Excessive(?) Entry of National Telecom Networks, 1990-2001

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1 Introduction

During the late 1990s there was tremendous capacity expansion and entry of new firms in the North American long-haul telecommunications industry. These expansions were driven by very fast demand growth for Internet and other data-oriented telecom services and by exponential decreases in the cost per bit transmitted using fiber optic communications equipment. But by 2001, competition and slowing demand growth were squeezing the profits of these carriers, and an equally unprecedented slowdown in spending occurred. The problems in the telecommunications sector have been blamed for dragging down growth in the entire U.S. economy.

As the expansion turned to bust, discussion of a "fiber glut" became increasingly common. Generally the fiber glut story revolves around three

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premises. First, Internet growth was not as fast as expected, and in particular, not as fast as Worldcom claimed (Odlyzko 2003). Second, the still-high growth rate of data traffic was "...not nearly fast enough to use all of the millions of miles of fiber-optic lines that were buried beneath streets and oceans in the late-1990s frenzy.[1]" Third, the equipment used to send data over fiber optic cable improved dramatically so that each strand of fiber could carry many more gigabits of data: "Perhaps never before has the efficiency of an industry's technology gotten so far ahead of demand.[2]"

Despite these gloomy statements, to our knowledge there is no economics literature analyzing the industry's growth and decline. Indeed, very little data has been collected on which firms entered when and where. Until 1998, Jonathan Kraushaar of the Federal Communications Commission published a yearly update on long distance fiber optic networks, but this was discontinued just as industry investment took off. In this paper we present newly collected data that merges Kraushaar's work with publicly available information on firms' entry decisions up to the end of 2001. We find that a large amount of the so-called investment consists of relatively fungible swaps and leases of fiber and conduit.

This paper begins by discussing the relevant theory of firm entry, investment, and sunk costs and applying it to the national telecom network industry. In passing, we also discuss some differences between today's telecoms and nineteenth century railroads. Next we describe our data sources

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[1] Dreazen, "Behind the Fiber Glut —Telecom Carriers Were Driven By Wildly Optimistic Data on Internet's Growth Rate," *The Wall Street Journal*, September 26, 2002, pg. B1.

[2] Dennis K. Berman, "Behind the Fiber Glut — Innovation Outpaced the Marketplace," *The Wall Street Journal*, September 26, 2002, pg. B1.

and methods of data collection. We then examine the pattern of entry and measures of industry concentration.

2 Sunk Costs and National Fiber-Optic Networks

The building of the national fiber optic networks is another chapter in the peculiar history of U.S. infrastructure industries. This history started with the canal boom of the early nineteenth century, reached its most dramatic episode in the railroad booms and busts of the late nineteenth century, and has continued since then with electricity transmission, Interstate highways, and cable television among others. All of these industries have been politically as well as economically important, and all have been characterized by financial instability and/or heavy government regulation.

In particular, the recent telecom boom and bust has been compared to the nineteenth century railroad experience, and the two do appear similar in many regards. In both cases, a large number of firms gained access to rights-of-way between major cities, built multiple parallel routes, and then engaged in intense competition that left many of them bankrupt. But we discuss below that the key to this comparison is the nature of sunk costs in the two industries, and that in fact the two are quite different in this regard.

Industrial organization economists often represent entry decisions in high-sunk-cost industries using a two-stage game (Sutton 1998). In stage 1, firms make irreversible investments that determine their characteristics, such as product variety or quality or some measure of capacity. These investments are sunk costs, so the firms do not exit the market later in the game. In stage 2, the firms compete according to Cournot, differentiated Bertrand, or some other type of competition. The terms of this competition are affected by the stage 1 decisions. Sutton suggests that a very loose requirement for a solution to this game is a criterion of viability. That is, firms will not make stage 1 investments that they cannot recoup as operating profit in stage 2.

