C–Inst.		D		D–Inst.	
CONSTANT	−1.0298	(4.05)	−0.9022	(3.13)	0.3671	(1.27)	0.3830	(0.99)
TIME	−0.0174	(2.68)	−0.0127	(1.85)	−0.0176	(2.74)	−0.0133	(1.68)
$TIME^2$	0.0791	(2.63)	0.0573	(1.79)	0.0751	(2.52)	0.0537	(1.49)
WIRELINE	0.0382	(3.60)	0.0430	(3.64)	0.0562	(4.58)	0.0516	(3.70)
DUOPOLY	−0.0481	(3.23)	−0.0347	(1.77)	−0.0331	(2.11)	−0.0208	(0.89)
YEAR92	−0.3085	(2.57)	−0.2347	(1.86)	−0.4040	(3.27)	−0.3280	(2.21)
MKTAGE	0.0010	(1.10)	0.0008	(0.85)	0.0013	(1.24)	0.0012	(1.06)
$MKTAGE^2$	0.0002	(1.50)	−0.0001	(1.31)	0.0000	(0.09)	0.0000	(0.19)
COMMUTING	0.0033	(0.83)	0.0026	(0.52)	−0.0062	(1.50)	−0.0025	(0.39)
POPULATION	−0.0104	(1.77)	−0.0084	(1.28)	0.0175	(2.52)	0.0164	(1.97)
POPAGE	−0.0056	(1.62)	−0.0061	(1.68)	−0.0095	(2.01)	−0.0107	(1.99)
EDUCATION	0.0717	(5.23)	0.0629	(4.23)	0.0314	(1.86)	0.0313	(1.54)
BUSINESS	0.0004	(2.08)	0.0004	(1.72)	−0.0008	(3.10)	−0.0009	(3.14)
GROWTH	−0.0225	(3.26)	−0.0181	(2.39)	−0.0044	(0.47)	−0.0038	(0.32)
INCOME	−0.0060	(2.79)	−0.0056	(2.61)	−0.0035	(1.55)	−0.0032	(1.24)
POVERTY	0.0009	(0.26)	−0.0014	(0.36)	−0.0023	(0.71)	−0.0032	(0.73)
REGULATED	−0.0031	(0.27)	−0.0056	(0.37)	−0.0424	(3.47)	−0.0463	(2.55)
AMERITECH	−0.0889	(4.25)	−0.0998	(3.22)	0.0153	(0.66)	−0.0083	(0.21)
BELLATL	0.1760	(6.38)	0.2057	(5.84)	0.3254	(10.57)	0.3179	(6.65)
BELLSTH	0.1242	(7.16)	0.1144	(5.56)	0.0824	(5.62)	0.0581	(2.68)
CENTEL	0.0183	(0.86)	0.0093	(0.36)	0.2005	(8.87)	0.1795	(5.75)
CONTEL	−0.0147	(0.64)	−0.0204	(0.73)	0.0413	(1.72)	0.0230	(0.65)
GTE	−0.0304	(1.48)	−0.0430	(1.62)	0.0529	(2.34)	0.0270	(0.76)
NYNEX	−0.0387	(1.74)	−0.0492	(1.64)	0.1233	(4.72)	0.1011	(2.46)
PACTEL	−0.0583	(3.52)	−0.0734	(3.97)	−0.0642	(3.32)	−0.0899	(3.79)
SWBELL	0.1109	(5.92)	0.0908	(3.41)	0.1347	(6.50)	0.0980	(2.80)
USWEST	0.0472	(2.20)	0.0307	(0.98)	0.1087	(4.57)	0.0850	(2.05)
AP_{peak}	−0.0162	(8.82)	0.0063	(0.26)	−0.0177	(7.38)	0.0411	(1.32)
$AP_{off-peak}$	−0.0003	(9.78)	0.0005	(1.14)	0.0002	(4.77)	0.0005	(1.04)
COVERAGE	−0.1110	(3.87)	−0.1194	(2.30)	−0.0941	(3.01)	−0.0774	(1.10)
PHS/PLI	−0.0387	(8.14)	−0.0351	(1.86)	−0.1134	(22.08)	−0.1008	(4.10)
Observations	1561		1561		1561		1561	
$Adj.R^2$	0.3009		0.2574		0.4229		0.2926	
LM	3.7863				4.1449			
$[p-value]$	[0.4357]				[0.3868]			

