NRRI 87-14

TELECOMMUNICATIONS MODERNIZATION: ISSUES AND APPROACHES FOR REGULATORS

by

Raymond W. Lawton
Associate Director
for
Telecommunications and Water Research

The National Regulatory Research Institute
1080 Carmack Road
Columbus, Ohio 43210

January 1988

This report was prepared by The National Regulatory Research Institute (NRRI) with funding provided by participating member commissions of the National Association of Regulatory Utility Commissioners (NARUC). The views and opinions of the authors do not necessarily state or reflect the views, opinions, or policies of the NRRI, the NARUC, or NARUC member commissions.

EXECUTIVE SUMMARY

The purpose of this report is to provide a conceptual basis from which commissioners and regulatory analysts may analyze and respond to various telecommunications modernization issues. Telecommunications modernization is an issue where the literature and concepts needed to address it are hard to find and not as well developed as, say, those used in ratemaking or other regulatory issue areas. Many modernization focal points are identified and examined in this report in order to provide a better understanding of telecommunications modernization from a regulatory perspective. Some of these include: replacement, technology substitution, accounting depreciation, network configuration, service demand, demand forecasting, investment decision making, economic depreciation, bypass, competition, abandonment, least-cost planning, write-offs, reserve deficiencies, comparably efficient interconnections (CEI), open network architecture (ONA), integrated system digital network (ISDN), and broad band integrated system digital network (BISDN).

No single item identified above allows for an integrated discussion of telecommunications modernization issues. Commissions acting in their traditional quasi-judicial mode integrate and synthesize information on modernization in hearings and other forums. This report reviews and analyzes telecommunications modernization using the above focal points and provides regulators with a framework that may assist in answering the important regulatory question: Who pays for modernization?

From a regulatory perspective several clusters of concern have arisen over telecommunication modernization. First, is the telephone utility industry's interest in positioning itself by acquiring a modernized equipment and facilities base sufficient to allow it to compete in unregulated telecommunications markets. Regulatory depreciation of some of the cost of modernization is more favorable than depreciation treatments available in unregulated markets. A second concern is the industry's worry that current depreciation practices may not provide for recovery of invested capital in a timely manner. Third, is the concern of regulators that equity and cost-minimization issues be addressed in determining capital investment decision making and capital recovery practices. The goal here is to see to it that the social contract equation does not become unbalanced to the detriment of either the utility or the monopoly ratepayer. A fourth concern is the awareness of regulators that the current wave of technology is not the last wave and that considerable information about the next generation of telecommunications technology is already available. Accordingly, the establishment of appropriate regulatory policies that would also be applicable in the future for deciding "who pays" for these even newer technologies is an important issue.

One of the most important sources of the regulatory dilemma over modernization stems from the discongruence between short-term and long-term costs and benefits. Said simply, the problem is that the premature retirement, or abandonment, of otherwise productive assets as well as the cost of the new technology must be picked up in the short-term before the long-term demand emerges to pick up its appropriate cost burden. Regulatory decision making is further confounded by the desire to avoid bypass and to promote viable competition.

Three models suitable for describing alternative telecommunications modernization deployment are presented and discussed and are used to illustrate the time and economic dimensions associated with modernization. In one scenario it can be seen that a range of 10 to 30 years may exist between the introduction of a telecommunications innovation and a 90% penetration of the residential market. A ten-year gap is likely to present few problems, whereas a thirty-year gap would raise serious inter-generational equity questions. The two economic studies of the diffusion of innovation are presented and suggest that (1) specialized and profitable sub-markets may exist for the older technology for a long period of time, and (2) the structure of the buyers' and sellers' markets may directly influence the rate at which a capital intensive innovation is disseminated.

Numerous current modernization issues are discussed and relevant data presented. Some of these include (1) a discussion of the dramatic decline in switching costs since 1965, (2) the non-vintage based retirement of older equipment, (3) the impact of regulation-induced modernization, (4) the impact of modernization on the emergence of viable competition, (5) the modernization activities of small telephone utilities, and (6) the existence and disposition of the "twenty-six billion dollar reserve deficiency."

Telecommunications Modernization Forecasts

Forecasts of telecommunications modernization are important both for the view they may provide of the future, as well as for the impact they have on the current actions of utilities and commissions. In part because of the need for utilities to position themselves advantageously for their likely role in certain deregulated, competitive telecommunications markets, forecasts that have predicted the need for extensive modernization have been readily accepted and widely circulated. Some of the current popularity of the Fisher-Pry technology substitution model among utilities may be ascribed to its ability to depict an exponential growth in the substitution of new technology for old.

An important feature of technology forecasting models is the impact of the predicted technology upon the subadditivity and physical interconnection of natural monopolies, including telephone utilities. Subadditivity means that it is cheaper if a true natural monopoly exists for one firm to provide service in a given territory than two firms. A second important feature of natural monopolies--electric, gas, water, and telephone--is the physical interconnection of the entire distribution system. Technological developments in telephony, such as microwave and Open Network Architecture (ONA), may affect both of these features and may provide an insight regarding the viability of traditional telephone monopolies.

Four macro network and eight micro telecommunications modernization forecasts are presented and reviewed.

The first is known as the Fisher-Pry technology substitution theory and is a forecasting model that describes and predicts the rate at which new telecommunications technologies will replace or substitute for older technologies. It bases its predictions on substitution data and predicts changes assuming a constant rate of substitution. It is felt that the forecasts are most accurate in a range where a minimum of 10% of all the substitution that is going to occur has happened to a maximum where 90% of all substitution has occurred. This report cautions analysts about the uncritical acceptance of reports that make predictions of the 99% substitution or replacement of electro-mechanical switching and other technologies based on the Fisher-Pry method.

Other features of the Fisher-Pry technology substitution approach that are examined and are the cause of some concern are: (1) the assumption of a constant rate of change, (2) the choice of a unit to measure change (Fisher-Pry tends to measure purchasing practices rather than total market penetration), (3) its ability to forecast accurately future technology substitution rates, (4) its ability to handle multiple relatively simultaneous substitutions, (5) how it accommodates discreet changes and changes in demand, and (6) the potentially self-fulfilling nature of the forecasting effort for regulated utilities. The inability of the Fisher-Pry method to explicitly model the underlying economic structure of telecommunications demand is a shortcoming of the model.

The second macro forecast examined uses the difference in switching and transmission costs to produce several distinct forecasts of alternative telecommunications futures. Using concepts extracted from the "geodesic network" report by Peter Huber, four forecasts have been constructed that describe the regulatory, economic, and modernization features for "status quo," "decentralized," "centralized," and "revolutionary growth" scenarios. Modernization efforts will be the strongest and least expensive for the revolutionary growth scenario, and the weakest and most costly for the status quo scenario. In the decentralization and revolutionary growth scenarios, regulation encourages entry, details transition strategies, and provides some level of regulatory oversight re pricing and quality of service standards during the "phase one" competitive market, as well as during the "phase two" oligopolistic market. The status quo scenario will be a period of little regulatory change, and the centralization scenario may have regulatory policies similar in many ways to current regulation.

An assumption that a ten percent market share is necessary for the economic viability of a telco attempting to provide ubiquitous national, long distance service, forms the basis for a third network macro forecast. This forecast allows an examination of the role of regional and other specialized carriers as well as emphasizing the importance of certain regulatory initiatives--such as comparable interconnection--in promoting a viable competition in the long distance national and regional markets.

A forecast of telephony in the year 2000 examines telephone technology, economics, usage patterns, and service needs and makes predictions based on the interrelationships among these factors. For example, it predicts that widespread diffusion of cellular telephone technology for the business person will depend in part on whether a business person will need information normally found on his or her desk, and whether calls can be handled in the field, away from office support facilities and staff.

Eight micro forecasts are examined based upon their ability to provide insights into some features of the macro network forecasts. Micro forecasts tend to be narrow in scope and focus on a small number of variables, such as the life expectancy of digital switching. However, such information allows profitable speculation on the impact of a long-lived asset such as digital switching on the cost of future systems. In particular, this example raises questions similar to those raised when digital switching replaced other long-lived (but not yet fully depreciated) assets.

Other topics covered by micro forecasts include: microwave, open network architecture, cost and service advantages of alternative transmission technologies, metropolitan area networks, ISDN, and central office adjustments to growth.

Depreciation Modernization Issues

While alternative depreciation methods have been advanced and investigated as being superior to straight line depreciation as a capital recovery method, the primary capital recovery method used by competitive firms is still straight line depreciation. Even high tech companies use straight line depreciation. In fact, the old Bell system during the most competitive earliest years of its existence--and at a time when it was one of a number of firms trying to dominate the market--chose and used straight line depreciation.

State commissions have acted over the last several years to address reserve deficiencies by adopting remaining life methods. Remaining life is an estimate that reflects the most recent retirement and replacement activities of the utility. Amortization of any recognized reserve deficiency has been the second most popular method selected by state commissions.

The findings of three recent studies of the comparative depreciation practices of utilities with those of unregulated firms are examined for their application to telephone utility modernization practices. All three studies affirm the predominant use of straight line depreciation by unregulated firms as well as by utilities. The studies show that the depreciation lives for telephone utilities are somewhat longer than those chosen for similar assets in unregulated firms. Unregulated firms tended to have fewer depreciation categories. Surveyed unregulated firms reported that they rarely change the depreciation method once chosen and use the same method company-wide.

Historical and industry practices were the most frequent standards reported by both regulated utilities and unregulated firms in considering modernization. A small but apparently growing number of utilities report using the Fisher-Pry technology substitution theory to forecast modernization actions.

One of the most important features that distinguishes regulatory depreciation from depreciation in unregulated markets is its "guarantee" over a wide range of circumstances of the recovery of capital prudently invested in used and useful assets. In non-regulated industries a depreciation schedule is a capital recovery mechanism having a degree of risk directly associated with current and future business conditions. The economic power of this guarantee stems from both the size of the monopoly customer base as well as the adherence by the commission to the reimbursement "terms" of the social contract. This strong linkage is increased by the regulatory commission's approval of original and revised depreciation schedules.

The regulatory implications of four alternative modernization scenarios are examined from a depreciation perspective. The scenarios are described below in table ES-1.

TABLE ES-1

MATRIX TYPOLOGY OF FOUR MODERNIZATION DEPRECIATION SCENARIOS FOR A TELEPHONE UTILITY ENGAGED IN SIGNIFICANT MODERNIZATION EXPENDITURES

No Replacement Of Existing Capital Assets		Existing Capital Assets Are Replaced	
Required Growth In Service Demand Occurs	Required Growth In Service Demand Does Not Occur	Required Growth In Service Demand Occurs	Required Growth In Service Demand Does Not Occur
Scenario One: No Depreciation Deficiency and Requisite Growth Occurs	Scenario Two: No Depreciation Deficiency, but Requisite Growth Does Not Occur	Scenario Three: Depreciation Deficiency, and Requisite Growth Occurs	Scenario Four: Depreciation Deficiency, but Requisite Growth Does Not Occur

Source: Author's construct.

The report also examines capital recovery from the accounting and economic depreciation perspectives, finding each to be useful in certain situations. The accounting allocation perspective appears best suited for ensuring capital recovery, particularly in a stable and a regulated industry. Economic depreciation seems to offer a distinct advantage in equipment modernization and replacement analyses. Both approaches work well in a regulated environment where capital recovery for prudently incurred capital investments is generally assured.

Assessing the Usefulness of the Abandonment Concept

A common feature of modernization is the replacement of equipment representing an older technology with equipment using a newer, more efficient technology. The replaced equipment is, thus, effectively abandoned. It becomes an asset that is not fully depreciated and that can no longer be considered used and useful in providing service to customers.

Given the extensive history regulatory commissions have had over time with plant abandonment--from railroad, bus, and trolly to nuclear and coal power plants--some parallels may be drawn with the abandonment that may occur as a part of the modernization process. In all of the abpve abandonment instances commissions have identified costs (through allowances and disallowances) and specified the cost recovery mechanism that balanced the interests of ratepayers and utility shareholders. For example, the concept of prudence has been used to determine if (1) the original decision to build or purchase was prudent, and (2) the decision to abandon was prudent.

The actions of the Financial Accounting Standards Board (FASB) are examined for the accounting treatment of the costs associated with abandoned plant. FASB Standard 71 requires that the amount of expected future revenues for abandoned plant be booked at their present value, instead of the gross amount of cash to be received. The cost of the plant that exceeds that present value has to be written off. A second standard (FASB-90) further requires disallowed costs to be recorded as losses and to-be-recovered costs of abandoned plant to be recorded at present value. When actual costs exceed present value, for most purposes, the difference must be written off as a loss.

The "end result" test of the Hope Natural Gas case is examined in the context of a recent electric utility case, where the FERC was instructed by the Court to explicitly consider the impact on the financial integrity of the utility of an abandonment disallowance. The main conclusion drawn in this report is that unless the scope of a commission's disallowance of modernization abandonment costs is such that the financial viability of the utility is threatened, the allowance or disallowance decision of a commission falls outside the area covered by the "end result" test.

The prudent investment test is examined, largely in relation to its application in electric and natural gas facilities abandonments. Actions of commissions in allowing amortization of some or all of the cost of prudently abandoned plants are examined. The actions in several abandonments and/or modernization cases are also analyzed. The recent write-offs by telcos attributed in part to modernization are noted and include US Sprint ($356 million), MCI ($448 million), and AT&T ($3.2 billion).

A Regulatory Modernization Framework

In most standard economics, accounting, and engineering economics texts the concept of modernization is treated as a routine, primarily technical issue; one that can be handled by straight-forward non-controversial techniques. The application of these techniques is, of course, much more complex in a real world setting where the choice of assumptions, rates, and ratios may vary widely between analysts, and the reliability of the data is uncertain.

For an unregulated firm, the financial consequences of a modernization effort rest solely upon the shareholders and unsecured debtholders. The financial consequences of a modernization investment for a regulated utility, as with most other important aspects of a utility's operations, are shared between the shareholders and the ratepayers. The risk sharing between ratepayers and shareholders is a fundamental aspect of the regulatory compact, where in return for monopoly privileges and the right to earn a fair rate of return on their invested capital, the ratepayer gets reliable utility service at reasonable rates.

Because regulatory commissions must identify and assign the financial consequences of risk, sophisticated depreciation methods have been developed. These complicated methods are required because commissions all but guarantee that the shareholder will recover investments that are prudently incurred and "used and useful."

The clearest examples of these cost recovery principles in the regulatory arena has been the treatment of cost-sharing and capital recovery for utility investments in building and/or abandoning nuclear power plants. While significant variation exists among the state and federal commissions regarding the exact importance and application of these principles, they have been used to determine the rate base treatment of a utility's investment in completed and abandoned nuclear power plants.

A qualitative, descriptive model of modernization in a regulatory framework is presented. Following an overview of the framework, key parts are elaborated, e.g., replacement and efficiency.

To modernize means to replace present technology with a more efficient technology. For regulators it tends to apply to the replacement of a physical asset, such as a piece of equipment. Efficiency is defined as either saving money or providing new or better services. In order to make a rational modernization decision, it is necessary to conduct an analysis to determine whether money would be saved and if a new or better service can be provided by the newer technology.

The heart of the modernization investment decision analysis lies in the determination of the net future revenue stream of the newer technology relative to the technology being replaced. While the calculations are not simple and the reliability of the data used is often problematical, the decision rule is relatively simple. If the net future revenues of the newer technology exceed those of the older technology, then the decision should be to replace the old and modernize the asset. If the result is a newer technology that is more efficient in terms of cost or enhanced services, then you are engaged in modernization.

The choice of the analytical method and the data being used can cause different modernization choices to be made. Differences may occur when a decision analytic approach is used versus a single discounted cash flow approach. Least cost planning concepts can also be employed and may cause different outcomes.

The qualitative descriptive model provides a simple framework from which to describe and analyze telecommunications modernization. It necessarily remains simple because an extensive modernization public record --like that produced through hearings and various publications for nuclear power plant construction--does not yet exist for telephone modernization.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

FOREWORD

Telecommunications modernization issues are increasingly with us. Because of their cost and hence pricing impacts, efficiency and equity considerations are of special importance. The operation of telecommunications utilities in mixed market conditions, competitive and non-competitive, adds to the complexity of the issues. While the term "modernization" is now commonly used, carefully focused thought about its content and implications is a good deal less common.

This report is intended to begin to help repair that deficiency.

Douglas N. Jones, Director
Columbus, Ohio
February 1, 1988

ACKNOWLEDGMENTS

The assistance of the members of the NARUC Ad Hoc Capital Cost Recovery Task Force, chaired by Walter D'Haeseleer, was greatly appreciated and very useful in the preparation of this report.

The author also expresses his gratitude to Douglas Jones, Mohammad Harunuzzaman, William Pollard, John Horning, and Clark Mount-Campbell for their review of earlier drafts of this report. The author, of course, remains solely responsible for any errors of commission or omission.

In addition, this report has benefited from the professional typing provided by Carole Prutsman, Evelyn Shacklett, Tina Zians, and Joan Morrison.

CHAPTER 1

TELECOMMUNICATIONS MODERNIZATION FROM A REGULATORY PERSPECTIVE

What Is Telecommunications Modernization?

At a recent meeting of regulatory staff experts from a number of state commissions (which was convened for another purpose) the author of this report was asked to describe the "telecommunications modernization" project he was working on to the group. He began the presentation by commenting on how difficult it was even to define modernization, let alone to do research on the topic. The staff interrupted the presentation at that point and responded almost as one and said, "No, you're wrong, modernization is well understood and straight-forward." When asked to provide the author with a definition of telecommunications modernization the following were offered:

Speaker 1: Replacement of equipment with a newer technology before its useful life has expired.

Speaker 2: Replacement of one generation of technology with a newer generation of technology.

Speaker 3: Modernization occurs when the depreciation time period is shorter than the useful life of the technology.

Speaker 4: The expenditures contained in the "modernization" sub-account for the former Bell Operating Companies.

Speaker 5: Modernization occurs when equipment replacement is motivated by the need to configure the entire network a certain way, rather than simply to meet a specific geographical, or customer, or service demand.

Speaker 6: Investment decisions that are not cost-justified in terms of present, provable customer demand, but are justified on the basis of the utility's forecasted demand for the new or expanded service.

Speaker 7: Modernization can only be understood once the entire basic equipment investment strategy of the utility is understood.

Speaker 8: A decision made to replace a failed piece of equipment with a newer technology once a cost/benefit analysis indicates the cost of repair to be excessive.

Speaker 9: Modernization refers to services, not equipment.

Speaker 10: Modernization is no different than any other equipment replacement decision, and occurs when an analysis indicates that an entire generation of equipment has outlived its economic life--the net present value of the future revenue stream for the old assets are less than the net future revenue stream of assets representing a newer, or more efficient technology.

As can be inferred from the above definitions, the audience consisted of engineers, accountants, attorneys, and economists. Their commentaries identify important regulatory policy issues concerning modernization, as well as the different ways different disciplines view the world. Key focal points noted include: replacement, technology succession or substitution, depreciation, useful life, investment account definitions, network configuration, service demand, strategic planning, forecasted demand, investment decision-making, cost/benefit analysis, value, and economic depreciation. Other important modernization concepts and related regulatory issues not explicitly addressed in the above definitions include: bypass, competition, abandonment, least cost planning, prudent investment test, used and useful standard, obligation to provide ubiquitous service on demand, write-offs, reserve deficiency, amortization, comparably efficient interconnection (CEI), open network architecture (ONA), integrated system digital network (ISDN), and broad band integrated system digital network (BISDN).

The purpose of this report is to define modernization and to provide several conceptual frameworks or models which regulators may use to answer what appears to be the key regulatory concern: "Who pays for modernization?" This will be attempted through an examination of the important regulatory concepts listed in the preceding paragraph. For our purposes here, it is sufficient to define modernization as the replacement of present technology with a more efficient technology.

It is important to note, however, that the data and concepts used by various parties before state commissions, whether commission staff, do not present a clear answer to either the benefits of modernization, nor who should pay the cost of modernizing the network. By way of comparison, the intended benefits and expected costs involved in the over building of nuclear generating capacity were well understood by all parties: what was at issue were the polity implications of these facts.

Relatedly, the systematic body of published literature on telecommunications modernization is slim. A simple measure of the lack of published literature explicitly dealing with the overall modernization efforts of telephone utilities is found in the fact that no explicit modernization citations are contained in the article indexes published by three leading newsletters that cover state telecommunications news: Telecommunications Reports, State Telephone Regulation Report, and the NRRI Quarterly Bulletin.

Some literature, of course, does exist, but this is not directed exclusively at state telecommunications modernization. For example, Kamien and Schwartz's (1975) classic review of the economic literature on market structure and innovation fairly consistently focuses on three key variables in explaining the diffusion of innovation: (1) the adoption by a firm of an innovation as influenced by the perception of profit opportunities, (2) the availability of the resources necessary to exploit these profit opportunities, and (3) the existence of and scope of the technical knowledge base and support infrastructure that produced the innovation.[1] Kamien and Schwartz conclude their literature survey saying, "Moreover, the relationship appears bidirectional, with the state of knowledge shaping and being shaped by profit opportunities and the availability of resources" (1975, p. 31).

As useful as the Kamien and Schwartz review is, it tends to deal primarily with unregulated industries and to do this largely from an economic viewpoint only. Given the need of regulatory commissions to operate in a quasi-judicial and interdisciplinary mode, a much wider range

---

[1] In the pre-divestiture period, the old Bell system triad of Bell Labs, Western Electric, and the Operating Companies was a classic structural affirmation of the importance of these three variables in describing the diffusion of technological innovations.

operate in a quasi-judicial and interdisciplinary mode, a much wider range of literature and concepts needs to be examined in order to provide a broad regulatory perspective on the various aspects of telecommunications modernization. Accordingly, several alternative conceptual frameworks and qualitative models are presented in subsequent parts of this report that reflect this broad perspective.

Regulatory Perspective

Both commissions and telephone utilities perceive modernization as an actual or an emerging problem. In rate cases, articles, papers, and in various regulatory meetings the industry has presented its concerns about telecommunications modernization. While it is hard to summarize the "industry position" regarding modernization, it is clear that most of the concern centers around two main points. The first and most important is the industry perception that sees telecommunications competition as inevitable and, in varying degrees, desirable.[2] Accordingly, regulated telephone utilities want to modernize their equipment base in order to increase their ability to compete in unregulated competitive markets.

Modernization will affect both switching and lines. A recent United States Telephone Association (USTA) sponsored report provides one measure of the possible extent of the telecommunications modernization effort by its forecast that by the 1993-1995 period electromechanical switching will serve less than 1% of the nation's access lines and that analog ESS switching will serve less than 1% in 1997-2001 (Lenz and Vanston, 1986).[3] Forecasts of the replacement of copper by glass fiber cable exist (Hodges, 1987) and show modernization as first occurring in the toll and special services lines, followed by an eventual replacement of parts of the local loop.

The second industry concern is the regulatory treatment of equipment that is replaced, before it is fully depreciated, by modernized equipment.

---

[2] See United States of America v. Western Electric Company, Inc., et al., Civil Action No. 82-0192, U.S. District Court, District of Columbia, pp. 37-69.

[3] Schray (1987, p. 36) found that 93.4% of small telephone utilities responding to his survey plan to be 100% digital by the year 2000.

to the "$26 billion reserve depreciation deficiency" in their presentations before state and federal commissions.

Regulators share both of these concerns and have a third cluster of concerns. The regulatory problems here are the need (1) to design, implement, and monitor a modernization policy that promotes the public interest during the transition period for that part of the telecommunications industry likely to be engaged in unregulated competition, and (2) to assess the impact of this policy on the remaining monopoly customers. While modernization is seen by telephone utilities as a means to an end, namely the ability to compete successfully in an unregulated market, regulators view it in terms of its impact on a wide range of regulatory goals.

Promoting the public interest is a difficult standard in the best of times and on the simplest of issues. Consider the state regulator who supported remaining life, accelerated depreciation schedules, and amortization of the reserve deficiency, only to find a deregulatory bill before the state legislature that would remove a significant part of the ratepayer-funded ratebase from commission jurisdiction and make it available for competitive purposes. In this instance, a regulator may be concerned about whether or not the monopoly ratepayer would get sufficient use out of the ratebase assets they have paid for.

A fourth area of concern that regulators have regarding modernization is the apparent difference in costs and benefits for the POTS residential and small business customer versus the needs of the multi-line large business customer. A study of usage in Ohio shows that approximately 20% of the business and residential customers account for most of the calls made, both local and toll.[4] The new services possible through modernized facilities are likely to be either first or exclusively used by the sophisticated, high volume, multi-line business customer. Later in this chapter we see that a

---

[4] Mount-Campbell et al. (1987, pp. 165-167) found that 20% of residential households accounted for 55% of total local usage and that 20% of the businesses accounted for 45% of all local business usage.

decade or more may separate the first use of a modernized service by a multi-line business from the 90% market penetration of that service for residential customers. Mount-Campbell (1987) found that less than 5% of residential customers use any sophisticated telephony such as computer modems (2.2%), automatic alarm systems (2.2%), automatic answering machines (8.8%), cellular telephone (.09%), or used the telephone key pad to access banking, long distance, or other services (7.5%).[5]

Consider, on the other hand, some of the characteristics of businesses reported in the above survey: 15.5% report doing data transmission over publicly switched lines, 6.7% have PBX systems, 41% have key systems, 3.6% use Centrex, 18% have lines dedicated to special terminal equipment, and 8.7% have WATS.[6] Residential single line customers presently have distinctly different telephone service needs from those of multi-line businesses. It is widely debated whether residential customers will migrate or upgrade their service demands over time such that they will use significant parts of a fully modernized telecommunications network.

A lot has been written recently about the social contract or regulatory bargain that exists between telephone utilities and regulatory commissions (Jones, 1987). The social contract involves two parties agreeing to balance their interests in some fashion by giving up something of value in exchange for receiving something of value in return. Traditionally this has meant that in return for being granted an exclusive geographical monopoly, the utility agrees to provide service on demand and to earn a constrained,

---

[5] Since answering machines are really customer premises equipment their percent use is not an indicator of the use of modernized network facilities. However the use by 7.5% of residential customers of the telephone keypad is interesting. In part the use can be explained by regulation; namely regulations that permitted competition between long distance carriers. In the Mount-Campbell survey it was found that of those using the keypad like a computer terminal 68.8% used it to connect to long distance carriers, 15.4% used it for answering service, 8.7% used it to bank by telephone, and 7.4% reported using it for other reasons.

