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IMPACT OF LOCAL COMPETITION AND REGULATION ON DEPLOYMENT OF ADVANCED TELECOMMUNICATIONS SERVICES FOR BUSINESSES

by

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B.S., Biomedical Engineering and Electrical Engineering (2001)

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Submitted to the Engineering Systems Division
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Technology and Policy

at the

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ABSTRACT

After a decade of development, advanced telecommunications services (ATS) are widely available in many markets. This thesis is concerned with the impact of local competition and government regulation on the deployment of advanced telecommunications services for business in the United States. These services include packet switching, digital signal level (DS) technologies and synchronous optical network (SONET) – optical carrier (OC) transport. Increasingly, businesses are using these services for intra and extra network communications. Access to advanced telecommunication services is important for economic development. Government policy makers are interested in identifying what steps can be taken to accelerate the roll-out of services in their communities. Business and corporate users are often interested in services that are different from what the residential customers desire.

This thesis focuses on a broader range of advanced services of interest to the business customers than most empirical research to date. It also provides a better and more insightful metric at a finer level of granularity to address these questions. The impacts of local business conditions, rivalry and regulations on the deployment of advanced telecommunication services are analyzed by means of econometric analysis. A rich data set has been constructed which identifies the competitive, regulatory and economic climates at each incumbent's wire center in the United States. A qualitative response model is used to estimate how business characteristics of the communities and their regulatory environments affect the deployment of ATS. I conclude that local competition, federal subsidies, 271 approval, and high unbundled network element (UNE) price to book cost ratio have positive impacts on advanced telecommunication services deployment, while federal price cap regulation and location in a rural area have negative impacts. These findings have significant implications on government regulatory policies.

The thesis recommends regulatory policies, which focus on services, such as rate-based rate-of-return regulation over price caps and encourages competitors' entry, facilities-based competition and federal support to accelerate deployment of advanced telecommunications services. It concludes by encouraging governments and organizations to support more research, experimentation and better data collection to increase understanding of underlying socio-economic and regulatory factors affecting deployment of advanced telecommunications services.

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To my parents,
For giving me life

To my sister,
For bringing me joy

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I gratefully acknowledge the help of Marty Millman of the Telcordia™ Routing Administration for providing the Local Exchange Routing Guide (LERG); and Rebecca Sanders of the National Exchange Carrier Association, Inc. (NECA) Tariff 4 for her help with the initial NECA data gathering. Without their help, the analysis of this research, which is largely based on the data derived from the LERG and NECA, would not have been possible. I acknowledge the Russell Sage Foundation for providing the funding to purchase the data. I would also like to thank Scott Kennedy for his kind assistance and insightful suggestions on the data sets.

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1 INTRODUCTION

Broadband is a term that originated from the characterization of a communication channel's capacity. Broadband and its deployment have grown in importance over the past decades with government officials, regulatory agencies, business and the general public as its penetration increases in the United States of America.[1,2] *Advanced telecommunications capability is the availability of high-speed, switched, broadband telecommunications that enables users to originate and receive high-quality voice, data, graphics, and video using any technology*, as defined by the Federal Communications Commission (FCC). They include services such as packet switching, digital signal level (DS) technologies, frame relay, Asynchronous Transfer Mode (ATM) and synchronous optical network (SONET) – optical carrier (OC) transport. Such availability have the potential to improve education, enhance access to health care services and information, create better jobs and living conditions.

In this thesis, we will be primarily concerned with the impact of local competition and government regulation on the deployment of advanced telecommunications services (ATS) for business in the United States. Broadband services are widely available in many markets after a decade of development. Businesses are increasingly using these services for intra and extra network communications. Access to advanced telecommunication services is important for economic development. Government policy makers are interested in identifying what steps can be taken to accelerate the roll-out of services in

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[1] Broadband subscription to high-speed Internet access in the US will have topped 10 million by the end of the third quarter 2002, according to a new survey by the National Cable and Telecommunications Association. The report shows that subscriptions grew by 2.8 million in the first nine months of 2002.

[2] According to "Report on the Availability of High-Speed and Advanced Telecommunications Capability" released by the Federal Communications Commission (FCC) on February 7, 2002, there were approximately 9.6 million high-speed (including advanced services) subscribers, as of June 30, 2001, a 36% increase during the first half of 2001 and a 250% increase from the FCC *Second Report* issued in August 2000, (which included data from 18 months ago, December 31, 1999). In addition, there were approximately 5.9 million advanced services subscribers, as of June 30, 2001, a 38% increase during the first half of 2001.

their community. Business and corporate users are often interested in services that are different from what the residential customers desire.

1.1 Related Work

Before evaluating the impact of local competition and regulation on broadband services available to end-users, we review different ways in which previous studies have analyzed these issues. While most empirical research to date, for example the FCC research, addresses the availability of cable modem and xdsl service for residential subscribers, this thesis will focus on a broader range of services of interest to business customers, including services such as packet switching, digital signal service level technologies and SONET – OC transport. Another point to note is that currently, the FCC's broadband data set is reported at the zip code level by billing address while this thesis studies the availability of service by address. The difference can be illustrated by the following example: assume that Massachusetts Institute of Technology (MIT) totally encompasses four zip codes - no other organization or individual reside in the area associated with the four zip codes. However, all the invoices are sent to one billing office and the billing office is associated with only one zip code. The FCC would report that services are billed at the one zip code and would report that service was not available at the other three zip codes (because no one is billed at the other three zip codes). My study overcomes this flaw because availability is defined in terms of geographical area covered by an incumbent local exchange carrier (ILEC) wire center.

In terms of competition data, FCC provides a list of geographical zip codes where competitive local exchange carriers (CLECs) have reported providing local exchange service to at least one customer as of June 30, 2002.[3] The list only denotes one to three CLECs reporting service to at least one customer in the zip code but this research contains fields in the data set that record the exact numbers of competitors (for example,

[3] Refer to FCC 2002 report on competition at http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/czip0602.pdf (The information is from data reported to the FCC in Form 477.)

one, two or three), which are not shown in the FCC report. This research focuses on facilities- based competitors that appear in the Local Exchange Routing Guide (LERG)[4] and presents competition data that is further aggregated to 3, 5, 7 or 10 miles, which are more relevant and meaningful than just the number in one zip code.

Furthermore, most studies on the impact of competition and government regulation on infrastructure investments have focused on such metrics as the percentage of digital switching machines or length of fiber optic sheath within a state. For example, the FCC Monitoring Report (2002)[5] provides switching system data, gross plant expenditures covering all types of plant and transmission system data to illustrate the rapid development of fiber capacity in terms of terminations, sheath kilometers, and links. The data is reported for each of the regional Bell operating companies (along with Verizion's GTE companies) with aggregated summary data for all the reporting companies. However, there are shortcomings to such observations based on facility deployment measurements. Firstly, end-users are most concerned about the types of services available to them over the fiber, not the particular type of facility deployed. Secondly, patterns of investment may vary significantly within a company, or within a state. These two situations are usually aggregated together in prior research works and this obscures some important variation in the data. It is necessary to have a better and more insightful metric at a finer level of granularity. This work, unlike those prior studies, focuses on the types of services that are provided over the facilities, rather than on facilities.

Other related literatures on the impact of local competition on broadband services available to end-users include a paper by Tomlinson (1994) on the impact of local

[4] The Local Exchange Routing Guide (LERG) is a comprehensive routing data produced by Telcordia™ Routing Administration (TRA). The data supports the current local exchange network configuration within the North American Numbering Plan (NANP) and identifies reported planned changes in the network. The LERG is primarily designed to be used for 1) routing of inter-LATA calls by inter-exchange carriers; 2) providing information on the local environment for the numerous carriers involved in the local arena; and 3) any other company needing information about the network, numbering, and other data in the product.

[5] FCC *Universal Service Monitoring Report*, Section 10, CC Docket Number 98-202, October 2002 (with data received through April 2002). http://www.fcc.gov/wcb/iatd/monitor.html

competition on network quality.[6] The paper asserts that more stringent, quantitative quality standards become more necessary as the strategic importance of business communications increases and as networks evolve to incorporate digital data and multiplexed voice transport. It further argues that if a digital line carrying critical data experiences bit errors due to a high noise environment, significant financial losses will result. It concludes by pointing out that the high-volume end-users and inter-exchange carriers (IXC) using dedicated access circuits in major urban centers have experienced increased network quality as both local exchange carriers (LECs) and Alternate Local Transport (ALT) companies or Competitive Access Providers (CAPs) have competed for their business and have provided self-healing fiber transport. The attainment of a high level of operational cooperation among network operators in a fully competitive environment is a more important factor than network technology and architecture in future network quality.

A lot of analysts have studied the choices and effects of certain regulatory plans on the deployment of digital technologies in the telecommunications industry. Donald and Sappington (1995) argued that a state is more likely to adopt incentive regulation when residential basic local service rates have historically been high; allowed earning under rate-of-return regulation in the state have been either particularly high or low; the state's leaders tend to come from both political parties, rather than from a single party; and the bypass activity of competitors in the state is less pronounced.[7] Another empirical study by Kridel, Sappington and Weisman (1996) concludes that under incentive regulation, productivity, infrastructure investment, profit levels, telephone penetration and new service offerings have increased. Service penetration rates have generally remained stable or decreased slightly while service quality does not appear to have been affected

[6] Tomlinson, Richard G. (1994), *The Impact of Local Competition on Network Quality*, Connecticut Research.

[7] Donald, Stephen G., and David E.M. Sappington (1995), *Explaining the Choice Among Regulatory Plans in the U.S. Telecommunications Industry*, Journal of Economics and Management Strategy, Volume 4, Number 2, 237-265.

adversely.[8] Greenstein, McMaster and Spiller (1995) have found that price regulation and in particular, price caps is a more potent regulatory mechanism for infrastructure deployment by local exchange carriers than the standard earning sharing scheme. Secondly, when associated with an earnings sharing scheme, price regulation is less effective in triggering infrastructure deployment than when it is implemented by itself.[9] The unit of observation here was a company's operation in a state, while this study focuses on the micro level of geographical area covered by an ILEC wire center.

Willig, Lehr, Bigelow and Levinson (2002) argued that neither theory nor empirical data supports the ILEC argument that mandatory unbundling provision hinders ILEC investment.[10] These authors estimated that a 1% unbundled network element (UNE) rate reduction corresponds with approximately a 2.1% to 2.9% ILEC investment increase and concluded that unbundling of ILEC networks promotes competition, and thereby stimulates investment in telecommunications infrastructure by incumbents and entrants alike.

The report prepared by the Organization for Economic Cooperation and Development (OECD) on "The Development of Broadband Access in OECD Countries" (2001) concluded that the current bottleneck to growth in the communications sector is the limitations of local access networks.[11] These limitations are not just technological but also include the inheritance of many decades of monopoly provision of access networks -

[8] Kridel, Donald, David E.M. Sappington, and Dennis L. Weisman (1996), *The Effects of Incentive Regulation in the Telecommunications Industry: A Survey*, Journal of Regulatory Economics, 9:269-306

[9] Greenstein, Shane M., Susan McMaster, and Pablo T. Spiller (1995), *The Effect of Incentive Regulation on Infrastructure Modernization: Local Exchange Companies' Deployment of Digital Technology*, Journal of Economics and Management Strategy, Volume 4, Number 2, 187-236

[10] Willig, Robert D., William H. Lehr, John P. Bigelow, and Stephen B. Levinson (2002), *Stimulating Investment and the Telecommunications Act of 1996*

[11] This public report was prepared by Dr. Sam Paltridge of the OECD's Directorate for Science, Technology and Industry and published on the responsibility of the Secretary-General of the OECD. This report was presented to the Working Party on Telecommunications and Information Services Policy in June 2001, and was recommended to be made public by the Committee for Information, Computer and Communications Policy (ICCP) in October 2001.

there is usually only one or two networks passing most businesses in OECD countries and in certain cases, these networks are owned by the same company. For OECD governments, infrastructure competition is the key to increasing broadband access. Another necessary step is the opening up of network elements, of players in dominant positions, to competitive forces. Policies such as unbundling local loops and line sharing are key regulatory tools available to create the right incentives for new investment in broadband access. The OECD concluded that opening access networks, and network elements, to competitive forces increases investment and the pace of development.

1.2 Thesis Overview

Chapter 2 discusses in detail some of the advanced telecommunications or broadband technologies used in business, how and why they are used, including packet switching, digital signal service level technologies (DS), frame relay, Asynchronous Transfer Mode (ATM) and Synchronous Optical Network (SONET).

Chapter 3 will discuss briefly the impact of the 1996 Telecommunications Act on competition in local telecommunications services provision. This will set the stage for the discussion on the effect of local competition and regulation on broadband services available to end-users.

Chapter 4 describes the data sources and data sets collected. It highlights their importance and describes the different fields of the data set. It will briefly describe the accuracy and validity of the data sets and their sources.

This chapter will also attempt to address the following questions: i) if competition has a positive impact on the availability of advanced telecommunications services – according to Farrell and Katz (1998), innovation may occur more rapidly in a monopoly environment because the monopolist can capture all the rents associated with their efforts and therefore, sharing of the incumbents' facilities raises difficult issues for innovation incentives,[12] while Woroch's study (1998) supports the claim that facilities-based entry stimulates investment by both incumbents and entrants;[13] and ii) how different regulatory environments affect the behavior of the local exchange companies.

In order to examine these issues, a data set has been constructed that will allow for the econometric analysis of the above hypotheses. The econometric model needs to control for i) advanced telecommunications services availabilities such as packet switching (ATM is subsumed under this category), DS technologies and SONET – OC transport, by wire center (years 1994-2001); ii) local competition data (C++ program was written to find the number of wire centers served by competitive providers, located within X mile radius of wire centers served by an incumbent); iii) economic and demographic data by wire center from the 1990 census and forecasted census data for subsequent years; iv) business data by wire center, including ownership of wire centers; number of employees and payroll; number of small, medium and large type of business by standard industrial code; and v) regulatory environments. An explanation of the various variables and why they are included will also be described in this section.

Chapter 5 builds on the previous chapter and describes the econometric models used to test the hypotheses and determine the results, based on the data sets described in the previous chapter. Besides explaining important concepts, equations and assumptions embedded in the models, this chapter also analyzes the results and presents the findings based on the econometric models and regression analyses. It will restate and summarize the conclusions to the hypotheses tested: i) if competition has a positive impact on the availability of advanced telecommunications services; ii) if regulation affects the behavior of the firms and if regulatory measures can directly increase the benefits (e.g. more advanced services available) of consumers.

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[12] Farrell, Joseph, and Michael L. Katz (1998), *Public Policy and Private Investment in Advanced Telecommunications Infrastructure*, IEEE Communications Magazine

[13] Woroch, Glenn A. (1998), *Facilities Competition and Local Network Investment: Theory, Evidence and Policy Implications*, Industrial and Corporate Change, Vol. 7 601-614

Chapter 6 discusses the policy implication of the findings and suggests recommendations. It will attempt to answer question such as if entry stimulates new services by ILECs and make suggestions on regulatory policies to increase competition of local loop and provision of advanced data services for businesses. It will serve as a conclusion to the thesis and suggest possible directions for future research.

1.3 Summary of Findings and Recommendations

In summary, using the econometric tools and analyses presented in this thesis to evaluate the factors that affect the deployment of services by ILECs, we found:

1. The presence of CLECs has a strong positive impact on ILECs' tariff offering of advanced telecommunications services – packet switching, DS and OC, with ATS availabilities (and level of advanced services) highest within vicinities of large cities where there are a lot of competition from CLECs (Section 5.3.2.1).

2. The availability of tariff offering of packet switching is positively correlated to wire centers owned by Regional Bell Operating Companies (RBOCs) and medium size firms, with RBOC ownership showing slightly stronger affect. The availability of a more advanced service like DS3 is also positively correlated to RBOC and medium size firm ownerships, with medium size firm ownership showing slightly stronger affect. This shows that RBOCs have less incentive to provide DS3 services than medium size firms. OC availability is positively correlated to RBOC ownership but negatively correlated to medium size firm ownership, suggesting that OC is the level of ATS that the RBOCs are providing while the medium size firms usually do not provide OC (Section 5.3.3.1).

3. There are strong negative correlations between federal price cap regulation and availabilities of packet switching, DS and OC services (Section 5.3.3.2).

4. Location of wire center in a rural area has strong negative correlation with the availabilities of packet switching, DS and OC services. All else equal, if classified as rural (by FCC), lower likelihood of that ATS is provided (Section 5.3.3.2).

5. The availability of subsidized loans indeed accelerates the availabilities of advanced telecommunications services. The presence of Rural Utilities Services (RUS) support on the firms is found to have a strong positive correlation with the availabilities of packet switching, DS3 and OC services (Section 5.3.3.2).

6. The Bell Operating Companies (BOCs) must file applications with the FCC on a state-by-state basis in order to provide in-region inter-LATA services under Section 271 of the Communications Act of 1934 – known as the 271 approval process. This process yields a significant positive impact on the development of local competition. 271 approvals by the FCC have strong positive impact on the deployment of packet switching and DS3 services but show negative impacts on the deployment of OC services (Section 5.3.3.3).

7. To examine the impact of unbundled network element (UNE) prices on the deployment of advanced telecommunications services, we focus on the RBOCs. We found that the availabilities of packet switching, DS3 and OC have strong positive correlation to the ratio of forward-looking UNE prices to their embedded costs. In other words, the RBOCs and other ILECs are more likely to deploy ATS in states where the ratio of UNE prices to embedded costs is relatively high (Section 5.3.3.4).

Based on these findings, the following policies are recommended (Section 6.2):

1. Proactively take steps to promote accelerated deployment of advanced telecommunications services, especially at the local level.

2. Encourage new market entrants and local competition to accelerate roll-out of advanced telecommunications services.

3. Construct regulatory policy framework in such a way as to place more emphasis on facilities-based competition over unbundling.

4. Use appropriate policy instruments to address the gaps where facilities-based competition is unlikely to occur or may occur slowly, such as using rate-based rate-of-return regulation over price caps.

5. Understand the impact of mandates in the 1996 Telecommunications Act such as the 271 approval test on deployment of ATS and utilize such policy instruments appropriately.

6. Formulation of future regulation should focus on service rather than on particular transmission technology.

7. More efforts should be made to accelerate ATS deployment, especially in rural areas through grants and loans from organizations such as RUS.

8. Governments should support more research and development on access technologies, especially targeting the needs of non-incumbent players and areas that are not normally accessible to secure, private sector funding.

9. Encourage and support continued efforts on more comprehensive and up-to-date data collection and research on the underlying socio-economic, political and regulatory factors of advanced telecommunications services deployment.

2 TECHNOLOGICAL CONTEXT

Advanced telecommunications service is a term defined by the FCC to describe a range of high-bandwidth technologies developed for the transmission and delivery of high-speed data communication services targeted at business and residential end-users. The technology behind these advanced telecommunications services is one of the most important drivers (or constraints) of how such services can be deployed in terms of their availabilities, economics and cost issues. An understanding of the different advanced telecommunications technologies incorporated in the data set, why and how businesses use these technologies, is therefore crucial in our understanding of the deployment of advanced telecommunications services.

2.1 Need for Advanced Telecommunications Services

Network can be broadly characterized as private or public networks. The private network is usually owned by a single organization or company while the public network is usually owned by common carriers such as the local phone companies. Private networks often use local area network (LAN) technology with multiple LANs linked together in a building or campus and it operates autonomously from other networks such as the Internet. Business organizations are responsible for managing their own private networks by purchasing their own equipment, hiring network managers to design, implement, maintain and upgrade their networks. These private networks often need to be extended as large organizations may have multiple buildings or campuses. They may contract for leased lines from common carriers. In contrast, the public network is operated by common carriers, which may include local telephone companies or other organizations that build networks out of leased lines. Several business organizations may subscribe and connect to the public network. The data transits public network to other organizations.

High-bandwidth technologies and services are essential for businesses primarily due to the increased traffic on the private and public networks: local LAN segments; internetworking between local and remote LAN segments; and increasingly high-bandwidth business applications for computing and exchange of information and services.

There have been increasing terminal-to-host communications and file sharing applications in businesses occurring over LANs such as ARCnet, Ethernet and token ring. Coupled with the increased awareness and knowledge of LAN capabilities, the number of LAN users has significantly increased. Traffic per user has risen as well. These factors have contributed to the overall increase in traffic on LANs. Using routers or bridges, network managers in companies have frequently redistributed the increased data and information transfer by segmenting a large LAN into smaller sub-networks. However, once the network capacity is reached, a higher-bandwidth solution is critical to the continued operation of these businesses.