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 C and D 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}, $AP_{off-peak}$ is tested using (10)

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. It is in those cases when, in general, firms offer more foggy options. Firms thus 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. However, this result does not survive 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, always has a negative effect on fogginess: as the market matures and more consumers subscribe to cellular service, pricing becomes more transparent, thus reinforcing the effect of entry by the *nonwireline* carrier.

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 phase-out. Thus, consumers who subscribed this option in the past are not automatically switched to one of the new options, but the firm does not intend, neither expect, that new customers subscribe to such option any more. Fortunately the data includes which tariffs were offered in the past, and thus, I can control whether dominated tariffs respond to phasing out of previously offered options or not. 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 but rather the conscious implementation of deceptive strategies or an honest mistake in the design of tariff plans.

PHS/PLIis also endogenous as firms decide which tariffs and when to phasing them out. Overall, endogeneity of regressors is not serious. Langrange Multiplier tests do not reject the join exogeneity of AP_{peak}, $\text{AP}_{\text{off-peak}}$, COVERAGE, and PHS/PLI. After instrumenting, most results are robust and do not differ from those of columns C and D of Table 5. Certainly, the effect of competition on fogginess is now slightly smaller, but still negative and by far the most important one among the different regressors considered.

5 Instrumental Regressions

The curvature of tariffs, as measured by $\text{AP}_{\text{peak}}$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 with 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 to avoid the possibility of any endogeneity bias. Table 6 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 an cost variables. In instrumenting these variables I will include regres-