Faulhaber and Hogendorn (2000) argue that for infrastructure industries like national telecom networks, the basic game structure can be further refined as follows: In stage 1, firms invest in distribution capacity that determines where they can offer service in geographical space. Then stage 2 can be divided into two parts. In stage 2a, firms invest in production capacity that determines how much they can produce in each area that they serve, and in stage 2b they compete in each area subject to these production capacity constraints. The key to this interpretation is that distribution capacity is a sunk cost because investments like rights-of-way, conduits, and utility poles have no alternative use and are not fungible. But production capacity is not sunk because investments like locomotives, telephone switches, and transformers can be resold or redeployed and are therefore fungible.

Under this interpretation, the key to competition between infrastructure firms is geography, since the sunk distribution capacity means that once a firm enters a territory it can commit not to leave. Production capacity, on the other hand, may affect short-run competitive outcomes (for example, it might lead to Cournot outcomes in the manner of Kreps and Scheinkman (1983)), but it does not carry long-run commitment value. For example, entry by a second railroad between two cities would irrevocably increase the number of competitors to two, but it would not inevitably lead to zero-profit Bertrand competition since production capacity (e.g. the number of locomotives) could be adjusted periodically.

For long-haul fiber optic networks, distribution capacity involves securing a right of way, burying protective conduits in this right-of-way, building "huts" to house equipment at intervals along the route, and placing fiber-optic cable inside the conduit. Each strand of fiber potentially has gigantic data capacity, each cable contains many strands of fiber, and many systems have multiple conduits, so for the foreseeable future no further upgrades to this distribution capacity are necessary. (There are periodically advances in the quality of fiber-optic strands, so systems in which it is easier to install new fiber have an advantage in the long run.)

Production capacity consists of terminal equipment that takes electronic data from many sources, switches and combines it into channels, and converts it to optical signals using lasers. Such equipment is expensive but can be moved, resold, expanded, and contracted given sufficient lead time. Thus overcapacity and low prices on a particular route should eventually lead to redeployment of equipment away from that route. Nevertheless, in the current environment the marginal cost of production capacity relative to the size of demand is very small and appears to be causing very low prices.

Why did numerous firms invest in sunk distribution capacity when there were signs that operating profits would be low? Part of the answer is that the number of firms that installed production capacity is much larger than the number that installed distribution capacity. The reason this was possible is that owners of rights-of-way were willing to sell indefeasible rights of use (IRUs) by means of which firms could obtain either space in conduits or dark fiber (fiber optic cable with no terminal equipment attached at the ends). These IRUs convey many of the rights of ownership, but they are typically limited to 20 years, can be dissolved by mutual agreement, and are frequently abrogated by bankruptcy courts. Furthermore, despite the careful language of IRU agreements, in an industry with rapidly changing technology there are likely to be many noncontractables that could render an IRU economically obsolete earlier than its legal expiration.

The fact that so many fiber-optic networks are based on IRUs means that committed distribution capacity is much less than the number of national networks would suggest. Firms that go bankrupt and hold IRUs are likely to exit the industry once and for all. Only those firms that actually hold right of way are committed to continuing employment of their assets even in the face of bankruptcy reorganization.

Contrast this situation to the nineteenth century railroad boom. Arthur Hadley (1885) discussed how the sunk-cost nature of railroad right of way created perpetual instability in the railroad industry. When competition on a route (New York to Chicago was particularly competitive) was too great to support all the lines on the route, some railroads went bankrupt. But their sunk investment in right of way had no alternative use, so the insolvent line simply emerged from bankruptcy with its debt reduced and its line ready to disrupt the industry some more. This pattern, and the companies' collusive attempts to combat it, eventually led to regulation of the industry.