Distributed computing architecture constituted another source for increased inter-network traffic or LAN-to-LAN communication in companies. Solutions with less bandwidth like 56 Kbps leased lines had to be replaced by higher capacity DS solutions such as T-1 lines. These T-1 lines are comparatively more expensive and the distributed computing architecture often requires several T-1 lines at once. Cost of point-to-point circuits is an important consideration – economical and high-bandwidth LAN or wide area network (WAN) have become increasingly essential in businesses.

Business computing and desktop operations like computer-aided design (CAD), computer-aided manufacturing (CAM), complex mathematical computation and modeling and large database files have pushed the capacities of LANs and WANs to their maximum. Sometimes, time-sensitive applications such as multimedia and biomedical applications demand large bandwidth and low end-to-end delay. These applications again call for advanced telecommunications services in business operations.

Essentially, advanced telecommunications services for business consist of a few different modalities, which different businesses may select from based on needs, prices, capacities and complexity concerns. These modalities include direct connection from a business' facilities to either one another or to long-distance carriers or Internet service providers (ISPs). For example, businesses manage and purchase their own circuits in the case of DS or SONET – OC transport, and businesses outsource the networks and purchase access from common carriers in the case of frame relay or ATM. A brief comparison between frame relay and ATM and the reasons for choosing them are shown in Table 2.1 below.

Table 2.1: Comparison between Frame Relay and ATM

Frame Relay	Asynchronous Transfer Mode (ATM)
Speed and bandwidth	Higher speed and bandwidth
Good performance	Better performance with inherent quality of service (QoS) support
Cost-effectiveness	Less cost-effective
Reliability	Higher reliability
Consolidated line for data, voice and video	Better consolidation for data, voice and video
Low-entry price point	High-entry price point

In summary, a retail or wholesale business customer may just need more bandwidth. It may seek a form of transport such as DS or the higher capacity, more flexible SONET – OC. In this situation, the role of the ILEC is limited – it merely rents out a share of its network. Therefore, we broadly categorize the forms of transport into DS and OC. Alternatively, if the business customer needs some network intelligence on top of bandwidth, it may choose packet switching – using frame relay or ATM, in which the ILEC provides certain level of switching, network and security control. Here, the business customer is facing a decision tree where it decides in the first stage whether only bandwidth or some network intelligence is required. If only bandwidth is required, it then decides between DS or OC but if some level of network intelligence is necessary, packet switching is a sensible option.

These advanced telecommunications technologies and network services such as packet switching, DS, frame relay, ATM and OC, summarized in Table 2.2 on the next page, are critical to businesses as they offer high bandwidth and favorable economics in the increasingly complex and networked business environments.

Table 2.2: Brief Overview of Specialized Digital Network Services/ Technologies

Network Services/ Technologies	**Examples of Tariff Products**	**Areas Typically Used**	**How Used**
Packet Switching	Access concentrator functions: collects customer data from many access lines and provides concentration for delivery to the packet switch and vice versa	Medium to large organizations, ISPs, Telcos	Protocols in which messages are broken up into small packets and transmitted
Digital Signal Level (DS) Technology – DS1, DS3 etc. (Also known as T-1, T-3)	High capacity multiplexing: DS0 – 64 Kbps DS1 – 1.544 Mbps DS3 – 44.736 Mbps	Medium to large organizations, ISPs, Telcos	Backbones and access to long distance companies and ISPs
Frame Relay[14]	Connection-oriented frame transport services: 64 Kbps to 44.736 Mbps	Medium to large commercial customers	Public and primarily data network service for LAN to LAN connections
Asynchronous Transfer Mode (ATM)[15]	Data switching services: 56 Kbps to 622 Mbps	Telcos, ISPs, large organizations such as major universities	To switch high-usage backbone voice, video and data traffic
Synchronous Optical Network (SONET) – Optical Carrier (OC)	Data transmission: Up to 129,000 channels on fiber optic cable	Telcos	Provides extra reliability to large companies or corporate users. Transports voice, video and data traffic at high speeds over fiber networks

[14] Frame relay is generally subsumed under the packet switching category in our study.

[15] ATM is also generally subsumed under the packet switching category in our study.

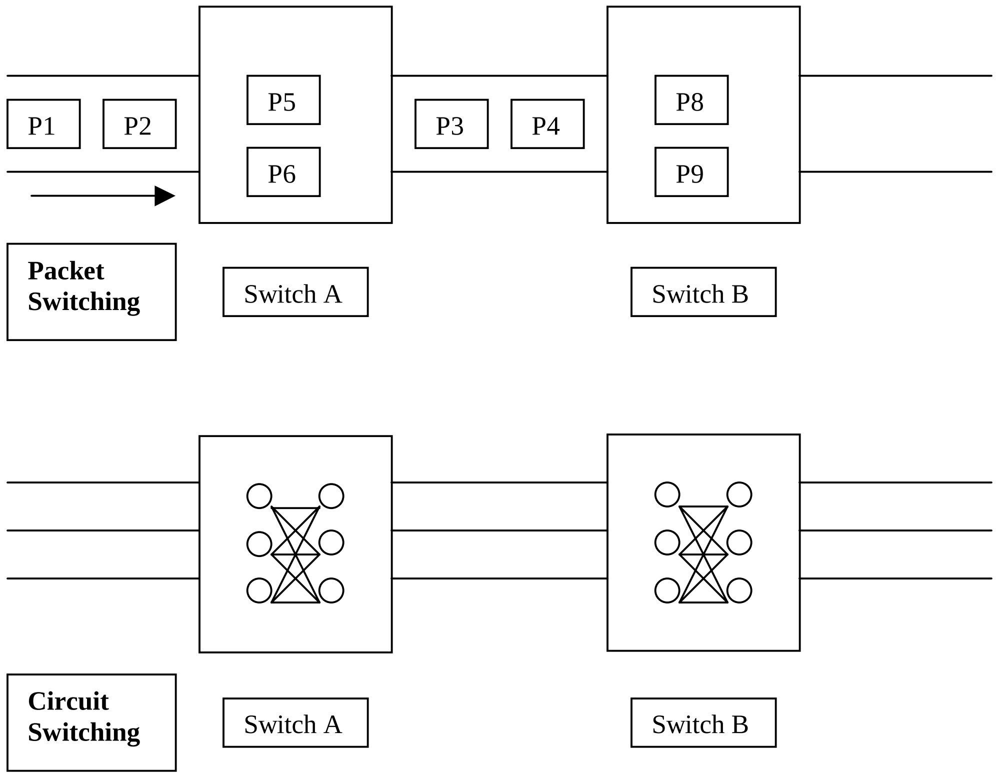
2.2 Packet Switching

Business inter-networks usually consist of a collection of servers, workstations and LANs linked together through WANs. Various switching technologies and services, such as packet switching and circuit switching connect the business end-user equipment to the network.

Packet switching refers to protocols in which messages are broken up into small packets before they are sent. Each packet is transmitted individually across the net, and may even follow different routes to the destination. Thus, each packet has header information about the source, destination, packet numbering, etc. At the destination, the packets are reassembled into the original message. Most modern WAN protocols, such as TCP/IP, X.25 and frame relay, are based on packet switching technologies.

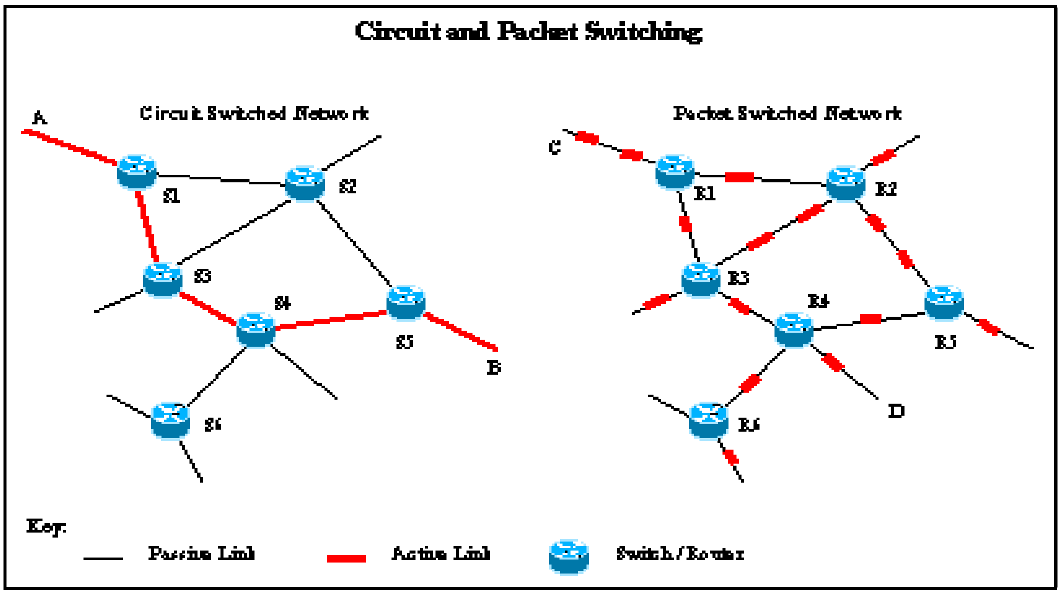
While most modern WAN protocols are based on packet switching technologies, normal telephone service is based on a circuit switching technology, in which a dedicated line is allocated for transmission between two parties. For example, when a telephone call is placed, various LEC and IXC switching systems establish a connection between the calling and the receiving parties. Once the connection is set up, the remote telephone rings and the end-to-end connection is complete when the receiving party answers the call. Circuit switching is ideal when data must be transmitted quickly and arrive in sequencing order at a constant arrival rate. This is the case with transmitting real time data, such as the phone conversation. Packet switching is more efficient and robust for data that is bursty in its nature, and can withstand delays in transmission, such as e-mail messages, and web pages. Figure 2.1 on the next page illustrates some of the differences between packet switching and circuit switching technologies.

Figure 2.1: Comparison of Packet Switching and Circuit Switching Technologies



In terms of the differences between a packet-switched network and a circuit-switched network, the latter predetermines the amount of bandwidth of the end-users while the former improves on it by allowing dynamic sharing of the available LAN or WAN bandwidth. In a packet-switched network, workstations send packets of information, which are switched into and out of hubs, servers, bridges and so on until they reach their destinations. In this case, communication lines are not dedicated to passing packets of information from the source to the destination. In fact, different messages (in packets) can pass through different routes. For example, in Figure 2.2 on the next page, when information is being transmitted from its source, point C to its destination, point D, a packet leaves C and is directed by switch R1 onto R3 onto R4 and finally onto D. However, when the connection between R1 and R3 experiences a delay or is not functioning for any reasons, R1 would redirect the packets to R2, then R5 and so on. Contrast this with a circuit-switched network – the circuit is pre-defined and reserved for one connection from the start to the end, and it only becomes available when that connection is terminated. For example, in Figure 2.2, if a connection between points A and B is required, a circuit can be set up through S1, S3, S4 and S5. Other routes are possible to allow for resilience, and the connections between the switches may consist of more than one circuit to allow for the set-up of multiple circuits at the same time.

Figure 2.2: Comparison of Packet-switched and Circuit-switched Networks (Source: O2)



Two basic techniques are usually found in packet switching: i) virtual circuit packet switching; and ii) datagram switching.

2.2.1 Virtual Circuit Packet Switching Networks

In virtual circuit packet switching, an initial setup phase is used to set up a route between the intermediate nodes for all the packets passed during the session between the two end nodes. In each intermediate node, an entry is registered in a table to indicate the route for the connection that has been set up. Thus, packets passed through this route, can have short headers, containing only a virtual circuit identifier (VCI), and not their destination.

Each intermediate node passes the packets according to the information that was stored in it, in the setup phase.

In this way, packets arrive at the destination in the correct sequence, and it is guaranteed that essentially there will not be errors. This approach is slower than circuit switching, since different virtual circuits may compete over the same resources, and an initial setup phase is needed to initiate the circuit. As in circuit switching, if an intermediate node fails, all virtual circuits that pass through it are lost. The most common forms of virtual circuit networks are X.25 and frame relay, which are commonly used for public data network (PDN).

2.2.2 Datagram Packet Switching Networks

Datagram packet switching adopts a different, more dynamic scheme, to determine the route through the network links. Each packet is treated as an independent entity, and its header contains full information about the destination of the packet. The intermediate nodes examine the header of the packet, and decide to which node to send the packet so that it will reach its destination. In this decision, two factors are taken into account:

- The shortest way to pass the packet to its destination - protocols such as RIP/OSPF are used to determine the shortest path to the destination.
- Finding a free node to pass the packet to - in this way, bottlenecks are eliminated, since packets can reach the destination in alternate routes.

In this approach, the packets do not follow a pre-established route, and the intermediate nodes (the routers) do not have pre-defined knowledge of the routes that the packets should be passed through. Packets can follow different routes to the destination, and delivery is not guaranteed although packets usually do follow the same route and are transmitted reliably. Due to the nature of this method, the packets can reach the destination in a different order than they were sent, thus they must be sorted at the destination to form the original message. This approach is time consuming since every router has to decide where to send each packet. The main implementation of Datagram Switching Network is the Internet, which uses the IP network protocol.

2.3 Digital Signal Level (DS) Technology

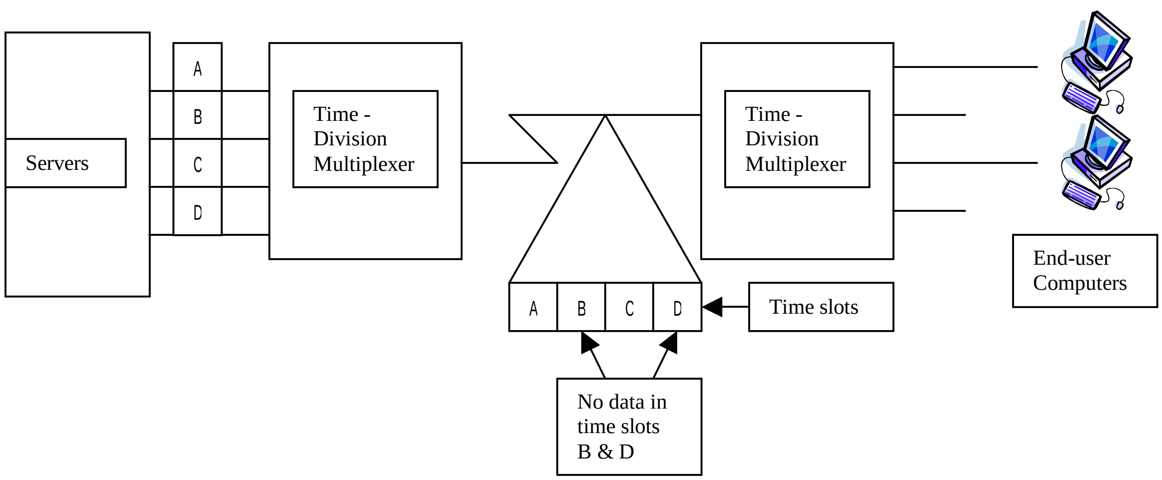
Digital Signal Level (DS) is the speed at which various T-1, T-3 and fractions of these speeds run. T-1 is also referred to as DS-1, which consists of 24 DS-0. The DS-1 service is a high capacity, point-to-point, line service that transmits simultaneous full-duplex digital signals at the entire bandwidth of the circuit, 1.544 megabits between a company designated point-of-presence (POP) in one exchange area and a company designated point-of-presence in another exchange area. DS-1 could also serve two customers or buildings in the same exchange area (that is, the DS-1 link does not have to connect to another exchange area). For example, ISPs use primary rate interfaces (DS-1) to connect their modem banks to the public switched network. Access to this service is only through dedicated access, which refers to an access line service consisting of a continuously connected circuit between a company's premises or serving telephone company central office and a company terminal, available on a full-time, unshared, basis, which is used for the origination or termination of services. The DS-0 service transmits at the speed of each channel of the T-1 circuit, 64Kbps.

Although each channel of T-1 is 64Kbps, the entire bandwidth of the circuit is higher than 24 x 64,000 or 1,536,000. The extra 8000 bits are used for synchronization to keep the timing set between frames, which denote a transmission where bits from each of the 24 channels have been sampled and put onto the T-1 line.

2.3.1 Time Division Multiplexing and Limitations

T carrier signals are based on time division multiplexing, where every device sending signal through a T-1 line is given a time slot. If there are four telephones all competing for the same T-1 circuit, time slots are assigned to each telephone for the length of the phone call. The same applies to personal computers (PCs). If a PC stops sending for duration of time, the slot will not be reassigned to another computer – the allocated time slot will be transmitted without any bits. This is quite inefficient in its utilization of the WAN as idle time slots and wasted bandwidth will result from pauses in data transmission (Figure 2.3).

Figure 2.3: Illustration of Wasted Time Slots in a Time Division Multiplexing Circuit



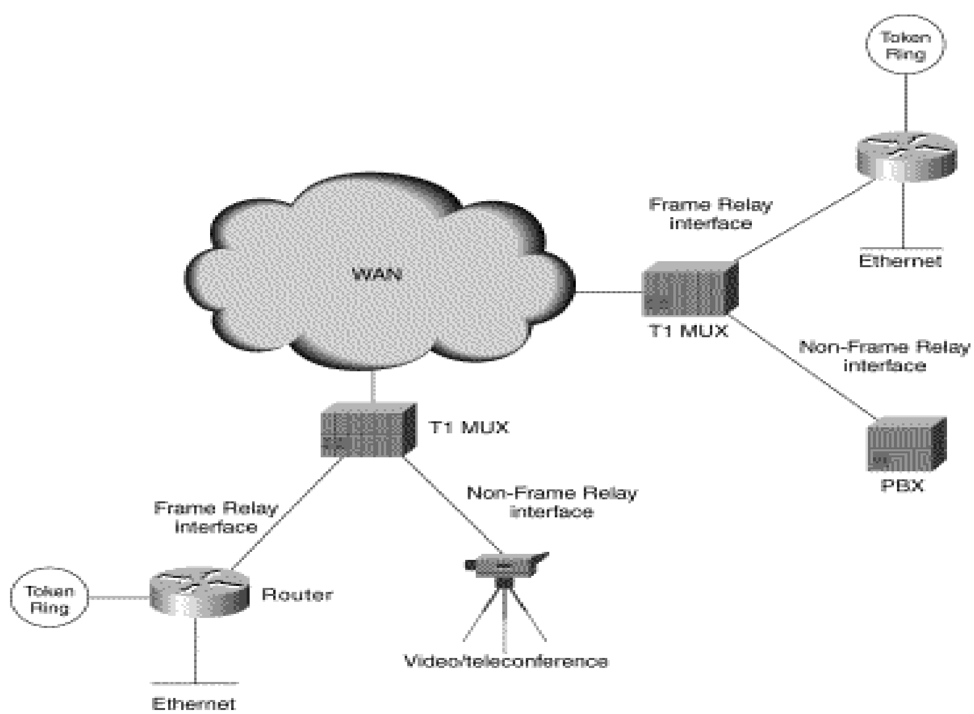
In contrast, Asynchronous Transfer Mode (ATM) uses newer transmission techniques that do not allocate individual time slots to every device – only transmitted bits use bandwidth. This guarantees a much more efficient transmission capacity and bandwidth use.

2.4 Frame Relay

Frame relay is a public network that allows businesses to transmit data between multiple locations. It uses a streamed lined Data Link Layer protocol, often compared to X.25. It provides a relatively simple, connection-oriented frame transport service commonly used to replace private lines in mesh topology networks (as illustrated by Figure 2.4 below). Using frame relay, business organizations reduce the need to plan, construct and maintain their own duplicate paths to each of their sites.

Most LECs and IXCs provide frame relay service as a tariffed offering. Both intra- and inter-LATA services are available. It acts as a virtual, private dedicated network service without requiring businesses to lease their own dedicated lines and provides a good alternative to businesses constructing their own private data networks. Access rates range from fractional T-1 (n x 56/64Kbps) to DS1 (1.544 Mbps) to higher rates like DS3 (44.736 Mbps).