[6] In a period characterized by utility concern about bypass, stranded investment, and loss of market share it is interesting to note that Mount-Campbell found that only 4% of all businesses expected the need for local service to decline over the next five years. Most firms expected it to stay the same (47.2%) and a number (42.1%) expected their use of local service to increase over the next five years.

"fair" profit for providing this service. Recently it has been used loosely to describe various strategies that may be used when and if the services presently regulated by commissions are subsequently provided on an unregulated and competitive basis. One such strategy is the balancing of "affordable universal service based on indexed pricing" for monopoly POTS customers against the proposed new freedom for the utility of being able to offer non-POTS services on a competitive and non-price regulated basis.

From the regulatory perspective the worry is that the equation that balances the interests of the monopoly, POTS ratepayer as against the utility's interest in providing various competitive enhanced services is in danger of becoming unbalanced. When utilities advance modernization proposals based on economic depreciation, these may often require the monopoly ratepayer to pick up the sunk cost of past, proposed to be abandoned, investments in older technologies. It may be that if the non-captive customers were responsible for these sunk costs, the resulting economic analysis decision might not support the same modernization decision.

Furthermore, in considering the new telecommunications technologies and their impact on ratepayers and the telephone utilities, regulators are aware of the fact that this wave of technology will not be the last to be added to the system. Digital switches, for instance, may be replaced by light-based switches that more efficiently interconnect with the light-based glass fiber.[7] The "next generation" of glass technology will likely be broad band ISDN (BISDN), and may carry any voice, data, or digital signal capable of being transformed into light signals.[8]

The concerns of regulators and companies over the impact of telecommunications modernization on the utility and on the ratepayer are

---

[7] Presently translation devices are required on both ends of a glass cable to convert light signals into electric signals. This is inherrently inefficient from both an economic and an engineering perspective. Basic developmental research is currently underway to develop a practical light-based digital telecommunications switch.

[8] AT&T's goal beyond ISDN is the creation of its Universal Information Service (UIS) which will integrate voice, data, and pictures in the same fiber optic strand (The Economist, Oct. 17, 1987, p. 32).

complex and varied. Regulators care about equity, cost minimization, and affordability. Utilities care about the impact on their profitability and organizational infrastructure resulting from the provision of both regulated and unregulated telecommunications services. Both regulators and utilities care about the rate of technological change, cost, and the impact of telecommunications on the economy.

Long- and Short-Term Attributes of Telecommunications Modernization Investments

At its most basic level, telecommunications modernization promises at least one of two outcomes: lower cost and/or increased service options. These two outcomes have an important temporal dimension, as is shown below in table 1-1.

TABLE 1-1

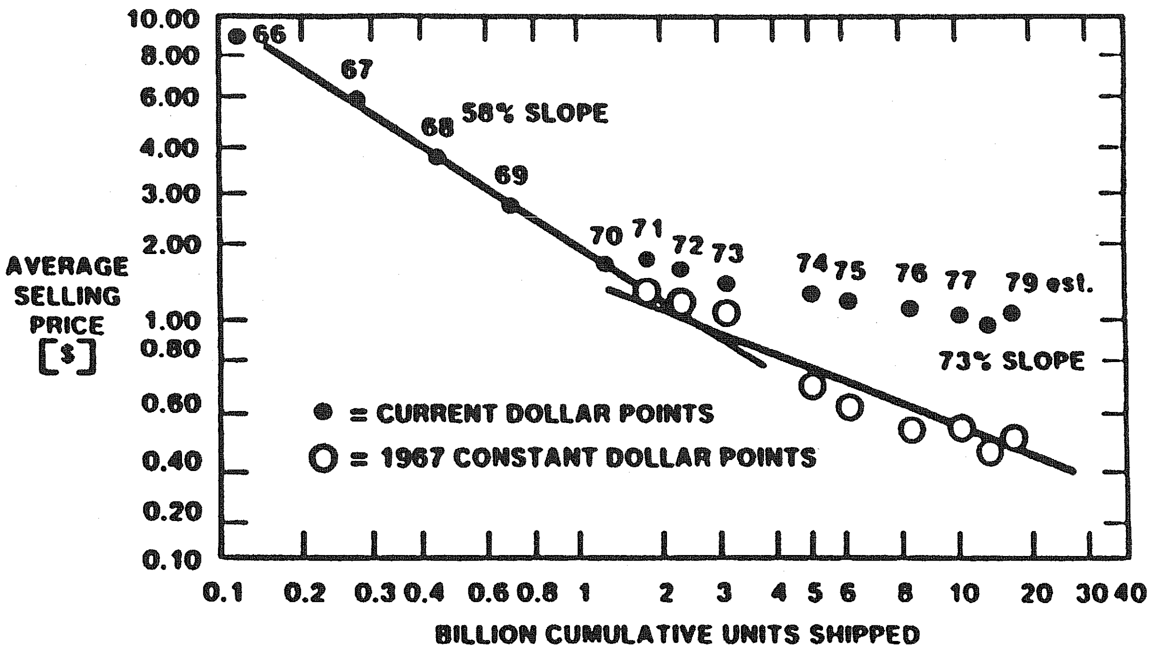
A COMPARISON OF THE LONG- AND SHORT-TERM ATTRIBUTES OF TELECOMMUNICATION MODERNIZATION INVESTMENTS

Outcome	Short-term Attributes	Long-term Attributes
Lower costs	1. Maintenance cost savings	1. Equipment, operating, and maintenance cost savings
	2. Implementation costs	
Increased services	1. Improved, but under-utilized services	1. Fully utilized services

The regulatory dilemma shown in the table 1-1 is that the short-term benefits of lowered maintenance costs do not necessarily outweigh the up-front cost of the new equipment. Assuming accurate forecasts, the benefits accrue in the long-term (as seen by equipment, operating, and maintenance cost savings) because use has grown to meet the service capacity of the modernized equipment. Rapid or accelerated depreciation would, of course, exacerbate this problem by making the short-term even more expensive without a corresponding increase in benefits. Most parties agree that the long term situation of full utilization and corresponding "cost-pickup" by the beneficiaries and users of the modernized services offers considerably less difficulty to regulators. A slower than predicted growth rate, or the failure of a significant market to emerge for a particular service further increases the regulators' difficulty in allocating costs. Where the modernized facility simply offers less expensive service, but not necessarily any new services, the regulatory issue is primarily one of deciding the appropriate fill rate or investment period.

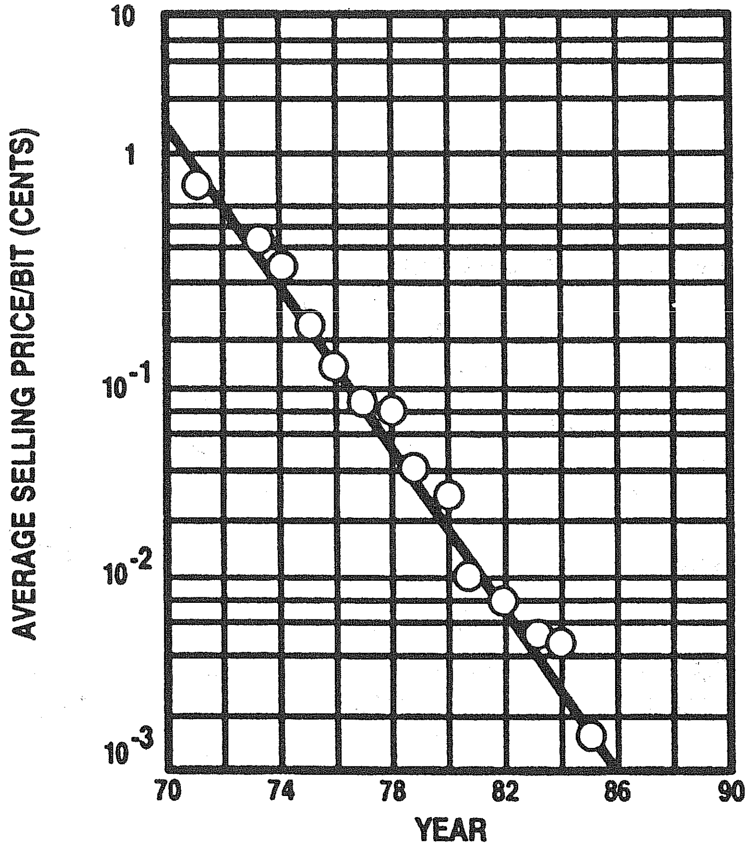
Declining Cost

The long-term/short-term dilemma for regulators is complicated by expected decline in the cost of the equipment. In figures 1-1, 1-2, and 1-3 (White, 1987) evidence is presented regarding the declining price of electronic equipment (figures 1-1 and 1-2) and the advances in bit rate speed for glass fiber (figure 1-3). These figures suggest, and are representative of the basic thrust of telephone industry presentations regarding the forecasted benefits of modernization, that modernized facilities will be able to provide increased service at a lower and lower cost. Again, for the regulator who must approve the up-front cost of expensive equipment through the setting of depreciation rates, the countervailing pressures are intense. On one hand there is no direct and widely accepted evidence that the "plain old telephone" (POTS), monopoly single line residential and business customer will need, use, or benefit from these enhanced and less costly services. Most would agree that the fact that bit speed for data transmission for glass fiber is increasing and the price for this service is or could be dropping, does not have an



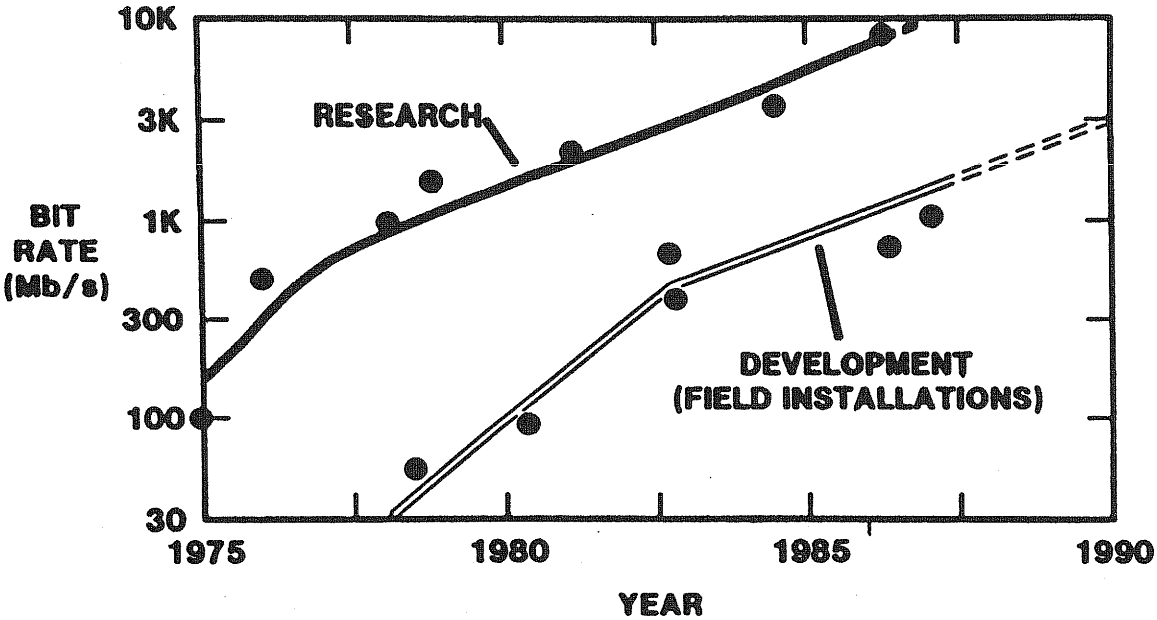
Source: P.E. White, "Trends in Telecommunications Transmission Technology" (handout) , USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-1. U.S. integrated circuits industry experience curve



Source: P.E. White, "Trends in Telecommunications Transmission Technology" (handout), USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-2. Average selling price/bit vs. time



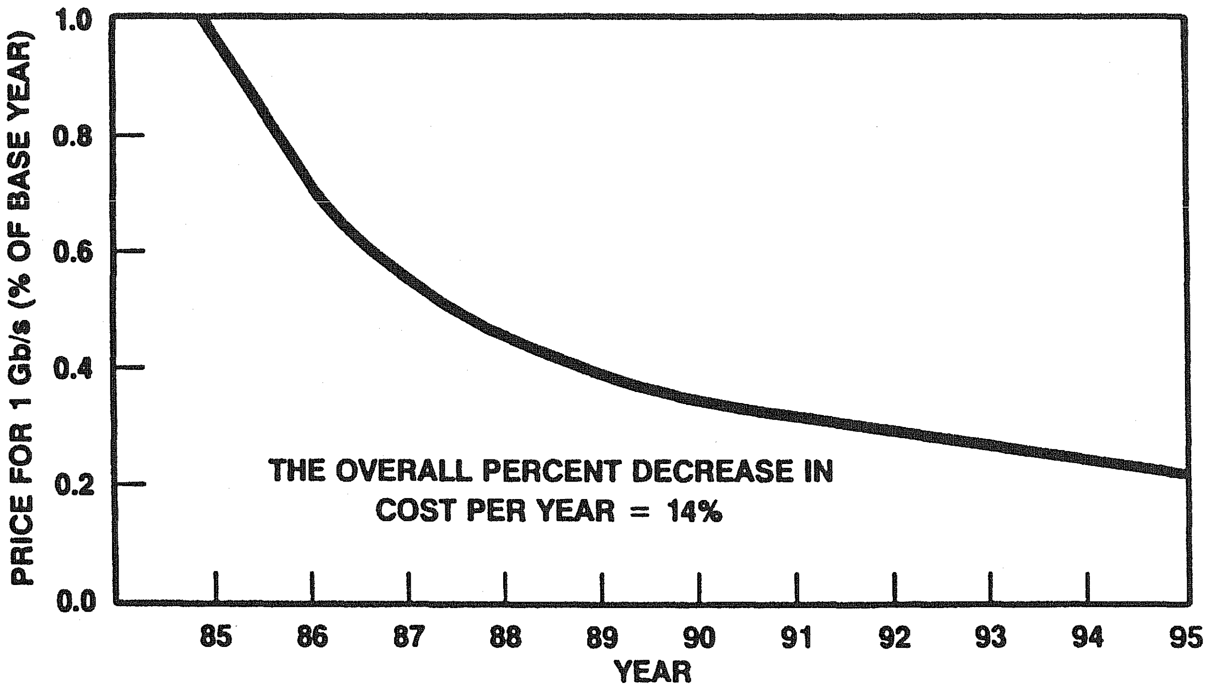
Source: P.E. White, "Trends in Telecommunications Transmission Technology" (handout), USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-3. Advances in light wave bit rate immediate and provable benefit for the average POTS customer. On the other hand, the ability to have costs decrease at an estimated 14% per year (see figure 1-4 below), the desire to avoid bypass and stranded investment, the need to respond to the service needs of large users, and the goal of fostering competition are all powerful pressures on regulators to encourage modernization.

Telecommunications Modernization Deployment Model

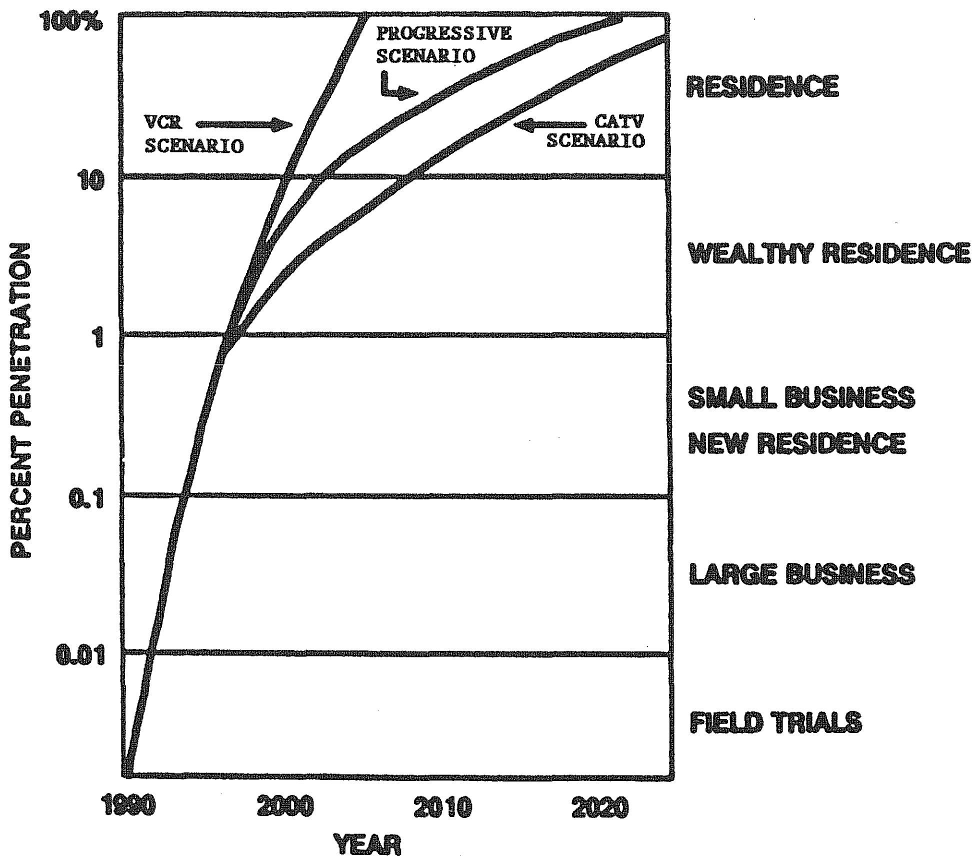
An interesting model of the deployment of the next generation of telecommunications technology is presented below in figure 1-5. It describes a hypothetical scenario of the development and national distribution of a broad band integrated system digital network (BISDN). Broad band ISDN would allow telephone utilities to deliver any digital service--voice, data, or visual--over a single glass fiber. And because of the ability to deliver an almost unlimited array of digital services on one line, the BISDN technology may have the potential of greatly lowering the cost per customer, by spreading the cost over a large customer base, and thus make it economically feasible to connect residential customers with glass cable.

Several components of the descriptive model are worth noting. First, the categories of users or beneficiaries of the BISDN services are arrayed in the order in which they will receive the new service: first with field trials for the most promising business customers, and last with mass residential hook-up. These categories seem to reflect the generic way in which new telephone technologies (and the resulting services) have been deployed in the past. Namely, (1) that a utility's customers make economically rational decisions and only demand a service when its immediate economic or service enhancing benefit to them is readily apparent; and (2) that the rank ordering of the customer classes reflects the generic, time-ordered ability each customer class has to take advantage of any new telephone service--independently of whether the advantage is economic or service based.



Source: P.E. White, "Trends in Telecommunications Transmission Technology" (handout), USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-4. Light wave system price trends (projected)



Source: P.E. White, "Trends in Telecommunications Transmission Technology" (handout), USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-5. A sequential model of BISDN deployment

Second, there are three forecasting scenarios drawn using the model. If the video camera recorder (VCR) scenario is the correct one to use in predicting the implementation rate of BISDN, then regulators would likely have few problems because of the small time difference between the first large business adoption and the last residential adoption of BISDN. On the other hand, if the cable television (CATV) scenario is correct, and this scenario has a lot more relevance to the issue than the purchase of stand-alone and "un-networked" VCRs, then the thirty-plus year gap in ultimate deployment causes a much greater problem for regulators. The thirty-year gap could constitute a serious inter-generational equity issue if monopoly POTS residential and small businesses are asked to pick up part of the cost of a BISDN system thirty years before a 90% market penetration is assured.[9]

A third point to extract from figure 1-5 is that information regarding cost and service characteristics will be generated from the moment the first field trials are implemented until the ultimate deployment. BISDN as presently envisioned will be a wire-based technology, and will likely be supportable and most efficiently delivered by a utility having an exclusive territorial monopoly. Accordingly, commissions will have cost and quality of service concerns that will require a different data base than currently exists. In the same sense that the development of a uniform system of accounts offered commissions and utilities a common ground from which to discuss issues, commissions desiring information about these potentially important new services could work with the companies in the field trial stage to ensure that data are collected in a way that is useful to both the commission and the utility. If BISDN ultimately becomes a non-wire technology, one that bypasses the local loop, the monopoly status and any commission role could be unnecessary.

---

[9] One of the reasons the Fisher-Pry technology substitution model (described in detail in Chapter Two of this report) is popular for utilities may be because of its tendency to predict a relatively rapid deployment for new telecommunications technologies.

Two Models Describing Economic Factors Affecting Deployment

Reinganum (1981) argues that even if a new cost-reducing innovation is adopted fairly widely, that a good number of firms will delay introducing the innovation on very rational and strategic grounds. Namely, because there will exist for a significant amount of time a profitable market willing to buy the "old" service at an appropriate price. Following this line of reasoning, businesses will assess their need for a new telecommunication service in a way that includes their perception of the correct time/value discount appropriate for their strategic plans. Accordingly, it could be argued, that all residential and small business ratepayers do not need to have their local exchange company offer to them the full range of business services. From this perspective, not only will a significant sub-market exist for plain old telephone service (POTS), but the market is likely to exist and be profitable for some time.

In a Bell Journal of Economics article, Quirmbach (1986) expanded upon the work of Reinganum (1981) and examined the diffusion of new technology and how the market power of the buyer and the seller may influence the diffusion rate. He shows that if adopted later rather than sooner a capital-intensive innovation has a lower incremental benefit and a lower adoption cost. He also develops a method for comparing diffusion rates for different market structures in the capital equipment market.

The diffusion of capital equipment, he notes, occurs during a period of time when the incremental benefits and the cost of new equipment fall over time. The later adopters get lower benefits and must wait until they are justified by lower adoption costs. Market power on the buyers' side, as represented by a joint venture of user firms, slows the diffusion of equipment because it considers the harm that each adoption does to existing investments. Non-cooperative adopting firms think only about their own profit from the marketing advantage that they gain from adopting the new technology (Quirmbach, 1986).

When there is monopoly power in the equipment market, the first adoption occurs before that with non-cooperative firms. This is because the monopoly equipment seller can more easily subsidize initial deployment in order to start the process, being insulated from competitive pressure.

These subsidies are, of course, recovered and assured by the monopoly status of the seller.

Both articles present a rational economic model of the diffusion of technological innovation. The key factor upon which the usefulness of each model depends is the existence of important sub-markets. To the extent that all of a telephone utility's customers conduct an economic and service enhancing analysis and conclude that they all must immediately have the new technology, the significant sub-markets may not exist. If a significant number of ratepayers decides that the value to them is insufficient in the short-to-medium term, then a slower net deployment rate may be expected.

Centralizing and Decentralizing Tendencies of Telecommunications Modernization Investments

Telephone utilities and the vast, sophisticated electronic national infrastructure to which they are interconnected can seem too complex to be understood, much less explained or regulated. In understanding the role and benefit that a modernization strategy may play, two organizing concepts seem especially useful:

1. There are only two components to a telephone network: lines and switching nodes.[10]

2. Modernization simply makes the lines and/or switching nodes more efficient or effective.[11]

Accordingly, all modernization efforts engaged in by telephone utilities can be characterized as either improving lines or switching nodes. The significant improvements already made and forecasted for glass fiber

---

[10] Lines include traditional copper wire, glass fiber, microwave, and radio technologies that deliver a signal from one switching node to another. Switching nodes include central office switches as well as PBX, satellites, and any originating or terminating equipment (CPE). It may be the case that future technological developments may find some way of integrating switching capacity on a glass fiber, but until that time the above typology of telephone utility equipment and facilities is valid.

[11] Concepts such as efficiency may have different meanings when used by economists and engineers. Both perspectives will be employed and discussed throughout this report.

cable are representative of the modernization of line technology, and the digital switching improvements for switching technology.

At the current stage of technological development, modernization improvements in switching technology may have a decentralizing trend that may be harmful to jurisdictional utilities.[12] Traditionally telephone utilities centrally receive and dispatch telephone calls through their central office switching nodes. With the advent of PBX and digital switching technologies it is now possible, and in fact fairly common, for customers to use a PBX to switch their own calls and reduce the number of local lines they rent from the local exchange company. Every new, non-central office switching technology installed may lower the number of local loops serviced by the telephone company. Due to the availability of remote switching technology, a significant bypass of the telephone utility's central office switching may occur. Businesses would be the first to buy and benefit from this technology. Every business that "opts out" and buys its own switching capacity has an affect on the telephone company and over the long run may lessen the need for centrally provided, utility switching services, at least as they are now presently configured.[13]

Modernization of switching technology offers both an opportunity and a challenge to the traditional concept of a jurisdictional utility. The

---

[12] Some of the same decentralizing and centralizing tensions can be seen in the long-term evolution of the electric utility industry. New technologies such as solar may be best suited to being used in a decentralized, potentially non-utility mode, whereas fusion technologies would likely be best distributed through a utility-based network similar to that used today to dispatch electric power over an integrated grid.

[13] The effect is likely not as gloomy as some have predicted, with an increasing amount of stranded investment caused by bypassers leading to a death spiral of increasing costs and unfunded capital recovery. The effect of modernization-induced or competition-induced bypass on a telephone utility depends in large part on whether the supply of telephone services is "zero-sum" or non-zero sum. If the demand for telephone services is fixed or growing at a rate matched by capacity additions, then every switched call lost by the telephone utility is a real loss, potentially resulting in unused switching capacity, and future per call cost increases. The sum of all transactions in this instance sums to zero, with the utility's lost call being recorded as another firm's sale. In a non-zero sum situation where the demand for telephone service is growing or is greater than the supply, all firms' sales grow continually and no loss occurs.

opportunity is the technology-induced chance to provide new or less expensive services to either the regulated or unregulated market. The challenge is to compete successfully where a competitive market exists and to avoid significant bypass by monopoly customers. The deregulation of the customer-owned equipment switching market, the modernization of this switching equipment, and equal access to the utility-operated switched network have combined to provide a powerful set of economic and institutional incentives to large users to act to decentralize their switching away from the local exchange carrier.

