geographic market. The Commission has also subsequently used the number of firms providing service as an indicator of the competitiveness of the market.[35]

Using information provided to us by CTIA, we have attempted to determine the number of firms currently offering wireless voice service – actually *providing service* and soliciting new customers – in particular geographic markets. In Table 3 we summarize the results from the top 100 MSAs.[36] As can be seen, 92% of the people living in the top 100 MSAs have a choice of 5 or more competitors while over half of the people in the top 100 MSAs have a choice of 6 or more.

It is important to note that it is not only the largest MSAs that have at least four competitors. When the top 100 MSAs are grouped into sets of 20 by population, the average number of competitors for the largest 20 MSAs is 5.61, not much different from 4.69, the average number of competitors for MSAs 81 through 100.

CTIA has also supplied us with provider information by BTAs, which are the smallest geographic units over which PCS spectrum licenses are awarded. Table 4 shows that all BTAs are served by at least two CMRS providers. Over 70% of the people in the US live in BTAs that are served by 5 or more providers and over 80% of the people in the US live in BTAs that are served by 4 or more providers.

BTAs in which there are fewer than four providers tend to be quite small, and may not support a higher number of competitors. When BTAs are ranked by population, only

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[35] Fifth Report at 17-18.

[36] These are the top 100 MSAs ranked by population. CTIA has only matched the top 100 MSAs to the closest MTAs and BTAs. The number of competitors presented here differs slightly from that presented in the Commission's Fifth Report. This is, most likely, due to the timing of the information and differences in how providing service is determined.

BTAs with an average population of less than 118,000 have less than three providers on average. With a national average penetration rate of approximately 37%,[37] that would imply that each provider is serving, on average, less than 22,000 subscribers in these BTAs.

Finally, the increasing importance of national competition and pricing plans noted earlier is likely to constrain pricing also in smaller markets with fewer competitors. For example, consider a hypothetical market that has three competitors. At least one of these is likely to be a national provider, and such a firm sets its prices on a national basis. The national prices, in turn, will be determined largely by competitive conditions in the majority of (population-weighted) markets in which most of the national providers do compete. Thus, as a result of geographic pricing uniformity by national providers, national competition will constrain pricing also in smaller markets where the number of competitors may be smaller.

3. Number of Firms Holding Spectrum

The previous analysis only counted firms that have built out and already provide service in a particular MSA or BTA. There are additional firms that have acquired spectrum but do not yet provide service; presumably, such firms would provide service in the reasonably near term. Thus, such firms are likely future entrants.

When we include firms that hold licenses, but have not yet publicly stated that they are offering service, the number of firms in a particular geographic area increases as follows. Using spectrum ownership information provided by CTIA (See Table 8), we

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[37] See Table 1.

find that over 63% of the people in the US reside in BTAs where 7 or more firms currently hold spectrum. Over 93% of people in the US reside in BTAs where 6 or more firms hold spectrum. Even when BTAs are broken out into groups of 100, the number of firms holding spectrum does not vary much over this range. In the top 100 BTAs, ranked by population, there are 7.07 firms, on average, that hold spectrum, while in BTAs 401-493 an average of 5.87 firms hold spectrum.

C. Prices Have Continued to Fall and Output Has Continued to Rise

As the Commission has pointed out, prices for wireless voice services have fallen substantially in the past and are continuing to fall.[38] Price has declined not only to heavy users, but also for all subscribers.[39]

A price measure available from the US Department of Commerce, the US City Average Price Index for Cellular Services, reflects price changes for providers' most popular plans. This Index dropped from 91.7 in December 1998 to 71.1 in December 2000.[40] This trend has continued through the most recent report in February 2001 where the index stands at 68.9. (See Table 5).

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[38] Fifth Report at 19 ("nevertheless, [reports] clearly show that the average price of mobile telephony has fallen substantially since the *Fourth Report*, continuing the trend of the last several years." (footnote omitted)).

[39] Id. ("This may indicate that competition is continuing to make mobile telephone services more affordable for all Americans and not just those who can afford price plans that provide 500 or 1,000 MOUs per month.").

[40] The Bureau of Labor Statistics (BLS) computes changes in the price of cellular telephone services as a component of the telephone services index, which is included in the education and communication group of the Consumer Price Index. The BLS gathers price data directly from the providers or from their internet home pages. Providers are asked to supply price data and characteristics for their most popular calling plans. The BLS adjusts the price index for changes in characteristics, usually free minutes included in the plan. See generally: *How BLS Measures Price Change for Cellular Telephone Service in the Consumer*

The number of subscribers to wireless services continues to expand rapidly. CTIA reports as of June 2000 there were over 97 million wireless service subscribers.[41] This was an increase of over 27% from June 1999. Paul Kagan Associates estimates that at the end of 2000 there were more than 112 million wireless subscribers.[42] The majority of new subscriber growth is going to PCS providers and Nextel.[43]

Strong subscriber growth is projected to continue. A recent Strategis Group Report projects that total US subscribers will increase to over 200 million in 2007. (See Chart 1) In addition, this growth is not only expected in the largest US cities, but across the entire US. Again using Strategis data and projections (See Table 6), the average penetration rate in the top 100 BTAs is currently 36%. The average penetration rate for BTAs 401 through 487 only drops to 30%. Average penetration in the top 100 BTAs is projected to be 66% in 2007, while average penetration in BTAs 401-487 will climb to 62%. It is clear from this information that rapid subscriber growth is expected to continue in both large and small markets.