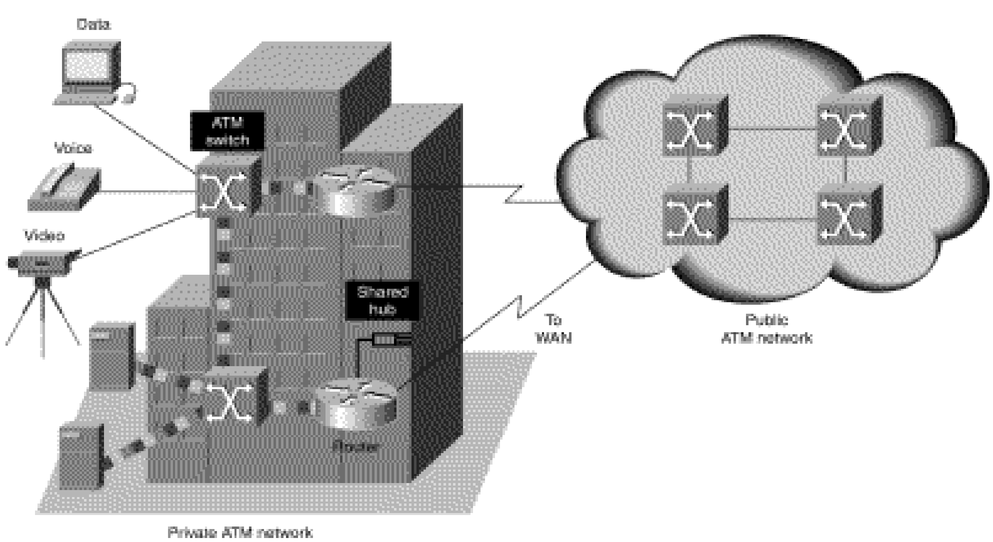
Figure 2.4: A Simple Frame Relay Network that Connects Different Devices to Various Services across WAN (Source: Cisco Systems Inc.)



2.5 Asynchronous Transfer Mode (ATM)

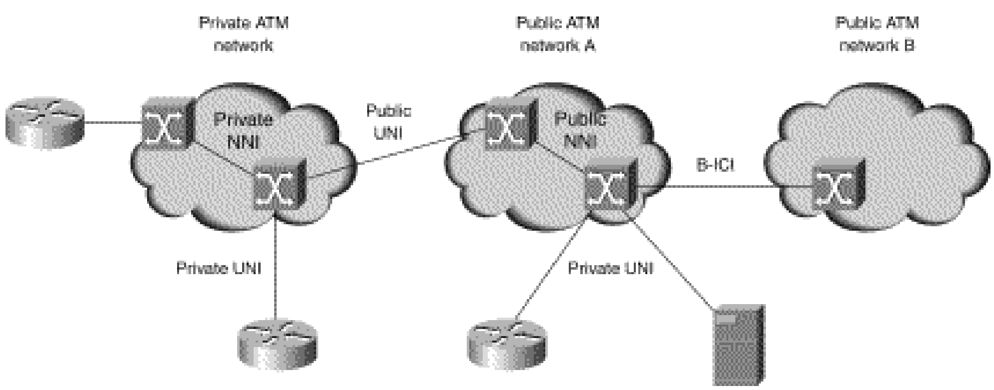
ATM is the abbreviation for Asynchronous Transfer Mode, a network technology that is an International Telecommunication Union – Telecommunications Standards Section (ITU-T) standard for information transfer, whereby information of various types, such as voice, video, or data, is transmitted in small, fixed-size *cells* or *packets*. In this study, ATM is subsumed under the packet switching category. The cell used with ATM is relatively small compared to units used with older technologies. The small, constant cell size allows ATM equipment to transfer audio, video and computer data over the same network, and assures that no single type of data hogs the line. Figure 2.5 below illustrates a private ATM network and a public ATM network for businesses carrying voice, video, and data traffic.

Figure 2.5: Private ATM Network and Public ATM Network Carrying Voice, Video and Data Traffic (Source: Cisco Systems Inc.)



ATM is a connection-oriented service for both LAN and WAN applications. While some people believe that ATM holds the answer to the Internet bandwidth problem, others are skeptical. An ATM network consists of a set of ATM switches interconnected by point-to-point ATM interfaces or links. ATM creates a fixed channel, or route, between two points whenever data transfer begins. This differs from TCP/IP, in which messages are divided into packets and each packet can take a different route from source to destination. This difference makes it easier to track and bill data usage across an ATM network, but it makes it less adaptable to sudden surges in network traffic. Nearly all major LECs and IXCs currently develop ATM products and services. Figure 2.6 below illustrates the ATM network and interface architecture for private and public networks.

Figure 2.6: ATM Network and Interface Architecture for Private and Public Networks (Source: Cisco Systems Inc.)



ATM technology attempts to combine the advantages offered by the circuit switching and packet switching transmission protocols – the guaranteed delivery of circuit-switched networks and the robustness and efficiency of packet-switched networks.

When businesses are purchasing ATM services, there are generally four different types of services for selection:

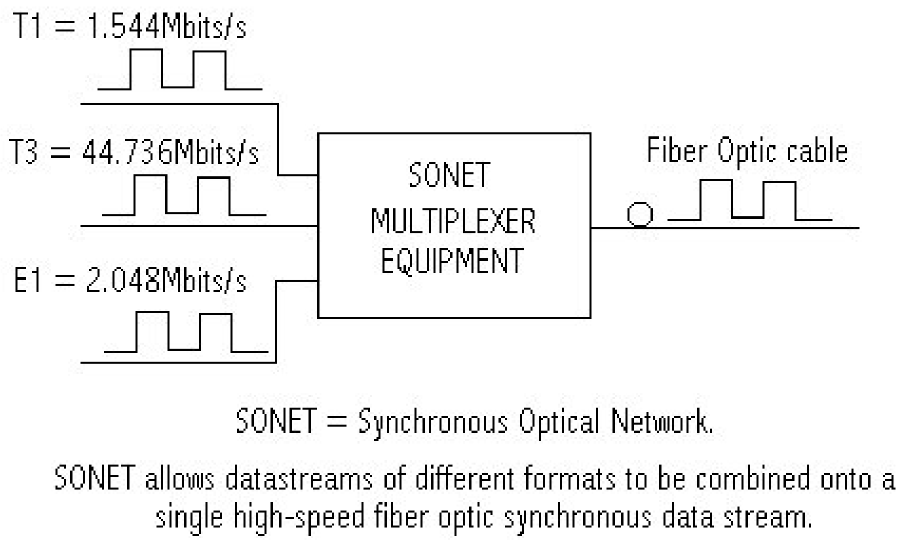
1) *Constant Bit Rate (CBR)* specifies a fixed bit rate so that data is sent in a steady stream. This is analogous to a leased line.

2) *Variable Bit Rate (VBR)* provides a specified average throughput capacity but data is not sent evenly. This is a popular choice for voice and videoconferencing data.
3) *Unspecified Bit Rate (UBR)* does not guarantee any throughput levels. This is used for applications, such as file transfer, that can tolerate delays.
4) *Available Bit Rate (ABR)* provides a guaranteed minimum capacity but allows data to be bursted at higher capacities when the network is free.

2.6 High-Speed Transport - Synchronous Optical Network (SONET)

SONET stands for Synchronous Optical Network. SONET was proposed by Bellcore in the middle 1980s and is now an ANSI standard. As communication between different networks often requires complicated multiplexing (or demultiplexing), coding (or decoding) processes to convert a signal from one format to another format, SONET offers a solution by standardizing their rates and formats. It is a standard way to interconnect high-speed traffic from multiple vendors. The Synchronous Transport Signal (STS) is the basic building block of SONET optical interfaces. The STS consists of two parts, the STS load, which carries business data information and the STS overhead, which carries the signaling and protocol information. At one end of the communication system, signals with various rates and formats are fed into the SONET multiplexer equipment. A signal is converted to STS and transmits through various SONET networks in the STS format until it terminates. The terminating equipment converts the STS back to the standard user format. Figure 2.7 on the next page illustrates this standardization process.

Figure 2.7: Standardization Achieved by a Synchronous Optical Network (SONET)

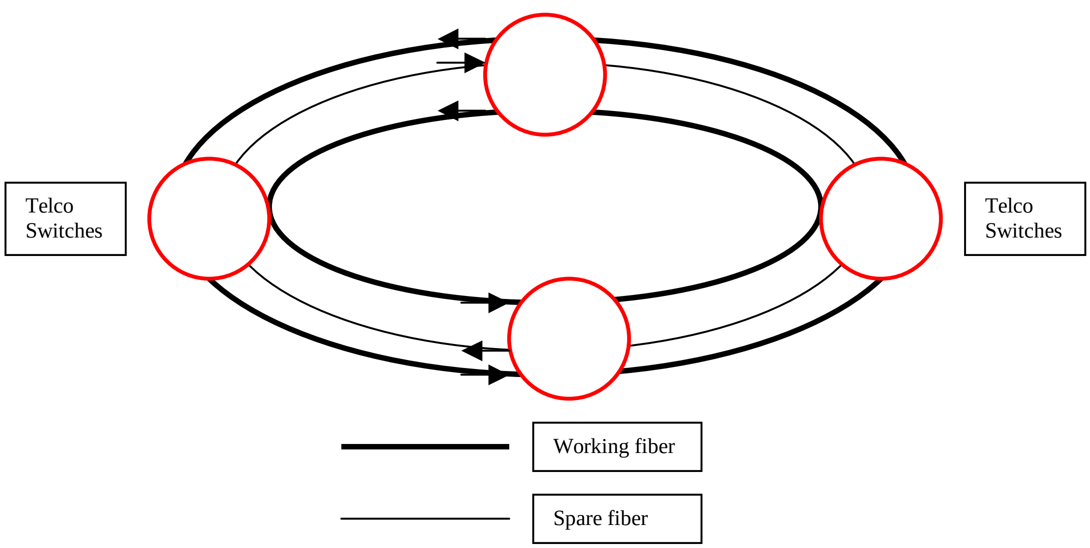


Whereas ATM is a switching and multiplexing technique, SONET is a transport device using fiber optic cabling. SONET defines interface standards at the physical layer of the Open System Interconnection (OSI) seven-layer model. The standard defines a hierarchy of interface rates that allow data streams at different rates to be multiplexed. ATM is a Layer 2 service as it performs switching, addressing and error checking. SONET is a Layer 1 service. Layer 1 functions define interfaces to physical media such as copper and fiber optic cabling. SONET takes data and transports it at high speeds called optical carrier (OC) speeds. SONET links transport data from ATM switches, T-1 and T-3 multiplexers.

SONET establishes OC levels from 51.8 Mbps (about the same as a T-3 line) to 2.48 Gbps. Prior rate standards used by different countries specified rates that were not compatible for multiplexing. With the implementation of SONET, communication carriers throughout the world can interconnect their existing digital carrier and fiber optic systems.

Reliability can be achieved with higher speeds derived from the fiber network. In contrast to a copper cut which only impacts one customer, a failure in the SONET ring which serves major police departments, armed forces units, hospitals or civilian organizations can have severe and adverse impacts on the health, safety, national security and important daily functions of those communities. To increase the level of reliability, SONET deployment often uses a ring topology – one set of fiber strands serves to send and receive while the other serves as a spare. If one set of fiber strands is disconnected or damaged due to any reasons, the traffic will be rerouted through the spare set in the other direction. Compared to fiber strands running in a straight line topology, which offers no other route for traffic in case of disconnection, this configuration offers more reliability and less intervention by the carrier in case of an emergency. Figure 2.8 below illustrates this concept.

Figure 2.8: Illustration of the Reliability of a Fiber SONET Ring



Note: In this Figure, one set of fiber strands serves to send and receive while the other serves as a spare. If one set of fiber strands is disconnected or damaged due to any reasons, the traffic will be rerouted through the spare set in the other direction.

2.6.1 Telecom Company SONET Offerings – Higher Capacity at Lower Costs

Many local telecommunications company are offering spare fiber-based SONET ring capacity to business customers. Offerings to interconnect T-1 and more importantly, T-3 services to the SONET rings for extra reliability are not uncommon. These services target businesses and call centers such as airlines, financial services industry or emergency response services that demand both capacity and reliability.

The speeds of SONET rings are increasing. This translates to less investment on overhead costs such as equipment and fiber strands and higher capacity to deliver vast amount of traffic. For example, Qwest Communications Corporation is installing an OC-192, fiber-based SONET network to prepare for higher demands in motion, color and video applications that will drive the network capacity. Qwest is using Nortel SONET gear and multiplexing eight OC-192 streams onto fiber. This allows 80 megabits or one million calls on each fiber route.

It is now easier for new carriers to reach OC-192 speeds due to technological advances. OC-192 demands a special fiber known as zero dispersion fiber – thinner and has fewer impurities than previous standard single mode fiber for carrier networks. This raises the quality and grade of fiber optic cabling in their cabling plants and reduces upgrade costs, as they do not need to upgrade older multiplexers and SONET devices.

2.7 Location and Service Availability

Today, businesses that are dependent on information technologies have a variety of options available to them, including the different types of advanced telecommunications services. Different technologies and services offer different comparative advantages for these businesses, especially in terms of their economics. For example, OC transport is a dedicated facility and is therefore, comparatively more expensive than frame relay for transmission of moderate amount of traffic. The choice of the types of services these companies may subscribe to and the locations of these companies are crucial – they are partially dependent on the types of telecommunications services available in an area. These companies will employ careful planning and consultation on the availabilities of services in different areas of the country before making important corporate decisions with regard to their locations. This chapter highlighted some of the advanced telecommunications services and technologies these businesses may subscribe to. In the subsequent chapters, the patterns of deployment of these services across the United States will be discussed in greater details.

3 IMPACT OF THE 1996 TELECOMMUNICATIONS ACT ON COMPETITION IN LOCAL TELECOMMUNICATIONS SERVICES PROVISION

3.1 Background and Aims of the 1996 Telecommunications Act

The Telecommunication Act of 1996 is a landmark in the history of telecommunications in the United States and is central to many of the competition and regulatory policies discussed in this thesis. In general, the Act removes from each state the ability to approve and disapprove competition in local telecommunications, whereby state utilities are restricted from stopping entry of any qualified entrant into interstate or intrastate telecommunications service. An exception is the case of rural carriers where state public utilities commissions can decide if these rural companies have to provide unbundled network elements (UNEs).[16] The Act sets the time frame and method whereby competition will be opened to a variety of suppliers. It outlines a procedure where local telephone companies can expand their operations into manufacturing and inter-LATA,[17] in-region and out-of-region, telecommunications.

The Act was passed twelve years after the breakup of AT&T in 1984. It updates the Communications Act of 1934 and provides a national policy framework that relies on competition and market forces to advance the deployment of communications infrastructures throughout the country. The Act envisions competition in all telecommunications markets, both in the markets for the various elements that comprise the telecommunications network and for the final services the network creates. It touches

[16] See Section 253 of the 1996 Telecommunications Act and the order before the New Mexico State Corporation Commission in 1997 concerning the "Interconnection Contract between AT&T Communications of the Mountain States, Inc. and GTE Southwest, Inc." (Docket Number 97-35-TC).

[17] LATA refers to Local Access Transport Area. At a divestiture in 1984, LATAs were set up as the areas in which Bell telephone companies were allowed to sell local telephone services. LATAs cover metropolitan statistical areas based on population sizes. The rules of divestiture decreed that long distance telephone companies like AT&T, Sprint and MCI were allowed to carry calls between LATAs but that a Bell telephone companies could only carry calls within a LATA.

almost every aspect of communications including: telephone services including local, long-distance, and wireless; free, over-the-air broadcast television; cable television; content and programming on television and computer networks including the Internet.

In the case where there is only one company serving the market, a monopolistic situation may arise. Monopoly refers to a situation in which a business enterprise, in a particular market, is in a competition-free environment or enjoys overwhelming domination (compared to its competitors) in the setting and control of prices. Sometimes, there is an oligopoly, which refers to the dominance of the particular market by a few firms, which may engage in anti-competitive behaviors like predatory pricing or setting of prices above the competitive level. The "particular market" denotes the territory or scope in which business enterprises compete in marketing certain merchandise or services. The behaviors to maximize profits by the dominant firm or firms, which possess economic power in these situations may drive up prices above the competitive level and thus, increase the costs for the consumers and significantly reduce consumer welfare.

Regional Bell Operating Companies (RBOCs), or "Baby Bells," and other local exchange carriers (LECs) currently provide most of the local phone service in the States. Drawing experience from the long distance market, which was gradually transformed from monopoly to an effectively competitive market, the 1996 Act attempts to correct imperfect competition in the market by fostering competitive local telecommunications markets that would eliminate the last bottleneck in telecommunications services – the "local loop". It is the connection from the home or business to the local switch, which has been dominated by local monopolies for nearly 100 years. The Act uses both structural and behavioral instruments to attain its objectives. It attempts to reduce regulatory barriers to entry and competition. It restricts artificial barriers to entry, which are set up by firms dominating the local exchange markets, in order to maximize the level of competition. It also makes compulsory the interconnection of telecommunications networks, unbundling, non-discrimination, and cost-based pricing of leased parts of the network, to ease competition by component, as well as by service.

The 1996 Act imposes conditions to make certain that *de facto* monopoly power is not exported to complementary or vertically-related markets. It therefore requires competition be established in local markets before the RBOCs are permitted in long distance service (other "non-RBOC" ILECs face no such restrictions). The Act recognizes the telecommunications network as a network of interconnected networks. Telecommunications providers are required to interconnect with entrants at any feasible point the entrant wishes. Most importantly, the Act requires that ILECs, predominantly the RBOCs to (i) lease parts of their network (unbundled network elements) to competitors "at cost"; (ii) provide at a wholesale discount to competitors any service the ILEC provides; and (iii) charge reciprocal rates in termination of calls to their network and to networks of local competitors. Moreover, the Act requires that ILECs that originated from the Bell System meet a number of requirements, including a public interest test – the inter-LATA services approval process under Section 271 of the Communications Act of 1934, before they may enter and compete in the long distance market. Thus, the Act provides some safeguards against the export of ILEC monopoly power to other parts of the network. These are shown in Table 3.1 below, which summarizes the key provisions of the 1996 Telecommunications Act relevant to the deployment of advanced telecommunications services.

Table 3.1: Key Provisions of the 1996 Telecommunications Act Relevant to Deployment of ATS

Section 251

This section of the Act establishes a series of obligations applicable to telecommunications carriers. Some of them apply to all telecommunications carriers – local, long distance and others, while others apply only to providers of local telephone. The most detailed requirements apply to incumbent local telephone companies like the RBOCs. Those regulations concerning the incumbents consist of a collection of obligations designed to facilitate entry of competitors (new service providers) into local markets and increase their ability to compete with the incumbents. For example, these regulations include a requirement that incumbents make available parts of their local networks to competing providers on just, reasonable and non-discriminatory terms and conditions – procedures for implementation of these requirements are set forth in *Section 252*.

Section 253

This section generally preempts, with certain exceptions relating to universal service and other public policy objectives, any state or local statute or regulation that prohibits or has the effect of prohibiting the ability of any entity to provide any interstate or intrastate telecommunications service.

Section 254

This section promotes access to advanced telecommunications and information services in all regions of the United States. Universal service principles to be implemented by the FCC include ensuring: quality services at reasonable and affordable rates; access to advanced telecommunications services; access to such services in rural and high-cost regions; that all providers of telecommunications services make an equitable and non-discriminatory contribution to the preservation and advancement of universal service; that specific and predictable support mechanisms are in place to conduct such preservation and advancement; that there is access to advanced telecommunications services for schools, health care, and libraries; and that other principles that the joint federal-state board and the FCC may determine are necessary and appropriate for the protection of public interest are implemented.

Section 259

This section mandates that ILECs make available to any qualifying carrier any public switched telecommunications equipment or information as should be requested by the qualifying carrier, except in situations under which it would be economically unreasonable or against public interest for the ILECs to comply. It allows joint ownership and seeks to ensure that the ILEC is not treated as a "common carrier for hire" and that the carrier seeking the use of facilities will be allowed their use on just and reasonable terms. Section 259 also demands a transparent process – requiring the ILEC to report the terms and conditions of any facilities-sharing arrangements.

Section 271

This section mandates that the FCC consult with the U.S. Department of Justice and relevant state commissions before ruling on a Bell company's request to offer in-region inter-LATA services. Upon application by a Bell company, the FCC has 90 days to consider if the applicant has met a 14-point competitive checklist of market-opening requirements contained in the section and if the company's entry into the inter-LATA service market is in the interest of the public. This is commonly referred to as the 271 approval process or the inter-LATA approval process.

Section 706

This section attempts to promote the deployment of advanced telecommunications services in a reasonable and timely manner. It tries to carry this out by means of price cap regulation, regulatory forbearance, measures promoting competition in the local telecommunications market and other regulating methods that remove barriers to infrastructure investment. This section also mandates the FCC to follow up with enquiries into the progress of deployment. Reports issued in August of 1999 and 2000 found deployment reasonable and timely based on subscription levels, service and technology options, and infrastructure investment at the time of the inquiries.[18] The August 2000 report pointed out that advanced services may be unevenly distributed due to differences in wealth and population concentration across the United States.

As the telecommunications policy framework is reframed to encourage competition through deregulation, the national policy must recognize that no market mechanism is perfect and that profound social and economic costs will be incurred when some individuals or groups of individuals are isolated from the information society due to

[18] FCC, 1999, "Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996: First Report", CC Docket No. 98-146, FCC, Washington, D.C., August; and FCC, 2000, "Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996: Second Report", CC Docket No. 98-146, FCC, Washington, D.C., August 21.

prohibitively high cost of connection to the local telecommunications network infrastructure. There are many social and economic benefits from connecting all Americans. They include improved education, enhanced access to health care services and information, better jobs and living conditions.