Changes in wire-based technologies do not yet have the same decentralizing impact for local operating companies, although changes in line technologies may add to this trend. Glass fiber, a wire-based technology, seems to be a technology that will be centrally provided by telephone utilities for the forseeable future, except possibly for the largest and most specialized users.[14] The reasons for this are (1) the call carrying capacity of a single glass cable would generally exceed the needs of a single customer--but not the trunk-linked needs of a utility's many customers, and (2) it still appears that a service which is physically ubiquitously, such as a glass cable network, covering a large geographic territory can be provided least expensively by a natural monopoly. Assuming that currently constituted telephone utilities are reasonable approximations of natural monopolies for copper wire technologies, it seems likely that this economy of scale would continue for glass fiber cable.

Telephone utilities will obtain an uncertain advantage when they modernize and/or encourage research and development in switching technologies. The advantage to jurisdictional telephone utilities is much clearer regarding modernization of local, line-based facilities. If telephone utilities can manage the modernization transition in such a way as to be the only service provider in an area with ubiquitous glass cable and

---

[14] Research in superconductivity is still at its earliest stage and so any forecasting about the retention of copper cable as the most efficient technology, is speculative.

state-of-the-art digital switching, they will have a significant, structural advantage over many different kinds of competitors.[15]

Selected Trends and Current Issues

Because the term modernization can encompass part of a utility's current operations, as well as future services that are only broadly described (and whose economic and service characteristics are undocumented), it is impossible to express the extent of the industry's modernization effort in a single statistic or trend line. In this view, modernization is not identical with "total utility capital investment." Modernization has a future-orientation in its capital expenditures. In part this is a definitional issue, as over time modernized facilities and equipment become standard network components and are no longer thought of as modernization, but rather as straight-forward capital investments.

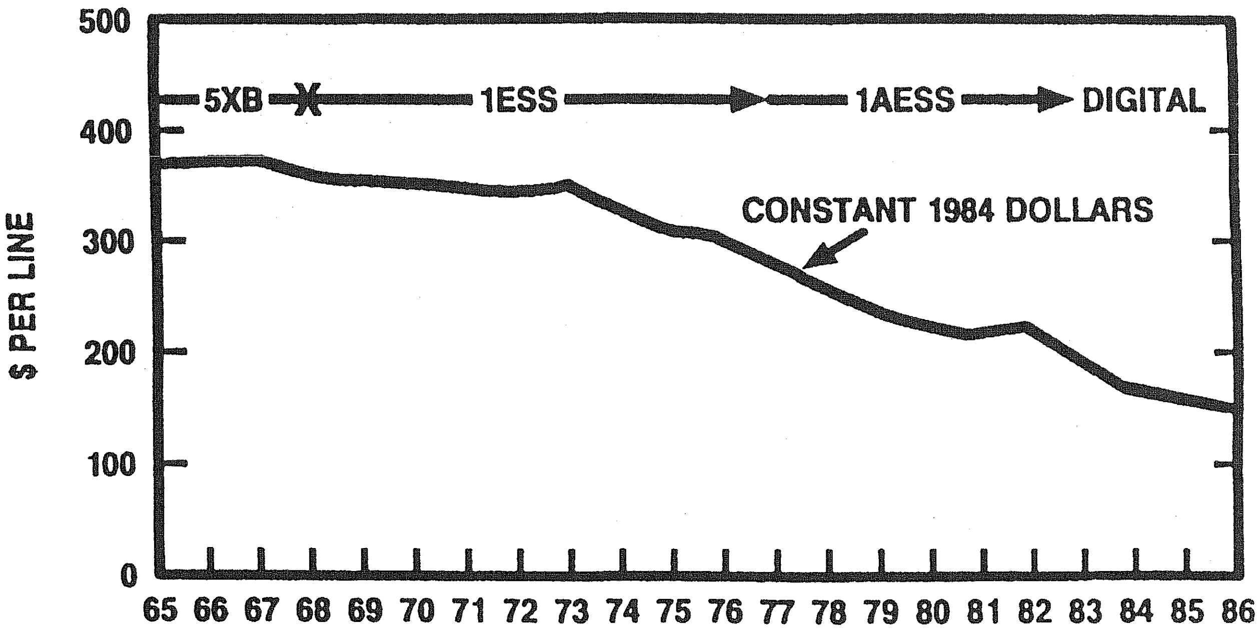
Selected modernization trends and current issues are presented below in the following sections, along with a detailed description and analysis of the depreciation reserve deficiency thought to be related to telecommunications modernization.

Extent Of Modernization-Induced Change

Pressure for modernization of telecommunications equipment comes in part from the significant decreases in cost possible from the newer technologies. In figure 1-6 it can be seen that the historical cost of local switching, as expressed in constant 1984 dollars, has declined since 1965. This decline has coincided with the installation of different generations of local switching technologies over a twenty year period (as seen in the top line of the figure). The decline in cost per line should, of course, result in savings to the business and residential ratepayer.

---

[15] This statement necessarily assumes that the relative economic and engineering advantages and disadvantages of today's technologies continues into the forseeable future. Or said another way, that some new switch based technology does not emerge sufficient to permit direct point-to-point connection with any other switch.



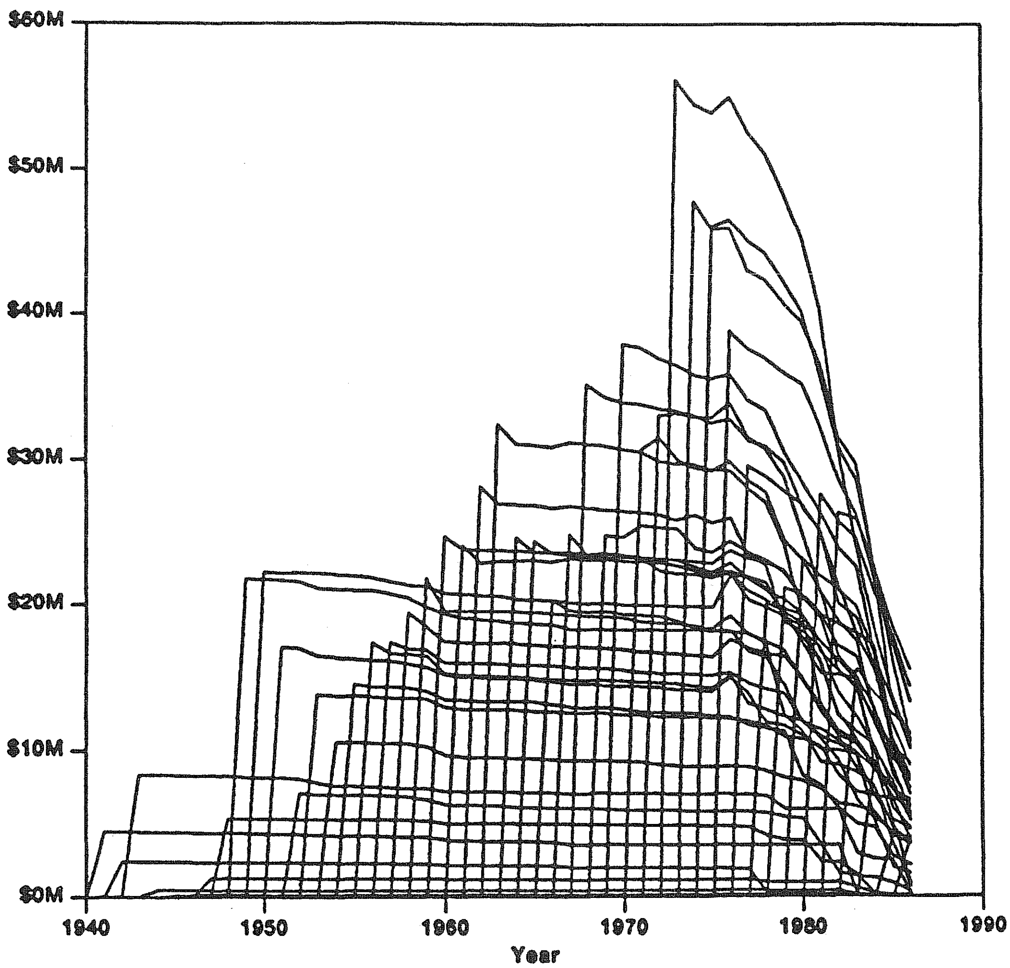
Source: P.E. White, "Trends in Telecommunications Transmission Technology" (handout), USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-6. Historical local switching cost

Another problem occurs when modernization arises from the "premature" replacement of existing telecommunications equipment. In figures 1-7 and 1-8, survivor curves for various vintages of step-by-step switches are displayed. The trend in the survivor curves shows that independent of vintage, or the actual age of individual switches, that step-by-step switches are being replaced. Twenty year old switches have been replaced at essentially the same rate as much newer switches. The regulatory policy issue here is whether the early replacement of the older switches was to the net benefit of current or future ratepayers, and whether the change was economically justified, particularly for the "POTS" customer.

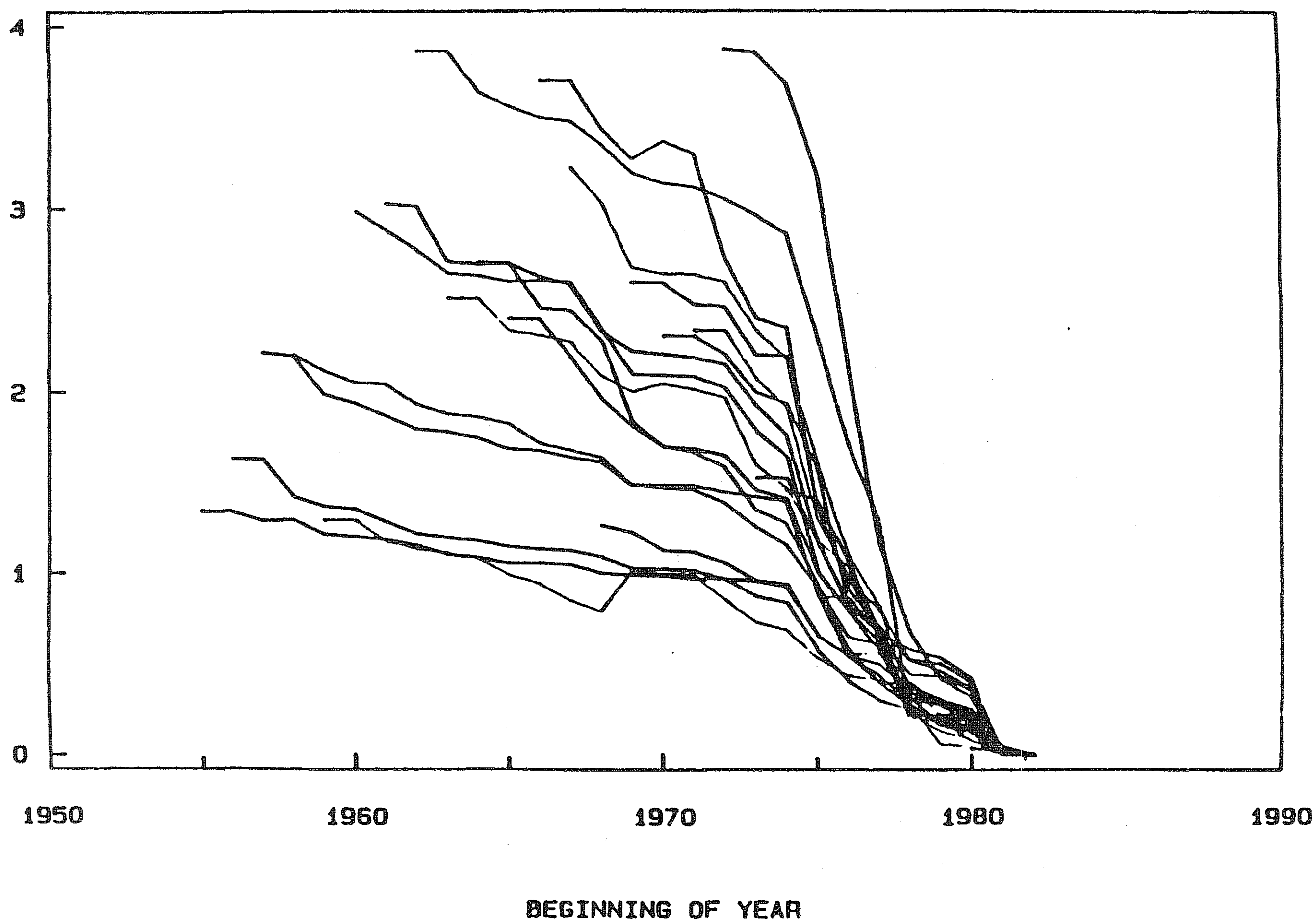
Depreciation and modernization are inextricably intertwined in the present rate base regulation currently practiced by state and federal commissions. Changes in depreciation expenditures affect the revenue requirement, which in turn affects the rates charged to the utility's customers. Other established regulatory mechanisms for treating capital expenditures include amortization, price-indexing, and write-offs. Currently depreciation is, after maintenance expenditures, generally the largest single operating expense for utilities, accounting for over 20% of total operating expenses (FCC, Accounting and Audits Division Report, 1987, p. 5). The potential cost impact of the steeply declining survivor curves depicted above may mean correspondingly steep increases in consumer prices as increased depreciation expenses are incurred. If depreciation expenditures are not accelerated and recovered through a depreciation method such as remaining life, rates would not necessarily increase. The typical regulatory response to the accelerated retirement or abandonment of these assets has been to change the depreciation rate correspondingly.

In 1986, jurisdictional telephone utilities petitioned the FCC for a $2.172 billion increase in depreciation rates and accruals. The FCC final orders on these petitions ultimately approved a $799.1 million change in depreciation charges, primarily directed at reserve deficiency concerns (USTA, 1987, p.7). This increase is one of a series of increases granted by the FCC over the last few years intended to directly assist in ameliorating reserve deficiencies. Indeed, across all major U.S. telephone companies the



Source: R.A. Huta, "Capital Recovery in the Local Exchange Network," (handout), USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-7. Survivor curves of crossbar switching



Source: R.A. Huta, "Capital Recovery in the Local Exchange Network," (handout), USTA Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 1-8. Survivor curves of large step-by-step switches, 1955-1980 depreciation rate increased from 7.2% in 1985 to 7.6% in 1986 and the depreciation reserve percentage increased from 26.4% to 28.5% (USTA, 1987, pp. 2-4).[16]

Regulation-Induced Modernization

In addition to the direct modernization incentives provided by regulatory depreciation policy, state and federal commissions have acted in a number of ways that have encouraged modernization strategies for jurisdictional utilities. Perhaps the most sweeping impact has occurred through the various pro-competition policies and decisions of the commissions regarding equal access.

The FCC's decision in Computer Inquiry III regarding comparably efficient interconnection (CEI) required the BOCs to unbundle and tariff the interfaces for each enhanced service offered. Everyone subsequently offering the service through BOC facilities can get on comparable terms the same quality of interconnection as the anyone else, including the BOC. This regulatory policy had the affect of treating all potential long distance carriers as equals, allowing them to offer the same ease of dialing for long distance service. The changes in equipment or programming required to offer CEI is not generally thought of as modernization, although it is likely that the upgrading and standardization that accompanied the CEI implementation has had a positive affect on the modernization programs of jurisdictional telephone utilities.

Given the "fungibility" of programmed switches, it would be very difficult and would require an extraordinary amount of regulatory oversight to determine if or how much of any EI technology was useable in other,

---

[16] Some recent data suggest that an important difference exists between the depreciation rates of small telephone utilities and the rates of large utilities. Schray (1987, p.11) reports that only 28% of the small telcos had depreciation rates as high as 7%, when the industry average depreciation rate was 7.6%. Further, that while the industry average reserve ratio was 28%, 73% of the small telcos had reserve ratios in excess of 30% and some 25% had ratios in excess of 45%. Size of reserve ratio alone is not, of course, sufficient to indicate that a problem exists as rapidly growing or recently modernized service territories may have large ratios.

distinct modernization efforts. It is reasonable to assume that some benefit accrues to the BOC through regulatory mandated CEI, but in an uncertain amount.

The same appraisal would occur for open network architecture (ONA). ONA requires the BOCs to reconfigure their networks in ways that allow vendors to lease the individual network components necessary to provide services. The BOCs presented their plans to accomplish this to the FCC on February 1, 1988. The ONA regulatory requirement has the potential of offering the same modernization benefit to BOCs as was suggested above for CEI.

Because of the technologies involved, digital switching and glass fiber tend to increase the proportion of nontraffic sensitive (NTS) costs. For example, the fixed cost portion of glass cable varies directly with the band-width, resulting in a higher proportion of NTS costs (Cardullo and Moellenberndt, 1987, p. 41). Furthermore, digital switching technology allows the consolidation onto one switch of functions that were formerly performed by separate pieces of equipment, thus further complicating the allocation of costs. This is particularly important because of the trend to have more NTS costs picked up by the local company. In other words, at the same time that "cost-causing" principles are assigning more costs to the local company, it may be the case that the adoption of the new technologies will result in a greater part of a local operating company's costs being defined as NTS.

Impact of Modernization on Competition

In the above section the effect of competition on modernization was briefly identified. Competition was seen as a factor influencing a more rapid rate of modernization than would otherwise have been the case. Modernization, in turn, may have an impact on the kind of competitive market that emerges. This can occur through the economic and service features of the modernization technologies. If the new technologies require a massive financial and corporate base, a market characterized by monopoly, duopoly, or oligopoly may emerge. If the modernization technologies are not capital intensive and the local telephone utility serves as a true common carrier, a vigorous market with many competing firms may emerge.

Market failure has historically been one factor used to explain the need for regulation. In its simplest expression, society acts to regulate once the free market is unable to provide adequate services at reasonable prices. One responsibility that commissions have in analyzing the many competition proposals before them is the need to consider market failure. No one expects the commissions to be omniscient in predicting which proposals will produce a realistically competitive market. Nor are commissions supposed to be completely risk averse when considering pro-competition policy alternatives. Some services probably will not end up being workably competitive. In addition to the economic and structural reasons that might explain these failures, the lack of the "right" modernization technologies to emerge may also be a factor occasioning these failures. For these market failures it is reasonable to predict some form of re-regulation.[17]

In the rush to promote competition, some analysts seem to feel that a "hundred flowers" will bloom where only one had bloomed. While policy makers have yet to agree on how much competition is sufficient to protect the residential and small business ratepayer, it is important that all parties explicitly acknowledge that some level of failure is likely. Indeed failure may be one of the more important indicators of a competitive market. Regulatory analysts and policy makers have to expect that some telephone service providers will fail and that the remaining service providers may be either oligopolies or effective monopolies. The availability of technology does not guarantee that competition will emerge (Kasper, 1972 and Williams, 1982). Kamien and Schwartz (1981) report that as technologies mature, scale and efficiency in production become more important and the opportunities for smaller firms fewer.

---

[17] Failure means that no realistic alternative vendor or technological substitute exists to provide the service at a fair price. On the other hand, the availability of a low cost and widely dispersed cluster of modernization technologies, all other things being equal, may increase the probability of a sustainable competitive telecommunications market.

Small Telephone Utility Modernization

Small telephone utilities are in general more financially sound and have a more modern equipment base than would be suggested by a casual look at their small service territories or customer base. This is due in part to the Rural Electrification Administration's (REA) pairing of low interest loans with what has been traditionally seen as a proactive REA equipment modernization policy.[18]

And unlike the case in the water utility industry, for example, where most small utilities significantly lag the large utilities in terms of their adoption of modern technologies, small telcos may have more modern facilities than some large utilities (Lawton and Davis, 1983). A recent survey of small telephone utilities (Schray, 1987) revealed that 48.4% of those responding had 76-100% of their customers served by digital lines. Only 27.2% reported serving less than 25% of their customers with digital lines.

It is difficult to explain the reasons for the modernization differences that exist between large and small telephone utilities. It does seem from the studies cited in this report that the differences that do exist may be somewhat counterintuitive (e.g., small does not equate with an inability to modernize), and may not parallel those found for other small utilities.

The $26 Billion Reserve Deficiency Deficit

Telephone utilities during the first part of the 1980s have appeared before state and federal commissions and presented various plans to eliminate what they identified as a twenty-six billion dollar reserve

---

[18] The REA telephone loan program was not the only cause of modernization in rural areas. Other factors included the effect of rising rural incomes, the reduction in the telephone excise tax, and changes in separations and settlements (Horning, 1982).

depreciation deficiency.[19] Because telephone assets have fairly long stipulated lives, and because telephone companies had for various reasons (including modernization) replaced these assets with new equipment at a rate not matched by depreciation contributions to the depreciation reserve account, the companies argued that a serious reserve deficiency existed.[20] Responses to these requests by state and federal commissions varied and included examinations of utility modernization policies, service life estimation, and use of remaining life depreciation and amortization to address the purported reserve deficiency.[21]

While there is a consensus that a reserve deficiency existed due to the accelerated replacement and modernization activities of the telephone utilities, the size of the reserve deficiency has been in dispute. A recent FCC report describes the results of its investigation into the deficiency, and the salient part of its analysis for our purposes is reproduced below.

> In the early 1980s, the [FCC] staff prepared its first comprehensive analysis of industry theoretical reserves. In 1983 we estimated the industry's theoretical reserve to be 33% of its plant investment. At the time the plant investment was $160 billion and the book reserve ratio was 20%. Our studies showed that the industry had a 13% or $21 billion reserve deficit.

---

[19] See Joseph Foggarty. "Telephone Company Capital Recovery: Crisis and Dilemma Persist," Public Utilities Fortnightly, Feb. 6, 1986, pp. 23-28, for a representative article describing this concern. He argues that due to the threat of competition, telephone utilities have at most a five year window to recover the reserve deficiency (p.24), otherwise competition will have drained off the big users and left the POTS customer with the responsibility for what would then be an overly large undepreciated ratebase.

[20] A reserve deficiency occurs if, for instance, an asset had a forecasted service life of 10 years and annual contributions to the depreciation reserve account were being made at that rate for the first 5 years, only to find that the actual life was 7 years. Unless corrective action is undertaken, the reserve account will end at the seventh year with three years of unfunded depreciation obligations remaining.

[21] Some feeling of the size of the depreciation arena can be gathered from the fact that the FCC's depreciation authority in 1987 covered $199 billion in plant investment, with $177 billion of that amount owned by local exchange carriers, and the remainder largely owned by AT&T and Alascom (FCC, 1987, p. 5).

> Our current [1987] studies show that the LECs have a 30%[22] theoretical reserve ratio. With $180 billion in plant investment and a 28%[23] book reserve ratio, we believe the LECs have a reserve deficiency of 7%, or $13 billion.
>
> (FCC, 1987, p.11)

Further, the FCC report notes that due to its acceptance of the use of equal life group (ELG) procedures (that result in a higher reserve percentage early in the life of the asset),

> If the procedures currently in place are continued, we predict that the LEC's 1990 book reserve ratio will be 35%, and we are forecasting the reserve deficiency to be approximately 2% or $5 billion, by that time. This is well within the uncertainty range that surrounds all depreciation calculations.
>
> (FCC, 1987, p. 11)

By and large the commissions have acted to reduce the reserve deficiency such that the reserve ratio appears to be at a reasonable level.

Organization Of The Report

The remainder of the report is organized into five chapters. In chapter 2 selected forecasting models are examined and the impact of

---

[22]Appears as footnote No. 20 in the original FCC text. The cited footnote follows: Industry estimates of the reserve deficiency are much higher than our figures. The most recent figure cited by the industry is $26 billion, precisely the same figure it estimated several years ago, when its book reserve ratio was a full 5% lower. The industry's higher deficiency estimates apparently are attributable to its use of life and salvage factors and methods which differ from those prescribed by the FCC.

[23]Appears as footnote No. 21 in the original FCC text. The cited footnote follows: Note that the LECs have a 28% book reserve ratio compared with the 29% ratio listed for the industry in table one [not included in this NRRI report]. This is so because AT&T, which has a 36% ratio, is included in the industry figures. As indicated in footnote 2 [not included in this NERI report], the tremendous progress in AT&T's reserve is a result of a 1985 Commission prescription order.

alternative technology forecasts on telecommunications modernization decisions is discussed. Chapter 3 explores modernization in the context of commission depreciation policies. Chapter 4 assesses the applicability of the abandonment concept as a focal point for modernization analyses. The depreciation and modernization concepts and principles in these two chapters are then combined in chapter 5 and are used to present a preliminary qualitative model of telecommunications modernization from a regulatory perspective.

CHAPTER 2

FORECASTING TELECOMMUNICATIONS MODERNIZATION

Introduction

The attention of researchers and regulatory policy makers has been drawn to the issue of modernization by the forecasted size and impact of telephone utility modernization scenarios presented before commissions and in other forums. In some forecasts a highly competitive telecommunications market is envisioned, one inextricably embedded in a mature information-age economy. Other forecasts see an oligopolistic market with an unspecified amount of regulation, and a hybrid economy.

In this chapter we will present and examine several forecasts of the future of telephony. No attempt is made here to address all possible macro network forecasting models, and the primary emphasis is on the conceptual basis of the models. Several micro models are also presented that can be used in isolation or in concert with the macro network models. The intent here is to provide a range of different forecasted outcomes that regulators can use as benchmarks in evaluating telecommunications modernization forecasts presented before the commission.

One Utility's Modernization Plan

Each telephone utility has a plan for the future configuration of its service offerings as well for as the configuration of equipment needed to most economically provide these services to its customers. These plans are the codification of the business decisions made by the utility regarding how it will meet the future demand in its service area. One example of this kind of planning is briefly presented below and illustrates the kind of modernization decisions already being made by jurisdictional telephone utilities.[1] The focus here is only on one part of the plan, the forecasted evolution from copper to glass fiber in the local exchange network. In figure 2-1 below, GTE of Florida has pictorially displayed what it believes is the likely progression or migration from a primarily copper-based local distribution system to one that is predominantly glass fiber. Note that the transition occurs first on the trunking coming out of the central office and eventually goes beyond GTE's enhanced remote line unit. This particular display has no time table attached because the actual timing, but not the order of GTE's proposed sequencing, is yet to be determined.[2] While this planned evolution seems on the surface to present no particular problem, it may become a regulatory concern because of the assumptions made regarding the depreciation lives of outside plant.[3] The issue posed by the assumptions is illustrated below.