In short, there is entry by vibrant new players, declining prices, and rapidly expanding output and services.[44] For reasons explained earlier, we believe it is not necessary to reach a determination about the precise degree of competition in order to

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Price Index, BLS Consumer Price Indexes, available at http://www.bls.gov/cpifactc.htm, (accessed 4/10/01).

[41] *CTIA's Wireless Industry Indices*, Semi-Annual Data Survey Results, Released November 2000.

[42] "Wireless Market Stats," Paul Kagan Associates, March 9, 2001, p. 4.

[43] 51% of new subscribers went to PCS and Nextel in the fourth quarter of 1999 according to Fifth Report, Table 6.

[44] The Commission has itself noted: "In the year 2000, the CMRS industry continues to benefit from the effects of increased competition as evidenced by lower prices to consumers and increased diversity of service offerings." Fifth Report at 4.

confidently conclude that anti-competitive consolidations in the CMRS industry can be effectively prevented through antitrust review, without retaining the cap. A sufficient condition is that the industry has completed the transition phase from two cellular licensees and entry has been successfully established. On that, there can be little doubt.

III. THE CAP CAN INDUCE VARIOUS DISTORTIONS

In past proceedings, the Commission has asked for a showing that raising the spectrum cap would allow firms to realize significant efficiencies.[45] We emphasized earlier that the burden of proof should *not* be on carriers to prove that efficiencies have been foreclosed. We noted, nevertheless, that firms in some markets are at or very near the cap. More importantly, we explained that even if firms were not near the cap in many markets, it would be improper to conclude that the cap does not constrain business plans.

For completeness, however, we now discuss some distortions that may be created by the cap today or in the foreseeable future. Most of these distortions have been identified by other economists commenting in previous proceedings,[46] but it is helpful to synthesize the arguments here. The economic effects of these distortions can be to inflate the cost of providing existing services, curtail the quantity of such services, and deter or

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[45] 1998 Biennial Review Order on Reconsideration at ¶11.

[46] Affidavit of Jerry A. Hausman, submitted with Comments of Airtouch Communications in GN Dkt. No. 93-252 (filed June 20, 1994); R. Preston McAfee and Michael A. Williams, "Competitive Implications of Spectrum Caps," submitted with Comments of Airtouch Communications in GN Docket No. 93-252 (filed June 20, 1994); Declaration of Robert W. Crandall and Robert H. Gertner, submitted with Comments of Bell Atlantic Mobile, Inc. in WT Dkt. No. 98-205 (filed Jan. 25, 1999); Bruce M. Owen and Mark W. Frankena, "An Economic Evaluation of the Federal Communications Commission's Commercial Mobile Radio Services Spectrum Cap," submitted with Comments of AT&T Wireless Services, Inc. in WT Dkt. No. 98-205 (filed Jan. 25, 1999); Declaration of J. Gregory Sidak and David J. Teece, submitted with Comments of GTE Services Corp. in WT Dkt No. 98-205 (filed Jan. 25, 1999).

delay the introduction of new services; these adverse effects would harm consumers through higher prices and reduced service options.

A. Possible Distortions and their Resulting Harm

It is widely agreed that a firm needs less than 45 MHz to provide only mobile voice service. However, the advent of new wireless services could require spectrum above this cap, especially if such services would be provided by some firms in addition to mobile voice and other services they already offer. Joint provision of services by some firms can be more beneficial, at least for some consumers, than having the services provided only by separate firms (to avoid being constrained by the cap). Efficiencies from joint provision can arise for both supply-side and demand-side reasons.

On the supply side, the previously-mentioned commentators have noted that economies of scope are likely when wireless services are provided by the same firm. That is, it can be less costly for one firm to provide multiple services than to have those same level of services provided by different firms, each specializing in a different service. The cost savings arise because multiple services can share certain resources, and such sharing can occur more effectively within the same firm than between separate firms. The relevant resources could include: physical facilities, such as transmission and switching; common personnel, such as for customer support and billing; and intangible assets, such as reputation and brand names used in marketing. It may also be easier to develop consumer equipment to work for multiple services (e.g., voice and data) provided by the same firm.

On the demand side, consumers may value joint provision for the convenience, simplicity, and other benefits from one-stop-shopping. Another class of benefits derives from the ability of multi-service providers to offer existing services in new combinations and with new pricing options, essentially increasing product variety. (Conceptually, one-stop-shopping can also be viewed as introducing a new "product.")[47]

Given such potential efficiencies from joint provision, and the potential for the cap to constrain joint provision, several types of economic distortions can emerge.