3 Data

Given our discussion of sunk costs, we orient our data collection to measures of the distribution capacity actually installed and the amount installed under IRUs and similar agreements. In our case, the simplest summary measure of distribution capacity is route-miles of network. Since all of our networks reach all major American cities, higher route miles indicate more small cities served and/or more redundancy in the network. In nearly all cases, the promotional and technical materials made available by telecom firms do not differentiate between route miles owned outright and those owned through IRUs. Thus we reconstruct the process by which each network was built, noting which routes are based on IRUs and which on owned right of way. In some cases, routes are jointly owned, in which case we count one-half the miles for each of two owners and one-third for each of three. Jointly owned routes are a much smaller portion of total mileage than are IRUs and do not greatly affect our results.

During the period 1986-1998, the FCC collected similar data from the interexchange (long distance) telephone companies. These data were compiled and analyzed by Jonathan Kraushaar in what was then the Commission's Common Carrier Bureau, and the reports continue to be available at the FCC's website. The FCC data collection proceeded through voluntary questionnaires and telephone calls, and they received a high response rate. Toward the end of the sample period, they expressed concern that fiber routes miles were being double-counted, precisely for the same reasons we discussed above. We use the FCC data for nearly all firms that had fiber networks during the period 1990-96. For 1997-98, we use the FCC data primarily as a check against our own data. From 1999-2001 we must rely on our own data exclusively. We found that in most cases our data was remarkably consistent with the FCC's.

Our main source for total route miles is the firms' annual reports and investment prospectuses as filed with the Securities and Exchange Commission and available through the online EDGAR database (primarily forms 10-K and S-4). Some companies included very meticulous network data with these filings, while others simply mentioned route miles in passing.

To supplement that source, we also searched each company's press releases using the archives on LEXIS/NEXIS. In many cases, firms obtained

IRUs by swapping access to their own right of way for access to the right of way of their competitors. The firms often announced and promoted these swaps as an inexpensive way to build their network quickly. In several cases, firms swapped access to an IRU for an IRU on another firm's route, so that the swaps could be more than one layer deep. Because of this, we frequently know that a route is based on an IRU but cannot definitely determine the source of that IRU. Fortunately, this problem does not affect the computation of owned versus shared route miles.

We checked our results on a route-by-route basis against network maps available at the companies' web sites (in most cases) or from Internet service provider resellers (for Qwest, MCIWorldcom, McLleodUSA, and ENRON). We also checked against the map "North American National and Regional Fiberoptic Long-Haul Routes Planned and In Place" published by KMI Research and dated May 2002. The inconsistencies were minor.

Although we are quite confident that the shared routes we have identified are in fact shared, we expect that there are additional IRUs and swaps that we were not able to document. As such, our database is conservative since it attributes more owned miles to each network than they probably in fact own.

We limit our sample of firms to those that either had achieved national reach or had announced aspirations to national reach. There are several regional networks whose miles are not counted here. In addition, some firms purchased access to entire national networks but did not own any mileage of their own and did not participate in any swaps of IRUs. We do not list these firms because we consider them customers of the carriers listed and not peers.

