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Appendix 1

1994 Price Regression for Top 30 Cellular Markets
Left hand Side Variable: Log of Price <1

Variable	Estimate	Standard Error
Intercept	0.539	2.052
Log of Income <2	0.203	0.236
Log of Population <3	-0.029	0.052
Log of Commute Time <4	0.624	0.266
Regulation	0.150	0.052

Number of Observations	58
Standard Error of Regression	0.148
R Squared	0.396

Notes:
1> Minimum monthly bill is based on 128 minutes of peak calling and 32 minutes of off-peak calling.
2> Log of per capita personal income. Source: Survey of Current Business, April 1992.
3> Log of population. Source: 1992 Statistical Abstract.
4> Mean commute time from home to work. Source: 1990 U.S. Census, Tape File 3c.

Appendix 2

1989-93 Price Regression for Top 30 Cellular Markets
Left hand Side Variable: Log of Price at 160 MOU <1

Variable	Estimate	Standard Error
Intercept	2.549	1.150
Log of Income <2	0.075	0.143
Log of Population <3	0.050	0.030
Log of Commute Time <4	0.091	0.170
Regulation	0.142	0.029
Year 89	0.173	0.041
Year 90	0.127	0.036
Year 91	0.075	0.034
Year 92	0.039	0.033

Number of Observations	198
Standard Error of Regression	0.152
R Squared	0.367

Notes:
1> Minimum monthly bill is based on 128 minutes of peak calling and 32 minutes of off-peak calling.
2> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
3> Log of population. Source: NPA Data Services, Inc., April 1994.
4> Mean commute time from home to work. Source: 1990 U.S. Census, Tape File 3c.

1989-93 Price Regression for Top 30 Cellular Markets
Left hand Side Variable: Log of Price at 250 MOU <1

Variable	Estimate	Standard Error
Intercept	1.027	0.918
Log of Income <2	0.256	0.114
Log of Population <3	0.048	0.024
Log of Commute Time <4	0.129	0.136
Regulation	0.150	0.023
Year 89	0.159	0.033
Year 90	0.122	0.029
Year 91	0.070	0.027
Year 92	0.040	0.027

Number of Observations	198
Standard Error of Regression	0.121
R Squared	0.543

Notes:
1> Minimum monthly bill is based on 200 minutes of peak calling and 50 minutes of off-peak calling.
2> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
3> Log of population. Source: NPA Data Services, Inc., April 1994.
4> Mean commute time from home to work. Source: 1990 U.S. Census, Tape File 3c.

1989-93 Price Regression for Top 30 Cellular Markets
Left hand Side Variable: Log of Price at 30 MOU <1

Variable	Estimate	Standard Error
Intercept	4.701	1.752
Log of Income <2	-0.278	0.217
Log of Population <3	0.027	0.046
Log of Commute Time <4	0.257	0.259
Regulation	0.184	0.044
Year 89	0.102	0.062
Year 90	0.082	0.055
Year 91	0.072	0.051
Year 92	0.063	0.051

Number of Observations	198
Standard Error of Regression	0.232
R Squared	0.165

Notes:
1> Minimum monthly bill is based on 24 minutes of peak calling and 6 minutes of off-peak calling.
2> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
3> Log of population. Source: NPA Data Services, Inc., April 1994.
4> Mean commute time from home to work. Source: 1990 U.S. Census, Tape File 3c.

1989-93 Price Regression for RSA Cellular Markets
Left hand Side Variable: Log of Price at 160 MOU <1

Variable	Estimate	Standard Error
Intercept	4.341	0.411
Log of Income <2	-0.023	0.044
Log of Population <3	-0.066	0.010
Regulation	0.186	0.023
Year 89	0.267	0.048
Year 90	0.289	0.024
Year 91	0.193	0.019
Year 92	0.059	0.018

Number of Observations	577
Standard Error of Regression	0.169
R Squared	0.356

Notes:
1> Minimum monthly bill is based on 128 minutes of peak calling and 32 minutes of off-peak calling.
2> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
3> Log of population. Source: NPA Data Services, Inc., April 1994.

1989-93 Price Regression for RSA Cellular Markets
Left hand Side Variable: Log of Price at 250 MOU <1

Variable	Estimate	Standard Error
Intercept	4.137	0.417
Log of Income <2	0.025	0.045
Log of Population <3	-0.049	0.010
Regulation	0.159	0.024
Year 89	0.291	0.047
Year 90	0.329	0.024
Year 91	0.191	0.019
Year 92	0.058	0.018

Number of Observations	578
Standard Error of Regression	0.172
R Squared	0.359

Notes:
1> Minimum monthly bill is based on 200 minutes of peak calling and 50 minutes of off-peak calling.
2> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
3> Log of population. Source: NPA Data Services, Inc., April 1994.

