NET Institute*

www.NETinst.org

Working Paper #05-13

October 2005

Consolidation in the Wireless Phone Industry

Jeremy T. Fox
University of Chicago

* The Networks, Electronic Commerce, and Telecommunications ("NET") Institute, http://www.NETinst.org, is a non-profit institution devoted to research on network industries, electronic commerce, telecommunications, the Internet, "virtual networks" comprised of computers that share the same technical standard or operating system, and on network issues in general.

Consolidation in the Wireless Phone Industry

Jeremy T. Fox

University of Chicago*

November 5, 2005

Abstract

The initial wireless phone industry in the United States had many competitors, but due to mergers and acquisitions the industry has become highly consolidated. This paper documents the history of the consolidation. More importantly, I use the geographic path of consolidation to distinguish whether consolidation has been motived by retail market power or efficiency explanations. One efficiency explanation is that consumers prefer national coverage areas. I use data on roaming agreements in the early cellular industry to analyze whether contracts can substitute for roaming agreements. Finally, in joint work with Patrick Bajari and Stephen Ryan we estimate the consumer valuation for national coverage areas using plan demand data.

*Financial support of the NET institute (http://www.NETinst.org) is gratefully acknowledged. Research assistance has been provided by Edmund Cheng, Charles Kinzer, and Manasi Vydyanath.

1 Introduction

Many network industries are dominated by a few large firms. This high degree of concentration naturally raises the antitrust concern that firms might have high degrees of market power, allowing them to charge higher prices for and produce lower quantities of their products than would be socially optimal. Concentration might also occur for efficiency reasons: larger companies might take advantage of cost-side returns to scale and scope, as well as the demand side benefits of offering customers larger networks. Economists wish to understand the different roles of increasing efficiency and exploiting market power in explaining concentration.

This paper seeks to understand the relative roles of efficiency and market power in determining the concentrated industry structure of the modern US wireless phone industry. I use three types of data to understand multiple aspects of the reasons for consolidation. First, I examine the history of consolidation over the past 20 years. Firms can choose to merge to create national or regional agglomerations of coverage areas, or to increase presence in individual markets. Increasing a carrier's presence in a local market in consistent with a desire to exploit local market power. Second, carriers can create national coverage areas by signing roaming agreements instead of merging. I examine data on roaming agreements from the early wireless industry to see if national coverage areas were indeed created. Finally, efficiency reasons for merging can include both cost-side returns to scale and scope and demand side benefits from offering customers larger native coverage areas. It is possible to isolate demand-side efficiency gains by focusing on the behavior of consumers. As part of joint work with Patrick Bajari and Stephen Ryan, we use data on the preferences of customers for wireless phone plans to semiparametrically estimate consumer demand for wireless plan characteristics, especially national coverage areas.

In most network industries, a major concern with empirical investigation of the different causes for concentration is that often no variation in industry structure is observed, so the outcome of industry structure is not an informative dependent variable for distinguishing between efficiency and market power reasons for the observed concentration. In European mobile phone markets, typically a regulator issues franchises to a few large companies, ensuring a concentrated industry structure. If the regulator determines the industry structure, the industry structure cannot be inverted, using economic theory and a profit maximization assumption, to recover the preferences of firms over alternative industry structures.

The mobile phone service industry in the United States is highly concentrated: four large, national carriers currently dominate the industry. However, this high degree of concentration is relatively recent. At the outset of the industry, the US government issued two licenses to operate phone service per geographic market, and these licenses were issued to a great number of companies. The modern state of consolidation occurred through a long history of voluntary merger and acquisition activity. Thus, the US mobile phone industry allows us to observe the transition from an unusual unconcentrated industry chosen by a regulator to a concentrated industry chosen by the voluntary actions of wireless phone carriers. These voluntary merger and acquisition decisions are indicative of the relative profitability of the observed industry outcomes compared to structures that are not observed.

The mobile phone industry has a second institutional advantage: competition for new subscribers is local. The US government must issue a geographically-specific spectrum license to a carrier before it can enroll new subscribers in a particular geographic market. These licenses are limited in number, and as part of maintaining a license a carrier must operate a mobile phone network. Therefore, if a firm wants to increase its retail market power, at a first glance only consolidation with other firms operating in the same city can achieve this goal. By limiting the number of firms competing for any given customer, firms might in-

crease market power. By contrast, mergers that occur only across geographic markets will not limit the choices of any given customer, and should not have first-order impacts on retail market power.

The first part of the empirical work examines whether consolidation occurred mainly between firms in the same market or firms in different markets. The US government does not collect a usable history of the firms controlling each license, although the information is, strictly speaking, publicly available. I have collected a panel comprising the identity of the firms controlling each geographic license over the roughly 20 year history of the industry. To a first approximation, analyzing the geographic pattern of consolidation provides evidence about whether efficiency based explanations or retail market power is more important in driving consolidation.