The U.S. Congress has concluded that consumers would benefit from the opening up of the telecommunications market, and the adoption of policies by policy makers to promote the deployment of advanced telecommunications services.[19] While there are little disputes about these policy principles, different parties disagree on how to achieve these objectives. Since the implementation of the Act, several legal challenges on different fronts have been raised by the ILECs. This has resulted in the slow, and in some cases, the lack of implementation of the Act. This thesis hopes to provide insights on how appropriate use of public policy and regulatory instruments can be employed to achieve the objective of promoting deployment of advanced telecommunications services.

3.2 The Lack of Success of the Telecommunications Act

In the telecommunications industry, dramatic cost reduction has occurred in transmission, due to the use of fiber-optic technology; and in switching and information processing, due to the reductions of costs of integrated circuits and computers. Such cost reductions have enabled the provision of many data- and transmission- intensive services. Usually, such cost reduction would lead to entry of new competitors in the market and increased level of competition. However, entry of new competitors has been limited.

At the end of 2001, competitive local exchange carriers (CLECs) served only 10.2% of switched access lines and only 6.6% of the residential and small business market for local telecommunication services.[20] The Telecommunication Act of 1996 has generated many

[19] See Section 706 of the 1996 Telecommunications Act.

[20] Local Telephone Competition: Status as of December 31, 2001, Industry Analysis and Technology Division, Wireline Competition Bureau, Federal Communications Commission, July 2002, Tables 1 and 2. http://www.fcc.gov/Bureaus/Common_Carrier/Reports/FCC-State_Link/IAD/lcom0702.pdf

unintended consequences and has had little success in spurring local competition, driving down costs and increasing consumer welfare. Instead, the laws initiated a frenzy of mergers and acquisitions. Incumbent telecommunications companies acquired other firms and new services, re-branded them, tapped into new markets and won broader customer base.

Although it is the Congress' intention to promote competition in the telecommunications market and advanced services, these goals may be incompatible. The network elements owned by the ILECs have to be constantly maintained and upgraded for new capabilities and services to be available. This requires significant financial and time investment on the part of the incumbents. To innovate and develop such new facilities only to sell their network elements away at low UNE cost would create serious disincentives for these incumbents. Furthermore, the ILECs may be unwilling to bear the high risk associated with investment of such magnitude if they cannot fully benefit from it.

In the increasingly deregulated markets, telecommunications service providers, especially the ILECs, will attempt to introduce new and innovative products and services unless the regulatory environment is unsuitable for such implementation. In general, incompatibility of goals in the promotion of competition and advanced telecommunications services in the local markets may jeopardize the intended goals of the 1996 Telecommunications Act.

The 1996 Telecommunications Act was aimed at opening up the market, promoting competition and advancing public interest, as laid out in Table 3.1. It will be a significant failure on the part of the U.S. political, legal and regulatory systems if interests and welfare of the public cannot be advanced. In the following chapters, this thesis will go on to investigate the effect of several key provisions of the 1996 Act on the deployment of advanced telecommunications services.

4 METRICS AND DATA SOURCES

Innovation is defined as "the practical use of an invention to produce new products or services, to improve existing ones, or to improve the way in which they are produced or distributed. Innovations include technologically improved products or processes, where processes may involve changes in equipment, human resources, or working methods."[21]

Progress in developing a theoretical understanding of innovation has been hindered by difficulties in measuring its outputs as determinants of industrial performance and economic growth. One cannot produce useful and insightful results unless one has good data.

In order to address questions such as i) the impact of competition on the availability of advanced telecommunications services ; and ii) how regulation affects the behavior of the local exchange companies, an extensive micro data set has been collected and compiled over a period of one and half years. Naturally, the data set draws from different sources – from government surveys and the U.S. census to university publications and private companies information – in an attempt to make the regression analyses as comprehensive as possible. In order to provide useful insights to the aforementioned policy questions, the rich data set incorporates a tremendous amount of detail about the nature of telecommunications markets throughout the United States.

The aim of this chapter is to provide a detailed description and clarification over the complexity of various metrics and variables used for this research. It will also highlight the importance and validity of these data sets and their sources while discussing some of their limitations.

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[21] Cooper, Ronald, and Stephen Merrill (eds) (1997), *Industrial Research and Innovation Indicators: Report of Workshop,* Washington, D.C., National Academy Press http://www.nap.edu/openbook/0309059941/html/R1.html

4.1 Choice of Metrics for Study

The comprehensive data set has been designed and constructed to allow for the econometric analysis and verification of these two main hypotheses: i) competition has a positive impact on the availability of advanced telecommunications services; ii) regulation affects behaviors of the firms to deploy advanced telecommunications services. The data allows the investigation of how the availability of advanced telecommunications services, such as packet switching, DS technologies and SONET – OC transport, are affected by such factors as i) local competition data; ii) economic and demographic data by wire center; iii) business data by wire center, including ownership of wire centers, number and characteristics of business establishments; and iv) regulatory environments in each state.

4.2 Categories of Metrics

4.2.1 Advanced Telecommunications Services Availability

4.2.1.1 Approach and Data Source

Various advanced telecommunications services availabilities, such as those described in Chapter 2 have been incorporated into the data set. Specifically, they are packet switching, different levels of DS technologies and SONET – OC transport by wire center[22] for years 1994-2001.

It is important to describe how this set of data is obtained and aggregated because it affects the validity of the regression analyses. Firstly, the availabilities of the different types of ATS were obtained from the National Exchange Carrier Association, Inc. (NECA)[23] tariff data (2001) using the office type codes contained in it. Next, information

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[22] Wire centers typically house switches for the ILECs and CLECs.

[23] National Exchange Carrier Association, Inc. (NECA) is founded in October 1983 and is mandated by the Federal Communications Commission (FCC). The FCC was responding to the rapid and unprecedented changes occurring because of the divestiture by AT&T of its Bell Operating Companies and its own efforts to promote long distance competition. The breakup was the result of an antitrust settlement made between

on the economic characteristics of the territory served by a wire center was needed. The economic characteristics of a wire center were obtained by doing an overlay of the service territory of the wire centers over the zip code boundaries. A wire center consists of one or more of the areas designated by a particular zip code (or a percentage of some zip code areas), while a zip code area is made up of a few census blocks. The business and household census and various other sources, classified by zip codes, were also used to determine the economic characteristics of the wire centers.

After collection and aggregation of data, if the wire center, for example, has the capability of OC, the corresponding space under that particular wire center in the data set will indicate a one and if such capability does not exist, it will indicate a zero. The primary software used for data entry and compilation is Microsoft Access. This is illustrated in Figure 4.1 on the next page.

AT&T and the federal government in the name of fostering competition in the U.S. telecommunications market. The FCC needed NECA to serve as an intra-industry body to implement key portions of its access charge plan. NECA is also responsible for the preparation of cost and demand forecasts for pooling companies and filing and defense of tariffs reflecting pool revenue requirements, under the FCC's access charge rules. In addition to these access tariff and pooling functions, NECA also acts, in accordance with FCC rules, as administrator of the FCC's interstate Telecommunications Relay Services Fund.

Figure 4.1: Sample of Data Segment on Wire Center and Advanced Telecommunications Services Availability

WIRECENTER	ASEC_NM	RESID	CATEGORY	packet_switching	DS1 as of 2001	DS3 as of 2001	OC as of 2001
2	BRYANT POND TEL CO	ME	ILEC	NO	NO	NO	NO
3	LINCOLNVILLE TEL CO	ME	ILEC	NO	YES	NO	NO
4	LINCOLNVILLE TEL CO	ME	ILEC	YES	YES	NO	NO
5	CHINA TEL CO	ME	ILEC	YES	NO	NO	NO
6	CHINA TEL CO	ME	ILEC	YES	NO	NO	NO
7	CHINA TEL CO	ME	ILEC	YES	NO	NO	NO
8	COBBOSSEECONTEE TEL	ME	ILEC	NO	NO	NO	NO
9	ISLAND TEL CO	ME	ILEC	NO	NO	NO	NO
10	ISLAND TEL CO	ME	ILEC	NO	NO	NO	NO
11	ISLAND TEL CO	ME	ILEC	NO	NO	NO	NO
12	ISLAND TEL CO	ME	ILEC	NO	NO	NO	NO
13	HAMPDEN TEL CO	ME	ILEC	NO	NO	NO	NO
14	HAMPDEN TEL CO	ME	ILEC	NO	NO	NO	NO
15	HARTLAND & ST. ALBANS	ME	ILEC	NO	NO	NO	NO
16	HARTLAND & ST. ALBANS	ME	ILEC	NO	NO	NO	NO
17	HARTLAND & ST. ALBANS	ME	ILEC	NO	NO	NO	NO
18	COMMUNITY SERVICE TE	ME	ILEC	NO	NO	NO	NO
19	COMMUNITY SERVICE TE	ME	ILEC	NO	NO	NO	NO
20	COMMUNITY SERVICE TE	ME	ILEC	NO	NO	NO	NO
21	COMMUNITY SERVICE TE	ME	ILEC	NO	NO	NO	NO
22	COMMUNITY SERVICE TE	ME	ILEC	NO	NO	NO	NO
23	COMMUNITY SERVICE TE	ME	ILEC	NO	NO	NO	NO
24	COMMUNITY SERVICE TE	ME	ILEC	NO	NO	NO	NO
25	OXFORD COUNTY TEL & T	ME	ILEC	NO	NO	NO	NO
26	OXFORD COUNTY TEL & T	ME	ILEC	NO	NO	NO	NO
27	OXFORD COUNTY TEL & T	ME	ILEC	NO	NO	NO	NO

4.2.1.2 Limitations

One limitation to the NECA tariff 4 data is the question of self-reporting of data. The ILECs themselves determine how to classify what services are and are not available. There is no independent effort by a neutral third party to verify the accuracy and validity of the self-reported data. However, it is important to note that these companies have an incentive to self-report accurately because customers rely heavily on the tariff data to find out services and product availabilities and locations.

Nevertheless, inaccuracy in the indication of capability in each wire center may exist. For example, in the state of Connecticut, most of the DS and OC capabilities in the wire centers currently reflect a “one” – indicating the availability of those services. This is particularly high considering the status of other neighboring New England states. Very recent code entries changes occurred in Connecticut. They were primarily updates for DS and OC functionalities by Southern New England Telephone (SNET) (see also Footnote 36) and these dramatically raised the number of wire centers that were DS and OC capable. This revealed the possibility that telecommunications service providers may not tariff services like DS and OC even if such capabilities exist in their wire centers. A LEC may not tariff a service because it could then charge higher special service charges to customers. This situation may also exist in the NECA data for other states. The recent tariff modifications made in Connecticut highlights that this analysis focuses on services offered to customers, not the physical capabilities of a network.

4.2.2 Local Competition Data

4.2.2.1 Approach and Data Source

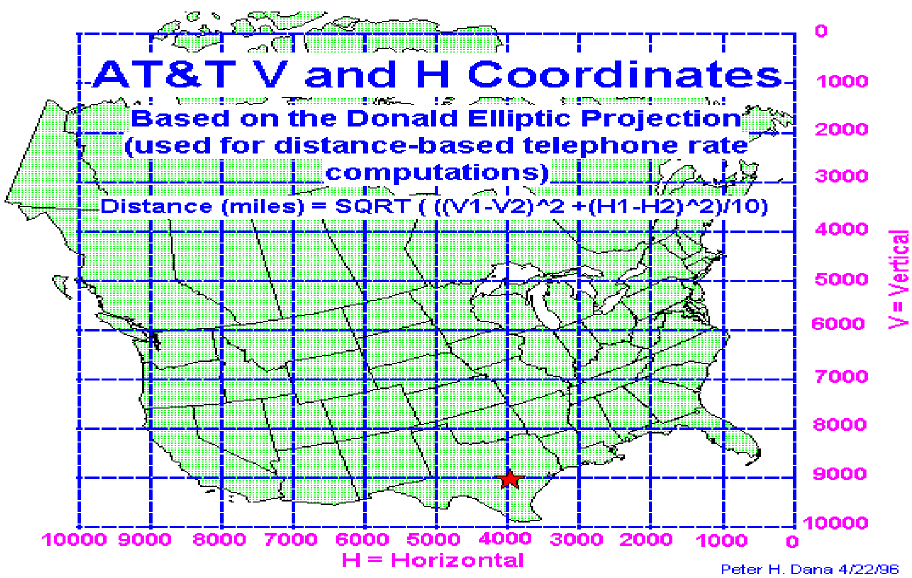
An ILEC may be induced to introduce newer and more advanced services at a faster pace if it observes that its competitors are operating in the same region. If it does not offer these services, its business customers have great tendency and motivation to switch to its competitors if such services are required.

In order to examine how competitive entries into the market affect the deployment of advanced telecommunications services, the number of wire centers served by CLECs that are located within 3, 5, 7 or 10 mile radius[24] of each wire center served by ILECs in 2001 and 2002 was ascertained.

[24] The number of wire centers served by CLECs that are located within 1 mile radius of each wire center served by ILECs in 2001 and 2002 was also computed but it was found that the general lack of presence of competitors within that distance across the states made it insignificant for regression analysis. That is, due to the lack of variation in the explanatory variable, it was difficult to obtain a statistically significant estimate of the coefficient on the explanatory variable.

To achieve this aim, a C++ program was written to search and determine the number of wire centers served by competitive providers – CAPs or CLECs, located within the specified mile radius of wire centers served by an incumbent – independent telephone companies (ICOs)[25] and Regional Bell Operating Companies (RBOCs) or ILECs. The program made use of the horizontal and vertical coordinates of each wire center, provided by the Local Exchange Routing Guide (LERG)[26] database and used Pythagoras theorem to determine the specified radius (3, 5, 7 or 10 miles) from each ILEC wire center. The vertical and horizontal coordinates are converted to miles based on the "Donald Elliptic Projection", shown in Figure 4.2 below. The same process is also highlighted in NECA Tariff 4 report – Wire Center and Interconnection Information: Mileage Measurement, issued on August 17, 1999, by the director of Access Tariffs and Access Planning.

Figure 4.2: Conversion of Vertical and Horizontal Coordinates to Miles Based on Donald Elliptic Projection (Source: Peter H. Dana, Department of Geography, University of Colorado at Boulder)



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[25] Independent Telephone Company (ICO) refers to the initial telephone company that provides wireline local exchange service in a non-RBOC geographical area. ICOs and RBOCs are often referred to as the incumbent local exchange carrier (ILEC).

[26] The Local Exchange Routing Guide (LERG) is a comprehensive routing database produced by Telcordia™ Routing Administration (TRA). The data supports the current local exchange network configuration within the North American Numbering Plan (NANP) and identifies reported planned changes in the network. The LERG is primarily designed to be used for 1) routing of inter-LATA calls by inter-exchange carriers; 2) providing information on the local environment for the numerous carriers involved in the local arena; and 3) any other company needing information about the network, numbering, and other data in the product.

The competition data derived from the program is then entered and compiled into the data set. This is illustrated in Figure 4.3 below.

Figure 4.3: Sample of Data Segment on Competition Variables (from LERG), Other Business and Regulatory Variables and Their Abbreviations

WIRECEN	ASEC_NM	2001 3 Miles	2001 5	2001 7	2001 10	2002 3	2002 7	Rural	Type	Ratio_LoopRatetoLoopCost
791	NORTH EASTERN PENN	0	0	0	0	0	0	R	A	0.81
792	NORTH EASTERN PENN	0	0	0	0	0	0	R	A	0.81
793	NORTH EASTERN PENN	0	0	0	0	0	0	R	A	0.81
794	NORTH EASTERN PENN	0	0	0	0	0	0	R	A	0.81
795	NORTH EASTERN PENN	0	0	0	0	0	0	R	A	0.81
796	NORTH PENN TEL CO	0	0	0	0	0	0	R	C	0.81
797	NORTH PENN TEL CO	0	0	0	0	0	0	R	C	0.81
798	NORTH PENN TEL CO	0	0	0	0	0	0	R	C	0.81
799	NORTH PITTSBURG TEL	0	1	0	4	0	2	R	A	0.81
800	NORTH PITTSBURG TEL	1	2	1	4	2	4	R	A	0.81
801	NORTH PITTSBURG TEL	0	0	0	3	0	1	R	A	0.81
802	NORTH PITTSBURG TEL	0	0	0	0	0	0	R	A	0.81
803	NORTH PITTSBURG TEL	1	2	1	12	1	2	R	A	0.81
804	NORTH PITTSBURG TEL	1	2	1	4	1	5	R	A	0.81
805	NORTH PITTSBURG TEL	0	0	0	0	0	0	R	A	0.81
806	NORTH PITTSBURG TEL	1	3	1	6	1	4	R	A	0.81
807	FRONTIER COMMUNICA	0	0	0	0	0	0	R	C	0.81
808	FRONTIER COMMUNICA	0	0	0	0	0	0	R	C	0.81
809	FRONTIER COMMUNICA	0	0	0	0	0	0	R	C	0.81
810	ARMSTRONG TEL CO N	0	0	0	1	0	0	R	A	0.81
811	PALMERTON TEL CO	1	1	0	2	1	1	R	A	0.81
812	PALMERTON TEL CO	0	0	0	2	0	0	R	A	0.81
813	PALMERTON TEL CO	0	0	0	1	0	0	R	A	0.81
814	PALMERTON TEL CO	1	1	0	2	1	1	R	A	0.81
815	PENNSYLVANIA TEL CC	0	0	0	0	0	0	R	A	0.81
816	PYMATUNING INDEP TE	0	0	0	2	0	0	R	A	0.81

In order to increase statistical significance and reduce statistical variation, a large number of observations (20,755) is considered in my analysis. There is significant presence of competitors in the same region as the incumbents as indicated by the means. These are shown in Table 4.1 on the next page, which provides a summary of the number of observations, the mean number of competitor wire centers located within 3, 5, 7 or 10 mile radius of an incumbent's wire center and their standard deviations. We postulate that the presence of a CLEC in close proximity would have a positive impact on an ILEC's tariff offering of advanced telecommunications services.

Table 4.1: Illustration of Competition Variables - CLECs' Point of Presence in Specified Number of Miles for ILECs (2001)

Variable	Obs	Mean	Std. Dev.	Min	Max
3 miles	20,755	1.63	5.15	0	147
5 miles	20,755	1.63	8.02	0	160
7 miles	20,755	2.57	10.72	0	188
10 miles	20,755	4.26	15.17	0	214

4.2.2.2 Limitations

There are certain limitations in this model. Although carefully conceived to detect interesting competition data variations, the distances of 3, 5, 7 and 10 miles are set arbitrarily. A challenge in future research is to find the critical distance in which the impact of competition on deployment of ATS will yield the most significant effect.