4 Entry and Investment

In Table 1, we show the total network route miles (owned plus shared) by firm for the period 1990-2001. During the early 1990s, the big-three long distance companies, AT&T, MCI, and Sprint, had been joined by Williams, a pipeline company that had also built a nationwide fiber optic network. Williams sold this network to Worldcom in 1995.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
360 Networks (Worldwide Fiber)									1,181	7,971	11,976	14,176
AT&T	32,398	32,500	33,500	35,000	36,022	37,419	38,704	38,704	39,576	39,576	42,551	46,500
Broadwing (IXC)	914	914	914	1,257	1,357	1,365	2,025	5,500	9,300	15,700	18,500	18,500
DTI								927	1,500	7,250	14,360	17,835
Dynegy												16,000
ENRON									3,400	16,281	16,281	16,281
EPIK (Florida East Coast RR)										3,801	11,500	1,244
Genuity (GTE)								5,283	12,000	17,500	17,500	20,800
Global Crossing (Frontier)								4,932	9,620	13,000	20,000	20,000
Level 3									410	9,084	15,236	15,639
MCI	16,000	16,700	17,040	19,793	21,460	21,049	23,096	25,234				
McLeodUSA (+CapRock)	332	332	332	332	519	519	621	866	5,052	8,036	16,600	26,000
Metromedia									3,099	18,000	18,000	18,000
Pathnet										478	1,500	
Qwest (Southern Pacific RR, +LCI)	1,210	1,406	1,406	1,406	1,408	1,408	3,977	7,101	15,000	25,500	25,500	23,700
Sprint (limited data)	22,093	22,725	22,799	22,996	22,996	22,996	23,432	23,574	23,574	23,574	23,574	23,574
Touch America (Montana Power)								2,770	9,770	10,466	17,370	21,370
Velocita (PF.net)												4,000
Williams	9,700	9,700	9,700	9,700	9,700	0	0	0	9,300	17,000	20,800	28,700
Worldcom/MCIWorldcom (LDDS)					1,300	11,000	12,589	19,619	47,529	47,806	47,806	47,806
XO (NEXTLINK)											16,000	16,000

Table 1: Total Route Miles of National Telecom Networks, 1990-2001

Beginning in 1997 (the year after passage of the Telecommunications Act), growth in route miles picked up quickly. This was a combination of expansion by existing networks and de novo entry. By 2001, there were 19 national networks, but profits were low and Pathnet had exited the market, while EPIK contracted back to its Florida base. In 2002, almost all of these firms were in bankruptcy.

EPIK's sudden contraction from national to regional network is suggestive of how un-sunk the distribution capacity of some of these companies was. In Table 2 we examine what percentage of route miles were actually owned by each firm in each of the years.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
360 Networks (Worldwide Fiber)									100%	47%	44%	48%
AT&T	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	97%	95%
Broadwing (IXC)	100%	100%	100%	100%	100%	100%	100%	84%	65%	71%	68%	68%
DTI								100%	100%	26%	32%	27%
Dynegy												0%
ENRON									51%	11%	11%	11%
EPIK (Florida East Coast RR)										21%	8%	100%
Genuity (GTE)								0%	0%	16%	16%	29%
Global Crossing (Frontier)								0%	0%	0%	0%	0%
Level 3									100%	99%	100%	100%
MCI	100%	100%	100%	85%	85%	85%	85%	100%				
McLeodUSA (+CapRock)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	57%	37%
Metromedia									0%	1%	1%	1%
Pathnet										50%	65%	
Qwest (Southern Pacific RR, +LCI)	100%	100%	100%	100%	100%	100%	100%	100%	96%	64%	64%	61%
Sprint (limited data)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Touch America (Montana Power)								5%	33%	32%	45%	38%
Velocita (PF.net)												37%
Williams	100%	100%	100%	100%	100%				20%	59%	71%	62%
Worldcom/MCIWorldcom (LDDS)					100%	100%	100%	71%	88%	88%	88%	88%
XO (NEXTLINK)											0%	0%

Table 2: Percent of Route Miles Owned Outright, 1990-2001

At the beginning of the 1990s, the networks were owned outright by the carriers. But entry in the later 90s involved so many swaps and IRUs that many "national" carriers owned only a small percent of their rights of way, and in a few cases owned none at all. The IRU strategy does not appear to have been a temporary expedient to expand network reach, since most carriers were decreasing their percentage owned even as they served more route miles.

The bulk of total investment in network route miles came during 1998, 1999, and 2000. The majority of the new miles in this period were based on shared facilities. New right of way built in this period is mostly accounted for by upgrades to the old AT&T and MCIWorldcom networks and the entry of three new major networks, Qwest, Level 3, and Williams (see Figure 1).