The geographic consolidation analysis cannot identify whether any supposed efficiencies are on the demand or cost side of the market. Nor does the consolidation analysis address the theory of the firm: why is it necessary to merge carriers in order to achieve scope and scale economies? On the demand side, it is technologically easier to offer larger coverage areas by signing roaming agreements, so that customers can use their phones in markets not served by their home carriers. Data on roaming agreements were publicly available in the early cellular industry. I examine this data to see whether demand-side benefits from national calling areas are likely a major force in explaining consolidation.

A more direct way of estimating the demand-side benefits for calling plans is to use actual demand data to estimate consumers' valuations for national calling plans. Modern wireless carriers offer both regional and local plans. Bajari, Fox and Ryan (2005) develop a new semiparametric discrete choice estimator that uses aggregate data, and more interestingly needs only the rank order of market shares, rather than the precise values of market shares, for estimation. We are able to use calling plan market share ranking data from the website

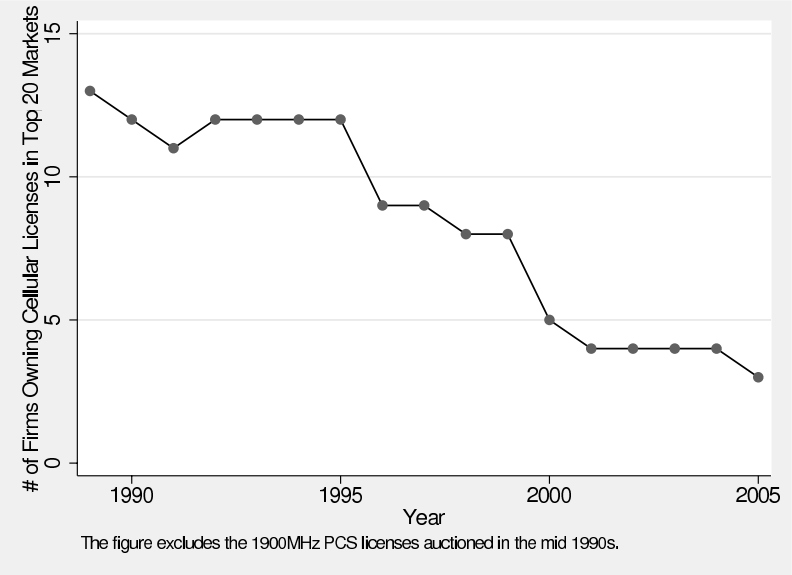
Amazon to estimate consumers' valuations for calling plan characteristics.

The empirical work in this paper complements work by Bajari and Fox (2005) in examining the behavior of potential wireless carriers in a narrower context: an auction of new geographic licenses to offer mobile phone service. Bajari and Fox use the revealed preferences of bidders to estimate whether geographically proximate licenses are complements, meaning that the sums of the payoffs of two licenses won separately are less than the payoffs of the licenses if won together. Indeed, bidders in the spectrum auction studied did have strong for creating larger contiguous coverage areas, which is consistent with the presence of demand and cost side returns to scale and scope. The auction studied offered only one license per geographic market and no bidders were incumbent carriers, so Bajari and Fox do not investigate the contribution of retail market power to bidder valuations.

Distinguishing retail market power from efficiency explanations for consolidation has important policy implications. If retail market power is an important driver of consolidation, then future merger activity may lower the welfare of consumers. More importantly, the government continues to issue more geographic licenses. The government can encourage more exploitation of the returns to scale and scope by targeting these licenses to incumbent carriers, or can encourage more retail competition by encouraging new entry.

Bajari and Fox (2005) document how implicit collusion in spectrum auctions prevents an efficient outcome from arising. Therefore, the government can alter the future of the industry by modifying the attributes of the licenses it auctions. To the extent that the returns to scale and scope, on both the demand and cost sides, are important, the government can ensure these returns are captured by issuing larger licenses, in terms of population and land area. To the extent that retail market power is important, the government can encourage more competition by auctioning licenses that individually provide access to smaller amounts of the scare radio spectrum needed to place phone calls.

Figure 1: Number of Distinct Firms Owning Original Cellular Licenses in the Top 20 US Markets by 1989 Population



2 History of Consolidation

As of September 2005, Cingular, Verizon, Sprint/Nextel and T-Mobile dominate the wireless phone service industry in the United States. The industry was not always so centralized. Figure 1 demonstrates the consolidation of the industry by presenting the number of distinct firms owning at least one of a balanced panel of the two original cellular licenses awarded for the Top 20 US geographic markets (for a total of 40 licenses). In 1989, 13 separate firms together owned the 40 licenses, while at the start of 2005 only three firms control those licenses, and two of those three, Verizon and Cingular, together own 39 of the 40 licenses.

The initial dispersion of control in Figure 1 can be traced to regulation by the Federal Communications Commission (FCC). The FCC issues licenses for the exclusive use of blocks

of radio spectrum in designated geographic markets.[1] Between 1982 and 1986, the FCC planned to use comparative worth regulatory hearings to assign licenses. However, the FCC did not have the engineering resources to evaluate the many proposals, so the FCC awarded licenses for smaller cities and rural areas using a passive mechanism: lotteries. The lottery assignment mechanism attracted entrepreneurs with very little capability to operate a wireless phone carrier.