4.2.3 Economic and Demographic Data

4.2.3.1 Approach and Data Source

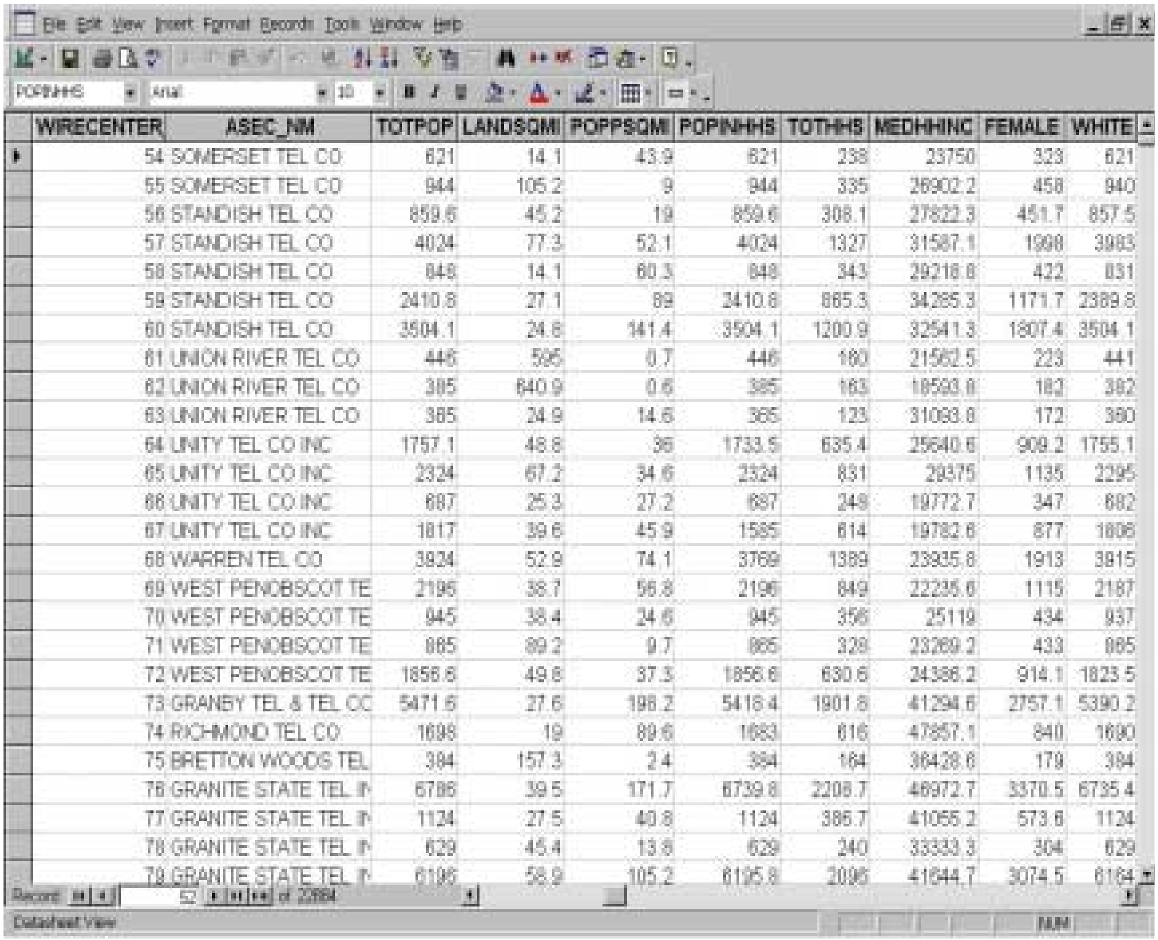
Although the main focus of this study is the deployment of services used by businesses, the economic and demographic characteristics of households, together with the number of people employed within the boundaries of the wire center, provide a good proxy for the size of the market.

The economic and demographic data by wire center are extracted from the 1990 census from the United States Census Bureau, in the United States Department of Commerce.[27]

[27] The business and household census data are available at the zip code level of observation. The territory of a zip code may be in one or more wire center boundaries. Data that provide geo-coded wire center boundary information are available. See, for example, http://www.geographic.com/home/prodservdisplay.cfm?ProdId=23&IndID=16 and http://www.mapinfo.com/community/free/library/telecom_catalog02.pdf (page 5 of 24).
This boundary data can be overlaid onto the census data in order to obtain a matching between the zip codes and wire center boundaries.

They are comprehensive and include variables such as total population; land area (in square miles); persons per square mile; total male and female population; persons living in rural area; persons living on farms, in family or alone; racial and ethnic breakdowns (in terms of numbers and percentages); percentages of population in each age group; total households; number and percentage of persons in households comprising of different numbers of family members; detailed household status (married couples, single parent households, number of children etc.); detailed household and family income status and income ranges; different levels of poverty; levels of education in each family and household by number and percentages; employment status; total number of employees; types of job functions in the population; status of housing and details of the buildings; values of housing and rent, among other variables. Some of these variables and their abbreviations are illustrated in Figure 4.4 on the next page.

Figure 4.4: Sample of Data Segment on Economic and Demographic Variables and Their Abbreviations from the United States Census (1990)



WIRECENTER	ASEC_NM	TOTPOP	LANDSQMI	POPPSQMI	POPINHHS	TOTHHS	MEDHHINC	FEMALE	WHITE
54	SOMERSET TEL CO	621	14.1	43.9	621	238	23750	323	621
55	SOMERSET TEL CO	944	105.2	9	944	335	26902.2	458	940
56	STANDISH TEL CO	859.6	45.2	19	859.6	308.1	27822.3	451.7	857.5
57	STANDISH TEL CO	4024	77.3	52.1	4024	1327	31587.1	1998	3983
58	STANDISH TEL CO	848	14.1	60.3	848	343	29218.8	422	831
59	STANDISH TEL CO	2410.8	27.1	89	2410.8	865.3	34285.3	1171.7	2389.8
60	STANDISH TEL CO	3504.1	24.8	141.4	3504.1	1200.9	32541.3	1807.4	3504.1
61	UNION RIVER TEL CO	446	595	0.7	446	180	21562.5	223	441
62	UNION RIVER TEL CO	385	640.9	0.6	385	163	18593.8	182	382
63	UNION RIVER TEL CO	365	24.9	14.6	365	123	31093.8	172	360
64	UNITY TEL CO INC	1757.1	48.8	36	1733.5	635.4	25640.6	909.2	1755.1
65	UNITY TEL CO INC	2324	67.2	34.6	2324	831	29375	1135	2295
66	UNITY TEL CO INC	687	25.3	27.2	687	249	19772.7	347	682
67	UNITY TEL CO INC	1817	39.6	45.9	1585	614	19782.6	877	1806
68	WARREN TEL CO	3924	52.9	74.1	3769	1389	23935.8	1913	3815
69	WEST PENOBSCOT TE	2196	38.7	56.8	2196	849	22235.6	1115	2187
70	WEST PENOBSCOT TE	945	38.4	24.6	945	356	25119	434	937
71	WEST PENOBSCOT TE	865	89.2	9.7	865	328	23269.2	433	865
72	WEST PENOBSCOT TE	1856.6	49.8	37.3	1856.6	630.6	24386.2	914.1	1823.5
73	GRANBY TEL & TEL CC	5471.6	27.6	198.2	5418.4	1901.8	41294.6	2757.1	5390.2
74	RICHMOND TEL CO	1698	19	89.6	1683	616	47857.1	840	1690
75	BRETTON WOODS TEL	384	157.3	2.4	384	164	36428.6	179	384
76	GRANITE STATE TEL I	6786	39.5	171.7	6739.8	2208.7	46972.7	3370.5	6735.4
77	GRANITE STATE TEL I	1124	27.5	40.8	1124	386.7	41055.2	573.6	1124
78	GRANITE STATE TEL I	629	45.4	13.8	629	240	33333.3	304	629
79	GRANITE STATE TEL I	6196	58.9	105.2	6195.8	2096	41644.7	3074.5	6164

4.2.3.2 Limitations

For the purpose of this study, the 1990 Census provides a good source of reference. This is because the 2000 Census has only been released recently, and the ILECs most probably have not referred to it before making their decisions to deploy ATS by May 2001 (as reflected in the data set) – they have compared different markets based on the 1990 Census.

In future studies, however, the coverage and accuracy of the different variables in the 1990 Census can be further improved, for example, by reducing the differential undercounts of certain population groups. One possibility is to incorporate the 2000 Census into the data set to reflect improvement in coverage.[28]

4.2.4 Business Data

4.2.4.1 Approach and Data Source

The business data by wire center is extracted and compiled from the "ZIP Code Business Patterns" series CDs, published by the U.S. Census Bureau, Economics and Statistics Administration under the U.S. Department of Commerce.[29] The latest issue, "ZIP Code Business Patterns 1999", published in November 2002, was also taken into account in the data set. The business data is comprehensive – it includes total number of business establishment; total number of employees and payroll; total number of small (1-19 employees), medium (20-99 employees) and large firms (more than 100 employees); and types of business by Standard Industrial Code (SIC).

In this analysis, particular focus is placed on industries which tend to make more intensive use of advanced telecommunications services, such as finance and insurance (SIC: 52); and professional, scientific and technical services (SIC: 54) As discussed in Section 4.2.3.1, the total number of employees and the total number of households are good predictors of the size of a wire center and the first set of regressions included only those explanatory variables. However, the ILECs and CLECs may target deployment of advanced services in areas that are heavy users of communications services. Therefore, subsequent set of regressions control for the types of industries, particularly for SIC 52 and 54, in each wire center except when the *Wald test* indicates that the joint impacts of the SIC coefficients are zero (see Section 5.3.3.1).

[28] See announcement from the US Commerce Department's Census Bureau on February 14, 2001 - preliminary estimates showed an apparent improvement in the coverage of Census 2000 over 1990, including reductions in the differential undercounts of certain population groups.

[29] See Footnote 26 for more details on wire center boundary overlay.

4.2.4.2 Limitations

As there is no publicly available information at the zip code level on the number of employees by Standard Industrial Code and information is restricted to the total number of small, medium or large establishments, this information is used in the regression analysis. It is not appropriate to sum the number of establishments of small, medium and large firms because the communications requirements of a large firm are very different from that of a small firm. Consequently, regressions were carried out using only the number of large firms by industrial codes.

4.2.5 Regulatory Environments

4.2.5.1 Approach and Data Source

To control for the regulatory regimes in each state, data was compiled based on the state surveys, regulatory publications and other sources.

Initially, regulation environments were broadly classified into five main categories: rate-of-return (ROR), price cap, price cap with interim rate freeze, rate freeze and non-indexed caps, and deregulation, based on information from table - "Forms of Regulation for Basic Services in the U.S. States" (2000)[30] and a study by Abel and Clements (1998) from the National Regulatory Research Institute (NRRI).[31] However, this approach has not sufficiently address the plethora of regulatory regimes for individual telecommunications service providers in each state. A detailed survey study was then conducted and surveys were sent to government agencies, mostly public service commissions, in all fifty states. The survey asked each state to indicate the exact forms of

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[30] Source: *State Telephone Regulation Report White Pape*r, 18 (20-22) (October 2000).

[31] Abel, Jaison R., and Michael E. Clements (1998), *A Time Series and Cross-sectional Classification of State Regulatory Policy Adopted for Local Exchange Carriers: Divestiture to Present (1984-1998)*, National Regulatory Research Institute.

regulation for individual telecommunications service providers, based on the indices created from a to k: from different forms of rate-of-return (ROR), rate case moratoria, rate-of-return incentive schemes, indexed and non-indexed price cap schemes, rate freezes, pricing flexibility for competitive services schemes, access pricing, to deregulation. The survey further requested each state to indicate business (basic and other services), residential (basic and other services) and advanced telecommunications access for every company in the state. This created a comprehensive and novel data set that gives us an insight into the complex regulatory environments in every state in U.S. from years 1994 to 2002. For the purpose of this thesis, I have controlled for the forms of federal regulation – price cap versus rate-of-return regulation.

Furthermore, I gathered information from the Rural Utilities Services (RUS) Borrower list for year ending in 2001.[32] It includes important information such as borrower identification and names of telecommunications companies that had received RUS support. We postulate that, all else equal, companies receiving RUS support will more likely deploy advanced telecommunications services.

Also, data collected from the FCC was used to determine whether the telecommunications carriers were classified as rural by FCC[33] and whether they were under price cap or ratebase rate-of-return regulations. The natures of the carriers were indicated – rural or non-rural, together with other criteria that were incorporated to make the data set as complete and up-to-date as possible. The FCC rural classification (nature of carriers) gives an indication whether the carrier is classified as rural or non-rural carrier. We postulate that the presence of rural classification will adversely affect the deployment of advanced telecommunications services. Classification of firms under federal price cap regulation or ratebase rate-of-return regulation was also determined using the regulatory data collected. We postulate that the presence of federal price cap

[32] The United States Department of Agriculture (USDA) Rural Utilities Service (RUS) aims to help rural utilities expand and keep their technology up to date, and to help establish new and vital services such as distance learning and telemedicine through partnerships with rural cooperatives, nonprofit associations, public bodies, and for-profit utilities. RUS also grants loans to telecommunications companies to achieve these objectives.

[33] Information obtained from Interstate Regulatory Status (4th quarter 2002).

regulation will increase the likelihood that ATS is available more than the presence of rate-based regulation, based on the work of Greenstein, McMaster and Spiller (1995) who found that federal price cap regulation would have a positive impact. However, our regression analyses did not confirm this hypothesis (Section 5.3.3.2). Figure 4.3 in Section 4.2.2.1 illustrated some of these variables.

The Bell Operating Companies (BOC) must file applications with the FCC on a state-by-state basis in order to provide in-region inter-LATA services under Section 271 of the Communications Act of 1934. This is known as the 271 approval process or inter-LATA approval process, which has a significant impact on the development of competition. In order to control for 271 activities, the dataset also included the date that an RBOC receives 271 approvals from the FCC.[34] The inter-LATA approval process is a test given to the RBOCs to justify if their entry into the inter-LATA service market is in the interest of the public. We postulate that once the RBOCs have passed the inter-LATA approval hurdle, the deployment of advanced telecommunications services will be more likely and will be accelerated.

In addition, the database includes, among other fields, average monthly loop rates,[35] monthly total loop costs,[36] and ratio of loop rate to loop cost. The latter gives the ratio of unbundled network elements prices to their embedded costs for each RBOC in a state. The same ratio is used for all ILECs in a state (for example, in Texas, information is available only for UNE loop to embedded cost loop ratio for SBC, among the various companies. This ratio is applied to all ILECs in Texas under the assumption that the ratio is a good proxy for the state regulatory climate for all companies). This ratio serves as a good measurement of how friendly the regulatory regime in the particular state is to the RBOCs in terms of the unbundling and resale mandate according to Section 251(c) of the 1996 Telecommunications Act. The higher the ratio, the more friendly the regulatory

[34] See http://www.fcc.gov/Bureaus/Common_Carrier/in-region_applications/

[35] Data source: Gregg, Billy J., *Survey of Unbundled Network Element Prices in the United States* (updated January 1, 2002).

[36] These were calculated from the NECA data as of December 31, 2000 on the basis of total Loops.

environment is to the RBOCs and the reverse is true. We postulate that when the ratio is high, RBOCs are more likely to invest and deploy advanced telecommunications services since the possibility of recouping their investment is higher. More explanation is provided in the later sections of this thesis (Sections 5.3.3.4 and 6.1.1). Figure 4.3 in Section 4.2.2.1 illustrated some of these variables.

4.2.5.2 Limitations

Future research can explore the intricate relationships between ATS availabilities and each specific form of regulation by refining and redesigning current econometric analysis procedures.

In addition, in the data collection process, some assumptions were made about 271 approvals. For example, for GTE's properties in Pennsylvania, an assumption that the area was unaffected by the decision to grant 271 approval to the area served by the former BOC was made. We assumed that the 271 approval for Bell Atlantic Pennsylvania would have no impact on the former GTE Pennsylvania territory, which is also part of Verizon.

Other limitations exist in the data sets, despite their comprehensive details. In the RUS borrower data, even if the company which qualifies as a borrower can be identified, little or no information is included on the degree which the RUS company is utilizing the available funds. This could create possible discrepancy in the analysis when there are actually different degrees of usage of funds.

5 ECONOMETRIC MODEL AND ANALYSIS OF THE IMPACT OF LOCAL COMPETITION AND REGULATION

The establishment of robust competition among multiple telecommunications providers, including the providers of advanced telecommunications services, has always been the goal of many regulatory officials and is a fundamental objective of the Telecommunications Act of 1996. Under the present regulatory regime, two main paths toward competition are conceived: i) unbundling and resale; and ii) facilities-based competition. Unbundling of local loops and other network elements and resale are aimed at stimulating competition in the short-run and easing the cost of entry, while facilities-based competition involves new market entrants utilizing their own equipment and physical network to compete. With unbundling, it is harder for a CLEC to offer new services since it has to rely on the ILEC's network. Many policy makers, economists and consumer advocates believe that only with facilities-based entry, will there be competition in quality and diversity of services and not just on price (see Section 6.1).

There are concerns that companies facing insufficient competition or less than optimal regulatory regimes will compromise on the deployment of advanced telecommunications services – in terms of availability, level of services and quality. The report prepared by OECD on "The Development of Broadband Access in OECD Countries" (2001) showed that there were greater availability of advanced telecommunications services in the markets that were more competitive and found that "the most fundamental policy available to OECD governments to boost broadband access is infrastructure competition." Greenstein, McMaster and Spiller (1995) also found that less than optimal regulation may impede investments.

5.1 Pertinent Research Questions

The database constructed has provided the vehicle to address pertinent research questions regarding the impact of local competition and regulation on availabilities of ATS to businesses. In this thesis, the following questions are discussed: i) how competitive entry into the market affects ATS deployment decisions; ii) how corporate ownership (RBOCs, medium and small) affects ATS deployment; iii) how forms of regulation, for example, price caps versus rate base rate of return and unbundled network element (UNE) prices, affect the deployment of ATS; iv) how 271 approval process affects ATS deployment decisions. This set of questions is by no means exhaustive and potential future research can be carried out by expanding on this data set through addition of new variables (refer to Section 6.4 for discussion on possible future research).

5.2 Statistical Models

5.2.1 Qualitative Response Regression Model

The statistical model that will be used primarily for this analysis is the qualitative response regression model. The qualitative or discrete regression model is defined as those models in which the response variables (or dependent variables) assume discrete values. In our case, the response variable is binary. There are only two possible outcomes for the response variables – dummy variables coded 0 or 1 – a firm either does or does not offer an advanced telecommunications service such as packet switching, DS or OC. In the qualitative response models, both the logistic distribution and cumulative normal distribution curve are commonly used. They are referred to as logit and probit respectively.

In the following sections, the basic linear probability model – using the method of ordinary least squares (OLS) will first be introduced. Then, it is compared to the logit and probit models. Some potential problems with the former model in relation to the latter two models will be discussed. The description of the models in this section will conclude with the most appropriate choice of models – the logit and probit regression models.

5.2.2 Problems with Linear Probability Model

Historically, some statisticians have applied the method of ordinary least squares (OLS) estimation on linear probability models. When using the *method of least squares* in estimating regression parameters, the values of the population regression coefficients (0, β_1, …, β_k) are usually unknown and can only be obtained through estimation from a sample of data points. In the case of simple linear regression, for example, the method of least squares is employed to estimate such regression coefficients from the sample. In order to find the least squares estimators of β_0, β_1, …, β_k, the coefficients b_0, b_1, …, b_k that minimize the sum of squared differences between the observed values of y and the values of y predicted by $b_0 + b_1x_1 + \ldots + b_kx_k$ have to be determined first. Therefore, we minimize the equation:

$$\sum[y - (b_0 + b_1x_1 + \ldots + b_kx_k)]^2 \qquad [5.1]$$

The sample regression equation obtained by the method of least squares can be written as

$$\mathbf{\hat{y} = b_0 + b_1x_1 + \ldots + b_kx_k + e} \qquad [5.2]$$

where i) $\hat{y}$ is the predicted value of y, or the estimated probability (has value of 1 if event happens, has value of 0 if event does not happen); ii) b_0 is the coefficient on the constant term; iii) b_1, b_2, …, b_k are the coefficients on the iv) independent variables x_1, x_2, …, x_k; and v) e is the error term.

However, potential problems may exist in the predicted probability from such model. Whereas the OLS regression uses normal probability theory, logistic regression uses binomial probability theory. There are 3 main problems associated with the use of the linear probability model:

1) The error terms are heteroskedastic, which occurs when the variance of the dependent variable is different with different values of the independent variables: var(e) = p(1-p), where p is the probability that event =1. Since p depends on x, the assumption in "classical regression" that the error term does not depend on x_1, x_2, …, x_k is violated.
2) The error term, e is not normally distributed because p takes on only two values – this violates another "classical regression" assumption.
3) The predicted probability $\hat{y}$ can be greater than 1 or less than 0, which may give rise to potential problems if the predicted values are used in a subsequent analysis. Attempt to overcome such problems by setting probabilities that are greater than 1 to be equal to 1 and probabilities that are less than 0 to be equal to 0 can be falsely interpreted that a high probability of the event (nonevent) occurring is certain.

The fundamental concern about the linear probability model is that it is not logically very attractive because it assumes the expected value of the dependent variable "increases linearly with x (the independent variable), that is, the marginal or incremental effect of x remains constant throughout… This seems patently unrealistic. In reality, one would expect the p_i is nonlinearly related to x_i."[37] In our regression analysis, we need a function such as the cumulative distribution function of a random variable, where outcomes lie between 0 and 1 and the response process is not linear but an S curve shape, which is often observed in technology adoption curves (Geroski, 2000).[38] The logit and probit models have these properties.[39]

[37] Guarati, Damodar N. (2003), *Basic Econometric*, Fourth Edition, McGraw Hill, New York, p. 593.

[38] For a review of literature on technology diffusion models, refer to, for example, Geroski, Paul A. (2000), *Models of Technology Diffusion*, Research Policy, 29, p. 603-625

[39] An extended discussion is found in, for example, Pampel, Fred C. (2000: 54-68).