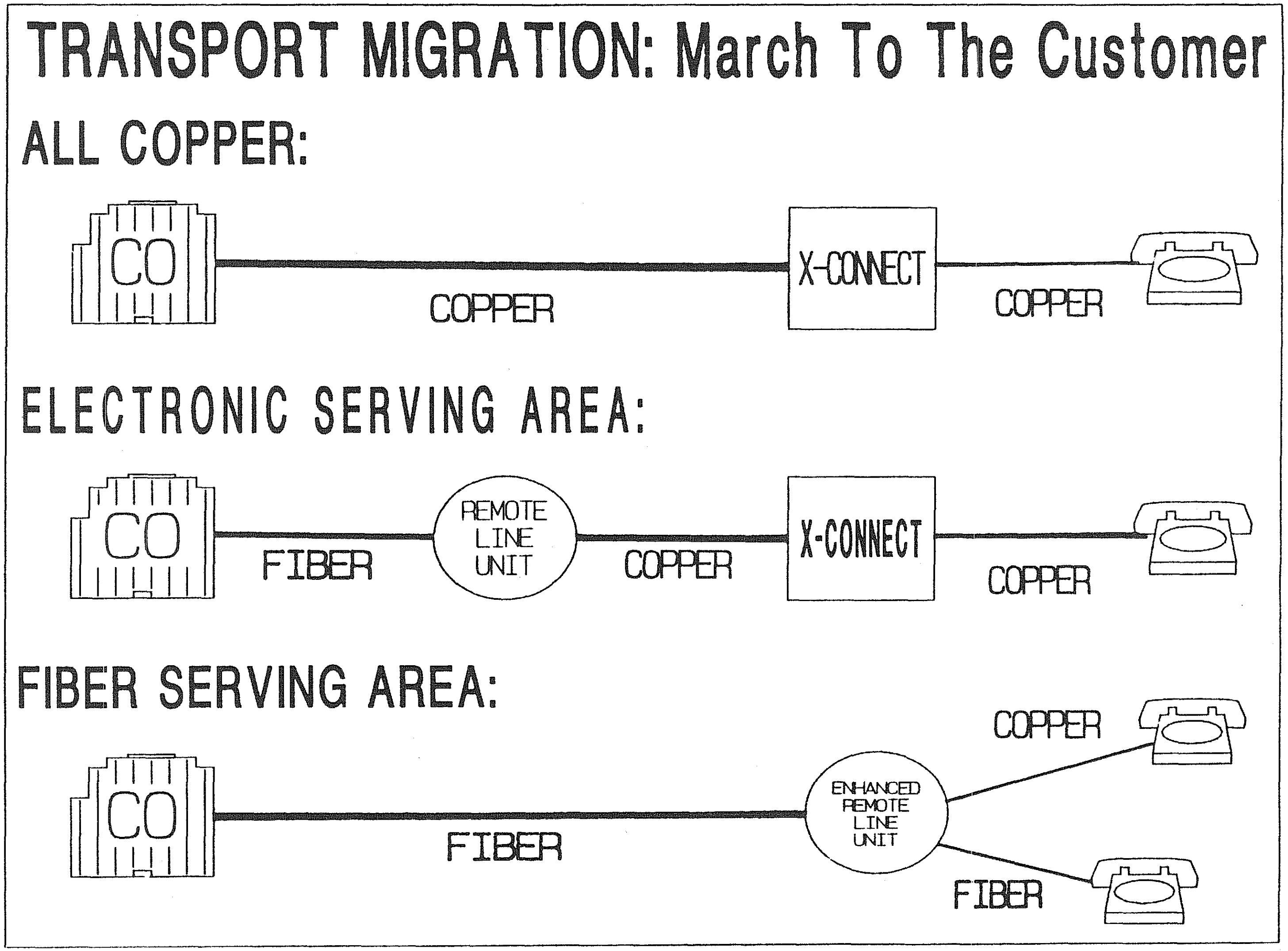
If the GTE of Florida aggregate outside plant survivor curves of figure 2-2 (currently prescribed) are compared to those of figure 2-3 (curves using technological forecasts) some insight can be gained regarding the "early retirement" problem that could arise if the scenario in figure 2-1 were followed. Figure 2-2 shows the vintage curves prescribed by the Florida commission and has, for example, a prescribed aggregate service life based on actuarial-type data for outside equipment installed in 1987 that extends well past the year 2016. In figure 2-3, by contrast, the aggregate

---

[1] By this example no claim is made as to whether or not the GTE of Florida plan is representative of the plans of other telephone utilities, or whether or not it is a "good" plan. Further the "plan" is more sophisticated and broad based than could be readily examined in this report. The analysis here is based solely upon a presentation by and handouts from Ray L. Hodges at the USTA 1987 Capital Recovery Seminar, Arlington, Virginia, September 21-22, 1987. The information reported here was filed as a study on June 30, 1987 with the Florida Public Service Commission and may be filed with the FCC in 1988.

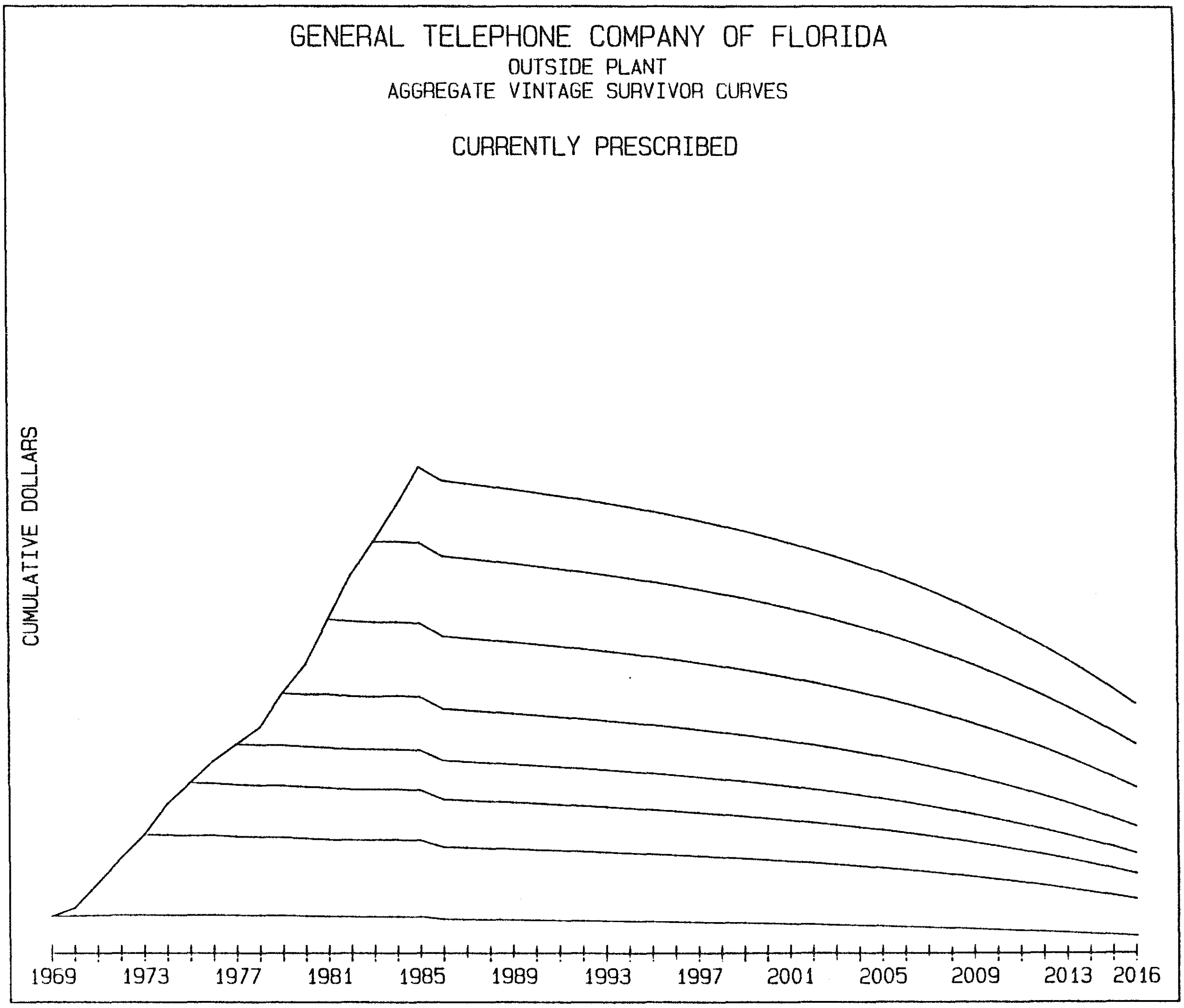
[2] Interoffice is expected to soon be 100% glass fiber; feeder lines are well underway; branch feeders are intended to start in 1990; and the dates for the distribution network are not established.

[3] The use of the term "regulatory concern" in no way presupposes, assumes, or asserts any concern on the part of the Florida Public Service Commission or any other specific commission. Rather the term is intended to have a general application covering the general regulatory community.



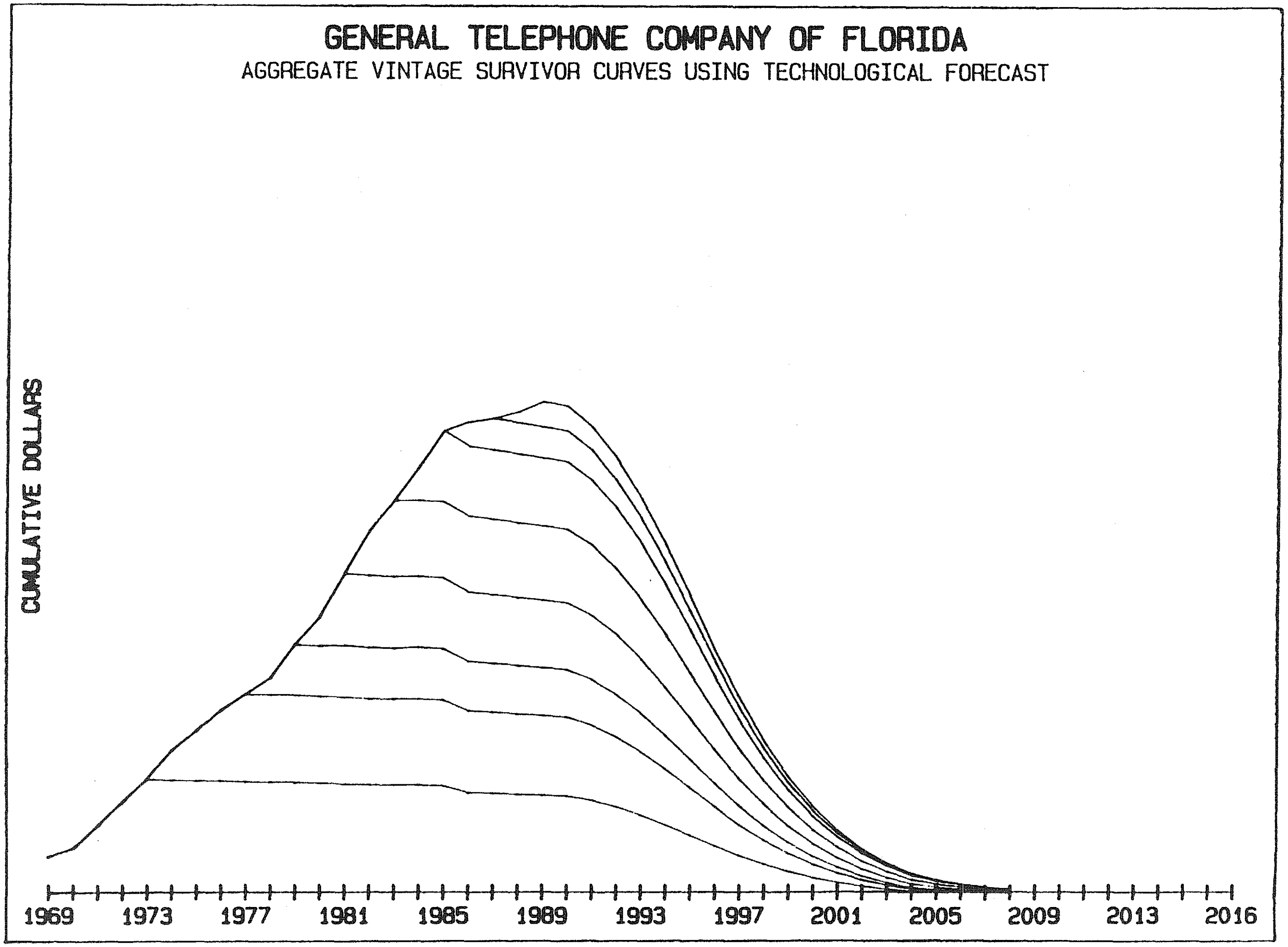
Source: R.L. Hodges, "GTE Florida Exchange Network Evolution and Capital Recovery Plans" (handout), USTA Capital Cost Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 2-1. Planned customer migration from copper to glass



Source: R. L. Hodges, "GTE Florida Exchange Network Evolution and Capital Recovery Plans" (handout), USTA Capital Cost Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 2-2. Currently prescribed aggregate vintage survivor curves



Source: R.L. Hodges, "GTE Florida Exchange Network Evolution and Capital Recovery Plans" (handout), USTA Capital Cost Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 2-3. Aggregate vintage survivor curves using technological forecast service life of outside equipment installed in 1987 will end by the year 2009, with the greatest portion of it being phased out by the late 1990s. It is the migration from existing copper to glass fiber that largely accounts for this difference in depreciation lives.

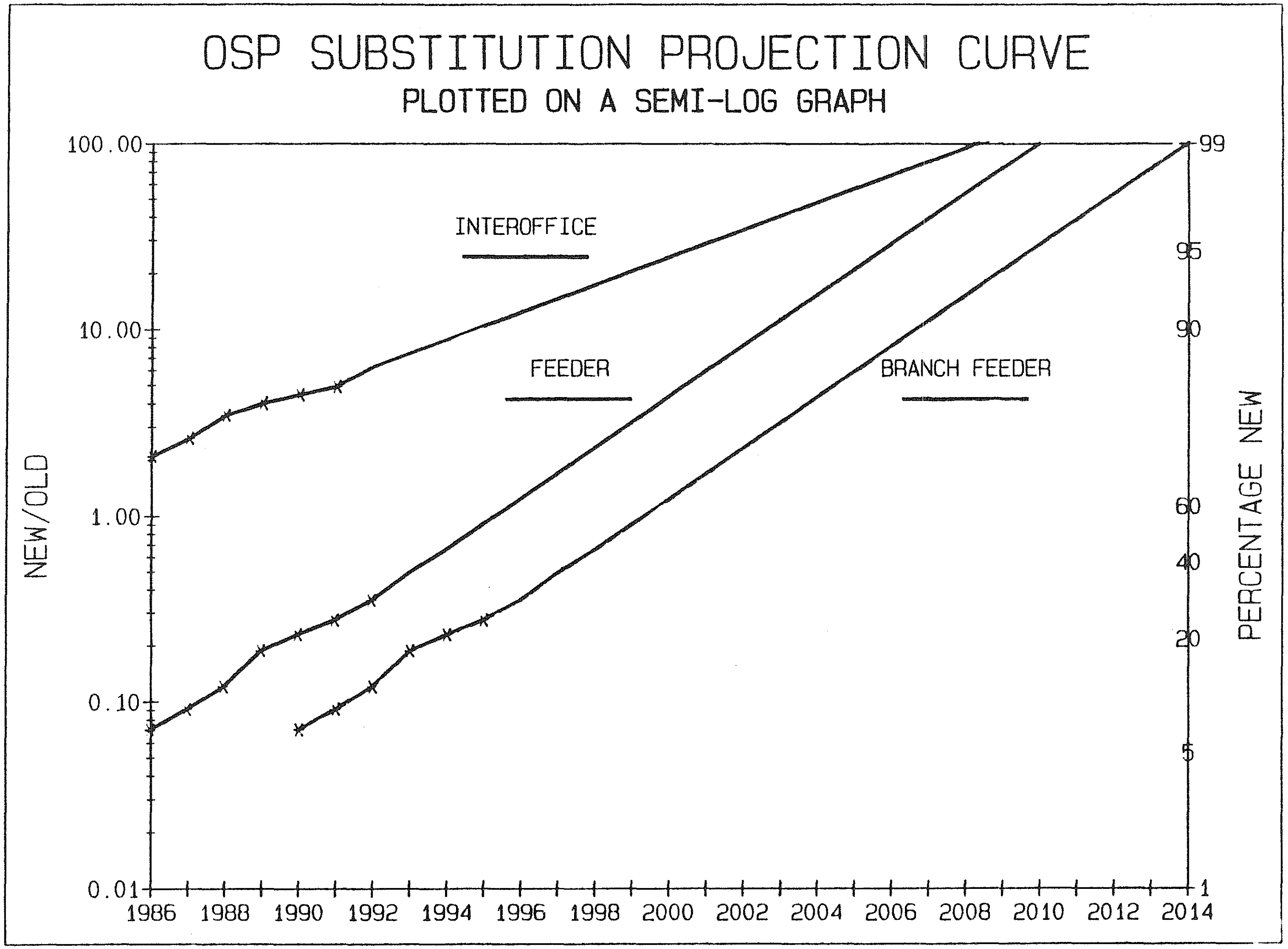
In figure 2-4, the forecasting methods contained in the Fisher-Pry Technology Substitution Theory show a sharp decline in the aggregate service lives of outside plant. In particular, the Fisher-Pry theory forecasts the installation of the new technology (figure 2-4) and, when correlated with the survivor curves in figure 2-3 above,[4] it is these new installations that cause existing equipment to be abandoned and retired.

Adoption by utilities of a forecasting method such as Fisher-Pry may lead to a premature abandonment or retirement of equipment. Utility investment actions then create a depreciation problem if regulators are asked to accelerate or to otherwise increase the annual depreciation expense. The GTE of Florida plan is one illustrative instance of this potential modernization forecasting problem. If, however, a clear consensus exists regarding the favorability of net future revenue streams when a utility follows the Fisher-Pry model, no regulatory problem necessarily occurs.

Full Macro Network Forecasts

Four macro network modernization forecasting models are presented and examined in this section. The models were selected for their ability to describe the entire network and because the concepts underlying the forecast were explicit. Only the Fisher-Pry model is widely known and used for forecasting. The switching and transmission cost differential scenario is derived from the geodesic model Dr. Huber prepared for the U.S. Department of Justice. The "10%" model and the "year 2000" models are forecasts that may not have been used in rate cases, but still offer both interesting forecasts and robust forecasting methods.

[4] A survivor curve shows the rate over time at which a particular type of equipment of the same age (vintage) is retired or otherwise taken out of service.



Source: R.L. Hodges, "GTE Florida Exchange Network Evolution and Capital Recovery Plans" (handout), USTA Capital Cost Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Fig. 2-4. Outside plant projection curve

Fisher-Pry Technology Substitution Theory

A relatively new technique for telecommunications technology forecasting has begun to be widely circulated and used by the BOCs and other large telephone utilities, namely the Fisher-Pry Technology Substitution Theory. The Fisher-Pry substitution theory was developed by John Fisher and Robert Pry and was based on their work at General Electric Research and Development Center. The use of the theory allows one to make a prediction regarding the rate at which a specific new technology will succeed or replace an existing technology. In some ways it is the "flip-side" of the Iowa survivor curves and predicts additions of new equipment versus the prediction by survivor curves of the retirement rate of old equipment. In the GTE of Florida example, both the Fisher-Pry method and survivor curves were used.

The two key concepts in the theory are the Fisher-Pry ratio and the Fisher-Pry rate of substitution. The Fisher-Pry ratio (F-P ratio) is defined as the amount of new technology deployed at a given time divided by the amount of the old technology in place at that time. It is a measure of replacement as well as a measure of the firm's decisions to serve new or projected growth with either the new or older technology. The Fisher-Pry rate of substitution (F-P rate of substitution) is the annual percentage change in the F-P ratio. The essential part of the theory is that the F-P rate of substitution is essentially constant during the major part of the substitution or replacement (Lenz and Vanston, 1987, pp. iii-iv).

In a recent study for USTA, Lenz and Vanston (1987) analyzed the pattern of technology substitution using the Fisher-Pry theory and concluded that uniform F-P rates were observed between the 10% and 90% substitution period for new technologies. They then extended their analysis and forecast that Stored Program Control (SPC) would replace 99% of electromechanical switching between 1993 and 1995. Their forecast for digital switching was a 99% substitution over analog switching by 1997.[5]

---

[5] Lenz and Vanston observe that "Completion dates for these substitutions may come earlier or slightly later for some companies, depending upon individual company economic and market circumstances" (1987, p. iv).

The Fisher-Pry Model and Procedures[6]

The portion of the Fisher-Pry model used for descriptive and forecasting purposes is built around two concepts that are easily expressed mathematically. The first is the F-P ratio and may be expressed as

$$f/(1-f) = \exp 2a(t-t_0)$$

where f = the fraction of the new technology

$2a$ = the slope of the line when the equation is plotted with a logarithmic vertical axis

t_0 = the time point where $f = 1/2$

The above form allows the model to be expressed on semi-log paper which facilitates regression analysis for predictive purposes.

The second concept is the F-P substitution rate and is the percentage change in the fraction $f/(1-f)$ between time $t+1$ and t. This may be expressed as a percentage by using the following formula:

$$4 = [\exp(2a) - 1] * 100$$

There are essentially eight steps involved in using the Fisher-Pry model. Step one is to correctly pair an established older technology with an emerging technology that is starting to displace the older technology. Step two requires the selection of the correct measurement unit to define the fraction of total usage of the old and the new technology. The choice of a unit of measure is an important step, particularly given the tendency to use the most easily obtainable data. Should, for example, the analyst choose "number of digital switches manufactured" or the "number of digital switches in use?" Both numbers measure different things, the first the

[6] The discussion of the Fisher-Pry model contained in this section is drawn entirely from Lenz and Vanston (1987).

manufacturing or buying preferences, the second the penetration or dominance in the field of each technology.

The third step requires the gathering of time series data on the new technology. These data are usually gathered in yearly increments. The fourth step is to convert the data into the Fisher-Pry ratio. The next step is to plot the data using four cycle semi-log paper, showing the F-P ratio against time. This step ends the descriptive portion of the Fisher-Pry model.

To use the Fisher-Pry model for forecasting purposes, the next step would be to select the earliest point in time at which the time-series has become reasonably uniform. This point then becomes defined as the origin and a regression may be used to make a forecast of the timing of future substitutions. The forecast must be revised each time new data are obtained and the analyst should reconsider all factors involved.

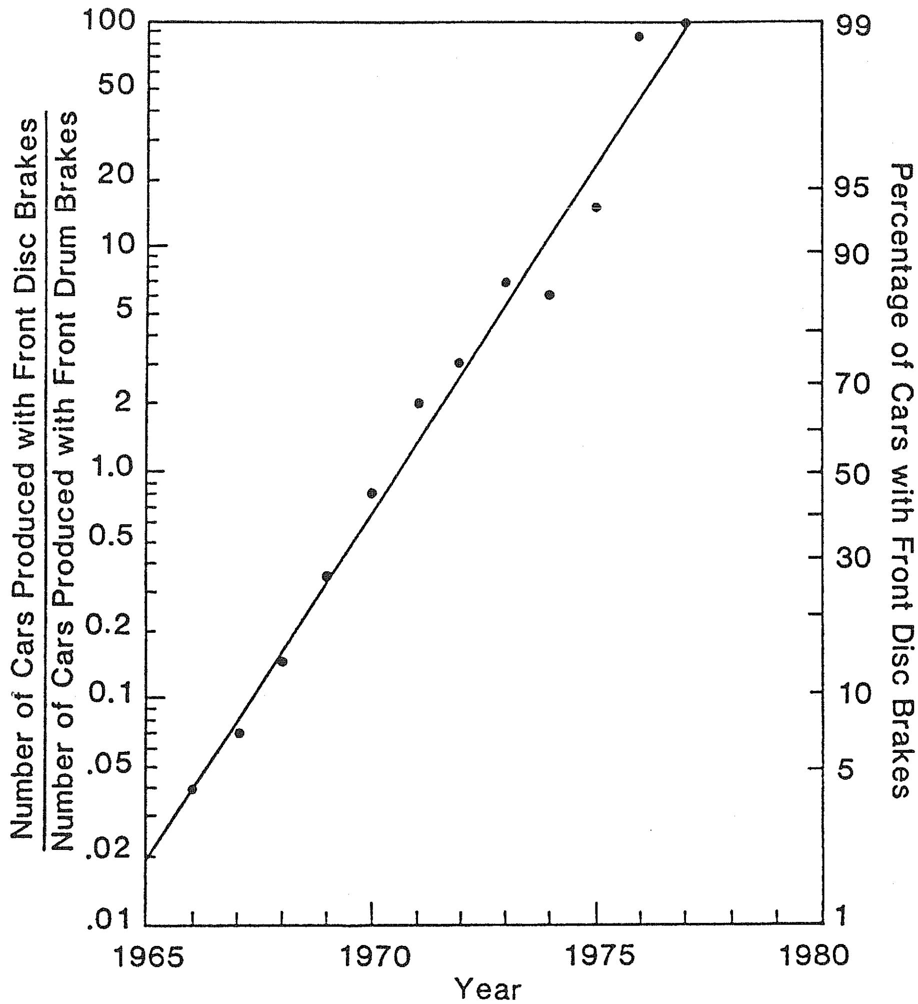
Figure 2-5 below shows the results of a purely descriptive use of Fisher-Pry to depict the substitution from drum brakes on cars to front disk brakes. Figure 2-6 and table 2-1 illustrate the use of Fisher-Pry for predictive purposes. Note that the historical descriptive data ends in 1985 and that the rest of the data are forecasted. Note also that the actual percentage change rate varies somewhat. If a forecast had been fit to the actual data points using the first five years (1969-1974) the 99% substitution may have been predicted as occurring much earlier than 1995.