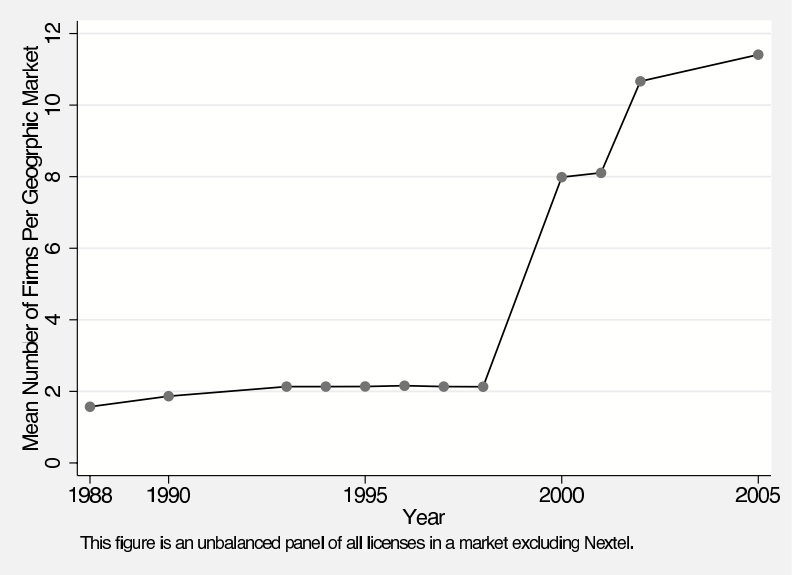
The FCC's licensing schemes created an industry with a large number of players. In a world without transactions costs, management of licenses should shift to those companies best capable of operating a wireless phone carrier. The FCC placed few restrictions on the ability of firms to merge across markets. The most famous aggregator of wireless phone licenses was McCaw Cellular, which grew to a national wireless phone carrier that was sold to AT&T for $17.3 billion in 1993.

In late 1994, the FCC began a process of auctioning new radio spectrum, the Personal Communication Services (PCS) licenses, for mobile phone use. AT&T Wireless (the former McCaw) was able to fill in holes in its burgeoning national network, a new national carrier (Sprint) was created, and the forerunner of another new carrier (today's T-Mobile USA) entered the industry. Using license ownership data I have collected, Figure 2 computes the mean number of firms per market (instead of over the top 40 markets, as before) for an unbalanced panel of all markets with operating cellular phone carriers.[2] The mean number of mobile phone carriers increased dramatically between 1998 and 2000 as the new PCS carriers came online. Further increases in the number of carriers after 2000 are driven by a phenomenon known as disaggregation: within a market, firms are allowed to split their

[1] Spectrum regulation prevents interference from multiple users transmitting on the same radio frequency.

[2] In 1993, Nextel surprisingly won FCC approval to use licenses it had purchased from paging and taxi dispatch companies to provide wireless phone service. Nextel soon became a new national carrier. Nextel and other companies using converted taxi dispatch licenses are not included in the figure. The new PCS G block licenses issued to Nextel in 2005 to resolve public safety issues are also not included, as Nextel is not currently using the new licenses to provide mobile phone service.

Figure 2: Mean Number of Distinct Firms Operating in a Geographic Market



spectrum blocks either in terms of either the radio spectrum itself or in terms of land area. Disaggregation primarily occurs for firms needing to raise capital through sales and for firms with large amounts of excess capacity.[3]

Figure 2 shows that, using the metric of the number of firms in a market, the entry of new carriers counteracts the consolidation of incumbents into national carriers. As I will show later, many new entrants are fringe players with fewer customers. Consequently, the mobile phone market is much more concentrated when measured using market shares rather than

[3]Disaggregation is an example of the many sales or trades of licenses between companies that happen outside of mergers. These fine-tuning transfers provide evidence about how firms value complementarities. For statistical purposes, transfers provide many more observations of changes in geographic market control than do the highly publicized mega mergers.

For the most recent years, Figure 2 exaggerates the number of firms in a typical market. The original two cellular licenses (per market) and the later PCS licenses are issued using different geographic market boundaries, and, because of the format of the books that data were collected from, Figure 2 lists the two cellular licenses and any PCS carriers with licenses that overlap the boundaries of the original two cellular licenses. Thus some carrier-market observations are double counted (appear in multiple markets) as the land area of a cellular license might overlap with two PCS licenses. I am working on ways to minimize the double counting.

the number of firms. Figure 2 rightly points to the high level of entry spurred by government spectrum auctions, but does not capture the reality that older incumbents tend to have more subscribers. In 2003, the major carriers served 125 million of the more than 150 million US wireless phone subscribers.

The regulated entry encouraged the FCC to raise the amount of spectrum that a company can own in one market, the spectrum cap.[4] The spectrum cap originally limited a carrier to owning no more than 35 MHz worth of mobile phone spectrum in a given geographic area. The FCC raised the spectrum cap to 45 MHz in 1996, 55 MHz in 2001, and eliminated the cap altogether in 2003. Today major companies with much overlap in coverage areas, such as Cingular and AT&T, can merge.