5.2.3 Logit and Probit Models

The logit and probit models solve these problems. In the logit model:

$$\mathbf{ln\ [p/(1\text{-}p)] = b_0 + b_1x_1 + e} \qquad [5.3]$$

Alternatively, equation [5.3] can be written as:

$$[p/(1\text{-}p)] = e^{b0}\, e^{b1}\, e^{x1}\, e^{e} \qquad [5.4]$$

where i) ln is the natural logarithm, $\log_{exp}$, where exp = 2.71828…; ii) p is the probability that the event Y occurs, p(Y=1); iii) p/(1-p) is the "odds ratio"; iv) ln[p/(1-p)] is the log odds ratio, or logit; v) all other components of the model are the same as those described following equation [5.2].

The logistic distribution constrains the estimated probabilities to lie between 0 and 1. For example, the estimated probability is:

$$p = [\exp(b_0 + b_1x_1)]/[1 + \exp(b_0 + b_1x_1)] \qquad [5.5]$$

Alternatively, equation [5.5] can be written as:

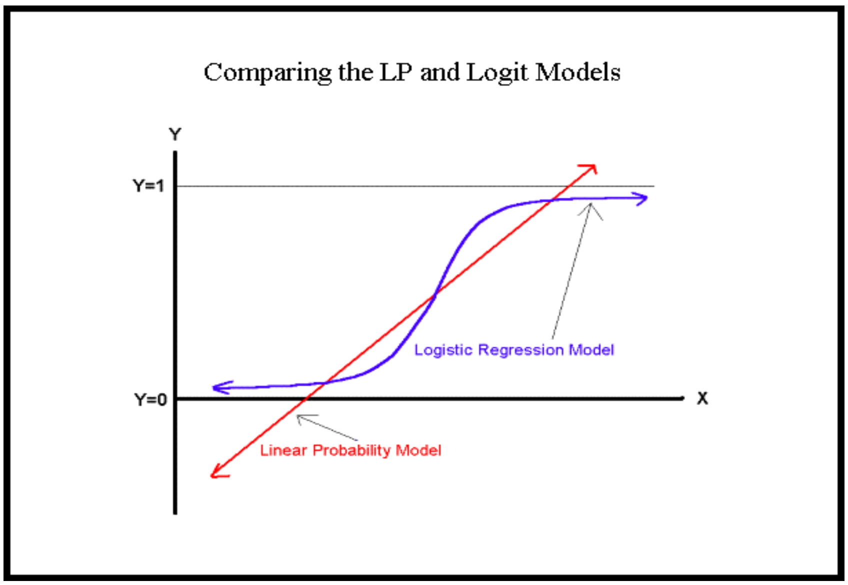
$$p = 1/[1 + \exp(-b_0 - b_1x_1)] \qquad [5.6]$$

This implies that i) if $b_0 + b_1x_1 = 0$, then p = 0.5; ii) as the term $(b_0 + b_1x_1)$ increases to infinity, p approaches 1; iii) as $(b_0 + b_1x_1)$ decreases to 0, p approaches 0.

The logistic regression model is simply a non-linear transformation of the linear regression model. It makes use of the logistic distribution, which is a S-shaped distribution function similar to the standard cumulative normal distribution used by the probit regression model. In general, the cumulative normal distribution and the logistic distribution are very close to each other, except at the tails. They yield very similar results unless a huge number of observations is used. Usually, the two estimations cannot be compared directly. As the logistic distribution has a variation of $\pi^2/3$, the results from the logit has to be multiplied by $\sqrt{3}/\pi^2$ to be comparable to the estimation from the probit model.[40]

A graphical comparison of the linear probability regression model and the logistic regression model is illustrated in Figure 5.1 below. The graph shows how with logit, unlike the linear probability model, ŷ falls between 0 and 1 and adopts an S-shape.

Figure 5.1: Comparison of Linear Probability Regression Model and Logistic Regression Model



[40] More details about these models can be found in econometric textbooks such as *Basic Econometric*, by Guarati, Damodar N. (2003).

5.2.4 Components of the Logit and Probit Regression Output Tables

The level of significance gives the precision with which the confidence intervals of the regression estimates are likely to contain the true regression parameters. The standard used for the level of significance in this statistical analysis is 5% (unless otherwise indicated).

The regression output tables for logit and probit will typically consist of the following information:

1) **Chi-square (χ^2)**: also known as the model likelihood ratio (LR):

$$LR(i) = -2[LL(b_0) - LL(b_0,b_1)] \quad [5.7]$$

The model LR statistic follows a χ^2 distribution with i degrees of freedom, where i is the number of independent variables. LL refers to the log of the likelihood function (L). The "unconstrained model", $LL(b_0,b_1)$, is the log-likelihood function evaluated with all independent variables included and the "constrained model" is the log-likelihood function evaluated with only the constant included, $LL(b_0)$. The Chi-square statistic determines if the overall model is statistically significant.

2) **R^2**: in OLS, the R^2 (coefficient of determination) denotes the proportion of the variance in the dependent variable (response variable) explained by the variance in the independent variables (predictor variable or explanatory variable), and lies between 0 and 1. Although there is no equivalent measure in logistic regression, there are several pseudo R^2 statistics. One of them is the McFadden’s R^2 statistic, or the likelihood ratio index (LRI):

$$\text{McFadden's-}R^2 = 1 - [LL(b_0,b_1)/LL(b_0)]$$
$$= 1 - [-2LL(b_0,b_1)/-2LL(b_0)] \quad [5.8]$$

where R^2 is a scalar measure between 0 to 1 like the R^2 in the linear probability model although pseudo R^2 is usually much less than that in the linear probability model - it is very difficult to "maximize the R^2" in logistic regression as the LRI depends on the ratio of the beginning and ending log-likelihood functions. The pseudo R^2 in logit and probit models are best used to compare different specifications of the same model instead of models with different data sets.

3) **Coefficient**:[41] instead of the slope coefficient (b_1) being the rate of change in the dependent variable (y) as the independent variable (x) changes in OLS, the slope coefficient here represents the rate of change in "log odds" as x changes. A more intuitive "marginal effect" of a continuous independent variable on the probability can be calculated: $dp/db_1 = f(b_1x)b_1$ where f(.) is the density function of the cumulative probability distribution function $F(b_1x)$, which ranges from 0 to 1. The marginal effects depend on the values of the independent variables - it is useful to evaluate the marginal effects at the means of the independent variables.

4) **Standard Error of Coefficient**: standard error of the estimated coefficients. This parameter provides a measure of the dispersion of the estimates.

5) **T-Statistic (T)**: enables the testing of the null hypothesis of a coefficient (or the hypothesis of the coefficient being 0) at the specified level of statistical significance. In general, for large samples, a standard 5% significance level and a one-tailed test, when the absolute value of the t value is observed to be 1.975 or greater, it would allow the rejection of the null hypothesis.

6) **Z-Statistic (Z)**: similar to T, except it is used only when the population standard deviation, σ, is known or when n is large (since T converges on Z asymptotically).

[41] The computation of the regression coefficients is usually quite complex and their values are cumbersome without using matrix notation – such calculations of the estimated regression coefficients are generally done using statistical software such as Stata or SAS.

7) **P-value (Probability value)**: this value gives the exact significance level associated with each coefficient. When the P-value is less than or equal to 5% (or 0.05), the coefficient is significant at the 5% significance level (take note to distinguish between a one and two-tailed test). The P-value denotes the likelihood that t value is obtained due to random effects. When the reported P-values are essentially 0%, it indicates that the observed relationship is very unlikely caused by random events and the relationship is statistically significant.

In summary, the logit or probit models are used because the adoption process is not linear and because of the 3 main statistical concerns about the linear probability model, identified in Section 5.2.2. Standard hypothesis testing can still be carried out despite the use of logit or probit. Such procedures would enable the testing of overall fit of the model, using Chi-square and of individual coefficients, using Z or T test. A more sophisticated model specifically tailored to take into account of the issue of endogenous competition variable – the bivariate probit model, which estimates maximum-likelihood two-equation probit models will be presented and explained in Section 5.3.2.1.

5.3 Econometric Analyses and Findings

Econometrics begins with a theory. I started the econometric analysis with a simple model – we postulate the availability of service is in part a positive function of the size of the market. The size of the market can be estimated by the following explanatory variables: i) total number of employees in all business establishments located in each wire center; and ii) total number of households in each wire center in the U.S.

To verify this hypothesis, testing using actual line counts for wire centers was conducted. The result was very robust – more than 80% of the variations in the number of access lines could be accounted for by just using the number of households and the number of employees as explanatory variables (see adjusted R^2 in Table 5.1 below). This calculation provided validation to the map overlay techniques employed in this research (as explained in Section 4.2.1.1) – if the overlays were not accurately done, the regression analysis would not have produced such robust results (i.e. the simple model using actual wire center line counts could not have explained up to 90% of the variations in actual line counts). Table 5.1 below illustrates this test.

Table 5.1: Verification of Robustness of Econometric Model Using Line Counts

Source	SS	df	MS
Model	2.9280e+11	2	1.4640e+11
Residual	4.5585e+10	1141	39951711.6
Total	3.3839e+11	1143	296051630

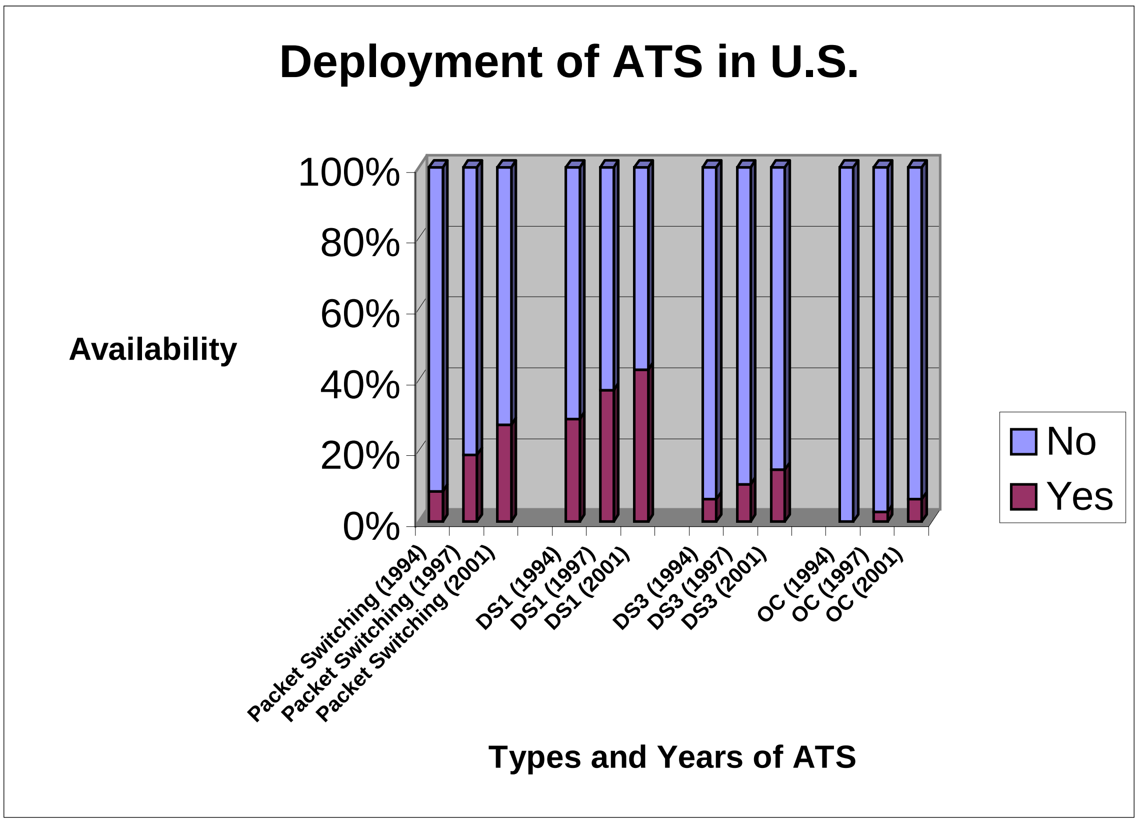
Number of obs	1144
F(2, 1141)	3664.45
Prob > F	0.0000
R-squared	0.8653
Adj R-squared	0.8651
Root MSE	6320.7

Loops in Service	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
# Employees	.5286943	.0222053	23.81	0.000	.4851266	.5722621
# Households	.974436	.0306513	31.79	0.000	.9142967	1.034575
cons	1952.739	229.8328	8.50	0.000	1501.797	2403.682

5.3.1 General Observations

From the data set, we observed an increasing trend in deployment across all levels of advanced telecommunications services in the United States over the past few years (see Figure 5.2 below).

Figure 5.2: Deployment of ATS in the United States



From the results of econometric regression analyses (Section 5.3.4), the first observation shows that the deployment of advanced telecommunications services (packet switching, DS and OC) are positively correlated to i) total number of employees in all business establishments located in each wire center and ii) total number of households in each wire center in the U.S. In other words, the number of employees and the size of the household population increase the likelihood of ATS being available.

In this set of regression analyses, the dependent variable is the availability of ATS. The independent (right-hand side) variables include items (i) and (ii) above. We have similar results for packet switching, OC, DS services for 2001. In this set of regression analyses, the relevant parameters (as mentioned in Section 5.2.4) indicate that the results are statistically significant. Throughout the rest of the regression analyses, statistically significant results are consistently obtained.

5.3.2 Impact of Local Competition

5.3.2.1 Bivariate Probit Model and Analysis

The *bivariate probit model* is used to estimate the equation where one of the explanatory variables, the competition variable, is endogenous.[42] The dependent variable is one of the advanced services such as packet switching, DS3 or OC. The equation to be estimated is:

Y = f (presence of competition, 271 Approval, RBOCS, medium size ILECs, RUS support, UNE price/ embedded cost, # of households, # of employees, federal price cap, rural federal classification, SNET variable,[43] total # small establishments in SIC 52,[44]

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[42] One of the fundamental assumptions for econometrics is that the explanatory variables are predetermined. If they are not predetermined, it will be very difficult to correctly estimate the impact they have on the dependent variable. When one of the explanatory variables (right-hand side variables) is endogenous (not predetermined), the coefficient estimates will be biased unless some corrective steps are taken. The two-stage bivariate probit model addresses this concern so that our coefficient estimates will be unbiased. To illustrate this concept with a simple example – imagine that we are estimating how the price in a market is determined. We know that demand is a function of price (so price is the explanatory variable) and we also know that price is not determined solely by the demand for a product, as it is also a function of the supply. If we fail to take into account that both demand and supply simultaneously determine the equilibrium price, our parameter estimates will be incorrect.

[43] SNET is the abbreviation for Southern New England Telephone, one of the ILECs in Connecticut. SNET variable is a dummy variable used in the regressions to control for the deployment of DS and OC by Southern New England Telephone (see also Section 4.2.1.2).

[44] SIC 52 refers to finance and insurance and SIC 54 refers to professional, scientific and technical services (see Section 4.2.4.1).

total # medium establishments in SIC 52, total # large establishments in SIC 52, total # small establishments in SIC 54, total # medium establishments in SIC 54, total # large establishments in SIC 54) [5.9]

In order to examine the impact of competitive entries into the market on the deployment of ATS, the number of wire centers served by CLECs that are located within 3 miles of each wire center served by ILECs in 2001 and 2002 are ascertained.[45] Data on the services provided by the CLECs is not included since data on their products and service territories are not as readily available as those for the ILECs. Therefore, the findings only reveal the behaviors of the ILECs.

The level of competition (explanatory variable on the right-hand side of the equation) is arguably endogenous to the model. When the level of competition is endogenous, the level of competition would be correlated with the error term of the model (refer to Equation 5.3). In this case, OLS regression will not be able to deliver consistent estimates of the parameters of a structural equation. To illustrate, in the equation:

$$y_j = a_j Y + b_j X + e_j \qquad [5.10]$$

where y_j is the availability of ATS, there is a direct dependence of the explanatory variable, Y – level of competition on the error term (structural disturbances) of e. However, the error term is independent of the exogenous variable in X. A Two-Stage estimator – the bivariate probit model or biprobit can be used to overcome this problem. Biprobit estimates maximum-likelihood two-equation probit models. Specifically, it is run as a seemingly unrelated bivariate probit in which each of the equations has different predictors. The equations are not independent since they are computed on the same set of subjects (hence the term “seemingly unrelated”).

[45] Qualitative results do not change if 5, 7 or 10 miles are used.

The bivariate probit model allows a two-stage estimation where effectively probit or logit is employed at each stage. This avoids the problems of using OLS mentioned in Section 5.2.2 to estimate the coefficients for binary dependent variables. This is a case of recursive, simultaneous equations model:[46]

$$\text{Prob}\,[y_1 = 1, y_2 = 1 |\, x_1, x_2] = \Phi_2(\beta'_1 x_1 + \gamma y_2, \beta'_2 x_2, \rho) \qquad [5.11]$$

Where the dependent variables y_1 = competition variable; and y_2 = types of advanced telecommunications services (packet switching, DS or OC). The regressor vectors are x_1 and x_2. The endogenous nature of one of the variables, the competition variable, on the right-hand side of the equation can be ignored in formulating the log-likelihood. Note that the ancillary parameter Rho (ρ) in the regression output tables measures the correlation of the residuals from the two models in the bivariate probit model. For further details and verification, please refer to Greene (2000).

It is postulated that the presence of a CLEC should have a positive impact on ILECs' tariff offering of ATS. Regression analyses confirmed a strongly positive correlation between the presence of CLECs in an area and the availability of tariff offering of ATS provided by ILECs. In other words, *the higher the number of rivals (CLECs) in area of each wire center served by ILEC, more advanced telecommunications services will be provided by the ILEC wire center*. Qualitatively, the results do not change for different types of ATS (packet switching, DS and OC), same type of ATS across different years (2001 and 2002), across states (50 states in the U.S.), and for different number of miles (3, 5, 7 and 10 miles). In this set of regression analyses, the dependent variable is the availability of ATS while the independent variables include competitors in different years and competitors within different miles of radii.

In particular, ATS availabilities (and level of advanced services) are highest within vicinities of large cities like New York City where there are a lot of competition from

[46] Greene, William H. (2000), *Econometric Analysis*, Fourth Edition, Upper Saddle River, NJ: Prentice-Hall

CLECs. In the cases of the state of North Carolina and Washington, analyses show that ATS has the highest availabilities near cities like Durham, Raleigh, Charlotte and Greensboro and Seattle. These are illustrated by Figures 5.3 and 5.4 on the following two pages, where the blue dots represent ILEC wire centers; the red squares represent CLEC wire centers; and ATS is available where the green and brown diamonds appear on the map. The maps show that the competitors and availability of ATS are concentrated in large cities.