Table 6: Instrumental Regressions

	AP_{peak}		$AP_{off-peak}$		COVERAGE		PHS/PLI	
CONSTANT	−16.7629	(2.83)	−16.7629	(2.83)	0.8390	(1.01)	−4.1670	(1.39)
TIME	−0.0243	(1.32)	−0.0243	(1.32)	0.0090	(1.45)	0.0328	(0.96)
TIME2	0.2538	(1.93)	0.2538	(1.93)	−0.0200	(0.83)	0.1924	(1.41)
WIRELINE	0.1704	(2.26)	0.1704	(2.26)	0.0000	(0.00)	−0.1512	(4.05)
DUOPOLY	−0.0426	(0.48)	−0.0426	(0.48)	0.2438	(15.07)	−0.3664	(4.50)
YEAR92	−1.1554	(1.54)	−1.1554	(1.54)	−0.0558	(0.50)	−1.9448	(3.59)
MKTAGE	0.0023	(0.38)	0.0023	(0.38)	−0.0019	(1.27)	−0.0053	(1.22)
MKTAGE2	−0.0005	(0.90)	−0.0005	(0.90)	0.0002	(2.01)	0.0004	(1.04)
COMMUTING	−0.1361	(2.78)	−0.1361	(2.78)	0.0080	(0.99)	0.0670	(2.42)
POPULATION	0.0077	(0.39)	0.0077	(0.39)	0.0086	(1.01)	−0.1227	(3.84)
POPAGE	−0.1291	(2.89)	−0.1291	(2.89)	0.0568	(7.53)	−0.0135	(0.46)
EDUCATION	0.5759	(2.92)	0.5759	(2.92)	−0.0721	(2.02)	0.0351	(0.28)
BUSINESS	0.0028	(2.99)	0.0028	(2.99)	−0.0011	(4.66)	0.0015	(1.49)
GROWTH	0.0252	(1.44)	0.0252	(1.44)	−0.0564	(5.69)	0.0049	(0.12)
INCOME	0.0047	(0.27)	0.0047	(0.27)	−0.0093	(1.86)	−0.0117	(0.66)
POVERTY	−0.0044	(0.42)	−0.0044	(0.42)	−0.0519	(11.23)	−0.0086	(0.48)
REGULATED	0.2895	(3.85)	0.2895	(3.85)	−0.0456	(2.68)	−0.3878	(6.10)
AMERITECH	0.6716	(3.02)	0.6716	(3.02)	−0.0456	(2.15)	−0.8023	(9.19)
BELLATL	0.4679	(2.21)	0.4679	(2.21)	0.3050	(8.04)	−0.5697	(4.01)
BELLSTH	0.5269	(3.11)	0.5269	(3.11)	−0.0537	(2.97)	−0.2652	(3.67)
CENTEL	0.6898	(3.09)	0.6898	(3.09)	0.1007	(3.58)	−0.4471	(4.61)
CONTEL	0.3501	(1.85)	0.3501	(1.85)	0.3971	(10.16)	−0.1496	(1.13)
GTE	0.6150	(2.56)	0.6150	(2.56)	−0.0673	(2.26)	−0.6217	(5.67)
NYNEX	0.5232	(3.21)	0.5232	(3.21)	0.0798	(2.47)	−0.6873	(4.60)
PACTEL	0.5081	(2.82)	0.5081	(2.82)	0.0403	(1.73)	−0.0819	(0.79)
SWBELL	0.5903	(2.74)	0.5903	(2.74)	−0.0706	(2.88)	−0.5117	(5.21)
USWEST	0.4643	(2.68)	0.4643	(2.68)	−0.0651	(2.40)	−1.1008	(8.66)
MULTIMARKET	0.0348	(1.64)	0.0348	(1.64)	0.0092	(3.84)	−0.0489	(3.96)
σ(POPAGE)	0.4571	(2.90)	0.4571	(2.90)	−0.1244	(6.92)	−0.0171	(0.22)
σ(COMMUTING)	0.1018	(2.51)	0.1018	(2.51)	0.0005	(0.06)	−0.0678	(2.09)
σ(EDUCATION)	1.3615	(3.02)	1.3615	(3.02)	0.0992	(1.49)	−0.3002	(1.08)
σ(INCOME)	−0.0401	(1.07)	−0.0401	(1.07)	0.0255	(3.83)	0.0170	(0.58)
LEAD	0.0043	(1.23)	0.0043	(1.23)	0.0009	(0.96)	0.0038	(0.80)
WAGE	0.0324	(1.86)	0.0324	(1.86)	−0.0017	(0.43)	−0.0201	(1.44)
ENERGY	−0.1084	(1.61)	−0.1084	(1.61)	0.0128	(0.82)	−0.1958	(2.89)
OPERATE	0.0734	(2.00)	0.0734	(2.00)	0.0007	(0.11)	0.1571	(6.37)
RENT	−0.0287	(2.18)	−0.0287	(2.18)	−0.0046	(2.13)	−0.0096	(0.99)
PRIME	0.1462	(1.92)	0.1462	(1.92)	0.0097	(0.88)	0.1976	(3.97)
ENG-COSTS	−0.0343	(0.50)	−0.0343	(0.50)	0.0169	(1.13)	0.3985	(5.41)
CRIME					0.0379	(9.38)	−0.0016	(0.08)
SVCRIMES					−1.0468	(3.67)	4.3434	(4.16)
DENSITY					−0.0053	(6.37)	−0.0003	(0.15)
TEMPERATURE					−0.0002	(0.64)	0.0051	(3.57)
RAIN					−0.0031	(1.06)	−0.0067	(0.42)
NORTH					−0.0127	(5.56)	0.0066	(0.67)
WEST					0.0034	(5.86)	−0.0129	(5.50)
AVGjSHFj							0.1981	(1.56)
AVGjHHFj							−0.0251	(0.66)
Observations	1561		1561		1561		1561	
$Adj.R^2$	0.0833		0.0833		0.5745		0.3827	

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

sors 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 6 regress AP_{peak}, $\text{AP}_{\text{off}-\text{peak}}$, 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. Thus, in order to identify these demand shifters that through complicated nonlinear relations will determine the shape of optimal tariffs, coverage and the phasing out of old tariff options, we need instruments that shift costs but that are uncorrelated with demand shocks. Since in addition data include competing firms, it necessary to account for firm specific cost shifters.[17] Regressions of Table 6 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 differentiated levels of efficiency due to 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 in several markets may have. While I am treating each market independently from each other, firms operating in several markets may enjoy some important cost savings as they could perhaps consolidate some activities across markets or establish a softer competition regime with other firms also present in several markets.