3 The Private Gains from Consolidation

The dramatic increase in concentration in the short history of the wireless phone service industry can only be explained by consolidation being in the private interests of the carriers involved. This paper seeks to distinguish between retail market power and efficiency explanations for consolidation. Efficiency reasons can be subdivided into the returns to operating scale and geographic scope, and such efficiencies can come from both the supply and demand sides of the mobile phone market. The goal of the analysis of the geographic path of consolidation is to decompose the reasons for consolidation into retail market and efficiency explanations. A secondary goal is to distinguish between operating scale and geographic efficiencies, although again the data on the geographic consolidation alone will not identify whether these economies arise on the demand or cost side of the mobile phone market.

[4]The licenses issued in the 1980's are for 25 MHz worth of spectrum, and the more recent PCS licenses auctioned in the mid 1990's were originally for either 30 MHz or 10 MHz.

The analyses of roaming agreements and demand estimation of the value of national coverage areas focus on the demand side of the mobile phone service industry. Roaming agreements allow cooperating carriers to mimic national coverage areas with contracts, and the incidence and characteristics of these contracts provide suggestive evidence about the importance of national coverage areas to carriers. Finally, structural demand estimates using wireless subscription data directly measure consumers' valuations for national coverage areas.

Consumers' interest in using their phones while traveling is the most recognized form for the returns to geographic scope and operating scale. A consumer may care about a carrier's total coverage area (scale), but is likely to be more concerned with available coverage and rates in geographic areas near to where the customer lives, and where there are many people for the customer to visit. The notion of geographic proximity can be extended to allow for long-distance travel via air by using data on actual travel between geographic markets.[5]

Consolidation can also create cost advantages. One can distinguish between economies of scale and scope. Economies of scale often involve spreading fixed costs over a wider user base. A carrier serving a market with a greater population (say New York City) will have a higher scale than a carrier serving only a smaller market. If the two carriers have the same fixed costs, the larger carrier will have lower average costs. Fixed costs include national marketing expenses and developing new mobile phone technologies.

Cost-side economies of geographic scope arise from the complementarities between different markets that exceed the economies from just raw size. For example, a carrier that serves two nearby markets might use one central service center from which service per-

[5]I treat a carrier owning two or more geographic markets as a multiproduct firm. The term "scope" refers to a proxy for the potential complementarities between the markets where the firm sells phone service. FCC market definitions are related to market definitions from the viewpoints of carriers as the FCC chooses market boundaries using demographic and commercial data.

sonnel are dispatched to repair cellular towers. The cost savings from the common service center would not be possible if the carrier provided phone service in two distant geographic markets.

Firms may also merge so that they can exploit market power by raising prices and lowering joint production. As phone technologies, price plans and coverage areas differentiate carriers, mergers between competing carriers might encourage firms to increase prices and therefore reduce the number of mobile phone subscribers. Future governmental regulation of the industry requires knowledge about whether past consolidation has primarily been driven by retail market power or efficiency considerations.

Economists traditionally use detailed cost (or its dual, production) data provided by a regulator to estimate the returns to scale or scope in an industry (Caves et al., 1981; Christensen and Greene, 1976). The FCC does not regulate the price of mobile phone service and does not collect cost, output and input data from carriers.

A more recent literature, often focusing on less regulated industries, uses the assumption that the observed actions of firms are profit maximizing to estimate unknown parameters about the economic environment firms find themselves in (Bresnahan, 1987). This project takes this revealed preferences approach to distinguishing efficiency from retail market power explanations.

The available data is on the transfer between firms of ownership of geographic licenses to provide mobile phone service. A transfer can be a sale of a license or part of a larger merger that combines all the operations of two firms. If transfers create packages of geographically or commercially (in terms of air traffic, etc) close markets, this is evidence that there are returns to geographic scope. Evidence that companies are amassing together otherwise unrelated but large markets identifies the role of operating scale in firm payoffs and hence consolidation.

In the mobile phone market, competition for customers is mainly local, as legally a carrier must provide wireless phone service in a market to enroll new subscribers there. The extent to which consolidation reduces the number of providers in individual geographic markets identifies an upper bound on the role of retail market power in driving consolidation.[6] Only an upper bound on retail market power is identifiable because within-market mergers might be motivated by efficiency reasons such as creating a dense grid of retail stores, offering more capacity to handle demand fluctuations, and reducing overhead in local operations.

A carrier offering its customers a larger coverage area can charge a higher price, which is a likely outcome of competition as otherwise there might not be any reason to purchase a subscription from a smaller carrier. This relationship between product price and product characteristics is a standard implication of a perfectly competitive hedonic equilibrium (Rosen, 1974). In an oligopoly market, a second-order effect can arise: firms with greater coverage areas might exploit their market power to raises prices further, as market power is a form of product differentiation that strategically behaving firms can exploit to earn higher profits. Thus, the economies of geographic scope, on the consumer demand side, are intertwined with market power. The demand estimates reported later directly measure consumer valuations, and will eventually provide ways of directly measuring the product differentiation motive for expanding coverage areas.