Excessive utilization of other inputs to substitute for spectrum. As noted earlier, it is possible to substitute other inputs for spectrum to some extent. An artificial binding constraint on the amount of spectrum that some firms may use will create incentives to employ excessive amounts of other inputs to alleviate this constraint. There exist at least two substitution possibilities. Additional physical capital can be employed to increase the number of cell sites, in order to permit greater reuse of spectrum in a given locality. Second, over a longer horizon, increased R&D resources might be devoted to developing technologies that permit more intense spectrum sharing, so as to increase the service capacity of a given amount of spectrum. While both responses will enable a given level of service to be provided using less spectrum, this represents a distortion in the input mix and is, therefore, economically inefficient. The other inputs are used excessively, to compensate for the artificial spectrum limitation; investments to economize on spectrum should be guided by spectrum's true opportunity cost, not by its artificial scarcity induced

[47] The existence of efficiencies from joint provision, however, does not imply that all firms will choose to supply multiple services. Specialist firms that develop greater skills in particular services may be able to survive and prosper while offering a narrower product range. Single and multi-product firms can coexist – and often do – because consumers vary greatly in their preferences, hence some may opt for the multi-product generalists, while others will choose the single-product specialists.

by the cap. The common effect of such inefficient input substitution is to inflate the costs of the constrained firms relative to the level attainable absent the cap.[48]

Curtailment of output by the constrained firms. Because input substitution is costly, a binding spectrum constraint will not only inflate the costs incurred by the constrained firms in providing the service levels that they offer (as explained above); it will also reduce these output levels relative to a world with no cap. The constrained firms are thus prevented from fully exploiting potential economies of scale or scope. Part of the decrease in the constrained firms' output is made up by non-constrained firms, but such diversion is itself inefficient, because it sacrifices economies on the supply or demand side; and part of the decrease in output is lost altogether to consumers. Both outcomes are clearly wasteful.

Impediment of new services. The reduction in output of constrained firms can involve not only the level of existing services. It could also entail forgoing certain new services entirely, or delaying their introduction until technology permits them to be offered within the spectrum constraints of the cap. Moreover, even if such services are ultimately introduced, they will be provided at unnecessarily high cost. We next discuss briefly some possible new services whose provision may be impeded.

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[48] Of course, there is a benefit from input substitution: it enables the spectrum-constrained firms to provide greater service levels than if substitution were not possible. This input-substitution ability was mentioned in Section I as having another benefit: it limits the market power from even a high concentration of spectrum, because curtailing the supply of spectrum in order to raise price will induce more intensive utilization of spectrum. Our point here, and earlier, is not that input substitution is undesirable, since in both cases it mitigates the harm from an artificial curtailment in the supply of spectrum; rather, the point is that imperfect substitution is not a complete cure for such curtailment, since it introduces its own costs.

B. New Wireless Services May Require Significantly More Spectrum

The Commission has asked for comments on whether the spectrum cap has impeded the development and implementation of new wireless services, including third-generation (3G) wireless services.[49] It is inherently difficult to predict the counterfactual – what new wireless services might be offered if additional spectrum were available. Further, wireless providers may understandably be reluctant to publicly acknowledge constraints on their ability to expand current services or to develop and implement new services. We must therefore depend on third party analysis and anecdotal evidence.

It is widely acknowledged that wireless data services will grow in importance.[50] A major new data service expected to be very popular with consumers is wireless access to the World Wide Web (Web). Web-enabled wireless phones are being introduced to the consumer market.[51] As the quality and functionality of consumer equipment improves, and as new Web sites suitable for portable terminals are developed, demand could expand significantly.[52] The predictable consequence is that network requirements –

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[49] "Or, do spectrum limits do more to impede the efficient development of new 3G technologies that may be spectrum-intensive in the short term?" NPRM, at ¶32. "In particular, we seek comment on the extent, if any, to which our regulations impede beneficial economies of scale and the introduction of innovative new technologies and services." NPRM, at ¶33.

[50] The Commission points out that "At the same time, virtually all wireless providers – from existing mobile telephone operators to numerous new entrepreneurs – have announced plans to offer consumers an impressive variety of mobile data services." Fifth Report at 5.

[51] Merrill Lynch estimates that nearly all of the phones that Nextel and Sprint PCS sell are web-enabled, and notes that Verizon Wireless, Cingular Wireless, and AT&T Wireless each offer several models of web-enabled phones. Next Generation V at 55.

[52] The FCC cites a number of market research reports that predict a rapid growth in wireless data services: "[a]nalysts forecast tremendous growth potential in the U.S. for mobile data services. One forecast estimates that by 2002 wireless data subscribers will outnumber wireline data subscribers. Another analyst expects at least $35-$40 billion in revenues by 2007 – an annual growth rate of 25 to 30 percent – and 100 million subscribers using some form of mobile data" (footnotes omitted) Fifth Report at 35.

and demand for spectrum – would also increase, placing further strain on existing capacity.[53]

Beyond wireless data services, there could be additional innovative services that were unexpected even a few years ago. For example, Sprint PCS has started to offer games and instant messaging services.[54] In addition, spectrum demands could increase as wireless voice service moves from being primarily a complement to wireline service, used mainly in mobile applications, to becoming a bona fide alternative to wireline services.[55]

C. European and Japanese Providers Have Considerably More Spectrum

European and Japanese wireless service providers do not currently face the same spectrum constraints as US firms and are already deploying new data services. The total amount of broadband spectrum available for wireless services is much larger in Japan and Europe, and the amount held by each firm is much larger as well.