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 that might affect subscription decisions, such as geographical location, weather, or crime.[18] [19]

[17] 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.

[18] 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).

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

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

The additional information available provides with 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 me measure it, competition increases the options available to consumers while reducing the fogginess of nonlinear tariffs.

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 an 16% increase in the number of the actual tariff options offered to customers and a 25% increase in the number of effective tariff options. 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 how we measure the tariff fogginess, the effect of competition is unambiguous: tariffs become simpler and less foggy, both in the short, but most clearly in the long run. Entry of a second carrier is accompanied by its offering of far simpler tariffs, likely, in an attempt to capture new customers.

Should we conclude that the idea of foggy tactics is hollow? No, the evidence presented in this paper corresponds to a particular industry in its infancy when tariffs were relatively simple. Fogginess involves the fine letter of contracts and those issues never stated explicitly in incomplete contracts. There

are many ways of hiding information from consumers but not all of them are suitable to be properly codified to conduct a proper econometric analysis. However, this paper makes use of an almost ideal data set where fogginess can be precisely defined and where entry occurs exogenously in several local markets. Results clearly favor the interpretatiion of foggy pricing as a short run strategy. Thus, broadening competition will eventually *lift the fog* and neither policy makers or social scientists would have to worry about the potentially mistaken choices of consumers.

Do the available economic models predict anything different from the reported results? The answer is 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 1 without any intention whatsoever of deceiving customers if the distribution of consumer types has relative large mass of probability concentrated around intermediate usage range and if commercialization costs are low enough to justify three options but too high to offer four. After a second firm effectively compete, the new equilibrium tariff would be much flatter, and in the limit, just a two-part tariff —*e.g.*, Armstrong and Vickers (2001) and Rochet and Stole (2002)— as the market gets fully covered and 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 simplifies tariffs in the direction hinted by theoretical models of nonlinear pricing competition.

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Appendix

A Variables Definition and 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*, as well as 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 comes from the 1989 *Statistical Abstracts of the United States*; U.S. Department of Commerce, Bureau of the Census, using the *FCC* Cellular Boundary Notices, 1982–1987, available in *The Cellular Market Data Book*, EMCI, Inc.; 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;[20] 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.

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

- 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 the largest carriers: AMERITECH: Ameritech Mobile; BELLATL: Bell Atlantic Mobile; BELLSTH: BellSouth Mobility; CENTEL: Century Cellular; CONTEL: CONTEL Cellular; GTE: GTE Mobilnet; NYNEX: Nynex Mobile; PACTEL: PacTel Mobile Access; SWBELL: South West Bell; and USWEST: US West Cellular.

- Industry cost indicators for each market are obtained from the Bureau of Labor Statistics; U.S. Department of Energy; *BOMA Experience Exchange Report: Income/Expense Analysis for Office Buildings*, various issues, 1985–1989; and *Cellular Price and Marketing Letter*, Information Enterprises, various issues, 1984–1988; and 1990 U.S. Census. They include the population density of the market (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;[21] 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-COSTSis an engineering estimate of the average cost of production for each firm in the sample.[22]

- Weather and location data is available on the web at http://cdiac.esd.ornl.org, and includes average temperature and precipitation for 1,221 stations in the contiguous continental states plus those of Alaska.[23] 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 100,000 inhabitants, CRIME; number of violent offenses per 1,000 inhabitants while the percent share of violent crimes in each market is denoted by, SVCRIMES.

- 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 AP_{peak} and $AP_{off-peak}$; 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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[21] These expenses include cleaning, repair and maintenance, administrative costs, utilities, local taxes, security and ground services, office payroll, as well as other leasing expenses associated with running an office.

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

[23] 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.