Analysis and Critique

Several features of the Fisher-Pry technology substitution model require special attention for proper application: the assumption of a constant rate of change, the choice of a unit to measure the change, the attempt to forecast future substitution rates, its ability to handle multiple relatively simultaneous substitutions, the capacity to handle significant discrete changes, the effect of non-zero sum growth, and the self-fulfilling nature of the forecasting effort.

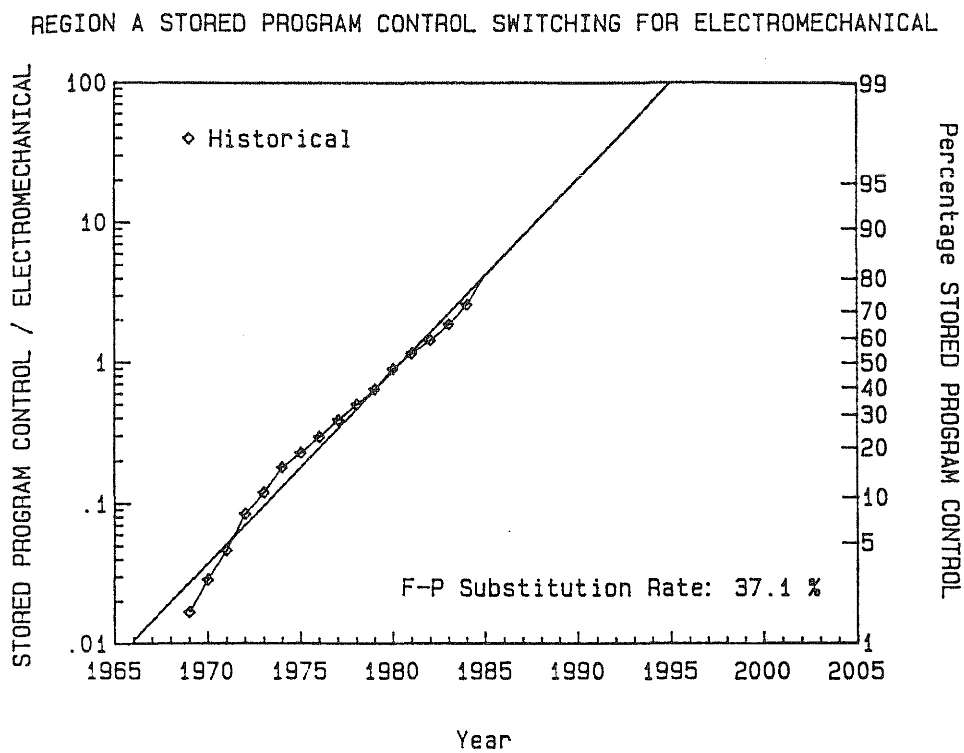
Regarding the assumption of a constant rate of change, the F-P model works best for descriptive and forecasting purposes when it is used in situations where 10% to 90% of all substitution that is going to occur has occurred. Like other forecasting models, it does not perform well when

FRONT DISK BRAKES VS. DRUM BRAKES ON U.S. CARS



Source: R.C. Lenz and L.K. Vanston, Comparisons of Technology Substitutions in Telecommunications and Other Industries, Technology Futures, Inc., Austin, Texas, 1986, p. 11.

Fig. 2-5. Fisher-Pry depiction of substitution of front disk brakes for drum brakes on U.S. cars.



Source: R.C. Lenz and L. K. Vanston, Comparisons of Technology Substitutions in Telecommunications and Other Industries, Technology Futures, Inc., Austin, Texas, 1986, p. 11.

Fig. 2-6. Fisher-Pry depiction of the substitution of stored program control switches for electromechanical switches.

TABLE 2-1

SOURCE DATA FOR FISHER-PRY ANALYSIS OF SUBSTITUTION
OF SHARED PROGRAM CONTROL SWITCHING FOR
ELECTROMECHANICAL SWITCHES SHOWN IN FIGURE 2-6

Old Technology: ELECTROMECHANICAL
New Technology: STORED PROGRAM CONTROL
Units: SUBSCRIBER LINES (000S)

Time	Old	New	Total	% Old	% New	New/Old	Comments
1969				98.34	1.66	0.0168	Historical
1970				97.21	2.79	0.0287	
1971				95.56	4.44	0.0494	
1972				92.21	7.79	0.0844	
1973				89.31	10.69	0.1197	
1974				84.71	15.29	0.1805	
1975				81.30	18.70	0.2299	
1976				77.09	22.91	0.2971	
1977				71.79	28.21	0.3930	
1978				66.48	33.52	0.5041	
1979				60.61	39.39	0.6499	
1980				52.58	47.42	0.9019	
1981				46.27	53.73	1.1612	
1982				40.97	59.03	1.4406	
1983				34.81	65.19	1.8728	
1984				27.82	72.18	2.5941	End Series
1985				19.06	80.94	4.2468	Projection
1986				14.66	85.34	5.8217	
1987				11.14	88.86	7.9802	
1988				8.38	91.62	10.9397	
1989				6.25	93.75	14.9957	
1990				4.64	95.36	20.5568	
1991				3.43	96.57	28.1786	
1992				2.52	97.48	38.6286	
1993				1.85	98.15	52.9507	
1994				1.36	98.64	72.5873	
1995				0.99	99.01	99.5062	

Fisher-Pry Annual Substitution Rate: 37.1%
FPR>10 = 30.4%
Filename: spcemra

Source: R. C. Lenz and L. K. Vanston, Comparisons of Technology Substitutions in Telecommunications and Other Industries, Technology Futures, Inc., Austin, Texas, 1986, p. 26.

underlying conditions change, such as a national or regional economic slow down that lowers the demand for the service provided by the new technology. If a utility were to base its modernization decisions on an economic depreciation analysis, a wholesale substitution--one not necessarily predictable from a F-P forecast--using the new technology could occur over a short time period. The lure of the Fisher-Pry model is that for planning management, and risk minimization purposes, it is very tempting to plan for a stable and predictable rate of technological change. Unfortunately, such a plan may cause a new technology to be installed in a monotonic way that may not be the most cost efficient method for ratepayers.

A commission receiving an analysis based on the Fisher-Pry theory may need to inquire as to whether the data are directly derived from national or regional data sets, or from specific utilities, or parts of utility service territories. Conclusions drawn from directly derived data ought to apply only to the unit for which the data were originally gathered. Technology substitution analysis should be most reliable when national data are used to support nation-wide regulatory decisions, and when utility-specific data are used to support regulatory decisions for specific utilities.

Indirectly derived data using, for instance, national data based on the experience of only a few utilities and that is adjusted by some factor to make it "representative" of a particular utility may need to be examined closely by commission staff. Some consulting firms, to cite but one example, sell state development departments economic forecasting models built on national data which are adjusted (by using state population or "state GNP" data) such that they are supposed to allow accurate state level forecasts. Unfortunately, unless the state is an exact microcosm of the U.S. national economy, the model will simply predict changes in a smaller version of the U.S. economy because it does not necessarily reflect the structural features of the economy of a particular state. Using adjusted national data or data covering only the densest portion of a company's service territory, would accordingly provide a misleading base from which to extrapolate and project future patterns of technology substitution.

The choice of the variable to employ to measure the substitution is of critical importance. The choice here is between measuring purchasing and manufacturing practices, or measuring penetration and usage. Reexamining figure 2-5, it can be seen that the measure chosen is a "purchasing and manufacturing" measure, namely the number of cars produced having a certain kind of brake. This appears to be an acceptable measure for new purchases. It may be a misleading measure, however, of the penetration or use by purchasers. If between 1965 and 1976 all of the manufacturers switched to the more modern technology (disc brakes) this does not mean that 100% of the cars on the road in 1976 will have disc brakes. The use or penetration in 1976 will depend on the number of cars having drum breaks already on the road, as well as their likely service life.

Purchasing and manufacturing measures are most useful for those concerned about the rate of change. Penetration and usage measures more accurately indicate the level of change. Consider the following simple example. Imagine a water tank with one ingoing pipe and one outgoing pipe. Three measures are of most interest: the rate of water entering the water tank, the level or amount of water in the tank, and the rate of water leaving the tank. Knowing the "F-P" rate of water entering the tank does not by itself tell us anything about the level of water in the tank, or the "retirement" rate of water leaving the tank. A high rate of water may enter a tank that is empty, half-full, or nearly full. The use of a sales and/or manufacturing change may overstate the extent of the actual change to the telephone system.

Commissions may need to examine closely the basis of the quantitative measures chosen in a Fisher-Pry analysis. Prudence may require that both rate and level versions of the variable of interest be used in order that a complete picture is obtained.

Other "choice of measure" problems exist and are too numerous to elaborate here. As a rule of thumb, however, it is certain that advocates of a particular policy will employ definitions and measures that most suit their needs. Those in favor of increased glass fiber will use measures that emphasize circuit counts or call carrying capacity, because that is the comparative advantage of fiber cable. Those seeking to deemphasize or slow the deployment of glass cable would tend to favor measures such as the number of miles of installed copper to the number of miles of installed fiber, particularly on the local distribution loop. The use by advocates of the data that best support their case is, of course, not new to commissions. Regulatory decision-making and planning will be enhanced to the extent that commissions can encourage multiple measures.

A third area of concern, and perhaps the main reason the Fisher-Pry substitution model is in use by utilities, is the appropriateness of using the Fisher-Pry model for forecasting. The appropriateness of the Fisher-Pry model for forecasting depends on two related factors: the representativeness of the historical data and the validity of the F-P assumption that technological substitution occurs at a constant rate, especially before the 10 and after the 90 substitution percentiles. Most analysts would agree that the data from the first few years of pilot tests, field trials, and first initial large-scale commercial installation are not representative of the installation and purchasing practices of the remaining portion of the service life of a particular technology. For forecasting purposes, the regulator needs to be confident that the historical years used to generate the forecast are sufficiently representative of the subsequent years. If the first few years represent the "easiest" sales and a growing economy, such a forecast may not adequately represent the underlying economic conditions in following years.

The assumption that technological substitution occurs at a constant rate is related to the factors discussed immediately above. Forecasts in the first 10% and after the 90% substitution rate have been achieved are likely to be unreliable as the technology substitution patterns in these regions are not representative of the 10%-90% "center" of the technology substitution curve (Lenz and Vanston, 1987). It is possible to construct statistical forecasting techniques that can arguably handle forecasts in the under 10% and over 90% regions, but the acceptability of such techniques may vary according to the policy position of the analyst.

The regulatory policy issue here is the use by some analysts of the Fisher-Pry model to forecast technology substitution to the 99% mark using data from the "under 10%" part of the purported technology substitution curve. Futhermore, if this type of forecast also uses an inappropriate "rate" measure, then the forecast will likely greatly overstate the amount of new technology installed and predict a 99% substitution date that is far too optimistic.

A fourth area of concern is the ability of the Fisher-Pry technology substitution theory to handle multiple, relatively simultaneous technology substitutions. It is commonly projected that the rate of technological change will continue to increase in the future. One practical consequence of this will be the rapid succession of new telephone technologies that are ready for installation before the existing capital assets have used up their originally estimated productive life. Digital switching appeared on the scene, for example, before electronic switching had fully replaced the older electro-mechanical switching technology. For instance, in figures 2-6 and 2-7 the Fisher-Pry model is used to describe or predict the substitution of one switching technology for only one other technology, whereas it may be the case that another, newer switch technology will cause this unusual substitution pattern to be altered. Thus, the newest technology will stop the merely "new" technology from ever totally replacing the "old" technology. Lenz and Vanston (1987) advance some options on handling this problem, but it is likely the case that with the wide range of options possible, that consensus on how to handle the problem of multiple substitutions may be difficult to achieve.[7]

A fifth feature is the ability of the Fisher-Pry model to handle significant discrete changes, either in the historical data, or in the projected forecast. For example, the regulatory "equal access" and "comparable efficient interconnections" initiatives caused some larger amount of new technology to come on line faster than would have otherwise occurred. If this regulatory-induced artificial inflator is included in the base years, subsequent forecasts may be too high. If a utility uses economic depreciation and the analysis shows that all the older technology should be modernized and replaced with a newer technology, the technology substitution rate forecast from the base years would likely be much too low.

The above problems are common to most forecasting efforts. Given that the Fisher-Pry forecaster is most often only going to be using part of the historical data to make a forecast, a commission should seek a substantial

---

[7] Having a "newer" (or third) technology available may make it especially difficult to determine crucial F-P benchmarks, such as the 10 and 90 substitution percentiles.

documentation of the forecasters' rationale for accepting the base years as representative of subsequent years. The problem of handling unknown, significant discrete changes in the future is, of course, not easily solved. Perhaps the best solution available here is to require that a range of possible outcomes be provided to the commission.

A sixth area of concern is the ability of the Fisher-Pry model to handle significant non-zero sum growth. If the demand for a service provided by the new technology is growing at a rate that would clearly exceed the equivalent amount of service provided by the older technology, then a non-zero sum growth may occur. If the market for a technology is growing exponentially, it may be very difficult to pick a good base period from which to predict a Fisher-Pry "even rate" of technology substitution. This problem may be further exacerbated if there are multiple technologies and at least two of the technologies are growing at a significant rate.

For a commission, again there appears the need to have the F-P analyst discuss and document the assumed growth rate and to indicate whether present rate of technology substitution is in the "under" 10% range, in the 10-90% range, or in the 90% plus range.

A seventh concern is the way in which the model handles the existence of sub-markets that may exist for the older technology. As Reinganum (1981) points out, if you assume economic efficiency and rational actors, there will very likely emerge specialized sub-markets for the now greatly marked-down prices for the older technology. The assumption of a constant rate of technological change is not necessarily antithetical to these observations, but does call for vigilance on the part of the researcher, particularly in the 90% plus range, to observe and record the behavior of these sub-markets.

The last concern covered here has to do with the self-fulfilling nature of the Fisher-Pry assumption of a constant rate of technological substitution, particularly for regulated utilities. In an unregulated firm or industry, technological substitution is most directly affected by demand for service and the economics of providing that service. If a firm introduced a technology at some monotonic rate, uninfluenced by demand or economics, it would likely be at a competitive disadvantage to the other firms that engaged in more economically rational, cost minimizing behavior. A regulated utility is by definition not subject to competition in its own service territory for services provided to monopoly ratepayers.

Accordingly, if it decides, with the concurrence of the appropriate regulatory commission, to install modernized equipment at a certain rate that is not directly and constantly affected by demand and economics, it will not necessarily be at a competitive disadvantage. A utility may choose the rate of substitution that best suits its own perception of its needs, and the Fisher-Pry model will subsequently document and validate this rate and use this information as the basis for future forecasts. In this instance all the Fisher-Pry model has added to the regulatory analysis is a method for calculating the rate of change, and does not otherwise validate any underlying economic structure to account for the rate of change.

Fisher-Pry Theory in Perspective

Presentations and analyses using the Fisher-Pry model tend to assume and portray a technological inevitability built on objective data regarding the past rate of technological substitution for a particular new technology. The cautions and concerns expressed above mirror those that commissions have faced in other arenas, most noticeably for nuclear power plant construction. One reason for the over-construction was that the demand projections of electric utilities did not accurately model the underlying economic structure of the demand for electricity; whereas these same forecasting techniques had reasonably accurately modeled the demand for electricity in the previous several decades.

The Fisher-Pry model has the same problem, as it does not model any underlying economic structure of the demand for telephone service.[8] A model that better incorporated the underlying features of the demand for telephone services--such as the impact of economic growth, demographic shifts, or inflation--would stand a better chance of making more valid forecasts than a Fisher-Pry type model.

[8] It can be argued that the model of telephone demand embedded in the Fisher-Pry theory is one that says that the comparative advantage of a new technology is increased on a constant basis after an initial implementation period.

Switching And Transmission Cost Differential Scenario

The Geodesic Network: 1987 Report on Competition in the Telephone Industry (1987), by Peter W. Huber is one of the most significant telecommunications reports in recent history.[9] The significance will be more for his breadth of vision and specification of his geodesic network model than for any policy consensus directly brought about by the report. Dr. Huber skillfully integrates and applies economic and engineering principles to describe the current telecommunications system and uses these principles to forecast the future development of this system. While a good part of his forecast is clearly prescriptive and open to argument, it does nonetheless offer a qualitative model for forecasting the future of the telecommunications.[10]

The Huber report is organized around the conceptualization of the telecommunications system as a geodesic network. Traditionally, and

---

[9] Dr. Huber's report was written in order to provide the U.S. Department of Justice with an analysis of the advantages and disadvantages of retaining section II.D of United States v. Western Electric Co., Inc., et al; Notice of Entry of Final Judgement, 47 Fed. Reg. 40392, 40393, 40394 (Sept. 13, 1982), which prohibited the BOCs from offering interexchange information services, or manufacturing, or any service other than exchange and exchange access service. After the release of the Huber report, Judge Green denied motions to remove the MFJ restrictions prohibiting BOC provision of interexchange service, and BOC manufacturing, but granted motions requesting the removal of restrictions on "other services" and on structural separation restrictions for subsidiaries. He also announced his intention to modify the information services restriction (United States v. Western Electric Co., et al., Civil Action No. 82-0192, pp. 2-3).

[10] It is not clear from the text of his report if Huber would explicitily recognize or present his work as a qualitative forecasting model. The model is a qualitative model because the concepts advanced are what are used to forecast future developments. A quantitative model would employ numbers and build a forecast based upon patterns observed in the data. A qualitative forecast works the same way--building a forecast based upon observed patterns often with equal validity. Both types of forecast are dependent on the the validity of the work the analyst does in extrapolating trends observed in one period to a future period. In the Huber report the centralizing and decentralizing trends of the geodesic model provide us with some ability to forecast future telecommunications developments. The explication of the model, and its implications are, however, the responsibility of the author of this report and are not attributed to Dr. Huber or the U.S. Department of Justice.

particularly in the pre-divestiture period when the old Bell system included both long distance and local exchange services all under one corporate umbrella, the telephone network was viewed as a classic example of an integrated hierarchy.[11] In the network system all access to local exchange service was provided through local central offices, which were then linked to other regions through a vertical hierarchy of long distance lines and toll offices that "handed-off" toll traffic according to an optimizing scheme that routed traffic through the shortest and least congested routes. The vertical hierarchy was thought to be the most efficient and effective system, given available technology, for handling the local and long distance calling needs of residential and business telephone customers. It also had, from the old Bell system's perspective, the happy coincidence of preserving the existing monopoly and discouraging competition.

Huber argues that the development and widespread availability of new and economically feasible telecommunications technologies, in addition to the industrial re-structuring brought about by the Modified Final Judgement, have combined to form a new telecommunications network that can best be described as a "geodesic network". A geodesic network is ring-like in structure, such that each component may be directly connected to any other part, using as much or as little of the local exchange company's facilities, or any other vendor's facilities, as it wishes. Huber feels that the old hierarchical system was designed, in part, because switching was expensive and transmission was cheap. With the advent of digital switching, PBXs, and microwave the old hierarchy became decentralized as switching capability was directly purchased or leased to companies, units of government, and to a wide assortment of re-sellers. With this change local exchange companies no longer had a monopoly on switching. Using microwave facilities of their own, the owners of these switches could, particularly for long distance or for certain other services, lift their calls via microwave to an alternative

---

[11] The idea originating with President Theodore Vail that the Bell system was an integrated whole is representative of the policy of comprehensive planning and construction followed by the telecommunications industry from the early 1900s.

service provider and effectively bypass the local exchange company for some portion of their calling needs.

A second feature of the new geodesic network is the change it will create in the structure of the entire telecommunications industry. Huber says that the initial decentralizing impact will result in a large number of firms providing services and products. After an initial period a shakeout will occur and an oligopolistic market structure will emerge. The reason for the emergence of and domination by large firms (such as IBM and AT&T) will be because most users would prefer to have one telecommunications firm to consolidate the wide menu of available telecommunication services. The large telecommunications firms will have a strong comparative advantage in (1) integrating a wide range of services, (2) providing the sales, operating, and maintenance staff needed over wide geographical areas, and (3) ensuring high quality connectivity with all other parts of the national or international telecommunications network. Huber forecasts that many of the smaller, more specialized telecommunications service providers and equipment manufacturers will be absorbed by the larger firms, even though they will continue to be profitable for some time. Other small independent firms may fail because of their inability to provide a uniform and ubiquitous telecommunications service.[12]

A third feature of Huber's geodesic network is the presumption of an increasing demand for telecommunications services and a corresponding increase in the provision of these services. For Huber the technological, deregulatory, and economic feasibility genies are out of the bottle(necks) and telephone services will never be the same. In particular, the heavy users will find new and more economical ways to meet their information and voice needs. Residential and small business customers will migrate into the

---

[12] In the deregulated airline, trucking, and railroad industries, a consolidation similar to that forecasted by Huber has already occurred, after an initial period of decentralization and growth. The top six less-than-truckload (LTL) trucking firms account for 60% of all LTL shipments and 90% of all LTL profits. The big six rail-freight carriers carry 83% of all rail-freight and earn 93% of profits (Business Week, December 22, 1986, p. 52). In 1986 the top ten airlines accounted for 96.1% of passenger traffic, versus 80.6% in 1985 (Aerospace & Air Transport Surveys, March 14, 1987, p. 29).

information age, once appropriate services and products are available for their use. It is important to note that these changes will happen neither overnight nor, necessarily, at a high rate. A significant growth in the demand for advanced telecommunications services is needed to fund the modernization and expansion of the existing network.[13] Regarding the potential for growth in demand for telecommunications services The Economist notes (October 17, 1987, p. 6):

> A PABX can now be used to switch and transmit computer data as well as ordinary telephone calls and to support all sorts of features like abbreviated calling, call forwarding, automatic callback and many other things that most office workers have not yet learned to use and are not sure that they need. (The Economist, Oct. 17, 1987, p. 6)

Extrapolating from Huber's geodesic model it is possible to use its most important features to construct a qualitative forecast regarding future modernization and regulatory needs.[14] In table 2-2 four alternative telecommunications scenarios are presented based on the differences between transmission and switching costs. As mentioned, Huber used these differences to partially explain the development of the hierarchial network and the evolution to the geodesic telecommunications network. In table 2.2 these differences are used to forecast alternative telecommunications futures. For example, if switching costs are low and transmission costs are high, a decentralized network would be predicted. Each of the forecasting scenarios is briefly examined below for its implications for modernization and regulation.

---

[13] A significant amount of excess capacity exists in many glass cables, in part because they have so much existing channeling capacity and because new enhancements allow even more call carrying capacity. Overseas satellites serving the high volume trans-Atlantic route carried only about 30% of their rated capacity, and new satellites having an even higher call and data carrying capacity are already scheduled to be launched. These idle, non-earning (at least in an unregulated market) assets need to be kept to an appropriate level if customer-provided funding (through sales) are the primary source of funding of growth.

[14] This effort represents this author's attempt to extend the principles found in the geodesic network report into a forecasting exercise.

TABLE 2-2

ALTERNATIVE TELECOMMUNICATIONS SCENARIOS BASED UPON DIFFERENCES IN SWITCHING AND TRANSMISSION COSTS

		TRANSMISSION COSTS	
		Low	High
SWITCHING COSTS	Low	Revolutionary Growth Scenario	Decentralization Scenario
	High	Centralization Scenario	Status Quo Scenario

Source: Derived from concepts contained in Huber, Peter, The Geodesic Network. U.S. Department of Justice: Washington, D.C., 1987.

Revolutionary Growth Scenario

In this scenario low transmission costs are accompanied by low switching costs.[15] The availability of inexpensive switching and transmission causes telecommunications customers to maximize their use of the communications network so as to improve their productivity and to obtain a competitive advantage over other firms. The demand for new services will beget a demand for even newer services, eventually requiring a new wave of modernization expenditures. The scenario will include both elements of centralization and decentralization. Huber envisions a situation where a large number of small specialized telecommunications firms initially appear in a decentralization phase. Subsequently, a centralizing tendency will emerge as consolidation occurs because of the small firms' inability to provide comprehensive service, and because it is easier for the large firms to buy up these specialized firms than it is for them to create from scratch

[15] Low and high costs for transmission and switching may be either used as absolute, nominal costs, or as the magnitude of the ratios of transmission to switching costs.

the capabilities represented by these small firms. Further, as an economic fact of life, the large firms possess the financial resources necessary to buy up smaller companies. Eventually telecommunication services will be provided by a small number of oligopolistic companies.

It may also be the case that as long as the local exchange companies have the only physically connected local loop, and no significant local loop bypass technology exists (e.g., an all airwave cellular system), the decentralization phase will be shorter and less profitable than Huber envisions. This scenario assumes that since (1) the technology exists, (2) the interconnections are effective, and (3) the costs are low, demand will grow at some significant rate. It does not take into account the possibility that the demand for services may be relatively low and that it will plateau at some level of use no matter how low the price to the consumer--unless the entire economy becomes a total information-based, telecommunicating economy.

Decentralization Scenario

In this scenario the cost differential favors the use of switching over the use of transmission. This differential causes more businesses and other public and quasi-public agencies to buy switching until the marginal rate of substitution of switching for transmission balances out at an equilibrium point that reflects the relative costs of each. The cheap switching makes it even in the interest of the local exchange carrier to favor switching over transmission in its own facilities.

The decentralized location of switching effectively bypasses all or a significant part of the local switching monopoly enjoyed by the local exchange carrier.[16]

---

[16] This concept holds true even when centrally provided switching services like CENTREX are available, because unless CENTREX-type services are significantly cheaper than small stand-alone PBX, large firms in particular will continue to have a more favorable cost structure through owning their own switches.

Centralization Scenario

Centralization of the communications network occurs when transmission costs are low and switching costs are high. The heart of a natural monopoly is the physical interconnection of its distribution facilities. If wire-based transmission costs are low, the service territory-based, natural monopoly should prove to be the most cost effective means of delivering telecommunications services. This cost structure should be the same for non-wire transmission technologies, unless a technological breakthrough occurs that allows millions of separate telephone calls to simultaneously use the airwave frequencies assigned to telephone use.