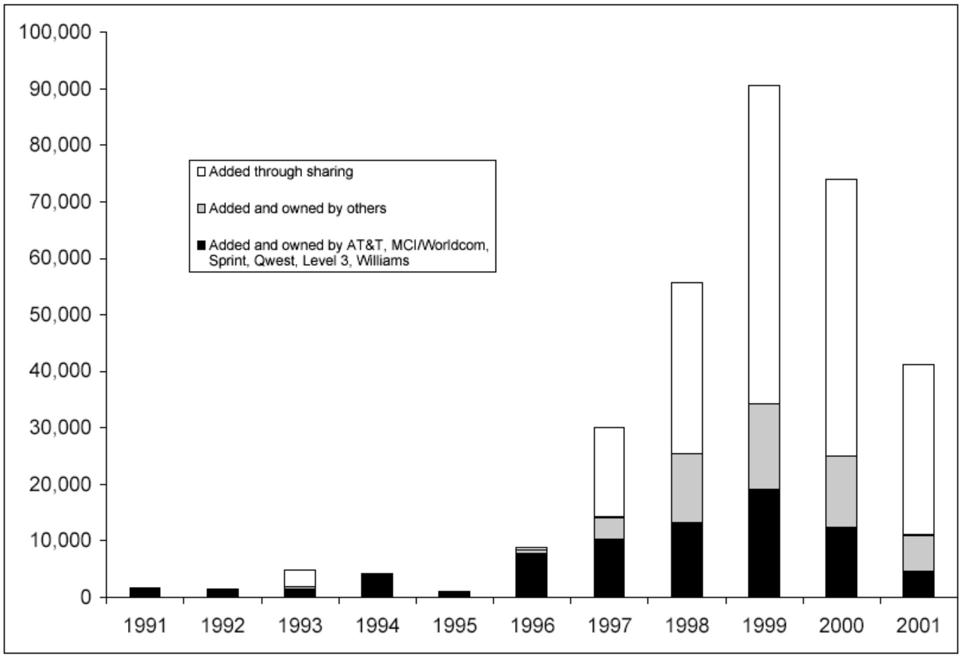
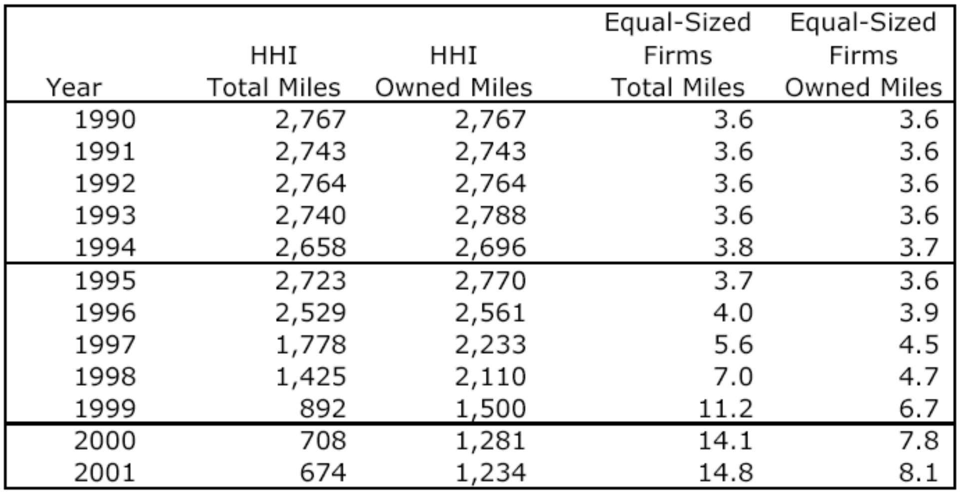


Figure 1: Yearly Additions to Total Route Miles, 1990-2001

These data suggest that the industry probably did not experience overbuilding and ruinous competition in the sense of the railroads of the late 1800s. Rather, the actual building of new rights of way represented more modest entry, but the system of IRUs created a hyper-competitive environment in which prices fell.