Implicit collusion through multi-market contact provides a second concern about distinguishing the roles of efficiencies from retail market power in understanding consolidation. If firms merge primarily across markets, the new national carriers serve many overlapping markets. These multiple markets may facilitate a collusive regime where attempts to price more aggressively in one market are punished by price wars in all markets.

[6]Consolidation also reduces the number of carriers purchasing handsets and infrastructure equipment, meaning that larger carriers may be able to bargain for lower prices from suppliers. This monopsony power does not vary at the market level and will be indistinguishable from the technological returns to operating scale in the data.

4 Data on License Ownership

This paper uses the revealed preference approach to distinguish between motives for consolidation: firms undertake the mergers and acquisitions that are profitable for all parties involved, and do not undertake mergers that are not profitable. Here "profit" is a generalized notion of economic returns that accommodates transactions costs for the mergers.

The dependent variable is thus the decision to merge, or not. The right-hand side covariates are the characteristics of the firms before they merge. For this study, a key carrier characteristic is the set of geographic spectrum licenses that a carrier controls, and the characteristics of the coverage areas of a hypothetical merged company.

Unfortunately, the US government does not have a easily accessible database of historical license ownership. However, almost every year in the roughly twenty-year history of this industry industry analysts have produced directories that list ownership information. I have collected back issues of these industry directories and have merged them together, creating a unique panel dataset about license ownership.

License ownership information on the early industry, before 1993, comes from the *Cellular Travel Guide* and the *Official Cellular Roaming Guide*. Information for the from 1993–1998 comes from *Kagan's Cellular Telephone Atlas*. Information for 2000 comes from the Prudential Securities publication "Wireless Market Summary–Licensing." Information for 2001, 2002 and 2005 comes from *Kagan's Wireless Telephone Atlas*. Data for 2003 and 2004 come from RCR's *Wireless Telephone Directory*.

Not surprisingly, many judgement calls are needed to integrate the disparate data sources. Future versions of this paper will document these details in an appendix.

5 The Geographic Patterns of Consolidation

The path of geographic consolidation is the outcome variable that this project will use to distinguish between retail market power and efficiency explanations for consolidation. Consolidation occurs through instances of transfers (sales) of licenses between carriers, and through mergers between carriers. The identification of the upper bound on the role of retail market power in industry consolidation comes from the year-to-year changes in ownership of geographic markets. There are not enough highly publicized mega-mergers for reliable statistical inference, but each year there are perhaps hundreds of small transfers of market control between carriers.

An explanation for the slow pace of consolidation is that merging and undoing mergers are costly, and due to uncertainty about future industry outcomes, it takes time to decide that a merger will be in the best interests of the companies involved. Uncertainty includes whether the FCC will allow new carriers to enter. Regulated entry episodes include the introduction of Nextel, the PCS spectrum auctions in the mid 1990s, and the forthcoming spectrum auctions.[7]

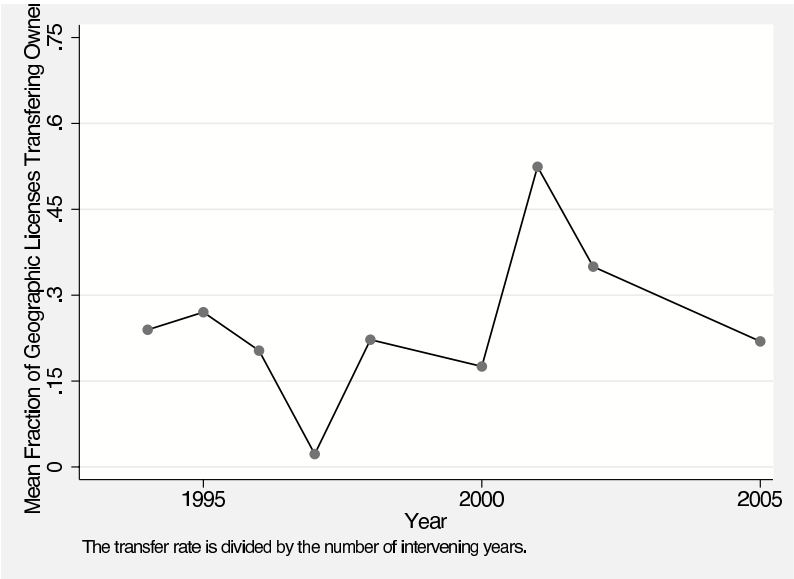
Figure 3 presents the number of geographic spectrum licenses that change hands in any given year. For each pair of years, only licenses with operating carriers in both years are considered in the figure.[8] A mean across years of 25% of geographic licenses change ownership in any given year.[9] These ownership changes reflect both mergers and transfers between companies. Each year, there are hundreds of changes in ownership not tied to mergers. By

[7] Not surprisingly, FCC decisions are announced well before they come into force. Legislation authorizing spectrum auctions was passed by Congress on August 10, 1993. The first broadband PCS auction started on December 5, 1994.

[8] I do not have data on all years. The fraction of ownership changes per time gap is divided by the number of years making up that time gap.