The active field trials and implementation by BOCs of glass fiber cable is one example of a technology that may lower local distribution costs, particularly if the demand for new services by residential or small business customers grows.

Status Quo Scenario

In this scenario, transmission and switching costs are high and approximately equal. Neither technology enjoys a cost advantage over the other. In this case, demand is stable and the demand for new services is low. Whatever configuration of services that exists at that time will continue as a stable pattern. Assuming a national economy that is significantly in the information age, it is expected that this scenario has a low probability of happening as demand should be strong enough to attract innovation and competition such that it is unlikely that both transmission and switching costs would be high and equal at the same time. It may, however, be reasonably descriptive of the current high cost situation for digital switching and glass cable.

Modernization and Regulatory Outcomes

In each of the four scenarios it is possible to forecast broad gauge outcomes based upon the differences in transmission and switching costs. Modernization efforts will be the strongest and least expensive per call for the revolutionary growth scenario, and weakest and most costly in the status quo scenario. The level of modernization in terms of total expenditures, and as expressed on a cost per call basis, should be approximately equal in the centralization and decentralization scenarios.

The modernization role of the jurisdictional local exchange company does differ in each of the scenarios. In certain growth scenarios the telephone utility is an aggressive participant, one seeking to modernize to retain or increase its market share. It has the strongest comparative advantage in the centralization scenario and for those parts of the revolutionary growth scenario where it can use its transmission capabilities. The utility and all other firms have a relatively quieter role in the status quo scenario. The utility is either at a disadvantage (or on an equal footing) in the revolutionary growth and decentralization scenarios in terms of its ability to modernize or to provide modernized services at a competitive price relative to other telecommunications firms. The tremendous marketing, engineering, operating, and financial advantages of the jurisdictional utility in these competitive scenarios may be offset by the ability of other well-managed and technologically sophisticated firms to selectively target modernized services to heavy users.

The design of regulatory policies appropriate for a particular state in each of these scenarios depends on the objectives the commission is trying to achieve. Some broad outlines are, however, discernable based upon the kind of telecommunications industry associated with each scenario. In the decentralization and the revolutionary growth scenarios, we would expect regulation that encourages entry, requires detailed transition strategies, and that provides for some level of monitoring and oversight re pricing (and perhaps service quality standards) during the "phase one" competitive market, as well as during the "phase two" oligopolistic market. The status quo scenario will have little change in whatever regulatory policies exist at that time. The centralization forecast will require regulatory policies most like those currently in use because the telephone utility will have some or all of the characteristics of a natural monopoly.

The cost differential-driven forecasting scenarios can provide some insight into the quantitative forecasts prepared using the Fisher-Pry technology substitution theory. Only in the revolutionary growth scenario would an analyst or regulator expect to see both switching and transmission being replaced at a high rate. One would also expect Fisher-Pry forecasts that predicted high replacement rates for switching would be most reliable under the decentralization scenario, and for transmission under the centralization scenario. The status quo scenario is a little more difficult to predict, but it would probably look like a scaled down version of the revolutionary growth scenario. That is, fairly equal, but much slower rates of substitution for both transmission and switching.

Another insight into the validity and usefulness of the Fisher-Pry theory under the qualitative forecasting scenario approach is that if all four scenarios are viewed as being equally likely to occur over time (or if at least two of the scenarios occur over a short-to-medium length time period), the Fisher-Pry assumption of a constant rate of technology substitution may be called into question.

The Ten Percent Forecast

A limited forecast of future network modernization efforts and the financial consequences of the decision to modernize can be gained from an understanding of the size and economies of scale factors of long distance carriers operating in a competitive market. According to one analysis, in order for a company to pay for a truly national, long distance, digital-glass fiber-microwave-satellite network, it will need 10% or more of the total interstate long distance market. Currently, AT&T has 75%, MCI 10%, and US Sprint about 5% of the long distance residential market. US Sprint expects to lose $500 million this year and MCI plans to report a profit for 1987 (The Economist, Oct. 17, 1987, p. 13).

Assuming for discussion purposes the validity of the "10% rule",[17] it would be possible to forecast that as long as AT&T retains its current long distance market share only two-to-three viable national, long distance carriers may emerge. This forecast, however, is silent on the market share regional companies might need to survive and prosper. There is a clear, but difficult to measure, cost incurred when a company attempts to provide a ubiquitous service--either for a service territory or for the nation. If

---

[17] The analysis works equally well with either a 15%, 10%, or 5% of the total market assumption.

it is in the public interest to have ubiquitous competition among a number of national carriers, a different market structure than currently exists may be required.

Under the dominant national carrier(s) scenario required in the 10% rule, the specialized regional or local carriers will have the strongest incentive to modernize--after all if they do not offer a clear technological and economic advantage to their customers, their economic raison d'etre will disappear and they will fail. The second strongest need for these small telcos will be for "CEI-ONA-ISDN-BISDN" access to the full technological capacity of the BOC and dominant carrier networks. This access will require considerable capital investment and should also result in the development of new accessing and modernization technologies.

In a scenario with several national carriers competing, the primary predictable feature will likely be the impact of the disparity in size between the dominant carrier (AT&T, unless major changes occur) and the other carriers. This may have a direct, but hard to predict, impact on the modernization practices of the national carriers.

Year 2000 Forecast

Datapro Research Corporation published a forecast of telecommunications use in the year 2000 written by E. Bryan Carne[18] that provides us with another qualitative forecast. His approach follows from several assumptions. These are:

1. It is not technology, but customer needs that will drive service-using and service-providing businesses.

2. As profit maximizers, firms will only adopt those telecommunications services (whether owned or rented) that increase their competitive advantage and profits.

---

[18] Carne is Associate Director of Research for GTE Laboratories Inc.. The occasion for his article was the congruence of his qualitative forecast made in 1972 with the actual state of telephony in 1985.

3. Residential services that contribute the most to the satisfaction of basic customer needs related to their life styles and to the attainment of personal goals will be the most successful.

4. If current demographic trends continue, roughly one third of all households will be occupied by retired persons, another third will be occupied by families with children, and the remaining third will be occupied by working adults without children. The telecommunications needs of the three groups will differ, and these differences will be affected by whether one or more of the workers in a household chooses to work to live, or lives to work.

Said simply, Carne builds his predictions for business firms on the axiom that technological innovations "...will be adopted as soon as appropriate services can be offered at the right price" (Datapro, September, 1987, p. 102). Carne's predictions for the year 2000 for various services have been extracted from his article and are listed below in the order in which they appeared.

General

1. Voice will continue to dominate the point-to-point markets.

2. Some combination of video and voice will dominate the one-to-many mass communication market.

3. On the basis of erlangs consumed, date will play an increasing, but modest, part in business markets and a minor part in residential markets.

Business Services

4. Both voice and text messaging services should achieve a respectable level of use, and there is likely to be some demand for text-to-voice and voice-to-text conversion.

5. Until advanced calling features (call-forwarding, call-waiting, call-park, and camp-on, for instance) are made more user friendly, little use will be made of them by the average business customer. We expect manufacturers to offer them as a means of differentiating their products and to improve the user friendly aspects. This may lead to increased use, depending upon the need for these business applications.

6. As costs come down cellular telephone could become a moderate fraction of all business telephones. If, however, answering requires information normally kept at the work office, answering the telephone anywhere, anytime, could be a chore businesses do not want.

7. Portable telephones that use short-range radio or infrared, operating on the premises of specially equipped buildings should be wide spread in the next decade. In new buildings it will greatly reduce inside wiring costs and for all buildings it will reduce rearrangement costs.

8. The future use of teleconferencing is difficult to predict, although the potential is there to effect significant reductions in time consumed and travel undertaken. Businesses will adopt teleconferencing as soon as inexpensive, quasi-on-demand conferencing connections can be provided. Some technical improvements needed include more satellite channels, more wideband fiber networks, and better video imagery. If air travel continues to be uncomfortable and inconvenient, perhaps all of the Fortune 500 companies will be using teleconferencing to conduct routine meetings.

9. Data communication is a business requirement and telcos will continue to match the growing need of industry for cost effective data transport. Data transmission will still, however, remain second to voice.

Residential Services

10. Information retrieval will be used mainly by those who live to work.

11. Shopping and banking by telephone are both likely to find acceptance in direct proportion to their convenience and their reliability.

12. The use of existing telephone lines is thought to be sufficient for the small number of households that will use data services.

Carne's forecasting model offers a much more sophisticated view of the adoption by business and residential customers of the wide range of available telecommunications technologies than does the Fisher-Pry or most any other monotonic forecasting technique. While Carne's forecast is better able to handle non-linear changes and discrete, "lumpy" variables such as "whether a business person will need information normally found on his or her desk" as a predictor of the widespread use of cellular telephones, Fisher-Pry may do a better job of expressing telecommunications substitution trends quantitatively.

Single Factor Micro Forecasts

In this section eight micro, or single factor, forecasts are presented and briefly characterized. Unlike the macro forecasts described above, the micro forecasts are more limited because of the constrained explanatory power of the variables they use. For example, a forecast based upon the expected life cycle costs of digital equipment is not sufficiently broad enough to forecast the development of an entire network, even though it may provide some valuable reference points.

Microwave Scenario

It is estimated that by 1989, 60% of all bypass links will be implemented through the use of microwave. Common reasons given include ease of installation, no traditional "right of way" requirements, easy growth capability, and low cost. The threshold for a reasonable pay back is estimated to be about two years and having in 1986 a $1,000 monthly private line bill (Friess,1985).

Microwave technology provided the first widespread technology able to physically bypass selected parts of the local and long distance network. It has been of most use for high-volume traffic, and least useful for low-volume and high-dispersion traffic. It is an integral part of network modernization examined above for high-volume corridors.

Equal Access

Modernization in the telephone industry has not been driven exclusively by economic pressures. The FCC equal access policy, for example, has been a major factor accounting for the early retirement of cross bar switches. In a Fisher-Pry forecast and in the other forecasts, the modernizing of network facilities to provide ubiquitous interconnection may have provided an artificially higher rate of substitution from which to predict future developments.

The continued availability of non-discriminatory interconnections is important in each of the network scenarios. Historically, it should be noted, that it was not just the old Bell system that tried to use interconnection blockage against potential competitors. The essentially unregulated computer industry has also experienced uneven success with connectivity due to the various corporate marketing policies designed to enhance a particular firm's market share. Three elements may mitigate the problem of any blockage: (1) the development of bottleneck bypass technologies, (2) the economic advantage that might accrue to a telecommunications firm acting as a totally open common carrier, and (3) regulation of interconnection.

Open Network Architecture (ONA)

ONA may have a significant affect on the modernization efforts of telephone utilities. At its core, open network architecture is intended to unbundle the telephone system into parts that may be sold or leased to firms for resale to ultimate consumers. These parts are called basic service elements (BSE). It is not clear how BSE will be ultimately interpreted. For example, are different BSEs needed for the various electromechanical, 1ESS, 1AESS, 5ESS, or DMS switching systems? If different BSEs are required for each switching technology and no technology migration occurs, ONA may not function as strongly as it would otherwise as a positive force toward modernization. It seems more likely that the resulting plans will encourage technological migration to the most economical and modern technologies. Accordingly, in response to the FCC regulatory initiative of ONA, state commissions could see increased modernization expenditures by jurisdictional telephone utilities. The increase in modernization expenditures directly attributable to ONA will be difficult to measure as ONA will likely not be implemented instantaneously or across all service options made possible by the repackaged BSEs. State commissions, depending on the specific service involved, may choose to affect the speed of the implementation as well as the cost of the BSEs involved in providing that service.

BOCs may feel they have an obligation to offer BSEs each time a new technology or improvement to an existing technology establishes itself.

This would add a new dimension to the "responsibility to serve" of telephone monopolies in their mandated service territories. An obligation or incentive to continually make available the most technologically advanced BSEs could change the way that utilities operate and would be a more costly and risky modernization strategy than currently exists. It would, accordingly, have a direct and powerful impact on the rate and extent of modernization activities of BOCs. Such an interpretation, unless thoroughly guided by cost-causation principles, could further exacerbate the problem of determining an appropriate pricing policy for POTS customers.

One crude but workable way of estimating whether or not the BOC's ONA plans submitted to the FCC will result in significantly increased modernization costs is to examine the degree of "openness" in the proposed plans.[19] As can be seen in table 2-3, the greater the amount of network openness proposed, the greater the amount of change required to the network.[20] Kennedy (1987) has outlined a simple model that gives some insight into the impact of openness on modernization.[21]

If the approved BOC plans fall in the moderately or proactive columns of table 2-3, it would be safe to forecast that significant increases in modernization capital expenditures are planned. If the more incremental, minimally open strategy is stressed by the BOCs, modernization expenditures may not rise any faster than would have been the case without ONA.[22]

---

[19] These filings are, of course, plans and are subject to change by the BOCs, the FCC , state commissions, economic conditions, and changes in technologies. At this stage, however, they offer us the only direct and comprehensive insight as to the possible impact of ONA-inspired modernization efforts by major telephone providers.

[20] It is assumed here that resellers that emerge will be primarily concerned with providing services based on the most modern of existing technologies, particularly the digital technologies.

[21] We have converted his graph format into a simple matrix and extended his work by adding the impact on modernization.

[22] As Nowick (1987,p. 14) notes, "Equipment vendors may find ONA a bonanza rivaling equal access. ONA could quickly become the Telecom Software Engineers Full Employment Act, given the changes it is likely to necessitate in central office switch software, central office interconnection arrangements, network operations and administration and maintenance systems, and local exchange carriers' billing systems."

TABLE 2-3

A SIMPLE MODEL FOR ESTIMATING THE IMPACT OF OPEN NETWORK ARCHITECTURE PLANS ON THE MODERNIZATION PLANS OF JURISDICTIONAL TELEPHONE UTILITIES

Degree of Openness Expressed in Basic Service Elements (BSE)		
Minimally Open Network Strategy	Moderately Open Network Strategy	Proactively Open Network Strategy
* Existing and planned from stored program control (SPC) * Switching systems	* SPC interfaces * BSEs for general service types: - voice storage and forward - meter reading - alarm information - TV channel request	* Network component interfaces - local loop - DOV channel (data) - Transmission facilities - switching offices * Operating support systems interfaces - billing - traffic information - maintenance status * Signalling channel access * Signal transfer point data base interfaces * Intelligent network mode interface

Source: Modified from Kennedy, Jim "For Whom The Bell Toil: Decisions That Companies Make In The Next Six Months Will Determine Their Futures" in ONA Opening The Network: How Far? How Fast?, a magazine supplement of Communications Week: Manhasset, New York, (1987) p. 11.

Forecasts Based Upon the Comparative Advantages of Various Transmission Technologies

Forecasts of the installation by telephone utilities of glass fiber may have different outcomes depending on whether or not the forecasts are based on short-term or long-term trends and conditions. A short-term forecast based upon the recent level of fiber installation and cost factors would suggest a slowing and even sluggish market in 1988. A long-term forecast based on future cost decreases is likely to be somewhat more optimistic regarding future installations by telephone utilities.

In the short-term, it appears that the demand for long haul applications peaked in 1985 with the 16 largest national long haul carriers nearing completion of their route upgrades.[23] While the feeder plant--that part of the local loop between the central office and the local user where calls are multiplexed--is thought to be the next major installation site for glass fiber, local companies in general have not yet acted to install it. Installation of glass fiber for distribution plant--that part of the local loop between the multiplexer and the customer--is forecasted not to begin until the mid-1990s. Because of competition and softer demand than originally forecast, some glass cable vendors have begun to diversify and find niches in specialty markets such as military and underwater applications.

Long-term prospects for fiber seem better if the cost declines and if the penetration of other markets by fiber (the feeder plant, for example) causes customers on the local loop distribution plant to want the service and economic characteristics of glass fiber. The continued installation of glass fiber is estimated to reduce the cost of long-haul communications to 2.6×10^{-8} cents/bit over the next few years (Datapro, October, 1987, p.111).

---

[23] The discussion on fiber optics comes from Datapro Research Corporation, "Fiber Optic Communications: Issues and Trends", Datapro, October 1987, pp.101-112.

After the service characteristics of new technologies have been established through field testing, the cost of the new technology compared to existing technologies is the next variable influencing whether a firm will adopt the new technology. Some perspective regarding the complexity of such a comparison, as well as some recent substantive information on the pricing of various "wire" technologies, can be gained from the information provided in table 2-4. All other things being equal, the data suggests that for a 6,000 circuit channel, microwave would be the choice for 250 mile routes and satellite for 2,000 mile routes. The choices change when circuit size increases to 20,000 circuits. Here glass fiber would be selected for the shorter routes and satellite for the longer route. It is of note that glass fiber even on the high volume routes is only slightly more economical than microwave, whereas microwave is significantly less expensive than glass fiber on low volume routes. The break-even point for choosing between copper and glass fiber is approximately 9,000 feet (or 1.5 miles). That is, if the distance is less than 9,000 feet, copper should be chosen. The break-even point, all other things being equal, was 2.5 miles in 1984.

TABLE 2-4

A COMPARISON OF THE COSTS OF MICROWAVE, SATELLITE, AND GLASS FIBER
(expressed in dollars per circuit mile)

	6,000 Voice Circuits		20,000 Voice Circuits	
	200 Mile Route	2,000 Mile Route	200 Mile Route	2,000 Mile Route
Microwave	$4.00	$3.50	$3.00	$2.50
Glass Fiber	$6.50	$6.25	$2.75	$2.50
Satellite	$16.00	$2.00	$13.00	$1.60

Source: Adapted from Datapro Research Corporation, "Fiber Optic Communications: Issues and Trends", Datapro, October 1987, p. 103.

Inspection of the relative merits of the two competing technologies as listed below in table 2-5 suggests that an optimal technological replacement of copper by glass (assuming economic feasibility) would not be done monotonically or reach a 100% substitution in even the medium term future. Copper is clearly the technology of choice where distances are short and the number of circuits is small. Glass fiber has distinct advantages on longer routes and for situations requiring a large number of circuits between two points.[24]

TABLE 2-5

A LIMITED COMPARISON OF THE ADVANTAGES AND DISADVANTAGES OF COPPER AND GLASS FIBER TECHNOLOGIES FOR TELEPHONE UTILITIES

	Copper Cable	Glass Fiber Cable
Advantages	* Splicing and repair less costly * Established technology * Less costly for short distances and fewer circuits	* No electrical interference * Broadband applications * High circuit capacity * Virtually negligible bit error rate in data transmissions * Less costly for longer distances and higher circuit counts
Disadvantages	* Sparking and other electrical interference * Lacks bandwidth and associated transmission capabilities * Requires more closely spaced repeaters	* Difficult and costly to repair * Susceptible to damage due to water and freezing * May be affected by chemicals

Source: Adapted from Datapro Research Corporation, "Fiber Optic Communications: Issues and Trends", Datapro, October 1987, p. 111.

[24] These advantages are over copper only. Other comparisons would show microwave and satellite to be more economical choices than glass fiber in certain circumstances.

An important time dimension exists that needs to be considered when evaluating the relative cost of copper versus optic fiber. Presently, optical fiber costs more to buy and to install than copper (The Economist, 1987, p. 4). As the call volume between two points increases and as economies of scale begin to occur because of a wider implementation of glass optical fiber, the price advantage currently enjoyed by copper may decline significantly. Other factors affecting the cost of glass cable may also decline over time; the availability of light-based digital switching will do away with the photoreceptors that are currently needed to convert light signals to electric signals and back again every time they pass through a repeater or a switch.

Metropolitan Area Networks

Datapro reports (October, 1987, p. 111) that BOCs expect over the next year to be able to provide wideband services using Metropolitan Area Network (MAN) architecture, a predecessor of ISDN. The MAN service is now available in downtown Chicago from Illinois Bell using fiber optic digital service for its "Novalink" facilities. South Central Bell has glass fiber links from certain large customers to their central offices, and Bell Atlantic provides dedicated point-to-point digital service for bulk data, video, LANS, and other applications. New England Telephone has installed a MAN for Harvard University. These MAN installations may function as early indicators of the economic and service characteristics for state commissions interested in forecasting the impact of modernization (and ISDN in particular) on ratepayers and on utilities. For those commissions interested in undertaking such a projection, it may be necessary to work early on in the process with the utilities using MAN to develop a common data base which both regulatory and utility decision-makers can use. The MAN experience may provide important insights regarding the next generation of telephone technology: broadband ISDN.

Digital Switch Life Expectancy

As reported in The Economist, (1987, p. 4), it appears that the "...life expectancies of AT&T's flagship digital system, the 5ESS, and of its main rival, Canadian Northern Telecom's DMS-1, extend well into the twenty-first century." In large part this is due to the fact that, as presently designed and used, adding new features requires that new software packages be added. Software accounts for approximately 80% of the cost of a digital switch exchange. Digital switching offers a complex picture to regulators. On the one hand, it is a key feature of most modernization scenarios and has accelerated the "premature" replacement of older switches. On the other, it is itself a physically long-lived asset, one capable of having one generation of software being prematurely retired while the "frame" and the discarded software still have a useful remaining service life. The reprogramming of its software will not, however, protect electronic digital switches from being "prematurely" replaced by the next forecasted switch technology, light-based digital switching.

Integrated Services Digital Network

Integrated Services Digital Network (ISDN) is a set of standards being developed by the International Telecommunications Union that will provide common standards for all nations and telecos to use when accessing publicly switched networks. The large carriers, most notably the Bell Regional Holding Companies and their operating subsidiaries, have begun ISDN lab tests and field trials.[25]

---

[25] US West plans six ISDN trials in five cities using four different switches and a variety of CPE. One trial will be the first in the nation to test primary ISDN access (23 "B" channels and one "D" channel). Southwestern Bell opened ISDN demonstration centers in nine cities, began a pre-ISDN utility telemetry test, and announced that it would start commercial ISDN service for two large commercial customers in mid-to-late 1988. NYNEX has said it planned to buy two NEC adjunct switching systems for lab and field testing of ISDN during 1987, and plans a customer trial of a Siemens switch. Illinois Bell will be testing in field trials with McDonalds CPE from 15 vendors in a program that may lead to the first commercial ISDN installation, which will use an AT&T 5ESS switch. Pacific Telesis is testing and exploring ISDN with NEC equipment and is exploring an ISDN "alternative" called project Victoria -- a proprietary multiplexing

(Footnote continues on next page)

All of the major communications carriers will (or plan to) have some form of ISDN operational for a number of areas by the late 1980s (Datapro, Feb., 1986, p. 117). Assuming successful trials, it seems that the equipment, carriers, and vendors needed to implement ISDN are generally in place. The problem for telcos will likely be one of user acceptance and identifying the actual cost economies possible through wide spread use of ISDN services (Datapro, Feb., 1986, p.118). Professor Eli Noam of Columbia University has argued that ISDN was initially an engineering decision, one made without full economic analysis (The Economist, 1987, p. 34).[26]

One possible outcome is that an oligopoly will emerge consisting of a set of telcos that engage in tacitly endorsed, quasi-monopolistic practices in order that ISDN be ubiquitously provided.

Local Office Modernization

Most of the technological forecasting reviewed here is done at the level of the network as a whole. Further, the forecasts tend to be multi-year. This top-down perspective of forecasting does not fully explain the incremental actions taken by utility on a daily basis as it changes equipment at a particular location. In order to gain a perspective on this bottoms-up mode of action by utility personnel, a brief example is presented below. This perspective is important when changes to the telephone system are implemented on a case by case basis.

Consider the situation where the customers served by a given central office switch desire a service presently unavailable on the switch. The

---

(Footnote continued from previous page)

technique that places seven data and voice channels on one ordinary twisted wire pair. Bell Alantic is conducting a demonstration of NEC exchange termination connected to an analog switch. BOC New Jersey plans service cutover for Siemens basic access trial in late 1987. Southern Bell plans to offer ISDN services to a bank in 1988 and is planning an "ISDN-like" service using digital multiplexers (Telecom Publishing Group, March 1987, p. 2).

[26] In particular, he feels that the public telephone agencies of Europe have embraced ISDN because it would give them a long-term project that would protect them from competition by creating a need for protection from cream skimming by potential competitors.

following is a non-exhaustive list of options available to the utility.[27]

1. Do nothing.

2. Check the schedule for upgrade of the switch, and if an upgrade is scheduled within a year or two, ask the customer to wait.

3. Check the schedule for switch upgrading and get the schedule accelerated.

4. Install a remote switch module compatible with the current switch, which can be hosted off the original central office switch.

5. Install a controlled environmental vault (CAV) to multiplex the customer channels into a T-carrier that may be transmitted to any switch where the desired services can be provided.

It can be seen from this listing that only one of the options considered, option 3, results in a non-incremental addition to capacity. Options 4 and 5 use incremental additions to transport the calls to other switches having both the service capability, as well excess capacity. For many situations it is appropriate to "hang on" discrete pieces of equipment at a particular location and transfer calls to another more efficient location. For other situations, the right solution is to add new equipment.

Regulators have little desire to get intimately involved in the actual micro decisions regarding the optimal installation of equipment at a particular location. They may have an interest in ascertaining whether over an entire service territory an optimal pattern of installation occurs for equipment modernizations. Their interest is to ensure that options 1 and 3, above, are not the actual choice in a disproportionate number of instances. In the short-term options 4 and 5 may be the least cost options preferred by rational economic actors. Extrapolated to the company level, commissions may care that legitimate modernization needs are met in a cost minimizing fashion that includes t-carrier options as well as the installation of new digital offices.

---

[27] This listing was supplied by a telephone company engineer to the author and represents one engineer's description of some of the major decision points he would consider when faced with this situation.

Conclusion

Telecommunications modernization forecasts are important because of the impact they may have on current utility plans and regulatory policy making. A forecast showing a need for an extensive modernization program may cause a utility to speed up its existing modernization efforts. The incentive for telephone utilities to seek out forecasting methods that depict a need for increased modernization is due largely to the desire of the utilities to position themselves for a time when they will have to compete in an unregulated market. Forecasts that allow the modernization effort to start while the advantages of regulatory depreciation still exist let utilities act to meet the challenges of competition in a most favorable manner.

Some of the current popularity of the Fisher-Pry technology substitution theory may well be because of the usually straight-line forecast it provides re the replacement of older technologies by newer ones.