5 Industry Concentration and Growth

The Herfindahl-Hirschman Indices (HHIs) and the equivalent number of equal-sized firms (calculated from the inverse of the HHI) for each year based on total miles and owned miles appear in Table 3. These indices are usually employed with regard to actual sales, and not all of the networks use their capacity equally, so Table 3 can only be interpreted as a rough guide to the potential level of competition in the industry.



Year	HHI Total Miles	HHI Owned Miles	Equal-Sized Firms Total Miles	Equal-Sized Firms Owned Miles
1990	2,767	2,767	3.6	3.6
1991	2,743	2,743	3.6	3.6
1992	2,764	2,764	3.6	3.6
1993	2,740	2,788	3.6	3.6
1994	2,658	2,696	3.8	3.7
1995	2,723	2,770	3.7	3.6
1996	2,529	2,561	4.0	3.9
1997	1,778	2,233	5.6	4.5
1998	1,425	2,110	7.0	4.7
1999	892	1,500	11.2	6.7
2000	708	1,281	14.1	7.8
2001	674	1,234	14.8	8.1

Table 3: HHIs and Equivalent Number of Firms, 1990-2001

The difference between competition in terms of total miles and owned miles is striking. Using total miles, the industry has moved from an oligopolistic HHI to a very competitive one. But using owned miles, the industry remains above the 1,000 limit for government scrutiny of mergers based on the *1992 Horizontal Merger Guidelines*. The method of equivalent equal-sized firms yields a figure of eight, which is a large number of competitors by the standards of previous infrastructure developments such as railroads and early telephone.

The International Telecommunications Union *Yearbook of Statistics* reports data on total revenue of the telecommunications industry by year. They break out data on mobile telecommunications, but otherwise all services, both local and long-distance, are rolled into one number. Because the larger firms (such as AT&T) do not report disaggregated revenue, we use total telecommunications revenue as a measure of growth in the national network industry. Yearly revenue (REV_t) and growth in revenue ($GROW_t = REV_t/REV_{t-1}$) is reported in Table 4.

Another way to look at industry growth and investment is to compare the growth in revenue to the growth in capacity. The final two columns of Table 4 report two variables CU_t^T and CU_t^O that represent a sort of capacity utilization measure using total and owned miles. Let firm i's total and owned miles in year t be $M_{i,t}^T$ and $M_{i,t}^O$. Then the capacity utilization measure is:

$$CU_t^j = \frac{\frac{REV_t}{\sum_i M_{i,t}^j}}{\frac{REV_{1990}}{\sum_i M_{i,1990}^j}} \quad j = T, O$$

Thus, we take 1990 as a base year when the industry was long run equilibrium and ask whether revenue relative to capacity is larger or smaller than in that year. Assuming 1990 capacity was adequate, $CU > 1$ indicates relative scarcity while $CU < 1$ indicates relative excess capacity. Of course, revenue is not necessarily a measure of traffic carried by the networks, but the relevant capacity measure here is route miles, not bandwidth. Thus, we interpret CU as a proxy for the degree to which investment opportunities have been taken up by firms.

An interesting feature of these data is that in 1996, there were arguably opportunities to add route mileage (based on revenue), particularly when looking at owned miles only. By the end of the sample period, this measure of capacity utilization shows substantial excess capacity. As before, owned miles show much less of this trend than total miles due to the extensive used of shared mileage.