1989-93 Price Regression for RSA Cellular Markets
Left hand Side Variable: Log of Price at 30 MOU <1

Variable	Estimate	Standard Error
Intercept	3.524	0.530
Log of Income <2	-0.068	0.057
Log of Population <3	0.012	0.012
Regulation	0.124	0.030
Year 89	0.122	0.061
Year 90	0.256	0.031
Year 91	0.170	0.025
Year 92	0.086	0.023

Number of Observations	577
Standard Error of Regression	0.218
R Squared	0.160

Notes:
1> Minimum monthly bill is based on 24 minutes of peak calling and 6 minutes of off-peak calling.
2> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
3> Log of population. Source: NPA Data Services, Inc., April 1994.

1989-93 Demand Regression for Top 30 Cellular Markets
Left hand Side Variable: Log of Subscribers

Variable	Estimate	Standard Error
Intercept	0.851	2.528
Log of Price <1	-0.402	0.155
Log of Income <2	0.188	0.309
Log of Population <3	0.949	0.065
Log of Commute Time <4	0.958	0.363
Regulation	-0.161	0.067
Year 89	-1.225	0.092
Year 90	-0.807	0.080
Year 91	-0.552	0.072
Year 92	-0.308	0.071

Number of Observations	196
Standard Error of Regression	0.322
R Squared	0.982

Notes:
1> Minimum monthly bill is based on 128 minutes of peak calling and 32 minutes of off-peak calling.
2> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
3> Log of population. Source: NPA Data Services, Inc., April 1994.
4> Mean commute time from home to work. Source: 1990 U.S. Census, Tape File 3c.

1989-93 Demand Instrumental Variable Regression for Top 30 Cellular Markets <1
Left hand Side Variable: Log of Subscribers

Variable	Estimate	Standard Error
Intercept	1.094	2.531
Log of Price <2	-0.500	0.172
Log of Income <3	0.196	0.309
Log of Population <4	0.954	0.065
Log of Commute Time <5	0.965	0.363
Regulation	-0.147	0.068
Year 89	-1.209	0.093
Year 90	-0.795	0.080
Year 91	-0.545	0.073
Year 92	-0.304	0.071

Number of Observations	196
Standard Error of Regression	0.321
Hausman Specification Test (χ^2_1)	1.73

Notes:
1> Instrumental variables include average price across other Top 30 MSAs, per capita income, population, commute time, and indicator variables for regulation and years.
2> Minimum monthly bill is based on 128 minutes of peak calling and 32 minutes of off-peak calling.
3> Log of per capita personal income. Source: NPA Data Services, Inc., April 1994.
4> Log of population. Source: NPA Data Services, Inc., April 1994.
5> Mean commute time from home to work. Source: 1990 U.S. Census, Tape File 3c.

THE CELLULAR SERVICE INDUSTRY: PERFORMANCE AND COMPETITION

Prepared for:

THE CELLULAR TELECOMMUNICATIONS INDUSTRY ASSOCIATION

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The Performance of the Cellular Industry

From its beginning, the business of supplying cellular telephone communications has been characterized by rapidly increasing volume, declining prices, expanded service offerings, and significant technological change.

The volume of cellular services can be measured either by the number of subscribers or by the minutes of airtime used. The number of cellular telephone subscribers had grown from only 91,600 in January 1985 to an estimated 8.8 million by June 1992. Growth has continued to be rapid, with the number of cellular subscribers increasing by 46 percent during the 12 months ending June 1991 and by 39 percent in the 12 months ending June 1992.[1] The number of cellular subscribers is projected to be 19 million by 1995 and 38 million by 2001.[2] Growth in cellular airtime also has been substantial, although it has been slower than the growth in the number of subscribers because later subscribers have tended to use the service less intensively than earlier adopters. This change reflects the increased importance of residential users of cellular telephones relative to business users.

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[1]Cellular Telecommunications Industry Association, Industry Data Survey, June 30, 1992, p. 1. The growth in volume that has occurred has far exceeded expectations. When commercial cellular service began in the United States in 1983, the potential demand in the year 2000 was thought to be between one and two million subscribers; see Coopers & Lybrand, Technological Change and the Cellular Telecommunications Industry (November 1991), p. 15.