[9] The fraction of changes between 1996 and 1997 is anomalously low, perhaps because the 1997 source used older, 1996 data.

Figure 3: Fraction of Geographic Licenses Changing Ownership by Year



contrast, the large fraction of ownership changes between 2000 and 2001 reflects the creation of the national carriers Cingular and Verizon through mergers of earlier carriers. Either way, Figure 3 shows that there are more than enough transfers of ownership for statistical analysis.

The main purpose of the consolidation study is to distinguish whether retail market power should be on the table as a major possible explanation for mergers. Consolidation to exploit retail market power should mainly happen within geographic markets. Unfortunately, I do not have data on market shares in terms of the number of subscribers. I do have an alternate measure: the amount of spectrum controlled by a carrier in a market. The amount of spectrum a firm controls is presumably highly correlated with its number of subscribers as a firm with excess spectrum should sell it in a disaggregation, and a firm will not buy extra licenses in a market without a projected need for more capacity. I define the market share of a carrier to be the fraction (in terms of MHz) of the market's total operating spectrum

controlled by the firm. With this MHz market share measure, we can construct measures of concentration, such as the Herfindahl-Hirschman Index (HHI).[10] For reference, a monopoly market has a HHI of 10,000, and the Department of Justice considers any market with a HHI above 1800 to be "highly concentrated".

Figure 4 shows the population weighted mean HHI for each year of the data. There were only two carriers per market until 1998 and the entry of PCS carriers after the spectrum auctions. Each duopolist had the same amount of spectrum, so the HHI for the majority of markets was 5000. With the entry of the new carriers, the mean HHI drops to around 2000 in the year 2000. Since 2000 the FCC has gradually eliminated the spectrum cap preventing mergers of carriers within the same market. Consequently, major carriers with overlapping portfolios, such as AT&T and Cingular, have merged.[11] By 2005, the mean HHI is above 6000. By the HHI measure, local mobile phone markets are more concentrated today than when there were only two companies equally splitting each market. In many cases, the early duopolists became AT&T and Cingular, and with the merger the new Cingular has dominant market shares in many local markets.

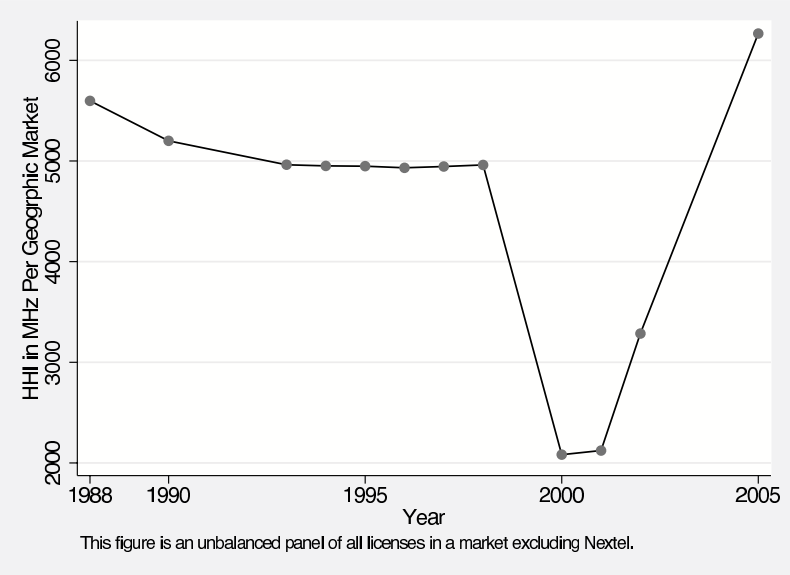
6 Roaming Agreements as a Substitute for Mergers

Inter-firm contracts may achieve the benefits from market power and the returns to scale and scope that mergers are thought to accomplish. Coasian logic suggests that firms will sign profit-enhancing agreements in the absence of transactions costs. The assignment of geographic markets to carriers should affect only the distribution of profits, not the joint profitability of the outcomes.

[10] If $s_{im} \cdot 100$ is the market share in percentage units of carrier i in market m, the HHI is $\sum_{i=1}^{I_m} (s_{im} \cdot 100)^2$, where I_m is the number of firms in market m.

[11] Nextel is not in the HHI calculation because it uses licenses converted from taxi dispatch use. Therefore, the Sprint/Nextel merger does not contribute to Figure 4's high HHI in 2005.

Figure 4: Market Concentration: Population-Weighted Mean HHI in Terms of MHz



I now examine whether contracts are indeed a good substitute for mergers. In mobile phones, roaming agreements achieve demand-side efficiencies by allowing customers to use their phones in markets where their home carriers do not provide service. I want to examine whether roaming agreements are a good substitute for acquiring larger native coverage areas through consolidation.

The technology to allow customers to use their phones outside of their native coverage areas existed in some form since the near beginning of the industry, and almost all carriers allow some sort of roaming. Therefore, a decision to allow roaming hinges on the demand side: will allowing my customers to roam on others' networks raise the number of subscribers, and will allowing other carriers' customers to roam on my network raise my revenue?