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[53] As we noted earlier, in top 10 MSAs by population, AT&T is already at the cap of 45 MHz in one MSA, while Verizon has 45 MHz in five MSAs. (See Table 2 for details.)

[54] Merrill Lynch observes: "Sprint PCS has seen some excitement regarding its introduction of AOL Instant Messenger as well as its introduction of games such as Gladiator. At this point, Sprint PCS subscribers can access over 25 different games on the Sprint PCS Wireless Web. As of November, Sprint PCS reported over 10,000 Gladiator players, averaging six minutes per game... Sprint PCS logged over one million minutes of use on AOL Instant Messenger within two weeks of service launch. We think that this application will be very popular, particularly once better handsets are available." Next Generation V at 55.

[55] As the Commission notes: "Increasing MOUs [Minutes of Use] most likely reflect the decreasing prices and the general wider acceptance of and reliance upon wireless service. This trend may also indicate that mobile telephony is moving away from just complementing existing wireline voice service and towards competing directly with it. According to one analyst, mobile telephone customers' share of total voice MOUs has increased from 3.2 percent in 1997 to 4.5 percent in 1998, and to 7.1 percent in 1999." (footnote omitted), Fifth Report at 23.

US wireless service providers currently have between 10 and 45 MHz in any particular market out of approximately 189 MHz available (50 MHz cellular, 120 MHz PCS, and 19 MHz SMR). Merrill Lynch estimates that national carriers, excepting Nextel, average 25 to 30 MHz per market.[56] In a separate report, Merrill Lynch calculates market-weighted spectrum holdings by national carrier (except Nextel) in the top 50 MSAs; these holdings range from a low of 24.4 MHz for Cingular to a high of 37.8 MHz for Verizon.[57]

The situation in Europe and Japan is quite different. In the United Kingdom, the newest entrant, TIW, has 35 MHz of spectrum, and the four incumbents have much larger allocations: Vodafone has 82.4 MHz; BT Cellnet has 77.4 MHz; One2One has 85 MHz; and, Orange has 85 MHz.[58] The story is much the same in Germany: "...the four incumbents each have 61-70 MHz of spectrum. The two new entrants, Mobilcom (France Telecom) and 3G (Telefoncia and Sonera), have 25 MHz each."[59]

In Japan there are three national carriers, each with significantly more spectrum than US firms. NTT DoCoMo has 86 MHz, KDDI has 98 MHz, and J-Phone has 50 MHz. The Japanese government reportedly has only allowed these three carriers to have 3G licenses, partly to ensure that each carrier had sufficient spectrum.[60]

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[56] "Wireless Spectrum, How Much do the US Carriers Have, and is it Enough?" Merrill Lynch & Co., October 19, 2000, (Wireless Spectrum), at 3.

[57] Next Generation V at 69, Chart 11.

[58] Wireless Spectrum at 4, Table 3.

[59] Id.

[60] "Our sense is that the Japanese Ministry of Post and Telecommunications (MPT) consciously limited the number of 3G licensees to three carriers partly to ensure that each has adequate spectrum for broadband services." Wireless Spectrum at 5.

The tighter spectrum constraints on CMRS carriers in the US are reflected in the greater intensity with which they utilize spectrum.[61] Merrill Lynch estimates that the US has anywhere from two to seven times more subscribers per MHz of spectrum than the UK, Germany, or Japan. When comparing the total population (actual plus potential subscribers) to the available CMRS spectrum (POPs per MHz), the ratio in the US relative to the same countries is even higher, ranging from three to nine.[62] Moreover, wireless penetration is lower in the US than in each of those countries.[63] If US penetration rises to narrow the gap, the ratio of subscribers per MHz in the US relative to the figure in those countries will climb further.

IV. CONCLUSION

The cap has outlived its original rationale, as an interim measure to ensure that potential entrants have an adequate opportunity to obtain spectrum and become established. The sound course now is to repeal the cap and entrust the prevention of anti-competitive consolidations in this industry to antitrust review, a system that has served us well in so many other industries. The flexibility of antitrust review will allow transactions that are not anti-competitive to go forward even if they exceed the cap, while

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[61] It would be incorrect to interpret the ensuing figures as evidence that US carriers are operating more efficiently in an economically meaningful sense. As we explained earlier, spectrum is being "economized" at the cost of employing greater amount of other inputs; the correct mix of spectrum and other inputs should be determined by the true opportunity cost of spectrum, not by artificial scarcity.

[62] Wireless Spectrum at 6.

[63] As of 6/30/2000, wireless penetration figures were: US 34.9%, UK 51.8%, Germany 38.7%, and Japan 42.3%. Wireless Spectrum at 6, Table 7.

effectively guarding against anti-competitive ones, both today and as industry conditions evolve.

QUALIFICATIONS

Marius Schwartz is Professor of Economics at Georgetown University. His areas of research and teaching include competition policy, regulation, and telecommunications. From September 1998 through May 2000 he served at the Antitrust Division of the U.S. Department of Justice as the Economics Director of Enforcement, and for six months also as the Acting Deputy Assistant Attorney General for Economics. His responsibilities included overseeing the economic analysis of telecommunications matters. From April 1995 to June 1996 he served at the President's Council of Economic Advisers as the Senior Economist responsible for industrial organization issues, working extensively on telecommunications reform, including the 1996 Act. He has consulted on competition and regulation for governmental agencies and private clients. His curriculum vitae is attached to this report.