Figure 5.3: DS3 and OC Enabled as of 2001 in North Carolina against Income Groups

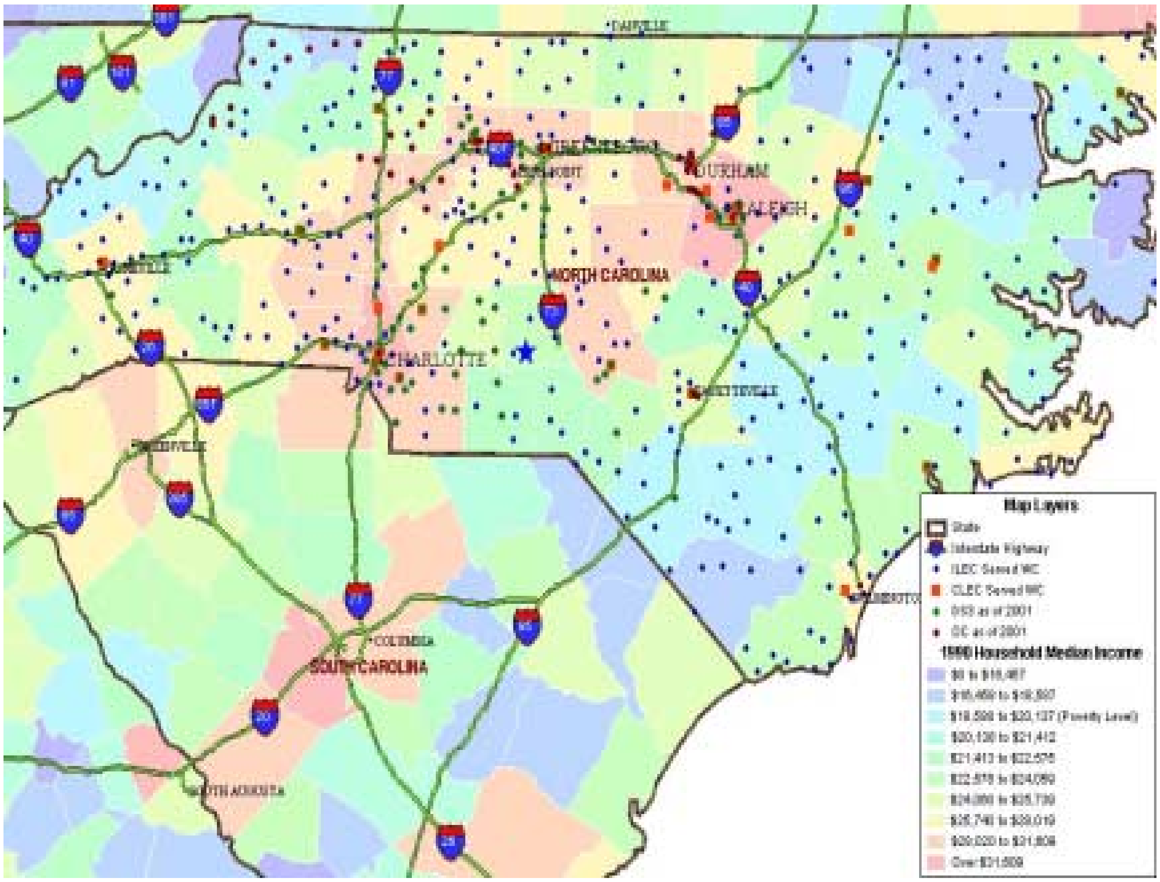
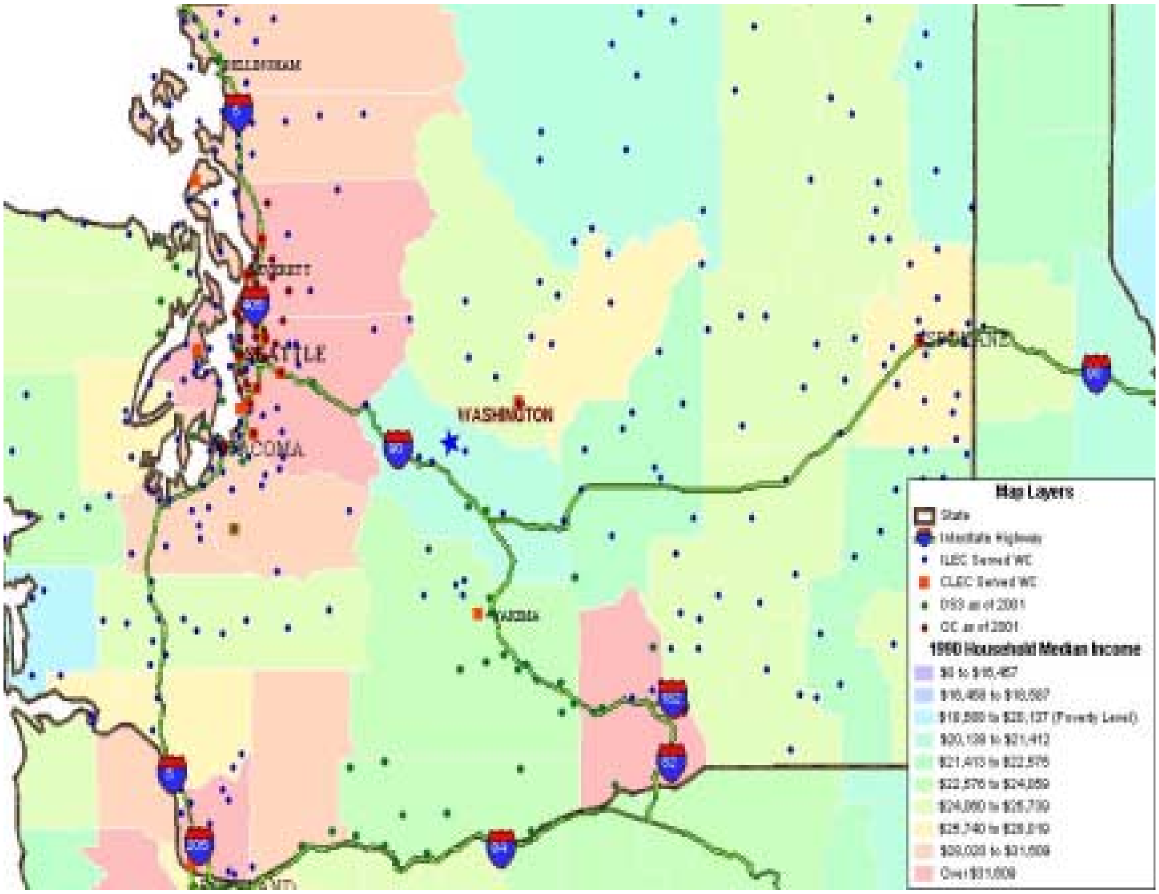


Figure 5.4: DS3 and OC Enabled as of 2001 in Washington against Income Groups



5.3.3 Impacts of Different Regulatory Variables

In the following sections, the impacts of different regulatory variables are examined and their implications are presented. It is interesting to observe the correlation of some of these regulatory variables in consideration, such as size of the firms (RBOCs, medium and small)[47]; federal price cap regulation; FCC rural classification of nature of carriers; and RUS support (see Table 5.2 below). We find that RBOCs are positively correlated to federal price caps but have strong negative correlation with the FCC rural classification and RUS support – showing most of the RBOC are not classified as rural by FCC and not receiving support from RUS. Medium size firms are positively correlated to FCC rural classification, federal price caps and RUS support in order of decreasing intensity. This shows some of the medium size firms are classified as rural carriers by the FCC and are receiving support from RUS. Finally, small firms are positively correlated to FCC rural classification and RUS support in order of decreasing intensity but negatively correlated to federal price caps. This shows most of the small firms are classified as rural carriers by the FCC and are receiving support from RUS.

Table 5.2: Correlation of Regulatory Variables

	RBOCS	Medium	Small	Price Cap	Rural	RUS
RBOCS	1.00					
Medium Size	-0.44	1.00				
Small	-0.72	-0.30	1.00			
Federal Price Cap	0.62	0.07	-0.71	1.00		
FCC Classified Rural	-0.73	0.14	0.67	-0.83	1.00	
RUS Support	-0.51	0.03	0.52	-0.63	0.52	1.00
(obs=20755)						

[47] See Section 5.3.3.1 for detailed firm size classification.

5.3.3.1 Corporate Ownership and Types of Businesses

To investigate the impact of corporate ownership – if medium size firms invest more in non-tier one areas (rural areas) than other areas, the ownership of the different wire centers has to be identified first. The wire centers are classified into those owned by RBOCs (including GTE and SNET), medium sized firms and small size firms. Medium size firms include telecommunications companies such as Alltel, Carolina Tel, Century Tel, Cincinnati Bell, Citizens Telecom, Frontier, Sprint, United, TDS Telecom and Valor. The rest of the firms are classified as small.

As the ILECs and CLECs may target deployment of advanced services in areas that are heavy users of communications services, a set of regression that controls for the relevant types of industries, specifically for SIC 52 and 54, in each wire center is needed (discussed in Section 4.2.4.1). The *Wald test* is conducted to ascertain if the SICs have a jointly positive impact on the availability of advanced telecommunications services. This can be done by verifying if jointly the SIC coefficients are zero. If the Prob > chi2 is less than 5%, the hypothesis that the joint impact of the SIC coefficients are zero is rejected. Different results are obtained from the Wald test for packet switching versus DS and OC transport. The hypothesis that the joint impact of the SIC coefficients are zero is rejected only for packet switching services – this results in keeping SIC for the packet switching regressions (Tables 5.3 to 5.5) but not for the DS and OC regressions (Tables 5.6 to 5.11). This is hardly surprising as packet switching products (essentially data) would seem to be tailored more to a small class of customers versus the DS3 and OC products, which would be provided in areas where there are a lot of aggregate traffic (voice, data and video).

Results showed that even in the set of regressions that control for those types of industries, the level of competition has a statistically positive impact on provision of packet switching (Tables 5.3 to 5.5).

Regression analyses (Table 5.3) indicate that in 2001, the availability of tariff offering of packet switching is positively correlated to wire centers owned by RBOCs and medium size firms (as indicated by the positive coefficient) with RBOC ownership showing slightly stronger affect. In the case of a more advanced telecommunications service like DS3 (Table 5.6), its availability is also positively correlated to RBOC and medium size firm ownerships but with medium size firm ownership showing slightly stronger affect. This shows that RBOCs have less incentive to provide DS3 services than medium size firms. In the case of OC (Table 5.9), the reverse happens – OC availability is positively correlated to RBOC ownership but negatively correlated to medium size firm ownership. This suggests OC is the level of ATS that the RBOCs are providing while the medium size firms usually do not provide OC.

5.3.3.2 Forms of Government Regulation and Support

The presence of price cap regulation is postulated to increase the likelihood that ATS is available more than the presence of rate-based regulation. Many economists concurred with this view. For example, Greenstein, McMaster and Spiller (1995) suggested that rate-based regulation has a negative impact on the availability of digital technology.

Regression analyses did not confirm this hypothesis by indicating strongly negative correlations between federal price cap regulation and availabilities of packet switching (Tables 5.3 and 5.4), DS (Tables 5.6 and 5.7) and OC (Tables 5.9 and 5.10) services. This result on price caps is considerably different from that of Greenstein, McMaster and Spiller (1995) although this could be due to the differences in the focus of the two studies – we focused on services while they studied facilities. All else being equal, the consistent findings indicate that there is less of a likelihood that advanced telecommunications services are provided in wire centers that are subject to price caps relative to ratebase rate-of-return.

Similar patterns are observed for different types of ATS (packet switching, DS and OC), same type of ATS across different years (2001 and 2002), across states (50 states in the U.S.), and across aggregated forms of regulations (price caps versus rate-based regulation). In this set of regression analyses, the dependent variable is the availability of ATS while the independent variables include: i) different forms of aggregated regulations; ii) forms of aggregated regulation across different years; and iii) forms of regulation in different states.

The presence of FCC rural classification[48] (the classification of rural and non-rural carriers by the FCC) has strong negative correlation with the availabilities of packet switching (Tables 5.3 to 5.5), DS (Tables 5.6 to 5.8) and OC (Tables 5.9 to 5.11) services. All else equal, if classified as rural, lower likelihood of that ATS is provided.

Next, the impact of RUS support is examined. The Rural Utilities Service is a federal agency that provides low cost loans to many independent telephone companies. U.S. Congress has passed legislation that requires RUS borrowers to make available advanced telecommunications services to their retail customers. The important question is if the availability of subsidized loans indeed accelerates the availabilities of advanced telecommunications services. To address this question, the database includes a field that identifies companies that are RUS firms and are able to borrow from RUS. The regression analyses indicate that indeed the presence of RUS support (on the firms) has a strong positive correlation with the availabilities of packet switching (Tables 5.3 and 5.4), DS3 (Tables 5.6 and 5.7) and OC (Tables 5.9 and 5.10) services. In terms of the magnitude of the coefficients, RUS support has the most positive impact on OC transport services than packet switching and DS3.

[48] Also see section 4.2.5.1.

5.3.3.3 FCC 271 Approval Process

In order to provide in-region inter-LATA services under Section 271 of the Communications Act of 1934, the Bell Operating Companies (BOCs) must file applications with the FCC on a state-by-state basis. This is known as the 271 approval process. I hypothesize that this process will yield a significant positive impact on the development of local competition. To control for 271 activities, the data set included information on the dates and names of RBOCs that receive 271 approvals from the FCC. Regression analyses have shown that 271 approvals by the FCC have strong positive impact on the deployment of packet switching (Tables 5.3 to 5.5) and DS3 (Tables 5.6 to 5.8) services in different years and across different states. However, for OC services, 271 approvals show negative impacts on their deployment (Tables 5.9 to 5.11).

5.3.3.4 Unbundled Network Element (UNE) Prices and Ratio

To examine the impact of unbundled network element (UNE) prices on the deployment (availability) of advanced telecommunications services, we focus on the RBOCs. This can be achieved by computing the ratio of the UNE loop price to the embedded cost as a proxy for regulatory treatment of collocation, interconnection and UNEs. This ratio represents, as explained in Section 4.2.5.1, how friendly the regulatory regime in the particular state is to the RBOCs in terms of the unbundling and resale mandate according to Section 251(c) of the 1996 Telecommunications Act. Although the data focuses on RBOCs, this ratio can be a good proxy for all companies.

The UNE obligation mandates that ILECs, such as the RBOCs have to satisfy the requirements in Section 251(c) of the 1996 Telecommunications Act. The various obligations collectively attempt to facilitate the entry of new providers into local markets and increase their ability to compete with the incumbents. For example, the RBOCs have to negotiate interconnection arrangements and make available their UNEs to competing service providers entering the local market on just, reasonable and non-discriminatory terms and conditions. The procedures for implementing these requirements for ILECs are further set forth in Section 252.

The regression results indicate that the availabilities of packet switching (Tables 5.3 to 5.5), DS3 (Tables 5.6 to 5.8) and OC (Tables 5.9 to 5.11) are strongly and positively correlated to the ratio of forward-looking UNE prices to their embedded costs. In other words, the RBOCs and other ILECs will increase the deployment of these ATS if UNE prices increase more than proportionately to their embedded cost (under suitable regulatory regimes).

The regression results have indicated that an increase in the ratio of UNE price to embedded cost will trigger an increase in the availability of all advanced telecommunications services considered. This suggests that if the government's objective is to encourage deployment of ATS by ILECs, the agencies should suitably increase UNE prices relative to their embedded costs. It further suggests that if government regulatory bodies like the FCC treat ATS like traditional telecommunications services such as voice and start to place them under strict regulation, it will provide a disincentive for the ILECs to invest to provide ATS.

5.3.4 Supporting Regression Tables

This section contains a selection of important regression results in the form of tables for cross-references from the previous sections. These regressions generally make use of three sets of response variables of ATS, in the order of packet switching, DS3 and OC, with the presence of competitors within 3 miles of ILEC wire centers in 2001 as the competition variable.

5.3.4.1 Packet Switching Regression Results[49]

[49] We have the greatest confidence in the packet switching results. DS and OC are point-to-point services. For OC and DS, an ILEC might install facilities and not tariff the product, in the hope of being able to

Table 5.3: Regression Table with Packet Switching as Response Variable (Constant – Small Size Firms)

Seemingly unrelated bivariate probit — Number of obs = 18437
Wald chi2(36) = 6848.96
Log likelihood = -13425.191 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
Packet 2001						
Competition	.424371	.1178843	3.60	0.000	.193322	.6554201
271 Approval	.4286624	.037301	11.49	0.000	.3555537	.5017712
RBOCS	.9423408	.045055	20.92	0.000	.8540346	1.030647
Medium size ILECs	.6622644	.03847	17.22	0.000	.5868646	.7376642
RUS support	.2131896	.03748	5.69	0.000	.1397301	.2866491
UNE price/ Embedded $	1.527147	.0625108	24.43	0.000	1.404628	1.649666
# Employees	.000023	2.72e-06	8.46	0.000	.0000177	.0000284
# Households	4.84e-06	2.61e-06	1.86	0.063	-2.64e-07	9.95e-06
Fed price cap	-1.05664	.060008	-17.61	0.000	-1.174253	-.9390261
Rural fed	-.5539457	.0573549	-9.66	0.000	-.6663592	-.4415321
Snet variable	-1.724256	.2786221	-6.19	0.000	-2.270345	-1.178166
# Small est 52	.0045594	.0009253	4.93	0.000	.0027458	.0063731
# Medium est 52	-.0404801	.0064804	-6.25	0.000	-.0531815	-.0277786
# Large est 52	.0402867	.0125683	3.21	0.001	.0156533	.0649201
# Small est 54	.0028803	.0004328	6.66	0.000	.0020321	.0037285
# Medium est 54	-.0250288	.0046386	-5.40	0.000	-.0341203	-.0159372
# Large est 54	-.0487679	.0123324	-3.95	0.000	-.072939	-.0245968
cons	-1.844079	.0840147	-21.95	0.000	-2.008745	-1.679414
/athrho	-.0720215	.0658074	-1.09	0.274	-.2010017	.0569586
rho	-.0718973	.0654672			-.1983378	.0568971

Likelihood ratio test of rho=0: chi2(1) = 1.19388 Prob > chi2 = 0.2745

Wald Test Results (on Sum of the SIC Coefficients Being Zero):[50]
chi2(1) = 37.07
Prob > chi2 = 0.0000

charge special construction charges. However, as packet switching is a switched service, if investment in the technology is made, a company would want to tariff the service so that customers across the states are aware that their packets (of data) can be sent to customers at that particular wire center.

[50] As mentioned in Section 5.3.3.1, the Wald test is used to ascertain if the SICs have a jointly positive impact on the availability of advanced telecommunications services. If the Prob > chi2 is less than 5%, the hypothesis that the joint impact of the SIC coefficients are zero is rejected. SIC 52 and 54 will then be preserved in the regression. This occurred for packet switching but not for DS3 and OC.

Table 5.4: Regression Table with Packet Switching as Response Variable (Constant – Medium Size Firms)

Seemingly unrelated bivariate probit — Number of obs = 14127

Wald chi2(34) = 6473.32

Log likelihood = -11165.465 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Packet 2001						
Competition	.7793308	.1107507	7.04	0.000	.5622634	.9963983
271 Approval	.4529325	.0378267	11.97	0.000	.3787935	.5270716
RBOCS	.4840829	.0392581	12.33	0.000	.4071384	.5610274
RUS support	.2679861	.0560133	4.78	0.000	.1582021	.3777702
UNE price/ Embedded $	2.234573	.0800101	27.93	0.000	2.077756	2.39139
# Employees	.0000213	2.76e-06	7.74	0.000	.0000159	.0000267
# Households	-3.91e-07	2.57e-06	-0.15	0.879	-5.44e-06	4.66e-06
Fed price cap	-1.002504	.0685094	-14.63	0.000	-1.13678	-.8682283
Rural fed	-.2827885	.0627058	-4.51	0.000	-.4056895	-.1598875
Snet variable	-1.553199	.2741773	-5.66	0.000	-2.090576	-1.015821
# Small est 52	.0042785	.0009237	4.63	0.000	.0024681	.0060889
# Medium est 52	-.0397376	.0064818	-6.13	0.000	-.0524416	-.0270336
# Large est 52	.0426785	.0125542	3.40	0.001	.0180727	.0672843
# Small est 54	.002977	.0004279	6.96	0.000	.0021382	.0038158
# Medium est 54	-.0289015	.0045684	-6.33	0.000	-.0378553	-.0199476
# Large est 54	-.0444533	.0121567	-3.66	0.000	-.06828	-.0206266
cons	-2.004825	.0961973	-20.84	0.000	-2.193368	-1.816282
/athrho	-.3219775	.0686352	-4.69	0.000	-.4565	-.187455
rho	-.3112939	.0619842			-.4272273	-.1852898

Likelihood ratio test of rho=0: chi2(1) = 20.9792 Prob > chi2 = 0.0000

Wald Test Results:

chi2(1) = 34.52

Prob > chi2 = 0.0000

Table 5.5: Regression Table with Packet Switching as Response Variable (Constant – RBOCs)

Seemingly unrelated bivariate probit Number of obs = 9634
Wald chi2(28) = 4693.34
Log likelihood = -8010.6008 Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Packet 2001						
Competition	.5972955	.1382823	4.32	0.000	.3262672	.8683238
271 Approval	.4903943	.0391685	12.52	0.000	.4136254	.5671632
UNE price/ Embedded $	3.21005	.1046231	30.68	0.000	3.004992	3.415107
# Employees	.0000217	3.17e-06	6.83	0.000	.0000154	.0000279
# Households	3.85e-06	2.85e-06	1.35	0.177	-1.73e-06	9.43e-06
Rural fed	-.6916545	.2184438	-3.17	0.002	-1.119797	-.2635125
Snet variable	-1.483891	.2822806	-5.26	0.000	-2.037151	-.9306316
# Small est 52	.0045184	.0010051	4.50	0.000	.0025484	.0064883
# Medium est 52	-.0407063	.006976	-5.84	0.000	-.0543791	-.0270336
# Large est 52	.0499791	.0139344	3.59	0.000	.0226682	.0772901
# Small est 54	.0026242	.0004601	5.70	0.000	.0017224	.003526
# Medium est 54	-.0241919	.0052049	-4.65	0.000	-.0343933	-.0139905
# Large est 54	-.0466287	.0144625	-3.22	0.001	-.0749746	-.0182828
cons	-3.294817	.0862844	-38.19	0.000	-3.463932	-3.125703
/athrho	-.2130085	.0821153	-2.59	0.009	-.3739516	-.0520654
rho	-.2098443	.0784994			-.3574433	-.0520184

Likelihood ratio test of rho=0: chi2(1) = 6.50251 Prob > chi2 = 0.0108

Wald Test Results:

chi2(1) = 16.97
Prob > chi2 = 0.0000

5.3.4.2 DS Regression Results

Table 5.6: Regression Table with DS3 as Response Variable (Constant - Small Size Firms)