The qualitative network modernization forecasts presented in this chapter do a better job than the Fisher-Pry model of describing underlying economic and/or demographic factors that may cause changes in demand. These models are built on certain specified and explicit relationships--such as the difference in cost between switching and transmission--that are deductively derived and are capable of having multiple measurement strategies used in conjunction with them. As qualitative models they are not, of course, currently constituted to produce the quantitative forecasts favored by utility planners.

Regulators have had an important role in the development of policies that have encouraged both competition and modernization. Equal access, comparably efficient interconnection, open network architecture, and various depreciation concepts, have all had a positive impact on the modernization actions of telephone utilities. It is likely that regulators will have a similarly important impact on future modernization actions, and it is important that they have the best available forecasting analyses before them.

CHAPTER 3

TELECOMMUNICATIONS MODERNIZATION AND DEPRECIATION PRACTICES

Introduction

The traditional way regulators address telecommunications modernization is through depreciation. Depreciation is a method through which the capital invested in productive utility assets by a utility is recorded and then recovered annually at a rate and amount specified in advance by the regulatory commission. Telecommunications modernization investments are a subset of all the capital investments made by a regulated utility.

Modernization becomes a significant depreciation issue when either the amount of capital invested is considered to be excessive to meet the needs of ratepayers, or when the stipulated depreciation life of an asset is thought to be insufficient to ensure the recovery of the capital invested in the asset. The investment in nuclear plant technology is an example of over investment, and the current concern over a depreciation reserve deficiency an example of the latter. Only passing attention will be paid in this chapter to the potential problem of over investment, as the investment levels in telecommunications modernization do not appear to be of the same magnitude as those that occurred over the past decade in the electric utility industry. Most of the chapter will focus on the role depreciation plays in capital recovery and modernization.[1]

An almost standard feature of many depreciation texts is the reference to the "Deacon's one horse shay," where all parts of the shay wore out and disintegrated at the same, planned-for, time. As the old song broadly illustrates, capital recovery is affected by the congruence of the predicted

---

[1] For an introduction to regulatory depreciation practices see, Public Utility Depreciation Practices (1968), edited by the Depreciation Subcommittee of The NARUC Committee on Engineering, Depreciation, and Valuation of the National Association of Regulatory Utility Commissioners.

or stipulated life of the asset with the actual productive life of the asset. Definition of the productive life of an asset is the basis for much of the regulatory depreciation controversy over modernization, as the mathematical calculation of a depreciation rate is relatively straightforward once the length of the productive life of the asset is agreed upon.

The remainder of the chapter is organized into several interrelated sections. In the first section the results of three recent comparisons of the depreciation practices of unregulated firms with utilities are presented. In the second section the role of depreciation in a regulated industry is discussed, with particular reference to the certainty of the recovery of prudently invested capital. The third section explores the difference between accounting and economic depreciation as it relates to the definition of "productive" life. The fourth section addresses the role of depreciation in modernization investment decisions. The fifth section presents three empirical studies on depreciation and modernization. A final section presents conclusions.

Recent Comparisons of the Depreciation Practices of Regulated and Unregulated Firms

As regulated telephone utilities begin to strategically plan and manage their operations and their investment modernization decisions with regard to the competitive environment that may exist for a significant number of the currently regulated services, the depreciation practices of large, unregulated, and capital intensive firms have been scrutinized by telephone utilities. This examination has been motivated in part by the feeling that the depreciation practices of unregulated firms could result in a more rapid capital recovery than that currently allowed for regulated telephone utilities, and that this information could be used to convince regulators to modify their depreciation policies. A second motivation was the desire of utility executives to begin to plan for changes that might be necessary in order for the telephone utility to compete successfully in an unregulated market. Three studies that examine these practices are presented and discussed below.

The Ernst & Whinney Study

The United States Telephone Association (USTA) asked Ernst & Whinney to compare procedures used to account for depreciation by telephone utilities with those used by companies from other industries "with similar characteristics." The report, Review of Depreciation Policies and Procedures in Selected Industries (1986), describes and analyzes depreciation methods, depreciation lives, and relevant management practices of sixteen airline, cable TV, computer manufacturing, and electric utility companies. Major findings include:

* Fourteen of the sixteen firms surveyed use only the straight line method of depreciation.
* All of the unregulated companies use unit depreciation accounting and they reflect gains or losses on the disposal of assets in their income statements.
* The two computer firms (in the survey) used a double declining balance method.
* None of the companies said that tax depreciation plays a direct role in the selection of a particular depreciation method.
* The majority of the unregulated companies maintain 24 or fewer depreciable categories of investment, while the electric utilities reported using 40-50 categories.
* None of the companies reported changing depreciation methods in the recent past--once a method is chosen the company stays with the method.
* Companies used a range from $250-$1,000 in choosing whether to capitalize or expense a long-lived item, i.e., they capitalized it if it were higher than a certain amount and expensed it if it were lower than the specified amount.
* None of the businesses use different depreciation methods for different business segments or locations.
* Most unregulated companies spend less than one man-year at the middle management level to evaluate depreciation.
* Technological obsolescence is the most frequently cited factor which influences depreciation lives.

* In virtually all surveyed firms, depreciation rates and accruals have no effect on capitalization and modernization. Rather economic conditions, franchise requirements, product changes, and long-term replacement policies determine levels of capitalization and modernization.

The Arthur Andersen & Co. Original Study

A second recent study that compares the depreciation practices of regulated and unregulated firms was prepared by Arthur Anderson & Co. and is entitled Illinois Bell Telephone Company Capital Recovery Survey (March, 1987). The purpose of the survey was to examine the depreciation policies for "support" assets used by large nonregulated firms. The survey was conducted in December 1986 with 48 nonutility companies on the Forbes 500 listing participating in the survey. In this survey support assets were defined as those assets "...incidental to the primary production process, such as buildings, leasehold improvements, motor vehicles, furniture and office equipment, computer equipment, telephone equipment, etc." (Arthur Andersen & Co., 1987, p. 1).[2]

The results parallel the Ernst & Whinney (1986) findings and are listed below.

* Approximately two-thirds of the companies responding to the survey exclusively use straight line depreciation for their support assets. The remaining companies used some combination of straight line and accelerated depreciation. None of the companies used only accelerated depreciation for support assets.

* The most common support asset depreciation categories used and the range of lives reported are not unsimilar to regulated companies in that outside plant shows a longer life than inside plant. Computer

---

[2] Illinois Bell's depreciable support assets are recorded in FCC Accounts 212, "Buildings", Acct. 261, "Furniture and Office Equipment," and Acct. 264, "Vehicles and Other Work Equipment." Each of these support assets is depreciated using remaining life and/or equal life group straight line depreciation rates as prescribed by the FCC and the Illinois Commerce Commission. Examination of the 1985 financial statements of the responding companies indicated that fixed assets, net of accumulated depreciation, were an average of 14% of total assets.

lives for both regulated and unregulated companies are quite similar (see table 3-1).

* A summary of factors considered most important by the responding companies in determining the lives of depreciable support assets revealed the most important factor to be the experience of the company, followed by industry averages (see table 3-2). Marketing, pricing, and degree of competition were ranked the least important factors.

* Most companies do not perform a specific review of depreciable lives or depreciation rates on a periodic basis.

* Individual unit depreciation accounting is used exclusively at 36 of the responding companies and for 88% of the depreciable support assets.

TABLE 3-1

DEPRECIATION LIVES OF THE SURVEYED UNREGULATED FIRMS

	Depreciable Lives (years)	
Property Class/Type	Range	Average
Buildings	5-67	32.09
Motor vehicles	3-10	4.87
Furniture and office equip.	3-20	8.66
Computer equipment	2-10	4.81
Telecommunications equip.	4-10	5.83
Other equipment	3-30	10.42
Improvements	5-45	17.85
Aircraft	5-20	8.80

Source: Arthur Andersen & Co., Illinois Bell Telephone Company Capital Recovery Survey, March, 1987, Appendix 3, p. 1.

TABLE 3-2

FACTORS CONSIDERED IMPORTANT BY SURVEYED UNREGULATED FIRMS IN DETERMINING THE SERVICE LIFE OF SUPPORT ASSETS

Depreciable Life Determination Factors	Average Ranking	Number of Times Ranked[1] 1	2	3
Company experience	2.09	24	7	9
Industry averages	3.28	5	9	16
Engineering estimates	4.02	3	5	6
Product life cycle	4.05	8	6	6
Tax lives	4.12	7	6	3
Conservatism	4.34	3	8	5
Marketing estimates	6.08	1	0	2
Pricing policies	6.90	0	1	1
Degree of competition	7.95	0	1	1

Source: Arthur Andersen & Co., Illinois Bell Telephone Company Capital Recovery Survey, March, 1987, Appendix 3, p. 2.

[1] Not all responding companies assigned a ranking to each of the factors listed. In addition, some companies assigned the same ranking to more than one factor.

In sum, the Arthur Andersen study shows clearly that the depreciation policies of unregulated Forbes 500 companies for depreciable support assets are to use straight line depreciation, are not periodically reviewed, and are established based on actual experience rather than on speculative analyses.

Arthur Andersen & Co. Stoltz Study

In a separate report using much of the same data found in the Arthur Andersen & Co. report, Stoltz (1987) compared the average depreciation lives for selected items[3] for the surveyed Forbes 500 companies with the Illinois Bell projection lives for most of the same items. In part because of the small sample size and to increase the generalizability of the results, the averages for the Forbes 500 companies were adjusted and converted to a range such that it could be estimated with 95% confidence that the average depreciable lives are within the range of years shown. The analysis shows (see table 3-3) that for six categories Illinois Bell's depreciation categories exceeded the Forbes 500 and that for four they were under the upper most value of the range. Following Stoltz's method, it appears that six of the ten depreciation lives examined for Illinois Bell are slightly higher than the lives of similar assets in the nonregulated Forbes 500 companies.

Taken as a group the three depreciation studies quite clearly show that competitive firms overwhelmingly use straight line depreciation to recover the capital they have invested. The competitive firms have asset lives shorter than those in use for telephone utilities, and the competitive firms tend to stay with a single depreciation method for the life of the asset. Unregulated firms tend to have a much smaller number of depreciation categories, and a somewhat higher capitalization level.

As can be seen in table 3-4 the vast majority of large telephone utilities use past history and subject matter expertise for calculating depreciation for their capital assets. Only six reported using economic value theory for calculating depreciation.[4] Use of Fisher-Pry substitution theory, was reported by 17 companies. Like economic value theory, it was also used in conjunction with more traditional methods. Fourteen of the 17 companies that used the Fisher-Pry substitution theory were Bell Operating

---

[3] In the comparison eight of the depreciation categories were dropped and not compared to the Illinois Bell Depreciation categories. If the categories dropped had been retained in the analysis, the total average depreciation life for the Forbes 500 companies surveyed would have been 11.1 years, versus the 10.3 years for the depreciation categories selected for analysis. While "total average depreciation life" is not a standard accounting concept, it does provide an indication that the differences shown in the study results between the Forbes 500 companies average and that of Illinois Bell should be adjusted for a more valid comparison.

[4] All of these firms used economic theory in conjunction with more traditional methods.

TABLE 3-3

COMPARISON OF THE ADJUSTED SURVEY RESULTS TO
ILLINOIS BELL TELEPHONE PROJECTED LIVES
(In Years)

Property Class Or Type	Average Lives Per Survey	Extrapolated Ranges Of Lives For Forbes 500	Illinois Bell Co. Projection Lives	Illinois Bell Projection Lives Over (Under) Upper Range
Buildings	32.09	28.86 to 35.32	41.00	5.68
Automobiles	4.04	3.58 to 4.50	6.50	2.00
Light Trucks	6.17	4.96 to 7.38	7.00	(.38)
Heavy Trucks	6.29	5.01 to 7.57	9.00	1.43
Trailers & Tractors	8.50	5.46 to 11.54	10.00	(1.54)
Furniture & Office Equip.	8.66	7.93 to 9.39	13.00	3.61
Computer Equipment	4.81	4.40 to 5.22	7.00	1.78
Telecommunications Equip.	5.83	4.75 to 6.91	7.85	.94
Other Equipment	10.42	7.42 to 13.30	11.00	(2.30)
Leasehold Improvements	15.27	9.46 to 21.08	17.70	(3.38)

Source: Stoltz, Michael G.. Overview of March 1987 Support Assets Capital Recovery Survey Performed By Illinois Bell Telephone Company. Presentation at USTA Capital Cost Recovery Seminar, Arlington, Virginia, September 22, 1987, p. 10.

TABLE 3-4

CAPITAL ASSET LIFE ESTIMATION METHODS
REPORTED BY TELEPHONE UTILITIES[5]

Estimation Method	Number of Companies
Past history	109
Subject matter expertise	105
Economic value theory	6
Fisher-Pry substitution theory	17
Other	12
Missing data	1

Source: Tabulations based on data found in USTA Capital Recovery User Group, 1987 State Authorized Depreciation Methods And Amortization Treatment Report, September, 1987, p.2.

Companies. Both the Fisher-Pry and the economic value theories are forward-looking and set depreciation rates based on future projections, versus traditional depreciation methods that rely on historical or actuarial data. Accordingly, both Fisher-Pry and economic value theory may have a much wider range of asset life estimations--depending on the assumptions made by the analyst--than those estimates prepared using traditional, actuarial methods.

[5] A second recent survey (Schray, 1987) reported small telephone company depreciation practices using the same categories found in this table. Schray found that 47.8% used past history, 36.8% used subject matter expertise, 0.4% the Fisher-Pry substitution theory, and 11% used "all other" methods.

Originally, the selection of a depreciation method was made by the telephone utilities themselves. In 1884 The Bell system, for example, long before it was subject to regulation by state commissions, selected straight-line depreciation and used this method until the 1970s, when it switched to an accelerated depreciation method for tax purposes to realize certain cash flow advantages. It is interesting to note that during the most competitive part of its existence, when it was one among many firms competing to provide telephone service (and not necessarily the largest firm), the Bell system chose the straight line method. This method, along with its other capital and revenue generation devices, was sufficient to build what most feel was the best telephone system in the world. Further, it pursued its growth and ubiquitous service policies in conjunction with several extensive modernization efforts.[6] Also, this system of depreciation was an integral part of the funding mechanism of the Bell system and was responsible, in part, for the basic research and implementation efforts that made the computer, the transistor, and the computer chip available for current telecommunications needs.

Modernization From A Regulatory Depreciation Perspective

Depreciation of productive capital assets is an integral part of rate base, rate-of-return economic regulation. As capital assets are consumed (at an annual rate and amount stipulated in advance by the appropriate regulatory commission), annual depreciation expenses are recorded and included in the utility revenue requirement to be recovered through commission approved rates. The recovered capital may be disbursed as earnings to stockholders, retained as internally-provided capital, or be used directly to replace old equipment, or to be used to acquire the newest available technology.

Since Smyth v. Ames (1898) regulators, utility management, and financial analysts have been concerned with the correct way to recover

---

[6] Consider the technological change involved, for example, when the Bell system went from manually switched local calls to the self-dialing, mechanically switched Strowger system.

utility company capital investments. During periods of deflation recovering the original cost of the investment looked attractive to the utility and was opposed by the commissions, which favored present value as a basis for determining the rate base. As Ostergren noted, "... there had been a slow but steady decline in prices since the Civil War...1898 was a turning point. Ever since then, with some reversals, the price trend has been upward"(1978, p.41). In 1944, the principle of original cost less depreciation reserve was established in the Hope Natural Gas case and with some important modifications, has provided the primary basis for the subsequent development of regulatory depreciation practices by state and federal commissions.

In periods of inflation the position of the parties may change. Advocates of reform argue that original cost is not sufficient to replace presently installed equipment due to general price level inflation. There are several concerns associated with any "general price level" accounting. First, the "replacement" thesis is flawed because there is no necessary presumption that depreciation funds returned to the utility are required to be re-invested in new equipment. Second, the reform is usually urged only during periods of rising inflation. Imagine the risk premium that might be necessary if capital obtained during a period of high inflation were returned to investors at some discounted, present value rate during a period of lower or declining price levels. Third, the American Institute of Certified Public Accountants and the Federal Accounting Standards Board (FASB) have several times considered various economic depreciation and replacement proposals and have declined to adopt them.

A further difficulty in calculating the correct depreciation method is the importance of and difficulty in determining current conditions. If the impacts of inflation or technological change are not considered, the original cost less depreciation formula offers all the guidance needed by an analyst. Once other factors besides original cost are considered, the problem for any analyst is the proper weighting of these factors. All definitions of depreciation include the consideration of other factors such as "technological obsolescence", but do not offer much direct assistance in how to weigh and use this information. Most definitions say the analyst should assess changes in technology, yet do not clearly say whether this assessment should outweigh the original cost information.

Part of the problem is due to the lack of congruence between the key time periods that a firm may use when it analyzes and manages its capital investments. If the physical life of an asset and its book depreciation life, tax depreciation life, and economic life were all identical like the case of the deacon's one horse shay, there would be little regulatory problem.

The central difference between the use of depreciation in a regulated market and a competitive market is the "guarantee" that depreciated capital investments that are prudently made and which conform to regulatory guidelines will be recovered. The recovery may not be as fast as desired by the utility, but it is certain. Financial markets and prospective security holders discount their risk premium accordingly. To an unregulated firm a depreciation schedule is simply a planned recovery of capital expenditures that may or may not happen depending on future revenues. In a competitive market a firm may have to write-off an unprofitable investment and not recover the invested capital.

Part of the economic power of the guarantee lies in the sheer size of the customer base and the general unavailability of any substitute provider. Investors have seen the performance over several decades of customers funding annual depreciation expenses approved by commissions via the rate structure. With the advent of competition and bypass in the telephone field, there is a concern, and one as yet unrealized, that the guarantee may not hold in the future as customers are lost to the telephone utility. The worry that a smaller and smaller customer base may have to support through higher rates an asset base designed to support a much larger number of customers has been raised in numerous forums.

Some have claimed (Rohlfs, 1987) that a window of opportunity exists to solve the stranded rate base "death spiral" phenomenon. In brief, it is feared that the large customers that are the biggest users will leave the system because it will be to their economic advantage to do so. Accordingly it is said that a loosely specified time period exists (due in part to the unavailability of substitute providers) before they will leave the system. Since the capital equipment base was built to serve their needs and would be partially abandoned because of their unplanned departure, some urge accelerating the depreciation rate to have these soon-to-be-lost customers pay their fair share of depreciation expense before they leave the system.

However, increasing the rates it can be argued, would likely increase the economic incentives of these users to get off the system and the artificially higher rates may send a false signal about the profitability of the local loop.

All agree that depreciation in either a regulated or unregulated market is a real economic cost that must be supported by the prices charged by the firm. The distinction, however, lies in the risk associated with the recovery of these costs more than in any real difference in how regulated and unregulated firms calculate the costs. A second source of difficulty, and one addressed in the following section, arises from the debate between those that advocate the use of economic depreciation as a more efficient depreciation method and those supporting conventional accounting depreciation methods.

In the spirit of examining the full spectrum of depreciation methods, some insight can be gained by looking at an early article written by H.C. Hasbrouck, the former chief of the the Division of Statistics and Accounts, of the Second District of the New York Public Service Commission. Hasbrouck wrote his article in 1925 and at a time when straight line depreciation in the utility industry was viewed as an untested theory. His essential argument is that depreciation means a loss in value of an asset and that the only time you can truly say an asset has lost value is when it is no longer in service. Until that time, he argues, all calculations regarding wear and depreciation allowance are purely speculative. Depreciation is to be recovered from the beneficiaries of the new plant and equipment who are receiving a service that would otherwise be unavailable from the deteriorated old plant.

Hasbrouck's focus on the intergenerational equity and the definition of when depreciation actually occurs are equally important today. As mentioned, straight line depreciation has been the standard form of book and tax depreciation for both regulated and unregulated industries for the major part of the twentieth century. Accelerated depreciation has been adopted from time to time, but has generally been viewed as a short-term departure from the norm, most often for tax purposes. Adoption of straight line depreciation based upon the estimated physical life of the asset assumes that the current users of the asset are the beneficiaries of the asset and should pay equal annual depreciation amounts to compensate the investor for the loss in value of the asset due to its use in providing, say, telephone services.

Accelerated depreciation methods modify these assumptions by having the beneficiaries of the service at the beginning of the service life of an asset pay a larger annual amount than those receiving service at a later point in time. The total amount of depreciation payments received, all other things being equal, is identical to the amount from the straight line approach.

It is clear, however, that for a specific asset objective and verifiable values based on external transactions are available at only two points in time: at the moment of purchase and at the moment of disposal. If these events occur within the same accounting period, then no depreciation problem occurs (Wright, 1964, p. 81). The lure of the post-retirement depreciation recovery theory is that loss in value can be calculated precisely because all the data are known. Less easily handled, however, are the questions of determining which generation of user is going to pay for the depreciation and how to treat an asset taken out of service for economic reasons rather than physical obsolescence.

Replacement, Accelerated Depreciation, and Amortization

Replacement

The use of replacement costs in depreciation is founded on the assumption that the primary purpose of depreciation is to provide the capital necessary to replace the worn-out equipment. From an accounting perspective it is highly debatable whether depreciation should be designed to do anything other than recapture the original dollar investment (Edelstein and Bernstein, 1961, p. 491). As most industries have experienced some form of annual inflation, the use of replacement cost rather than original cost tends to increase the size of annual depreciation allowances. Critics of the use of replacement costs argue that replacement cost concept has low validity because new equipment is usually more productive than the old and that any cost increase should ideally be more than offset by the increase in productivity (Edelstein and Bernstein, 1961). Further, if an intergenerational transfer of depreciation payments is necessary--that is an increased amount of depreciation payment from the old equipment is needed to make the purchase of the new equipment an economical proposition--then the economic replacement analysis may be flawed. In the telecommunications, computer, and electronics industries the declining costs (over time) and the technological enhancements of the newer generations of equipment combine to cast doubt on the validity of the replacement concept. Indeed, one would expect that when the price of capital goods declines, that advocates of replacement cost accounting will argue that replacement costs are irrelevant.

Other criticisms of the use of replacement cost (and accelerated depreciation) include (Edelstein and Bernstein, 1961, pp. 491-496):

1. The use of replacement costs may provide an incentive to over-capitalize, or over-invest by providing a non-market driven signal to buy new equipment.

2. The tax structure may be used to provide a safety net for entrepreneurial errors if obsolescence is used as the primary reason for replacement decisions and for using a faster write-off period.

3. A program of accelerated depreciation may increase inflation thus causing replacement costs to increase at a rate higher than would otherwise have been the case.

4. The inter-generational transfer of payments under replacement cost and accelerated depreciation charge off tomorrow's costs against today's profits (or today's tax structure).

5. Sheltering the technology investment decisions from the free play of economic forces in the market place may cause overcapacity.

Accelerated Depreciation

The tax incentive offered by accelerated depreciation tends to discriminate in favor of the inefficient producer at the expense of the more efficient one. As explained by Edelstein and Bernstein, 1961, pp. 494-5:

> Consider, for example, two companies producing identical quantities of identical products at identical prices and with identical labor and raw material costs. One company, however, has less efficient capital equipment than the other, and therefore has had to purchase more machinery. Hence it will be able to charge a larger

> depreciation allowance, and will consequently pay less in taxes to the government than the more efficient producer with the smaller capital write-off. The total cash flow available to the inefficient producer will obviously be greater than the money available after out of pocket expenses for the efficient producer.

Accelerated depreciation may have different effects on different firms in an industry, then, based upon the status of their current modernization efforts and the timing of the acceleration period. A firm already modernized and past the specified time period allowed for the accelerated rates, could subsequently be at a competitive disadvantage to other firms able to take advantage (especially during the initial capital recovery period) of the increased cash flow. If some form of accelerated depreciation is available to the regulated utilities prior to the deregulation of certain services and this accelerated depreciation is not equally available to the unregulated competitors, an initial competitive advantage will accrue to the utilities. If this advantage is significant, it could delay or stop the emergence of viable competition.

Amortization

Amortization has been the method chosen by many commissions to deal with the issue of a reserve deficiency for telephone utilities. It is in some sense a middle of the road compromise solution that guards the public interest and protects the utility, with neither party's interest dominating the solution. While there are many variations on the amortization theme, the basic thrust of amortization--whether used for a telecommunications reserve deficiency or for an abandoned generating plant--is to let the utility recover over a specified period of years the capital invested in the prudently abandoned equipment or facility. Such amortization usually does not include any opportunity for the utility to earn a return on the capital.

Amortization, therefore, is a risk sharing mechanism that is mid-way between the "used and useful" and the "prudent investment" tests in terms of capital recovery. It lets a commission recognize a problem like the reserve deficiency, which the utilities feel is caused at least in part by modernization, and provides the commission with a valid means for resolving

"Who should pay?" for the unused, abandoned facilities. The used and useful test would exclude unused plant representing the old technology from the rate base, thus denying the utility any direct mechanism for recovering their original capital or having the chance to earn a return on their investment. The prudent investment test is harder to apply, but allows the commission to sanction the recovery of all invested capital through its inclusion in the rate base, thus giving it a chance to earn a return on the capital. A problem arises when a utility says that it acted prudently in constructing a facility that is not currently used and useful in the provision of service to ratepayers. This problem is especially difficult when a utility modernization program causes it to voluntarily abandon a productive asset in favor of a more productive asset.

Economic and Accounting Depreciation

The definition of the productive life of an asset in a regulated market is contentious and important, particularly for telephone utilities undergoing extensive modernization. As regulators virtually guarantee the return to the investors of prudently invested capital, one consequence of a utility shortening the productive life of an asset is that the rates charged to ratepayers will go up.[7] While there is no necessary presumption that the capital returned to the utility via annual depreciation expenditures will be used exclusively for modernization expenditures, the non-recovery of the capital invested in the older technology may slow down the utility's ability (and perhaps even its desire) to invest in the newer technologies.

Economists and accountants view productive life differently, and this difference has important practical consequences for a utility's modernization program. The accounting definition of depreciation rests largely on the concept of original cost and how to properly allocate this fixed cost over the stipulated productive service life of the asset, adjusted for net salvage value. Economists view the asset in terms of its net economic value, which is measured in terms of the discounted value of

---

[7] Assuming all other things to be equal and regulatory concurrence.