A problem with studying inter-firm agreements is that contracts are often private. Because early mobile phones required manual intervention by users to activate roaming, informa-

Table 1: Native and Roaming Coverage for the Top Five Carriers in 1990

Carrier	% of US served by native coverage	% of US served by native + roaming
McCaw Communications	24.9	87.9
GTE Mobilnet	14.2	99.8
NYNEX Mobile	13.5	99.0
Southwestern Bell	13.4	99.5
PacTel Cellular	11.9	98.4

tion on roaming agreements was made public and easy to access. I have data on roaming agreements between carriers in 1990 from the *Cellular Travel Guide.*

There are two main stylized facts from the 1990 roaming agreements. First, roaming agreements are ubiquitous. Table 1 lists the five biggest carriers in 1990, the percentage of the US population served by each carrier's native coverage, and the percentage of the population living in geographic markets where each carrier's customers can use their phone, either through roaming or native coverage.[12] Four of the five carriers have near 100% coverage through roaming agreements.[13]

The second stylized fact is that roaming is expensive for customers. The mean per-minute fee for native coverage is \$0.40 compared with roaming fee of \$0.63, implying that the per-minute fee for roaming is typically 55% greater than the per-minute fee for native customers. The mean pro-rated daily fee for native coverage is \$0.88, compared with \$1.95 for roaming. The roaming daily fee is 122% pricier than the daily fee for native customers. Such expensive roaming coverage is a poor substitute for cheaper native coverage. Put together, the stylized facts show that for customers roaming agreements mimic the native coverage areas but not

[12]For both native and total coverage, the denominator for the US population considers only residents living in markets with active mobile phone service.

[13]In the complete data, a few firms lack roaming agreements, but I suspect this reflects noncompliance with the survey more than a desire to not allow their customers to roam.

the native fees associated with consolidated national carriers. Offering cheap, widespread coverage seems to require mergers instead of inter-firm contracts.[14]

The key question is why roaming agreements have high fees attached to them, especially in a world where customers do not a priori care whether their home carrier is offering native or roaming coverage in an area.[15]

I see two major explanations. One is that consumers, or a large fraction of them, do not care about large coverage areas. Subscribers who do not often travel and use their phones for local calls may be in this category. Under this explanation, the high prices charged to roamers may be a price discrimination scheme to charge higher prices to inelastic demanders such as business travelers. A concern with this explanation is that merged carriers often charge the same, lower fee for calls in the merged companies' combined calling area. A firm seeking to price discriminate would charge calls placed far away from a customer's home market, even if the carrier controls both markets.

Another explanation involves the theory of the firm: perhaps firm boundaries throw up transactions costs that prohibit carriers from cooperating too closely. Firms do not want to give a potential rival an advantage by offering a larger coverage area, so the equilibrium is that firms can only offer low prices for traveling subscribers by merging and offering larger native calling areas.

To some degree, the demand estimates in the next sections will address the first of these explanations by measuring how much customers value national calling areas.

[14]The divergence between roaming and native charges persists. In 2004, AT&T and Cingular pointed to lowering high roaming costs for customers as a justification to merge. The carriers did not mention that roaming costs could be lowered by signing a contract without a merger.

[15]In 1998, AT&T offered the innovative Digital One Rate plan, where for $90 a month AT&T paid a customer's roaming fees. AT&T's plan attracted enough new customers that AT&T had to buy new spectrum licenses to increase capacity. Some sources suggest the high roaming fees caused AT&T to lose money on the plan.

7 Demand Estimates of the Values of National Coverage Areas

The evidence of geographic consolidation of the wireless phone industry shows that many recent mergers have increased concentration within local markets. At the same time, the evidence on the universality of reciprocal roaming agreements, yet the high per-minute charges for roaming, suggest that carriers do not have a strong demand-side motive to offer customers large native calling areas. This section follows-up on the other analyses by directly estimating the willingness of customers to pay for national coverage areas.

Bajari, Fox and Ryan (2005) introduce a new aggregate data, semiparametric discrete choice estimator. It allows a researcher to estimate the parameters in a micro-level random utility model using data on overall choice probabilities. In demand estimation, choice probabilities are known as market shares. The estimator is easy to implement and, importantly, is semiparametric as it does not rely on specifying a functional form for the distribution of the error terms.

Let the observed characteristics / features of a calling plan j be x_j, and let its observed monthly fee be p_j. The utility if consumer i purchases plan j is

$$u_{ij} = x_j'\beta - p_j + \epsilon_{ij},$$

where ϵ_{ij} is an unknown individual and calling plan-specific shock. The consumer picks the plan that gives the highest utility u_{ij}.