John Gale is a Senior Associate with *The Brattle Group*. He has advised private clients on numerous telecommunications issues and has previously submitted comments to the Commission on Navigation Devices and Digital Radio. His curriculum vitae is attached to this report.

Table 1
National Provider License Coverage

Company	Total Cellular	Covered Population (000) by License Type PCS Licenses A/B	C	D	E	F	Total Covered Population	% Coverage	Subscribers	Penetration
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
1. Sprint PCS	0	204664	9385	75936	17918	0	281988	99.7%	9160	3.2%
2. VoiceStream-DT	0	140239	80991	55347	68155	75184	269992	95.5%	4080	1.5%
3. AT&T Wireless	108901	124052	69288	85398	72690	3971	265189	93.8%	13554	5.1%
4. Verizon	195834	60336	104635	0	0	35410	247558	87.5%	26282	10.6%
5. Cingular (SBC)	106270	91455	66628	12372	17313	19492	232734	82.3%	19391	8.3%
6. Nextel	0	0	0	0	0	0	232000	82.0%	6329	2.7%
US TOTAL							**282850**		**105182**	**37.2%**

Sources: [1] - [7] Paul Kagan Associates, Wireless Telecom Investor (Feb. 22, 2001 pg. 7)
[9] Paul Kagan Associates, Wireless Market Stats (Dec. 4, 2000 pg. 6)

Notes:
[7] Total unduplicated population
[8] [7] / 282,850 (U.S. Total unduplicated population)
[9] 3rd Quarter 2000
[10] [9] / [7]

Table 2
Bandwidth Ownership by National Providers
Top 10 MSAs

		AT&T Wireless		Cingular Wireless		Nextel [2]		Sprint PCS		Verizon		VoiceStream		Total [3]		HHI [4]	
MSA	Population [1]	Owned	Built	Owned	Built	Owned	Built	Owned	Built	Owned	Built	Owned	Built	Owned	Built	Owned	Built
1	14,921,254	35	25	0	0	19	19	30	30	45	25	30	30	189	129	1,599	2,050
2	13,862,513	35	25	30	30	19	19	30	30	45	25	10	0	189	129	1,599	2,050
3	7,261,176	30	30	25	25	19	19	20	20	35	25	30	0	189	149	1,487	1,717
4	4,856,881	30	30	35	25	19	19	30	30	45	25	15	15	189	144	1,641	1,753
5	4,531,636	30	30	25	25	19	19	30	30	25	25	20	0	179	129	1,470	2,050
6	4,029,662	30	30	25	25	19	19	30	30	45	25	20	20	189	149	1,515	1,717
9	3,949,075	45	25	25	25	19	19	30	30	30	30	30	30	189	159	1,627	1,705
7	3,686,592	35	25	30	30	19	19	30	30	35	25	10	0	189	129	1,571	2,050
8	3,660,758	30	30	25	25	19	19	30	30	45	25	20	20	189	149	1,515	1,717
10	3,493,644	10	0	25	25	19	19	10	10	35	25	30	30	189	139	1,263	1,817
Number of Markets:		**10**	**9**	**9**	**9**	**10**	**10**	**10**	**10**	**10**	**10**	**10**	**6**	**Average[5]:**		**1,552**	**1,916**

Notes:

[1]: 1990 Census population figures.

[2]: Assume Nextel controls 19 MHz in each market where it operates.

[3]: Total for all providers in MSA.

[4]: HHI calculated using ownership shares for all providers in MSA.

[5]: Population weighted average.

Table 3
Wireless Service Providers
Top 100 MSAs
(61% of Population)

	Number of Competitors in MSA [1]						
	8	**7**	**6**	**5**	**4**	**3**	**All [2]**
Number of MSAs	1	13	34	33	11	8	100
Population (thousands) [3]	667	15,598	63,498	60,960	7,191	5,039	152,953
% of Total Population	0.4%	10.2%	41.5%	39.9%	4.7%	3.3%	100.0%
Cumulative %	0.4%	10.6%	52.1%	92.0%	96.7%	100.0%	100.0%

	MSAs ranked by Population					
	TOP 20	**21 - 40**	**41 - 60**	**61 - 80**	**81 - 100**	**Top 100**
Average Number of Competitors in MSA Weighted by Population	5.61	5.65	5.55	5.14	4.69	5.52
Population (thousands) [3]	88,009	26,553	16,706	12,556	9,128	152,953
% of Total Population	57.5%	17.4%	10.9%	8.2%	6.0%	100.0%

Source:
CTIA Spectrum Ownership Research

Notes:
[1]: MSAs are matched to the closest BTAs. In cases where there are two or more BTAs for a given MSA (MSA 45, 48, and 56), the number of carriers is assumed to be the maximum number listed for a BTA.
[2]: Total Population for the top 100 MSAs.
[3]: 1990 Census population figures.