Year	REV	$GROW$	CU^T	CU^O
1990	150.0	-0.036	1.00	1.00
1991	148.3	-0.011	0.97	0.97
1992	151.1	0.019	0.97	0.97
1993	151.6	0.003	0.92	0.95
1994	155.7	0.027	0.91	0.94
1995	156.0	0.002	0.90	0.93
1996	182.5	0.170	0.96	1.00
1997	194.3	0.065	0.80	0.93
1998	195.3	0.005	0.57	0.77
1999	206.4	0.057	0.40	0.65
2000	209.7	0.016	0.33	0.58
2001	201.7	-0.038	0.28	0.53

Table 4: Revenue and a Capacity Utilization Measure, 1990-2001

6 Preemption/Race or Symmetric Buildout

The data we have presented above suggest that entry into the industry was fairly orderly until 1996 or 1997, after which it became much more rapid. Since the growth of the Internet and the Telecommunications Act of 1996 had opened up new opportunities during this period, at least some of this expansion was probably warranted by actual changes in the market. In this section, we examine whether the pattern of investment appears to indicate some type of preemption or race for dominance versus a more symmetric buildout.

We apply Gilbert and Lieberman's (1987) model of investment in oligopolistic industries. In order to implement their approach, we first construct several independent variables as follows:

Firm i's share of total industry mileage in year t is

$$SHARE^j_{i,t} = \frac{M^j_{i,t}}{\sum_i M^j_{i,t}} \quad j = T, O$$

The change in that share from year $t-1$[3] to year t is

$$DELSHARE_{i,t}^{j} = \frac{SHARE_{i,t}^{j}}{SHARE_{i,t-1}^{j}} \quad j = T, O$$

A "bandwagon effect" that measures investment by firm i's competitors during year t:

$$BAND_{i,t}^{j} = \frac{\sum_{k \neq i}(M_{k,t}^{j} - M_{k,t-1}^{j})}{\sum_{k \neq i} M_{k,t-1}^{j}}$$

Note that the bandwagon variable is different from $DELSHARE$ because it concerns investment in the current year and it does not account for a firm's own investment. The correlation between $BAND$ and $DELSHARE$ is $R = 0.10$ for total miles and $R = 0.14$ for owned miles.

The other independent variables are CU and $GROW$ which were discussed in the previous section. We also calculate interactions between all of the above and $SHARE$.[4]

The dependent variable is binary and measures whether route miles were increased by 10% or more in a given year:

$$Y_{i,t}^{j} = 1 \quad \text{if} \quad \frac{M_{i,t}^{j} - M_{i,t-1}^{j}}{M_{i,t-1}^{j}} > 0.10$$

and 0 otherwise. The reason to use the binary variable is that smaller firms may have huge percentage additions in some years, which could introduce scaling problems. Along the same lines, we eliminate the first year for new entrants from the sample.

The logic of Gilbert and Lieberman's method is that capacity expansions will be related to different independent variables under different mar-

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[3] Gilbert and Lieberman use a two year lag.

[4] Gilbert and Lieberman use a conventional measure of capacity utilization for the chemical industries they study; we cannot obtain comparable data for the national telecoms networks.

ket models. If firms behave as Cournot competitors, with or without tacit collusion, then investment will proceed in an orderly fashion. Investment will not be affected by CU, but it will respond negatively to $DELSHARE$ since firms will roughly maintain their market shares. By the same token, investment should respond positively to $BAND$ since firms have to keep up with one another in order to maintain their positions in the industry.

On the other hand, if the market model is one of preemption, then investment will not be affected by $DELSHARE$ since other, strategic considerations will drive firm behavior. Preemption implies that firms respond negatively to $BAND$ since this indicates their competitors have gotten the jump on them. And investment must respond positively to CU because successful preemption increases capacity but not its utilization.

Because small firms may differ from large firms, all variables can be interacted with $SHARE$. Since investment decisions must be taken at the beginning of the year, all variables are lagged one year except for $BAND$.

The results of logit analysis using total miles are reported in Table 5. The results give some weak support for the orderly investment hypothesis versus the preemption hypothesis. The capacity utilization measure does not affect investment, except perhaps for the larger firms, suggesting that the conditions for successful preemption are not present. And the positive coefficient on the bandwagon effect suggests that firms were not responding to preemptive behavior. However, firms did not appear to respond to changes in the route-mile share, which would be characteristic of an orderly investment pattern.