The goal of the econometric method is to estimate β, the willingness to pay in monetary terms for the plan characteristics in x_j. The estimator of β is any β that maximizes the

objective function

$$\sum_{j=1}^{J} \sum_{k=1,k\neq j}^{J} 1\left[x_j'\beta - p_j > x_k'\beta - p_k\right] \times 1\left[s_j < s_k\right] \times \left(x_j'\beta - p_k - \left(x_k'\beta - p_k\right)\right)^2,$$

where $1[\cdot]$ is the indicator function, equal to 1 if the condition in brackets is true, and 0 otherwise. Here, s_j is the market share of subscription plan j. The objective function asks whether a calling plan j with a higher market share than another plan k has a higher payoff, and if not, assigns a penalty equal to the difference between the payoffs. Bajari, Fox and Ryan (2005) show that this estimator is consistent, and discuss the calling plan application in more detail.

We do not actually have share data, but notice from the objective function that all is needed is the relative ranking of shares, as in the term $1[s_j < s_k]$. The website Amazon lists, for each cellular market, the rank orderings of the plans for sale in a given market. We use data from Boston collected in September 2005. Note also that our estimator relies on only the pairwise relative rankings of plans, so it is still consistent when consumers can choose plans that are not offered on Amazon and that we have no data on.

Table 2 lists estimates of the willingness to pay for various plan characteristics. For the purposes of this paper, the most important plan characteristic is whether plan offers national coverage, meaning coverage without roaming surcharges. Many carriers offer both a regional and a national calling plan; identification mainly comes from the variation in demand for national calling versus regional calling plans for the same carrier, as opposed to differences in the calling plans across carriers. Estimates of the value of national coverage are similar when carrier indicators are included in the analysis.

Table 2 suggests that a national coverage area is worth around \$1.90 a month to a typical customer. This works out to under \$24 a year. Given that carriers can spend hundreds of

Table 2: Estimates of the Willingness to Pay for Plan Characteristics from Bajari, Fox and Ryan (2005)

Characteristic	Value in Monthly Fee Dollars
National Coverage	**$1.90**
# Anytime Minutes	$0.0272 per minute
Activation Fee ($)	-$0.283
Unlimited in-Network Calling	-$0.0213
Family Plan	$9.09
Additional Line Charge ($)	$0.0218
Unlimited Internet	$4.73
Rollover Minutes (Y/N)	-$6.57
Blackberry Email	$6.30
Free Incoming Calls	$1.80
Walkie-Talkie Radio	$7.00
Unlimited Off-Peak Minutes	$6.72

dollars in subsidized handsets and other inducements to enroll a new subscriber for one or two years, $24 a year seems like a small value. It does not appear offering typical customers national coverage areas is a good explanation for the observed consolidation.

8 Conclusions

Typically, telecommunications industries are concentrated because of the actions of regulators. By contrast, the regulator of the US wireless phone industry initially chose a highly dispersed ownership structure, and consolidation happened over time through the voluntary mergers of carriers. Thus, the history of consolidation can be used to examine the reasons for the consolidation.

Most importantly, this paper seeks to distinguish between scale and scope efficiencies and the desire to exercise retail market as explanations for the consolidation. Initially, the gov-

ernment prevented within market mergers, and consolidation mainly increased the geographic coverage of individual carriers. More recently, the government severely loosened antitrust restrictions on within-market mergers, and many such mergers ensued. The large amount of within-market mergers raises the concern that the desire to exploit retail market power has been a motivating force.

Efficiencies can be on both the cost and demand sides. Two other parts of the paper present evidence that most customers do not have large values for national coverage areas, so that the demand side benefits of offering national coverage areas appear small. In the early cellular industry, data on roaming agreements was public. Roaming agreements were almost universal, meaning that any customer could place a call throughout the country. However, the rates charged for roaming agreements were quite high, meaning that carriers chose not to use contracts to create inexpensive national coverage areas for their customers. As creating such a national coverage area without mergers would have been relatively easy, one might suspect that customers do not value national coverage areas greatly.

I also examined demand data on calling plans offered on Amazon. Estimates show that customers are willing to pay $1.90 a month (around $24 a year) for a national, rather than regional, calling area. Compared to annual bills in the hundreds of dollars, $24 seems like a small valuation for a national calling area. It is likely business travelers have a much higher valuation for national coverage areas, but a small segment of customers is unlikely to drive consolidation.

Preliminary evidence suggests that demand-side synergies from offering greater calling areas is a poor explanation for consolidation. The remaining explanations are cost-side synergies, both within and across markets, and the desire to exploit retail market power in local markets. Further work will seek to distinguish between the remaining explanations.

References

Bajari, Patrick and Jeremy T. Fox, "Collusion and Complementarities in an FCC Spectrum Auction," April 2005.

_ , _ , and Stephen Ryan, "Semiparametric Discrete Choice Estimation with Aggregate Data," 2005. working paper.

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

Caves, Douglas W., Laurits R. Christensen, and Joseph A. Swanson, "Productivity Growth, Scale Economies, and Capacity Utilization in U.S. Railroads, 1955–74," *The American Economic Review*, December 1981, *71* (5), 994–1002.

Christensen, Laurits R. and William H. Greene, "Economies of Scale in U.S. Electric Power Generation," *The Journal of Political Economy*, August 1976, *84* (4), 655–676.

Rosen, Sherwin, "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition," *Journal of Political Economy*, 1974.