Table 4
Wireless Service Providers

All BTAs

	Number of Competitors in BTA							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**All**
Number of BTAs	3	16	46	66	71	131	160	493
Cumulative Number of BTAs	3	19	65	131	202	333	493	493
Population (thousands) [1]	1,819	20,586	76,850	79,555	23,825	30,478	19,444	252,557
% of Total Population	0.7%	8.2%	30.4%	31.5%	9.4%	12.1%	7.7%	100.0%
Cumulative %	0.7%	8.9%	39.3%	70.8%	80.2%	92.3%	100.0%	100.0%

	BTAs Ranked by Population					
	Top 100	**101 - 200**	**201 - 300**	**301 - 400**	**401 - 493**	**All**
Average Number of Competitors in BTAs Weighted by Population	5.53	3.83	3.31	2.61	2.47	4.92
Population (thousands) [1]	181,635	34,232	18,703	11,824	6,162	252,557
% of Total Population	71.9%	13.6%	7.4%	4.7%	2.4%	100.0%

Top 100 BTAs
(72% of Population)

	Number of Competitors in BTA						
	8	**7**	**6**	**5**	**4**	**3**	**All**
Number of BTAs	3	14	30	34	12	7	100
Cumulative Number of BTAs	3	17	47	81	93	100	100
Population (thousands) [1]	1,819	19,992	72,699	71,402	9,137	6,587	181,635
% of Top 100	1.0%	11.0%	40.0%	39.3%	5.0%	3.6%	100.0%
Cumulative %	1.0%	12.0%	52.0%	91.3%	96.4%	100.0%	100.0%

	Top 100 BTAs Ranked by Population					
	Top 20	**21 - 40**	**41 - 60**	**61 - 80**	**81 - 100**	**Top 100**
Average Number of Competitors in BTA Weighted by Population	5.64	5.65	5.32	5.01	5.26	5.53
Population (thousands) [1]	101,939	32,775	21,260	14,297	11,364	181,635
% of Top 100	56.1%	18.0%	11.7%	7.9%	6.3%	100.0%

Sources:
CTIA Spectrum Ownership Research

Notes:
[1]: 1990 Census population figures.

Table 5
Cellular Telephone Services
Consumer Price Index
U.S. City Average

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1997												100.0	
1998	99.0	98.1	97.4	96.4	96.2	94.4	94.2	93.9	94.1	93.7	92.4	91.7	95.1
1999	90.9	89.7	89.0	87.8	85.8	84.0	82.9	82.3	82.6	82.0	81.2	81.1	84.9
2000	80.6	79.7	79.2	78.9	78.2	76.8	74.9	73.7	72.8	73.0	72.9	71.1	76.0
2001	68.9	68.9											

Source: Bureau of Labor Statistics (http://146.142.4.24/servlet/SurveyOutputServlet?jrunsessionid=985299523913230701)

Table 6
Projected Wireless Penetration by BTA

All BTA's

Rank by Population		1-100	101-200	201-300	301-400	401-487	Total
Average BTA Population (thousands)		2055.44	371.98	201.96	125.91	68.99	**578.09**
Average Subscribers*	2000	2446.41	132.45	64.21	41.04	22.34	**1810.53**
	2007	4459.95	267.96	132.77	83.66	46.21	**3305.83**
Average Penetration	2000	36%	33%	31%	32%	30%	**33%**
	2007	66%	64%	62%	63%	62%	**63%**

Top 100 BTA's

Rank by Population		1-20	21-40	41-60	61-80	81-100	Total
Average BTA Population (thousands)		5892.13	1816.31	1169.06	768.10	631.58	**2055.44**
Average Subscribers*	2000	3912.04	684.11	437.94	266.94	209.70	**2446.41**
	2007	7084.09	1332.84	851.12	531.70	429.26	**4459.95**
Average Penetration	2000	41%	36%	37%	35%	33%	**36%**
	2007	70%	66%	67%	65%	64%	**66%**

Source: Strategis Group

* Weighted by population

Table 7
Wireless Service Bandwidth Owners
Top 100 MSAs

	Number of Owners in MSA [1]					
	11	**10**	**9**	**8**	**7**	**All [2]**
Number of MSAs	5	14	40	25	16	100
Cumulative Number of MSAs	5	19	59	84	100	100
Population (thousands) [3]	5,066	16,032	42,533	55,332	33,990	152,953
% of Total Population	3.3%	10.5%	27.8%	36.2%	22.2%	100.0%
Cumulative %	3.3%	13.8%	41.6%	77.8%	100.0%	100.0%

	MSAs Ranked by Population					
	TOP 20	**21 - 40**	**41 - 60**	**61 - 80**	**81 - 100**	**TOP 100**
Average Number of Owners in MSA Weighted by Population	8.00	8.91	9.16	8.61	8.54	8.36
Population (thousands) [3]	88,009	26,553	16,706	12,556	9,128	152,953
% of Total Population	57.5%	17.4%	10.9%	8.2%	6.0%	100.0%

Source:
CTIA Spectrum Ownership Research

Notes:
[1]: MSAs are matched to the closest BTAs. In cases where there are two or more BTAs for a given MSA (MSA 45, 48, and 56), the number of carriers is assumed to be the maximum number listed for an MTA.
[2]: Total Population for the top 100 MSAs, 61% of the total US Population.
[3]: 1990 Census population figures.