In Table 6 we report similar results using owned miles only. Here the results do seem to indicate preemption of large firms, though not for small

Variable	Uninteracted	Interacted
constant	-0.68	4.43
	(-0.76)	(1.32)
$SHARE^T_{t-1}$	-24.64**	-130.52**
	(-4.02)	(-2.02)
CU^T_{t-1}	0.36	-5.29
	(0.34)	(-1.51)
$CU^T_{t-1} \times SHARE^T_{t-1}$		122.33*
		(1.87)
$GROW_{t-1}$	14.04*	27.04
	(1.75)	(1.27)
$GROW_{t-1} \times SHARE^T_{t-1}$		-104.68
		(-0.52)
$DELSHARE^T_{t-1}$	0.33	-0.39
	(1.41)	(-1.24)
$DELSHARE^T_{t-1} \times SHARE^T_{t-1}$		8.10
		(1.37)
$BAND^T_t$	5.14**	9.71*
	(2.74)	(1.82)
$BAND^T_t \times SHARE^T_{t-1}$		-48.85
		(-0.57)
Log Likelihood	-43.82	-35.54
N	101	101

Table 5: Logit Analysis of Probability of 10% Expansion in Total Miles
Asymptotic t-statistics in parentheses.
* Significant at 0.05 level.
Significant at 0.10 level.

firms. This is based on the negative interaction terms for $BAND$ and $DELSHARE$, which suggest that the larger firms were deterred from expanding mileage due to entry of smaller firms. Again the capacity utilization measure does not appear to have played a role.

7 Conclusion

We have examined the number of fiber-optic route miles built by U.S. telecom firms from 1990-2001. By sorting through each firm's reports and press

Variable	Uninteracted	Interacted
constant	-1.15	-1.05
	(-0.78)	(-0.46)
$SHARE^{O}_{t-1}$	-20.49**	-41.28
	(-4.05)	(0.93)
CU^{O}_{t-1}	0.94	1.90
	(0.54)	(0.74)
$CU^{O}_{t-1} \times SHARE^{O}_{t-1}$		-27.70
		(-0.54)
$GROW_{t-1}$	22.59**	14.07
	(2.76)	(0.92)
$GROW_{t-1} \times SHARE^{O}_{t-1}$		211.44
		(1.27)
$DELSHARE^{O}_{t-1}$	0.02	-1.45**
	(0.26)	(-2.29)
$DELSHARE^{O}_{t-1} \times SHARE^{O}_{t-1}$		52.05**
		(2.16)
$BAND^{O}_{t}$	6.72*	16.51**
	(1.95)	(2.75)
$BAND^{O}_{t} \times SHARE^{O}_{t-1}$		-237.59**
		(-2.17)
Log Likelihood	-41.90	-33.92
N	97	97

Table 6: Logit Analysis of Probability of 10% Expansion in Owned Miles
Asymptotic t-statistics in parentheses.
* Significant at 0.05 level.
Significant at 0.10 level.

releases, we have been able to discover which routes are based on sunk investments in right of way and conduit and which are based on relatively non-sunk investment in IRUs. We find that more than half of total route miles added were based on these non-sunk forms of investment. We conclude that the loss-producing level of competition that has prevailed since 2001 is due more to the willingness of firms to sell IRUs than to actual overinvestment like that which occurred in the nineteenth century railroad boom.

We examined a measure of "capacity utilization" based on industry revenue and route miles. This measure suggests that there was a capacity crunch in 1996, but that investment after that proceeded much faster than revenue growth.

Using Gilbert and Lieberman's model of oligopoly investment, we find some evidence that the investment was orderly in the sense of firms roughly maintaining market share. The only preemptive behavior that appears to have occurred was that large firms were deterred from building more route miles due to the entry of smaller firms. This suggests that collective industry behavior was the cause of the rapid capacity expansion, not preemptive strategies.

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