[2]Linden Corporation, Cellular Network Technology, End User Requirements, and Competition to the Year 2001, 1991, p. 244.

Contributing to this increasing volume has been a steady decline in the costs of owning and using cellular telephones. For example, the nominal price for 250 minutes of prime airtime usage per month across the ten largest cellular service areas had, in 1989, declined by 19 percent from the inception of commercial cellular service in 1983. Even with a slight increase in carrier charges estimated for 1991 and 1992, the unweighted average of the lowest published rate for access and 250 minutes of usage during prime time in these ten service areas was only 85 percent of its 1983 level. When adjusted for inflation, the average of these rates in the ten largest cellular service areas in 1991 was only 62 percent of its 1983 level.[3]

The monthly cost of a mobile cellular telephone has declined by even more than carrier charges, from $79 in 1983 to $7 in 1991. During the same time, the quality of mobile telephone service was also enhanced by improvements in functions and features. When adjusted for inflation, the total cost of owning and using a cellular telephone in 1991 was only 44 percent of its cost in 1983.[4]

Cellular subscribers have benefitted not only from falling prices but also from the continually expanding variety of services offered by cellular operators. Only five years ago, there were no

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[3]Data are from Herschel Shosteck Associates, Ltd., Cellular Market Forecasts, Data Flash, September 1992.

[4]Data are from Shosteck, op. cit., and measure the "drive away" price of a single mobile telephone, including antenna, installation, and first-year maintenance.

value-added cellular services. Today, cellular providers offer a number of information services as well as features such as voice mail, call forwarding, and call waiting. There have been major advances in data transmission as well, including portable facsimile and wireless transmission for laptop computers. New services continue to be developed. For example, cellular telephones now are being used to verify credit cards and to transmit information to and from remote locations in computerized monitoring and reporting systems.

Technological advances in recent years also have enabled cellular systems to expand their capacity. Several capacity-increasing innovations have occurred in the conventional or analog cellular technology, such as adjusted power output, antenna tilting, dynamic channel assignment, and cell repeaters and umbrella (underlay/overlay).[5]

Notwithstanding the continuing improvements in analog-based cellular systems, even more dramatic advances are expected from the further development and application of digital technology. Virtually all cellular switches made today are digital, and the shift to this technology is expected to occur in base station radios and subscriber telephones during the 1990s.[6]

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[5]H. Shosteck, "The question marks over PCNs," Mobile Europe, January 1991, no pagination.

[6]Coopers & Lybrand, op. cit., pp. 59-60. During a transition period, cellular phones will be dual mode, adaptable to both digital and analog systems.

The conversion to digital technology, despite the substantial investment required, promises to yield even greater increases in system capacity and lower average costs for cellular operators. For example, the capacity of base stations will at least triple initially. In addition, digital technology will permit new services to be provided.[7]

Competition in the Supply of Cellular Services

This performance of the cellular service industry is the kind that economists associate with a young industry driven by market forces and developing in a competitive context,[8] and it has occurred without the industry's having a competitive structure, as economists define that term.[9] The FCC has determined that the cellular service business should be a structural duopoly: only two facilities-based suppliers, one wireline carrier and one nonwireline carrier, are permitted to operate in a service area, with additional facilities-based entry barred. Economists have recognized, however, that the behavior of firms and the performance of an industry can approximate the competitive outcome even if the

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[7]Ibid., p. 60.

[8]While this record of performance is consistent with a competitive industry, it does not prove that the industry is necessarily competitive, since even a monopolist facing conditions of increasing demand and reduced costs is likely to earn greater profits by lowering price, expanding output, and making innovations in products and methods of production.

[9]Economists call a market structure competitive when entry is easy, firms are numerous, and no firm has a large market share. As we point out in the text, the performance of a market can be competitive even if its structure is not.

industry does not consist of a large number of firms, none of which serves a large share of the market.

Economists consider the number and size distribution of firms in a market to be important initial indicators of the likelihood of noncompetitive behavior.[10] Collusive arrangements, whether explicit or tacit, are more likely when there are only a few firms, simply because coordination is easier. Similarly, the costs of monitoring the behavior of others and enforcing any collusive arrangement by punishing "cheaters" are lower when there are few industry participants.[11] The size distribution of firms also affects the ease of coordination. A small number of very large firms may serve as coordinators in an industry that also includes many small firms.