Table 8
Wireless Service Bandwidth Owners
All BTAs

	Number of Owners in BTA						
	8	**7**	**6**	**5**	**4**	**3**	**All**
Number of BTAs	71	141	191	81	8	1	493
Cumulative Number of BTAs	71	212	403	484	492	493	493
Population (thousands) [1]	80,529	80,042	75,622	15,582	600	182	252,557
% of Total Population	31.9%	31.7%	29.9%	6.2%	0.2%	0.1%	100.0%
Cumulative %	31.9%	63.6%	93.5%	99.7%	99.9%	100.0%	100.0%

	BTAs Ranked by Population					
	TOP 100	**101 - 200**	**201 - 300**	**301 - 400**	**401 - 493**	**All**
Average Number of Owners in BTA Weighted by Population	7.07	6.76	6.36	5.84	5.87	6.89
Population (thousands) [1]	181,635	34,232	18,703	11,824	6,162	252,557
% of Total Population	71.9%	13.6%	7.4%	4.7%	2.4%	100.0%

Source:
CTIA Spectrum Ownership Research

Notes:
[1]: 1990 Census population figures.

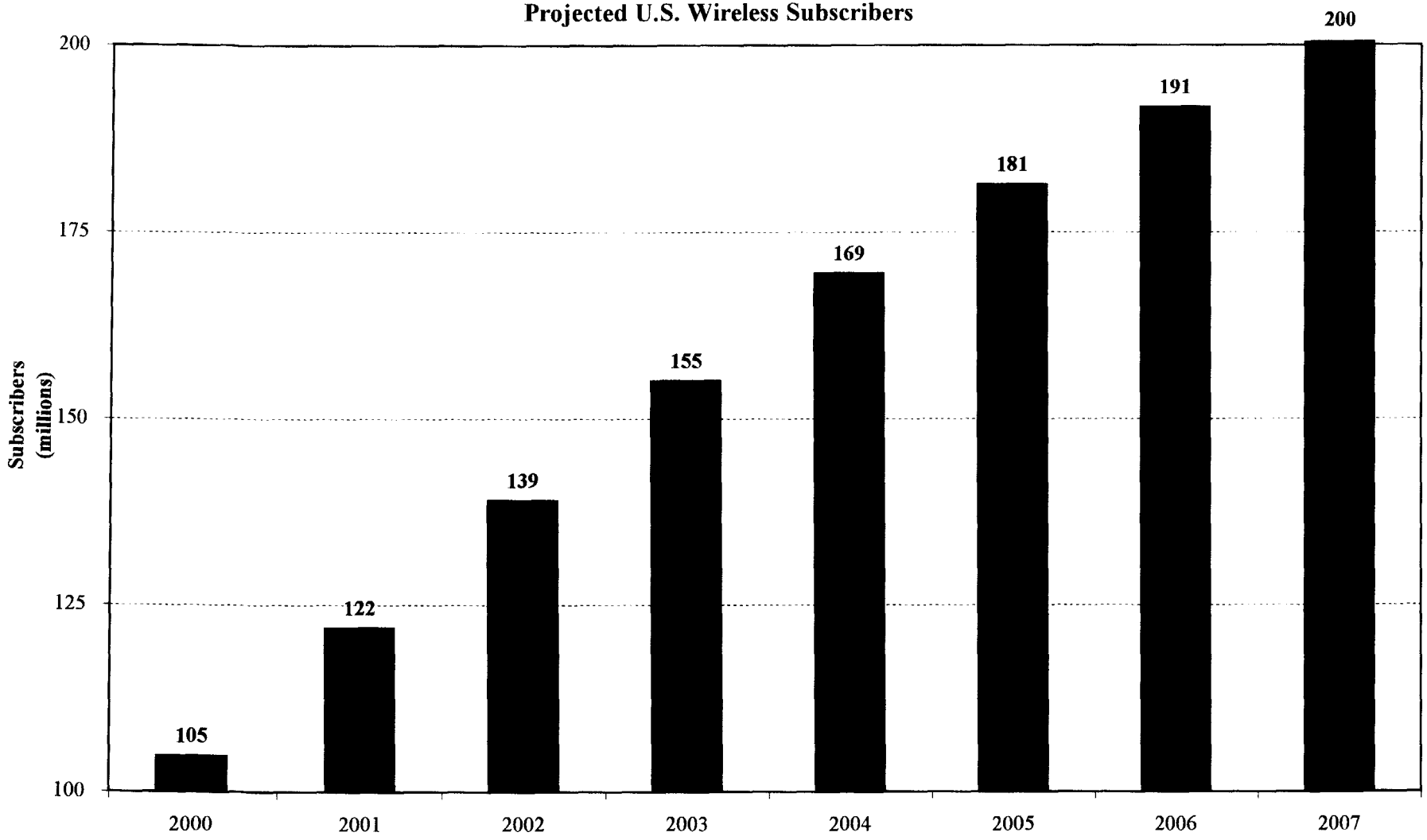
Table 9
Population Coverage by Spectrum Allocation