Seemingly unrelated bivariate probit Number of obs = 20652
Wald chi2(24) = 7275.32
Log likelihood = -12111.856 Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
DS3 2001						
Competition	.5282805	.0720325	7.33	0.000	.3870994	.6694616
271 Approval	.3372381	.0415698	8.11	0.000	.2557627	.4187134
RBOCS	.6459103	.0388395	16.63	0.000	.5697862	.7220343
Medium size ILECs	.8447944	.036315	23.26	0.000	.7736184	.9159705
RUS support	.209976	.0387932	5.41	0.000	.1339426	.2860093
UNE Price/ Embedded $	.364228	.0685613	5.31	0.000	.2298504	.4986056
# Employees	8.96e-06	1.29e-06	6.96	0.000	6.44e-06	.0000115
# Households	.0000133	1.79e-06	7.46	0.000	9.83e-06	.0000168
Fed price cap	-1.215787	.0667189	-18.22	0.000	-1.346554	-1.085021
Rural fed	-.5149145	.0636682	-8.09	0.000	-.6397019	-.390127
SNET variable	3.625292	.367923	9.85	0.000	2.904176	4.346408
cons	-1.14863	.0900921	-12.75	0.000	-1.325207	-.972053
/athrho	-.3015898	.0414386	-7.28	0.000	-.3828081	-.2203715
rho	-.2927668	.0378868			-.3651436	-.2168722

Likelihood ratio test of rho=0: chi2(1) = 54.8229 Prob > chi2 = 0.0000

Wald Test Results:

chi2(1) = 0.38

Prob > chi2 = 0.5397

Table 5.7: Regression Table with DS3 as Response Variable (Constant - Medium Size Firms)

Seemingly unrelated bivariate probit — Number of obs = 15910
Wald chi2(22) = 6228.19
Log likelihood = -10325.672 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
DS3 2001						
Competition	.5348595	.0670795	7.97	0.000	.4033861	.6663329
271 Approval	.3355981	.0408729	8.21	0.000	.2554887	.4157075
RBOCS	.2858283	.035039	8.16	0.000	.2171531	.3545035
RUS support	.3184637	.0615359	5.18	0.000	.1978555	.439072
UNE Price/ Embedded $	.3164687	.0826533	3.83	0.000	.1544712	.4784662
# Employees	6.14e-06	1.24e-06	4.96	0.000	3.72e-06	8.56e-06
# Households	.0000102	1.73e-06	5.92	0.000	6.86e-06	.0000136
Fed price cap	-.8358447	.0774187	-10.80	0.000	-.9875826	-.6841069
Rural fed	-.1172988	.0674456	-1.74	0.082	-.2494898	.0148921
SNET variable	3.561109	.3620637	9.84	0.000	2.851477	4.27074
cons	-1.065813	.105974	-10.06	0.000	-1.273518	-.8581077
/athrho	-.395349	.03999	-9.89	0.000	-.4737279	-.3169701
rho	-.3759624	.0343375			-.4412065	-.3067647

Likelihood ratio test of rho=0: chi2(1) = 103.414 Prob > chi2 = 0.0000

Wald Test Results:

chi2(1) = 0.00
Prob > chi2 = 0.9743

Table 5.8: Regression Table with DS3 as Response Variable (Constant – RBOCs)

Seemingly unrelated bivariate probit — Number of obs = 9849

Wald chi2(16) = 4555.35

Log likelihood = -6407.8941 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
DS3 2001						
Competition	.8358382	.1020321	8.19	0.000	.635859	1.035817
271 Approval	.3521881	.0427941	8.23	0.000	.2683132	.436063
UNE Price/ Embedded $	.5957317	.1062407	5.61	0.000	.3875038	.8039596
# Employees	.000014	2.08e-06	6.75	0.000	9.96e-06	.0000181
# Households	.0000147	2.27e-06	6.50	0.000	.0000103	.0000192
Rural fed	-6.337945	154388.8	-0.00	1.000	-302602.9	302590.2
SNET variable	3.70456	.3659133	10.12	0.000	2.987383	4.421737
cons	-2.0412	.0877957	-23.25	0.000	-2.213276	-1.869124
/athrho	-.4264858	.0633641	-6.73	0.000	-.5506772	-.3022945
rho	-.4023803	.0531048			-.5010276	-.293411

Likelihood ratio test of rho=0: chi2(1) = 43.7301 Prob > chi2 = 0.0000

Wald Test Results:

chi2(1) = 0.49

Prob > chi2 = 0.4827

5.3.4.3 OC Regression Results

Table 5.9: Regression Table with OC as Response Variable (Constant – Small Size Firms)

Seemingly unrelated bivariate probit   Number of obs = 20652
Wald chi2(24) = 7124.95
Log likelihood = -8273.444   Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
OC 2001						
Competition	.9650182	.0800387	12.06	0.000	.8081452	1.121891
271 Approval	-.3952834	.0609992	-6.48	0.000	-.5148397	-.275727
RBOCS	1.149569	.0566604	20.29	0.000	1.038517	1.260622
Medium size ILECs	-.1818668	.0787527	-2.31	0.021	-.3362193	-.0275143
RUS support	.2977223	.065137	4.57	0.000	.1700561	.4253885
UNE Price/ Embedded $	1.026241	.0928557	11.05	0.000	.8442475	1.208235
# Employees	2.96e-06	1.45e-06	2.05	0.040	1.30e-07	5.80e-06
# Households	.0000131	1.96e-06	6.70	0.000	9.27e-06	.0000169
Fed price cap	-1.893951	.2552465	-7.42	0.000	-2.394225	-1.393677
Rural fed	-1.018751	.2548332	-4.00	0.000	-1.518215	-.5192872
SNET variable	3.745349	.2878632	13.01	0.000	3.181147	4.30955
cons	-1.781961	.2595501	-6.87	0.000	-2.290669	-1.273252
/athrho	-.4036413	.0473419	-8.53	0.000	-.4964298	-.3108529
rho	-.3830603	.0403952			-.4593047	-.3012128

Likelihood ratio test of rho=0: chi2(1) = 76.5727 Prob > chi2 = 0.0000

Wald Test Results:

chi2(1) = 0.89
Prob > chi2 = 0.3465

Table 5.10: Regression Table with OC as Response Variable (Constant – Medium Size Firms)

Seemingly unrelated bivariate probit — Number of obs = 15910
Wald chi2(22) = 6565.86
Log likelihood = -7208.6235 — Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
OC 2001						
Competition	1.201865	.0808901	14.86	0.000	1.043323	1.360406
271 Approval	-.3799126	.0601838	-6.31	0.000	-.4978707	-.2619545
RBOCS	1.370561	.0619729	22.12	0.000	1.249097	1.492026
RUS support	1.327645	.1260033	10.54	0.000	1.080683	1.574607
UNE Price/ Embedded $	1.153286	.1140693	10.11	0.000	.9297145	1.376858
# Employees	1.69e-06	1.51e-06	1.12	0.263	-1.26e-06	4.64e-06
# Households	.000011	1.99e-06	5.52	0.000	7.08e-06	.0000149
Fed price cap	-.8121162	.6191753	-1.31	0.190	-2.025677	.4014451
Rural fed	-1.3161	.6188203	-2.13	0.033	-2.528966	-.1032348
SNET variable	3.966677	.3533955	11.22	0.000	3.274035	4.65932
cons	-3.202207	.6234048	-5.14	0.000	-4.424058	-1.980356
/athrho	-.5768158	.0553225	-10.43	0.000	-.6852458	-.4683858
rho	-.5203472	.0403433			-.5949191	-.4368941

Likelihood ratio test of rho=0: chi2(1) = 121.754 Prob > chi2 = 0.0000

Wald Test Results:

chi2(1) = 1.14
Prob > chi2 = 0.2847

Table 5.11: Regression Table with OC as Response Variable (Constant – RBOCs)

Seemingly unrelated bivariate probit   Number of obs = 9849
Wald chi2(16) = 4149.74
Log likelihood = -5409.4583   Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
OC 2001						
Competition	1.067509	.0934306	11.43	0.000	.8843884	1.25063
271 Approval	-.400079	.0609779	-6.56	0.000	-.5195935	-.2805645
UNE Price/ Embedded $	1.356131	.1233036	11.00	0.000	1.11446	1.597802
# Employees	1.30e-06	1.81e-06	0.72	0.473	-2.25e-06	4.85e-06
# Households	.0000171	2.23e-06	7.66	0.000	.0000127	.0000215
Rural fed	-6.516531	327074.4	-0.00	1.000	-641060.5	641047.5
SNET variable	3.999173	.3568219	11.21	0.000	3.299815	4.698531
cons	-2.827074	.1064417	-26.56	0.000	-3.035696	-2.618452
/athrho	-.5285457	.0609332	-8.67	0.000	-.6479725	-.4091188
rho	-.4842686	.0466434			-.5703035	-.3877242

Likelihood ratio test of rho=0: chi2(1) = 78.9777 Prob > chi2 = 0.0000

Wald Test Results:

chi2(1) = 1.30
Prob > chi2 = 0.2540

6 POLICY RECOMMENDATIONS AND CONCLUSIONS

Broadband and advanced telecommunications services have been the targets of policy makers in various political arenas. The nature and terms of these regulations have become part of the competitive process in the deployment of ATS. As mentioned in Chapter 5, two main paths toward competition have been conceived: i) unbundling and resale; and ii) facilities-based competition.

6.1 Unbundling, Resale and Facilities-based Competition

6.1.1 Unbundling and Resale

Unbundling refers to the division of an ILEC’s network into smaller subcomponents, which may either be technology components like phone lines, or service components like switching services. These elements can then be sold separately to other telecommunications service providers. The main objective of such unbundling and resale mandates is to enable new market entrants (e.g. CLECs) to compete with the incumbents without the need to undertake the risks and costs of building these elements by themselves. There is a distinct difference between physical unbundling of the network elements and simple resale of services: in unbundling, the competitors have more freedom to provide differentiated services that may combine the unbundled network elements with elements originally from the competitors themselves; while with simple resale, there is a restriction on the competitors – they can only obtain revenue from the differential between the resale and retail rates.

Resale and unbundling mandates evoke a number of concerns both from the perspectives of the facilities owners and the competitors. The facilities owners (usually the ILECs) have the ability and incentives to leverage on its ownership of the critical inputs that the competitors depend on to their disadvantages in the downstream market where the firms compete. There is also a possibility that the facilities owners will never fully recoup their costs under the regulator-mandated access prices. Many heated debates have been centered on such arguments. Unbundling is supposed to play a crucial role in broadband competition and deployment, as originally intended by the policy makers. Some CLECs have provided services in areas underserved by the ILECs and the presence of CLECs in these areas will further spur the deployment of ATS by the ILECs. However, there are major implications for huge investment by the incumbents under such regimes. The analytical model and justification on making the incumbents unbundle and resell their local network elements implicitly assumes that these networks are based on static technologies and involve only deployed facilities. In contrast, network elements have to be constantly maintained and upgraded for new capabilities and services to become available. This mandate could pose serious disincentives for the incumbents to invest in new facilities and innovate, only to sell their innovations at cost to their competitors. Particularly, the incumbents have to bear the high risks of large investment without fully benefiting from it under these regulations.

6.1.2 Facilities-based Competition

Market players compete directly with one another under this model, utilizing independently constructed and operated local access infrastructure.[51] A possible solution to the unbundling and resale mandate could lie in facilities-based competition – a preferred end state by many policy makers, economists and consumer advocates. An important argument is that only facilities-based competition is capable of allowing complete deregulation of local markets. The local loop unbundling and resale mandate could then be used as a transitional approach while facilities-based competition is still developing.

[51] Market players in facilities-based competition may still use facilities such as backhaul circuits owned by other telecommunications companies (including ILECs) and all facilities-based competitors must interconnect with other ISPs that constitute the Internet at some points.

6.2 Policy Recommendations

Several improvements can be made to the present policy framework, which centers on the 1996 Telecommunications Act. Although the importance of broadband data communication and services were appreciated by the key policy makers of the 1996 Act and reflected in several of the terms involving advanced telecommunications services, the crucial role of the Internet and the rapid development of advanced telecommunications services were not fully taken into account when the Act was drafted. Much of the Act was devoted to the voice telephony market. The Act also uses both policy instruments – unbundling and resale, and facilities-based competition to stimulate competition in the local networks.

The following is a list of important policy recommendations derived from the results of this research:

1. Proactively take steps to promote accelerated deployment of advanced telecommunications services, especially at the local level.

This research suggests that attaining nationwide ATS deployment may be an extended process requiring a combination careful regulatory measures and incentives. Regulatory measures should be applied at the local level to reflect the local conditions while many incentives should be locally based due to the wide diversity in local conditions for deployment of advanced telecommunications services.

2. Encourage new market entrants and local competition to accelerate roll-out of advanced telecommunications services.

Increased competition at the local wire center level has a positive impact on the deployment of advanced telecommunications services. Suitable regulatory measures and incentives should be employed to increase competition at the local level to stimulate ATS deployment.

3. Construct regulatory policy framework in such a way as to place more emphasis on facilities-based competition over unbundling.

Specifically, in a regulatory environment that is friendly to the ILECs, as indicated by the high ratio of unbundled network elements (UNE) prices to the costs it takes to construct the loops (embedded costs) in this research, the ILECs are more willing to invest and deploy advanced telecommunications services at the local wire center level. This implies that the policy framework should favor alternatives to unbundling mandates, such as facilities-based competition as the ultimate instrument to stimulate competition. This would largely remove the disincentives to investment by incumbents, which will not invest or innovate if the benefits derived are not fully captured. Favoring facilities-based competition over unbundling would also avoid deterring competitors from investing in their own infrastructure since unbundling can inhibit facilities-based competition by decreasing the amount of incentives for competitors to construct new facilities or upgrade existing ones.

4. Use appropriate policy instruments to address the gaps where facilities-based competition is unlikely to occur or may occur slowly, such as using rate-based rate-of-return regulation over price caps.

In areas where population density is low and per-passing cost burden is high, entry by a second facilities owner or competitor is unattractive and unlikely to occur. Policy makers should anticipate such situations and appropriately use regulatory measures to address these noncompetitive markets. For example, in this research, it is shown that rate-based rate-of-return (ROR) regulation, where firms are guaranteed a 11.25% rate of return, will increase deployment of ATS more than regulatory measures such as price caps, where firms have to accept the financial risks with no guaranteed return on invested capital.

5. Understand the impact of mandates in the 1996 Telecommunications Act such as the 271 approval test on deployment of ATS and utilize such policy instruments appropriately.

As shown in this study, effective use of policy instruments such as the 271 inter-LATA approval test can be used to accelerate or impede the deployment of advanced telecommunications services. This understanding is important for government officials and policy makers to set the right regulatory agenda to achieve their goals of widespread communications services deployment.

6. Formulation of future regulation should focus on service rather than on particular transmission technology.

Advanced telecommunications services, like telephony or broadcasting, will be constantly subjected to various regulations reflecting various socio-economic and political interests. Service and not particular transmission technology should be the focus of future regulations as service-centric approaches are more flexible and tolerant of technology diversity. This is essential, as advanced telecommunications services will be subjected to increasingly rapid changes and greater diversity as information and network technologies progress. Such focus on service will encourage technology-independent way of describing services and formulation of regulation, making regulatory regimes applicable in the long run.

7. More efforts should be made to accelerate ATS deployment, especially in rural areas through grants and loans from organizations such as Rural Utilities Services (RUS).

ATS deployment should be promoted in rural areas through more financial incentives in the forms of tax credits, grants and loans through agencies such as RUS. This has been proven in my research to accelerate the deployment of ATS and enhance the standard of business communication in these areas.

8. Governments should support more research and development on access technologies, especially targeting the needs of non-incumbent players and areas that are not normally accessible to secure, private sector funding.

To promote the development and continued deployment of ATS, governments and regulatory agencies should support more R&D on access technologies of ATS in general. They should place special emphasis on the needs of non-incumbent players and in areas that have high cost of providing advanced telecommunications services and are generally not accessible to secure private funding.

9. Encourage and support continued efforts on more comprehensive and up-to-date data collection and research on the underlying socio-economic, political and regulatory factors of advanced telecommunications services deployment.

Government and regulatory agencies should encourage more research of this nature and scope though financial support such as research grants and loans. More comprehensive data collection will enable detailed study and better understanding of the underlying social, economic and political impacts of ATS availability; and economic and regulatory barriers that may hinder the non-incumbent facilities providers. Ultimately, this kind of research would generate very positive impacts on the understanding of ATS deployment and measures needed to accelerate such deployment.

6.3 Conclusions

Advanced telecommunications services will grow in importance for businesses in the age of information technology and digital business. They are powerful tools for communications, trade, industrial development, research and innovation. It is important for policy makers to understand what is the desirable threshold of government intervention to accelerate the deployment of advanced telecommunications services and gain an insight on the patterns and factors of their deployment. The concern if most areas in the United States will ultimately obtain some forms of advanced telecommunications services is just as important as when deployment in rural areas will occur, after such services have been made available to the more densely populated areas.

I hope this thesis has shed some light on the topic and shown how certain competitive and regulatory forces have impacted the deployment of advanced telecommunications services today and how they will continue to shape their deployment tomorrow. Sustained efforts on the part of government regulatory agencies and private organizations should be encouraged as they are essential to support further data collection, research and experimentation on this topic to improve our understanding of the deployment of advanced telecommunications services and their impacts on our people.

6.4 Future Research

Three main future research areas that require further clarification and insights and are worth investigating have been identified:

Research looking at interests of non-incumbents should be encouraged. Much of the current research has focused on the interests of incumbents in terms of deployment of broadband services, access technologies and other policy and regulatory issues. Research looking at the interests and needs of non-incumbents should be encouraged. This could increase the quality of services and level of technologies that foster accommodation of several competitive service providers over facilities because such technologies may not be of direct interests to the incumbents.

More detailed study of the impacts of each form of regulation on different states can be conducted. Within each category of regulation such as price cap or rate-of-return, there are many forms and intricate details associated with each of them. For example, price cap can be combined with service obligations or earnings sharing schemes, while different forms of rate-of-return regulatory and incentive schemes have been employed in combination or separately in different states. The use of each specific regulatory measure depends on the needs of individual state and this could pose interesting research questions that will aid our understanding in the deployment of advanced telecommunications services.

Comparative studies of deployment of advanced telecommunications services in the United States with that of other countries can be carried out. By comparing the current status of advanced telecommunications deployment in the U.S. with other countries of similar or contrasting socio-economic and political environments, such as other OECD countries or even developing countries, we could gain deeper understanding and form generalizable frameworks of how certain factors (such as political, regulatory, economic barriers and consumer behaviors) have most impacts on their deployment. We could draw lessons from these deployment progress and setbacks abroad to form better conceived, more insightful and coherent national broadband policies and strategies.

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APPENDIX

Appendix A – List of Acronyms

ABR	Available Bit Rate
ALT	Alternate Local Transport Companies
ATM	Asynchronous Transfer Mode
ATS	Advanced Telecommunications Services
BOC	Bell Operating Company
CAD	Computer-aided Design
CAM	Computer-aided Manufacturing
CAP	Competitive Access Provider
CBR	Constant Bit Rate
CLEC	Competitive Local Exchange Carrier
CTPID	Center for Technology, Policy and Industrial Development
DS	Digital Signal Level Technology
FCC	Federal Communications Commission
Gbps	Gigabits Per Second
ICO	Independent Telephone Company
ILEC	Incumbent Local Exchange Carrier
ISP	Internet Service Provider
ITC	MIT Program on Internet and Telecommunications Convergence
ITU-T	International Telecommunication Union – Telecommunications Standards Section
IXC	Inter-exchange Carrier
Kbps	Kilobits Per Second
L	Likelihood Function
LAN	Local Area Network
LATA	Local Access Transport Area
LL	Log of Likelihood Function
LEC	Local Exchange Carrier
LERG	Local Exchange Routing Guide

LRI	Likelihood Ratio Index
Mbps	Megabits Per Second
MIT	Massachusetts Institute of Technology
NANP	North American Numbering Plan
NECA	National Exchange Carrier Association
NRRI	National Regulatory Research Institute
OC	Optical Carrier
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
OSI	Open System Interconnection
PC	Personal Computers
PDN	Public Data Network
POP	Point-of-presence
QoS	Quality of Service
RBOC	Regional Bell Operating Company
ROR	Rate-of-return
RUS	Rural Utilities Services
SIC	Standard Industrial Code
SNET	Southern New England Telephone
SONET	Synchronous Optical Network
TPRC	Telecommunications Policy Research Conference
UBR	Unspecified Bit Rate
UNE	Unbundled Network Element
VBR	Variable Bit Rate
VCI	Virtual Circuit Identifier
WAN	Wide Area Network