However, economists also recognize that the competitive outcome, where prices are driven to marginal costs, may obtain even in industries with as few as two firms.[12] Theoretical models of the strategic interactions between duopolists predict a broad range of outcomes, from monopolistic to perfectly competitive.[13] In

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[10]M. Spence, "Tacit Co-ordination and Imperfect Information," Canadian Journal of Economics XI (1978), pp. 497 and 499.

[11]J.S. Bain, "Relation of Profit Rate to Industry Concentration," Quarterly Journal of Economics LXV (1951), pp. 205-206.

[12]The best-known model demonstrating this result is found in J. Bertrand, "Théorie Mathématique de la Richesse Sociale," Journal des Savants, 1883, pp. 499-508.

[13]A large body of economic literature, predicting a range of competitive outcomes, is reviewed in J. Tirole, The Theory of Industrial Organization (Cambridge, MA: The MIT Press, 1988), pp. 225-308.

these models, firms choose whether to cooperate and at which price. The outcome depends on the reaction that each firm expects from its competitor to changes in its own price or output. This, in turn, determines the gains that each firm expects from undercutting a noncompetitive price, and the expected cost of being punished if such deviation is detected. Even duopolists do not necessarily react to each other's actions in ways that maximize joint profits: a duopoly is not the same as a monopoly.

The decision rules that comprise a firm's competitive strategy are difficult to infer from its observed behavior. Nonetheless, economists have identified a number of significant factors, in addition to the number of its rivals, that influence the strategies each firm pursues, and thus help to determine how close to the competitive outcome the industry's performance will be.[14] These are factors that make collusive practices more or less difficult to establish, and affect the ease with which deviations from a collusive outcome can be detected and punished. Several of these factors are likely to influence the performance of the cellular service industry, albeit to varying degrees.

One of the most striking features of the mobile communication industry is the rapid pace of technological innovation and diffusion. Transmission technology has evolved from analog to digital, and cellular telephones have become truly portable, shrinking to pocket size. The rate of technological change and the

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[14]G. J. Stigler, "A Theory of Oligopoly," Journal of Political Economy 74 (1964), pp. 44-61.

resulting speed with which the customer base is growing are two influences that economists consider procompetitive.

The rapid technological change in the provision of cellular service imparts a high degree of variability to the services offered and the prices of those services. In these circumstances, a collusive agreement is difficult to maintain, because the price of each new service must be integrated into the existing price structure.[15] As providers adopt new technologies, the introduction of new service packages offers opportunities to "cheat" on a noncompetitive agreement without provoking the "punishment" that might otherwise occur, because it is difficult for a rival to determine what the appropriate price of the new service should be. If new services are offered at more competitive prices, because it is easier to deviate from a collusive agreement when products are changing, or even if rivals only perceive that the new services are being offered at prices that are "too low" because they do not know what those prices should be, a collusive agreement may be difficult to establish and maintain.

The rapid rate of technological innovation not only hinders the smooth functioning of a collusive pricing agreement but, by leading to rapid market growth, also may weaken the incentive for firms to participate in such agreements. When markets are growing

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[15]R.A. Posner, Antitrust Law: An Economic Perspective (Chicago, IL: The University of Chicago Press, 1976), pp. 59-60.

rapidly, demand tends to be more inelastic, so the gains from deviating from a collusive price are greater.[16]

The importance of technological innovation in the provision of cellular services may lead to low prices for a third reason. Economic models predict there may be gains to pricing aggressively in industries characterized by significant learning economies. By keeping its prices low, a firm can increase production and achieve cost savings more rapidly as it moves down its learning curve.[17] These models predict that economic performance will be better if, instead of many small firms, the industry consists of a few large, long-run profit-maximizing firms. The predictions of such models are supported by experiences in the semiconductor and related electronics industries.[18]

The history of the players' competitive behavior shapes their future behavior as well.[19] Early in the history of cellular services, when the wireline carriers already were established and the nonwireline carriers were just beginning to serve customers, the new providers had an especially strong incentive to initiate price cuts. While they would realize lower revenue from their

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[16]J.J. Rotemberg and G. Saloner, "A Supergame-Theoretic Model of Price Wars During Booms," American Economic Review 76 (1986), pp. 390-407.

[17]A.M. Spence, "The Learning Curve and Competition," The Bell Journal of Economics 12 (1981), pp. 49-70.

[18]F.M. Scherer and D. Ross, Industrial Market Structure and Economic Performance, Third Edition, (Boston, MA: Houghton Mifflin Co., 1990), pp. 373-374.

[19]Posner, op. cit., p. 61.