		Population (millions) by Spectrum Allocation									
		5-10 MHz		11-20 MHz		21-30 MHz		31-40 MHz		41+ MHz	
Company [1]	Total [2]	Population Coverage	Share of Total	Population Coverage	Share of Total	Population Coverage	Share of Total	Population Coverage	Share of Total	Population Coverage	Share of Total
1. Sprint (PCS)	282.0	52.9	18.8%	24.7	8.8%	203.2	72.1%	1.2	0.4%	0.0	0.0%
2. VoiceStream-DT	270.0	32.5	12.0%	59.5	22.0%	115.0	42.6%	33.2	12.3%	29.8	11.0%
3. AT&T Wireless	265.2	49.2	18.6%	14.8	5.6%	69.2	26.1%	66.3	25.0%	65.7	24.8%
4. Verizon	247.6	8.4	3.4%	1.1	0.4%	92.5	37.4%	98.0	39.6%	47.5	19.2%
5. Cingular	232.7	47.4	20.4%	27.6	11.9%	87.6	37.6%	50.4	21.7%	19.8	8.5%
6. Leap Wireless	72.5	39.7	54.8%	17.3	23.9%	12.8	17.7%	2.7	3.7%	0.0	0.0%
AT&T-AK Native	71.9	70.8	98.5%	1.0	1.4%	0.0	0.0%	0.0	0.0%	0.0	0.0%
7. ALLTEL	63.1	11.5	18.2%	0.0	0.0%	33.7	53.4%	17.4	27.6%	0.6	1.0%
8. Northcoast Comm.	55.2	54.6	98.9%	0.6	1.1%	0.0	0.0%	0.0	0.0%	0.0	0.0%
9. Fortunet Wireless	38.6	35.0	90.7%	3.6	9.3%	0.0	0.0%	0.0	0.0%	0.0	0.0%
10. TeleCorp Holding	35.2	1.7	4.8%	11.7	33.2%	9.2	26.1%	11.4	32.4%	1.2	3.4%
11. US Cellular	33.9	1.7	5.0%	3.3	9.7%	23.2	68.4%	1.7	5.0%	4.0	11.8%
12. Dobson Cellular	30.3	18.1	59.7%	2.7	8.9%	7.9	26.1%	1.5	5.0%	0.2	0.7%
13. Qwest	26.1	26.1	100.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
14. Metro PCS	21.8	0.0	0.0%	0.0	0.0%	21.8	100.0%	0.0	0.0%	0.0	0.0%
15. ABC Wireless	16.5	0.7	4.2%	9.4	57.0%	6.5	39.4%	0.0	0.0%	0.0	0.0%
16. Mainstream PCS	16.3	0.0	0.0%	16.3	100.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
17. Triton PCS	13.5	0.0	0.0%	3.2	23.7%	10.1	74.8%	0.0	0.0%	0.3	2.2%
18. CenturyTel	12.0	1.4	11.7%	0.1	0.8%	8.8	73.3%	1.7	14.2%	0.0	0.0%
19. CFW Comm.	10.8	3.3	30.6%	0.7	6.5%	6.2	57.4%	0.6	5.6%	0.0	0.0%

Source: Paul Kagan Associates, Wireless Telecom Investor (Feb. 22, 2001 pg. 7)

Notes:
[1] Companies with 500K+ net populations.
[2] Total unduplicated coverage of US population.

Chart 1
Projected U.S. Wireless Subscribers



Source: Strategis Group Report

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EDUCATION

University of California, Los Angeles: Ph.D. in Economics, September 1982
University of California, Los Angeles: M.A. in Economics, March 1978
London School of Economics: B.Sc. in Economics (1st Class Honors), August 1976

PROFESSIONAL EXPERIENCE

Georgetown University, Department of Economics

Professor, June 1993–present (with intermittent leaves)
Associate Professor, August 1987–May 1993
Assistant Professor, January 1983–July 1987 (part time in Fall 1982)

Director of Graduate Studies: Spring 1993-Spring 1995

Courses Taught: *Graduate*—Industrial Organization, Microeconomics for executives and policy makers, Macroeconomic Theory I and II, Monetary Policy. *Undergraduate*—Antitrust, Industrial Organization, Mergers & Corporate Control, Microeconomics (Principles, and Intermediate), Topics in Competition and Regulation International Economics, Macroeconomic Theory.

President's Council of Economic Advisers

Senior Staff Economist, June 1995–May 1996 (part-time consultant April & May 1995, June 1996).

Served as the senior economist responsible for antitrust, regulated industries, and other industrial organization matters. Work included: Telecommunications Act of 1996; competition in international satellite services; competition in the electric utility industry; reforming the patent and trademark office; intellectual property rights; international trade disputes; health care.

U.S. Department of Justice, Antitrust Division

Acting Deputy Assistant Attorney General for Economics, January 1999–June 1999

Economics Director of Enforcement, September 1998–December 1998, July 1999–May 2000

In these positions, I was responsible for overseeing economic analysis at the Antitrust Division of numerous mergers and non-merger matters in various industries, including:

Mergers & Joint Ventures—Ameritech-SBC, Bell Atlantic-GTE, AT&T-BT, Cargill-Continental, Aetna-Prudential, CBS-Viacom, WorldCom-Sprint (I was outside expert on internet backbone).

Monopolization—suit against American Airlines for predatory pricing (pending).