Using economic depreciation, a whole generation of a given technology for the entire utility could be replaced at the same time. This would occur regardless of vintage. That is, an asset using the older technology installed one year ago as well as one installed twenty years ago would both be replaced.[11] A wholesale replacement strategy would be a radical departure from the vintage-based, incremental strategy historically used by telephone utilities.

Advocates of economic depreciation, from Hotelling (1943) onward do so from the perspective that economic depreciation provides the most accurate information about the worth of the asset. Knowing the worth of the asset, instead of just knowing the historical cost of the item, allows the firm and the financial markets to make accurate and rational decisions about future investments. Better information promotes economic efficiency and equity by avoiding uneconomic distortions caused by misleading information about the value of the asset and may avoid intergenerational inequity. Since straight line depreciation is constant over time, and the economic value of an asset changes over time, economists argue that competition may be hurt by sending out a signal that a firm's costs are higher or (at other times) lower than they actually are.

A number of operational concerns arise over the use of this concept when applied to utilities. In part these problems occur because the regulatory system guarantees the return of capital and holds the investor, within a very wide range of circumstances, harmless from any loss. The first operational concern for regulators occurs when the demand increases such that the price rises for the service produced by the asset. Economic depreciation determined in this circumstance could be negative and result in no depreciation charges for that accounting period. Also, if prices remain

---

[11] As few firms can afford or manage the simultaneous replacement of all of their older technology, it is likely the case that some phasing in of the new technology would occur. Unless influenced by maintenance or operating expenditures, the scheduling of the replacements could occur independently of the vintage or year of installation.

as originally forecast and operating costs are significantly lower than expected, depreciation could accordingly be reduced.[12]

A second concern has to do with the difficulty of accurately forecasting future outputs, prices, and costs. Consider the great promise inherent in the technological breakthroughs the telecommunications industry has experienced: What service offerings will prevail?[13] And at what price? How accurate can these forecasts be when the impact of ONA is unknown? It would seem to be very difficult to forecast exactly what services entrepreneurial vendors and resellers will fashion from their ability to purchase basic service elements (BSE) from telephone utilities at will. And how will the costs, prices, and demand for ISDN, BISDN, light-based switching, and cellular technologies affect established technologies?

The point here is not that the future is unknown and risky; for all investors and financial markets must deal with and assess risk in any transaction. Rather, it is the use of economic depreciation that adds one more unknown variable. And that across a very wide range of investments in unregulated firms, investors and financial markets have chosen accounting depreciation over economic depreciation as their primary capital recovery mechanism.

The third concern (Ernst & Ernst, 1977, p.64) is that the economic principles involved would require setting a depreciation policy and set of depreciation charges such that

1. During years when the asset has unused capacity, the marginal costs equal the operating costs and no contribution to depreciation is made; i.e., there is no depreciation expense in that period.

---

[12] As this discussion focuses on depreciation, it does not assess the firm's interest in replacing the "lost depreciation" with an increase in the annual return to the stockholder.

[13] As Fraser (1987, p. 2) notes, "The methods of engineering economics are much more easily applied to replacement investments than to modernization because it is easier (although still difficult) to forecast costs than to forecast the cash flow effects of improved functionality. What are the cash flow effects of a more modern computer system? Of a better response rate in answering calls? One assumes (or at least hopes) these will result in more revenues, but this is difficult to estimate credibly."

2. During years when the asset is used to capacity, price should be set so that the capacity output will be purchased. The difference between this price and the operating costs constitute the depreciation payment.

Thus, while economic depreciation will, if price is set to a long run marginal cost that includes operating and depreciation expenses, recover all capital, it will likely do so unevenly.

Lastly, regulators may be wary of economic depreciation because it is speculative and based almost entirely on estimates provided by advocates in a rate case. Having the telephone utility estimate a "low" economic value for an asset whose replacement will better position the company to meet its corporate goals re competition, and having this funded by the monopoly ratepayer, causes concerns for commissioners. This problem could be further exacerbated if a contending party in a rate case produced an alternative, "higher," economic value for the same asset. In these instances, independent of any other technical merit or virtue that may be ascribed to economic depreciation, it is no surprise that a regulator would prefer the certainty provided by the accountant's definition of depreciation. All the parties to a case can then debate how to treat the original cost, but will likely not engage in serious debate over the amount of the original cost.

A Brief Comparison of Economic and Accounting Depreciation

If the life of an asset subject to economic depreciation is short, or identical in length with an asset being depreciated using straight line, then the difference in outcome between the two methods is small, and only of academic interest. With fairly long telephone utility asset lives, it is likely the case that economic and straight line lives will not be equal. There has, for instance, been some shortening of the prescribed service lives in a number of jurisdictions through the use of remaining life and equal life methods.

One way to gain some insight into the difference between economic depreciation and accounting depreciation is to compare the different variables used by each discipline. Accountants need only to obtain information on five variables: (1) the original, reproduction, or replacement cost of the asset, (2) whether each asset is going to be considered singularly or be categorized and considered by group, (3) the projected service or depreciable life, (4) the annual depreciation rate, and (5) salvage value. Armed with this information an analyst can calculate straight-line, accelerated, or any other form of accounting depreciation. Economists,[14] on the other hand, need information for all possible technologies on (1) operations and maintenance expenses, (2) cost of capital, (3) replacement cost, (4) tax effects, (5) future revenues, (6) future operating and maintenance costs, (7) present value, (8) salvage value, and (9) the projected economic life of the new asset. An inspection of these brief listings clearly shows that the two approaches differ so much in outlook that they are only marginally comparable. Simply put, the approaches do different things. Neither has any logical feature that requires the analyst to juxtapose or consider the results of the other method.

Mainstream regulatory tradition tends to strongly favor the accounting definition of depreciation. Depreciation is an annual repayment of the capital provided by the utility's shareholders. Economic depreciation is more companionable with a different regulatory perspective: cost minimization.

In a regulated industry with prudently invested capital, the risk of an earlier than scheduled retirement of assets is largely carried by the monopoly ratepayer. In an unregulated industry, the same risk falls on the shareholders as an unaccounted-for cost of doing business (Ernst & Ernst, 1977, p.13).

It may be the case that economists and accountants are too tied to their profession's definition of depreciation to be able to undertake any meaningful dialogue or synthesis on the issue. Economists want to talk about economic value and accountants the allocation of capital costs. Over the last several decades telephone utilities seem to prefer the economist's definition because it returns capital faster as long as demand is increasing and technological improvements occur at an appropriate rate. The regulator

---

[14] There are a number of different ways to calculate economic depreciation, but for most practical purposes the ways do not differ significantly.

who tries to judge the policy debate on its merits finds little assistance and mostly rhetoric from each discipline. In part because the financial markets and most other types of investors understand and trust straight line depreciation, the accounting profession's view of depreciation has tended to dominate commission practices.

The policy debate, however, continues. For telephone utilities the economic definition, whatever technical merits it may have, offers the promise of extricating them from what they fear could, in a worst case, be a financial disaster. This scenario is based upon the telephone utilities' fear that if they do not modernize they will be left with an asset base having, say, a 25-year average remaining depreciation life and a declining customer base from which to fund the remaining depreciation. Competitors, utilities feel, would be able to modernize selectively and target only the most profitable routes, customer classes, and services. Regulators have tended to share some of this concern, but feel that the tremendous marketing power, financial resources, technical engineering skill, name recognition, customer inertia and loyalty, and commission formulated pro-competition rules offset the worst case-type, death spiral scenarios.

To the extent that a commission is more comfortable dealing with provable costs, then the accountant's definition should prevail. A commission willing to accept a utility's, or its own estimate of net future revenues, and which is willing to accept this as a depreciation and equipment replacement decision rule, may prefer to use the economists' definition. A commission that prefers the deepest insight into the problem might require both approaches to be filed with the commission, regardless as to which method it selects to use for ratemaking purposes.

Alternative Depreciation and Modernization Scenarios

Assuming the present ratebase, rate-of-return regulatory system, there are four logical alternative outcomes or scenarios that may occur when jurisdictional telephone utilities engage in significant modernization of their equipment and/or facilities.[15] The focus here is on the idea of significant modernization, because minor modernization can easily be accommodated through small changes in existing depreciation rates. The four modernization outcomes from a regulatory depreciation policy perspective are depicted in table 3-5.

The scenarios are arranged according to two major policy dimensions: the presence or absence of a reserve deficiency and whether or not the requisite growth needed to fund the new modernization occurs. A reserve deficiency occurs when an otherwise productive capital asset is taken out of service before it is fully depreciated and is replaced by a newer technology capable of providing either the same service at a lower cost or new services unavailable from the older technology.[16] A reserve deficiency does not occur when the utility provides a service to a new area, or otherwise modernizes in a manner that does not cause any existing equipment or facilities to be replaced, or abandoned.

---

[15] Current proposed bills before state legislatures around the country incorporate a "social contract" perspective that sidesteps modernization depreciation efforts by allowing the utility to (1) change its prices at will for competitive services, and (2) to change its prices to monopoly customers at will within some price zone or by some percentage of the change in the Consumer Price Index (CPI). If this feature of the proposed bills is incorporated into any ultimate legislation, regulatory depreciation accounting as it is currently practiced could cease to exist, unless some monitoring scheme is incorporated in the legislation or ordered by the commission through its oversight role. Telephone utilities will, of course, like all major corporations, practice some form of depreciation. The difference is that to the extent prices to the monopoly customer exceed short run marginal costs, these monopoly rents are available to the firm to accelerate its depreciation payments, or to use this money for other purposes. Use of the CPI will likely provide this opportunity to extract monopoly rents because it may indicate price levels radically incongruent with the structure of costs within the telephone industry. The salient feature of the cost structure of the electronics, computer, and telecommunications industries, for example, is a consistent decline in cost over time; whereas the most salient feature of the CPI is a moderate increase over time.

[16] A reserve deficiency can occur for other reasons, such as a misestimation of the service life.

TABLE 3-5

MATRIX TYPOLOGY OF FOUR MODERNIZATION DEPRECIATION SCENARIOS FOR A TELEPHONE UTILITY ENGAGED IN SIGNIFICANT MODERNIZATION EXPENDITURES

No Replacement Of Existing Capital Assets Required		Existing Capital Assets Are Replaced	
Required Growth In Service Demand <u>Occurs</u>	Required Growth In Service Demand <u>Does Not Occur</u>	Required Growth In Service Demand <u>Occurs</u>	Required Growth In Service Demand <u>Does Not Occur</u>
Scenario One: No Depreciation Deficiency and Requisite Growth Occurs	Scenario Two: No Depreciation Deficiency, but Requisite Growth Does Not Occur	Scenario Three: Depreciation Deficiency, and Requisite Growth Occurs	Scenario Four: Depreciation Deficiency, but Requisite Growth Does Not Occur

The requisite growth dimension is somewhat harder to define at an operational level. Conceptually the idea is quite simple. When a new, modernized piece of equipment is placed into service, it needs over time to provide enough service to pay for itself--that is it needs to cover capital investment, various overheads, operations and maintenance, as well as contribute to the utility's profits. If the requisite growth occurs within the planned time period, few regulatory problems arise. However, to the extent that growth does not occur, or the growth takes significantly longer to occur than originally forecasted, the disparity becomes a regulatory cost allocation issue. Where the difficulty may come when applying this concept is the definition of time period and whether embedded, average cost, or marginal cost pricing principles are used. The difficulty comes less from the compatibility of different time frames and costing principles than from the need to have both the commission and the utility using the same time frames, demand forecasting techniques, and costing principles.

Before comparing the four modernization scenario outcomes, two brief digressions are necessary. The first is the reaffirmation of the "Deacon's one horse shay" principle; few if any regulatory problems arise if everything falls apart (depreciates) at the same time. Stated another way, if for each year of the life of the asset economic depreciation = straight line depreciation = productive life = book depreciation = tax depreciation = remaining life, there would be no serious regulatory problem. Since these alternative depreciation methods tend in practice not to be equal and in fact represent the different policy views of contending parties, a regulatory problem exists.[17]

The second is the ability of economic depreciation, properly defined, to create a win/win consensus among all parties. Recall that the central feature of economic depreciation is its ability to allow a firm to make an economically rational decision about whether or not to keep or replace a capital asset based upon the favorability of net future discounted revenue streams. If the analysis shows the replacement or modernization net revenue stream to be greater, then the asset should be replaced--even if it was just placed into service. On its surface it would seem that regulators and utility managers would have little to argue about, barring faulty or fraudulent analysis or unreliable data sets. Assuming a valid analysis, it would be to the ratepayers net financial advantage to have the modernized equipment.

The problem is twofold. First, one reason for modernizing is to provide new types of services. To justify this economically, the company must make projections about the future demand for the new services. This forecasting effort is fraught with problems, and objective analysts can differ over the treatment of these problems. One particular difficulty for commissions happens when the "provable" demand for a new digital switch seems for the short to medium term to be limited to business customers, with only a more "speculative" demand seeming to exist regarding the residential demand for digital switching services.[18] When all classes of customers are

---

[17] The choice of a particular depreciation method, depreciation rate and/or service life is problematical and needs to be addressed in each of the four scenarios.

[18] Provable means that a good deal of consensus exists about the demand. Speculative indicates that less consensus exists.

asked to pay for the digital switch used in this example, it becomes a serious regulatory cost allocation issue.[19]

Second, economists discard the investment in the older technology and treat it as a sunk cost, one not to be considered in the analysis. However desirable this might be for simplicity of the analysis, this line of reasoning may trip-up over a micro/macro fallacy. The fallacy occurs when it is wrongly assumed that a treatment at one level is the same at another level. Thus, while an economist or replacement engineering analyst at the micro level does not need to be concerned with the sunk cost of an abandoned asset, at the macro level the top managers of the firm certainly do have to worry about all capital and operating expenditures.

Returning to the scenarios shown in table 3-5, it can be seen that scenario one, "no reserve deficiency and growth," offers the fewest problems for the regulator, as long as the growth occurs in a timely manner and for the customer classes as predicted.[20] The issue of which method of depreciation to use would be no more concern than it would be absent the increased capital expenditures due to modernization. The situation is less favorable in scenario two because while there is no initial depreciation

---

[19] The basis for asking that all customers pay for the more modern switch lies in the fact that even POTS customers will use the switch and should pay for using the asset. The concern is that the extra technological features of the switch support multi-line, and specialized business customers with services that POTS single line business and residential customers do not presently demand. The debate here centers on whether the POTS customers will over time expand their use of telephone services and use the whole menu of available telecommunications services or whether the present beneficiaries of the service (the multi-line and specialized business customers) are the only ones likely to use these services in the future also.

The interest of the local exchange companies, for example, in developing and offering broadband ISDN is directly related to their need to fill up their switching and glass fiber distribution network (when and if it occurs) so as to be able to offer services that residential and business can consume. This would help give telephone utilities a dominant market position as the lead wire-based digital signal provider at the local and intra-LATA levels.

[20] In these scenarios it is assumed that all other conditions are held equal and that the investments in the new technology and the reserve deficiency are equivalent for each scenario.

deficiency, the projected growth in demand does not occur and the commission will have to eventually determine the appropriate cost recovery technique.

Scenarios three and four start off with a depreciation reserve problem, with scenario four being the worst of the four outcomes. These two scenarios have the greatest amount of capital costs to be allocated as well as the most complexity in determining who should pay.

Some Empirical Studies on Depreciation and Modernization

Three representative empirical studies on several of the policy issues raised in preceeding sections are presented below. The first deals with the $26 Billion reserve deficiency deficit. The second section reports the results of a study of the short-term changes in actual scheduled retirements of a utility. The third addresses the response of financial markets to changes in accounting depreciation changes.

The $26 Billion Reserve Deficiency Deficit

Concerns about depreciation reserve deficiencies are not new or confined to telecommunications utilities. A reserve deficiency can occur when average service lives of capital plant decline or when the economic life of an asset is shortened and the regulatory depreciation rate is not changed. There are two main reasons for not changing a depreciation schedule. The first and most important reason is that the company and the commission disagree, for whatever reason, over the necessity of changing the existing schedule. The second reason stems from the utility's failure to review the adequacy of its depreciation practices. For example, the New York commission in a review of the depreciation practices of the Chenango and Unadilla Telephone Corporation used its decision in the Niagara Mohawk Power Corporation (1 PUR 4th 1) to reject an alleged reserve deficiency because the company did not make "... required periodic and continuing reviews of its depreciation practices" (PUF, Feb. 27, 1975, p. 49). The commission made it clear that it did not intend to penalize utilities for reserve deficiencies that resulted from diligent periodic reviews of their depreciation policies, especially with regard to changes in service lives.

State commissions have acted in a number of ways to address the reserve deficiency concern of telephone utilities. In recent years nearly all state commissions have instituted the remaining life method (see table 3-6) over more traditional methods. Remaining life has been advocated by the companies as a method that would better enable them to reflect the productive life remaining in an asset. Basically, remaining life substitutes the shorter remaining life estimate for the originally prescribed and longer whole life estimate.

Analysis of the data found in table 3-7 shows that most companies have a state commission approved recovery method for dealing with any reserve deficiency. The most frequently reported method is remaining life (62 companies), followed by amortization (34). Eight independent companies reported that they had no reserve deficiency.[21] A much smaller number of

TABLE 3-6

STATE COMMISSION AUTHORIZED DEPRECIATION METHODS REPORTED BY MAJOR JURISDICTIONAL TELEPHONE UTILITIES

	Whole Life	Remaining Life
Bell Operating Companies	0	49
Independents	12	53
Total	12	102

Source: Tabulations based on data found in USTA Capital Recovery User Group, <u>1987 State Authorized Depreciation Methods And Amortization Treatment Report</u>, September, 1987, p.2.

[21] While only a very small number of large telephone utilities reported having no reserve deficiency, a study by Schray (1987, p.31) found that out of 320 responding small telcos that 53% said that their utility did not have a reserve deficiency. Of those reporting a reserve deficiency, 40% are recovering it through remaining life, 38.7% through amortization, and 21.3% say they are not presently recovering the deficiency.

TABLE 3-7

DEPRECIATION METHODS ALLOWED BY STATE COMMISSIONS AS A RECOVERY METHOD FOR TELEPHONE COMPANY RESERVE DEFICIENCIES

	Number of companies reporting a depreciation method is	
	Disallowed as a recovery method by commission	Accepted as a recovery method by commission
Amortization	11	34
Equal Life Group	32	0
Remaining Life	11	62
None Approved	0	9
No Reserve Deficiency	N.A.	8*
Missing Data or Not Applicable	1	5

Note: * All eight companies reporting they have no reserve deficiency are Continental Telephone Operating Companies

Source: Tabulations based on data found in USTA Capital Recovery User Group, 1987 State Authorized Depreciation Methods And Amortization Treatment Report, September, 1987, p.2.

companies reported having a specific method disallowed by their commission. Eleven companies reported that amortization had been disallowed, 32 reported ELG, and 11 said that remaining life had been specifically disallowed.

Changes In Capacity Decommissioning Plans

Depreciation schedules and capacity decommissioning plans, which include both modernization and retirements, tend to look more rigid than the actual replacement and modernization practices of regulated companies. Depreciation schedules, of course, change at the discretion of the regulatory commission and tend to be relatively fixed over any short time period. Depreciation schedules do, however, change, usually as the result of a formal process that shows that the technological, or economic, or structural features of the asset being depreciated now differ significantly from those existing at the time the plan or depreciation schedule was approved. Commissions change the depreciation schedules to improve the net impact of the change in circumstances of the ratepayer and the utility.

Capacity decommissioning plans have even more fluctuation and change. Because of their huge investment in capital facilities, and their obligation to provide safe, reliable, and economical service to all those desiring to purchase it, utilities have developed sophisticated capital construction plans. These plans allow the utility to provide information needed to attract money from the various financial markets. Recently commissions have gotten even more involved in these planning efforts, particularly for electric utilities, through the development of least cost planning programs. The actual timing of the decommissioning of specific assets, whether for modernization purposes or for normal retirement and salvage, has a fairly wide fluctuation due to short-term pressures.

In a study of the factors affecting the timing of the retirement of capacity in a regulated utility, Liqukas (1980) found a substantial variation in the year to year ratio of planned retirement to actual retirement. His study used data covering the years 1959-1977 for the Central Electricity Generating Board, a publicly-owned electric utility serving England and Wales. Using planned retirement as the dependent variable, he found that planned retirement was positively related to pressure on capital spending and short-term capacity margin anticipations and negatively related to the level of currently committed investments. Similar relationships were found for actual retirements, except for capital pressure which had a negative coefficient (1980,p.253).

Liqukas suggests the following conclusions from his study:

1. Pressure for reduction in capital expenditure may result in the postponement of retirements to more convenient periods,

2. Anticipation of narrow capacity margins for the short-term future may lead to retention in service of obsolete plant, and anticipation of large margins to advancements of closures,

3. Retirement programs appear to provide a source of stability for investment, as prolonged retention in service of obsolete plant may enable the firm to smooth its peaks of investment, and

4. At least for the short-run, the hypothesis that retirement is a constant proportion of the capital stock is not supported.

Varying the actual timing of the retirement or abandonment of a specific unit can help the short-term financial health of a utility. For a telephone utility seeking to modernize its facilities on a territory-wide basis, it is clear that a lock step adherence to a pre-determined implementation time schedule may not be the best course of action. Abandoning and then modernizing the equipment in a particular location when the financial conditions are inappropriate, or if a significant short-term supply and demand imbalance exists, may cause the modernization effort to be more expensive than what would have been the case if the implementation had been delayed. It is a common practice for private sector firms to advance and delay construction targets due to short-term fluctuations in earnings or the financial markets, and because of changes in basic supply or demand parameters. Commissions need to decide if their interest in having a telephone utility provide a modernized service across their entire service territory is offset by the potential increase in costs that could occur if the modernization proceeded at a fixed rate.

Impact of Changes in Depreciation Methods on Firms

Changes in depreciation accounting methods can take place for a number of reasons and can affect how the stockmarket evaluates the stock of a company. Accelerated (ACL) depreciation requires larger initial annual payments than straight line depreciation (SL). A shift from ACL to SL will, all other things being equal, increase the amount of money available to be disbursed as earnings in the short-term. Comiskey (1971) studied the market response to a shift from ACL to SL depreciation by eleven steel companies and compared this response to a control group of steel companies that did not switch depreciation methods. He found the price/earnings ratio of the companies that changed generally declined, while those of the control group increased. He concludes that the market security pricing mechanism is not fooled by any depreciation tinkering that is not tied to any real improvement in the basic performance of the firm. If modernization is essentially a sound business decision, one could surmise that the financial and stockmarkets care a lot less about any short-term gain from cleverness in using a particular depreciation method, and more about the basic economic sense of the modernization strategy.

Conclusions

Several important conclusions can be drawn from the material presented in this chapter on the affect of depreciation practices on the modernization efforts of jurisdictional telephone utilities. The first is that regardless of the imputed ability of other depreciation methods to return capital in a more efficient way, the depreciation method used by unregulated firms is straight line depreciation. Even highly competitive and high technology firms predominantly use straight line depreciation as their primary mode of capital recovery. In fact, the Bell system during the most competitive early years of its existence chose and used straight line depreciation. Assuming straight line depreciation to be a constant across all types of industries and for most recent time periods, it is possible to conclude that modernization in an industry appears to occur for reasons other than depreciation policy.[22]

The second conclusion is that state and federal commissions have acted to modify existing depreciation practices through amortization, equal life, and remaining life such that the $26 billion reserve deficiency is no longer an issue. The third conclusion is that to the extent that a commission feels the modernization practices of jurisdictional utilities are directly influenced by capital recovered through existing depreciation practices, it may choose to modify these practices in order to achieve its preferred modernization policy. Finally, the long debate by economists and accountants over the correct method of depreciation may not be fruitless if there is a recognition that each serves a different purpose. Accounting depreciation is best at capital recovery, and economic depreciation has the edge in equipment replacement and modernization decisions. The choice of and the usefulness of either method may be helped by the development of a typology of modernization scenarios, such as that presented in this chapter.

---

[22] Tax depreciation policy is an exception to this statement.

CHAPTER 4

ASSESSING THE USEFULNESS OF THE ABANDONMENT CONCEPT WHEN ANALYZING TELECOMMUNICATIONS MODERNIZATION FROM A REGULATORY PERSPECTIVE

Introduction

One of the salient features of the modernization process is the substitution of a newer generation of technology for an older technology. The leaving behind, or abandonment of the older and discarded piece of equipment has a distinct parallel with the process utilities and state commissions have used to abandon facilities such as generation plant, transmission lines, and property or leases held for future use. The usefulness and validity of this parallel for the initial modernization decision and for the allocation of the associated costs is examined in this chapter.

Modernization as Abandonment

In order to envision the modernization process as similar to abandonment, it is necessary to assume that for every modernization investment there is a corresponding asset which is no longer used and useful in providing service. This abandoned asset may be treated in a number of different ways by a commission. The reasons for the abandonment may include a decline in demand, changes in technology, and economic obsolescence.

There are two main reasons to modernize facilities:

1. To save money (have an optimal stream of discounted cash flows)
2. To provide better service, either in terms of increased reliability or new and improved services.

Through bad luck, poor forecasting, regulatory problems, and managerial inefficiency some nuclear plants were built to serve a demand that did not materialize as forecasted, and at a cost that was much higher than planned. Most plants did not save money in the way originally intended, and sometimes had the negative effect of threatening the financial integrity of the company as well as its access to capital markets. Abandoned facilities had all of these problems, plus the confounding problem of not being used and useful. Furthermore, in addition to having to determine if the original decision to build was prudent, the prudence test had also to be applied to the decision to abandon the facility.

Viewing modernization from a plant abandonment perspective seems appropriate because in both modernization and abandonment a telephone utility decides to stop using a presumably prudently constructed, used and useful asset. If the utility then takes the asset out of the rate base, or if the asset is fully depreciated, the regulatory accounting and capital recovery problems are minor. The problem occurs if a utility requests continuing recovery for the asset even when it is no longer used and useful.

Regulatory experience with abandonment began in the transportation field when railroads ceased serving a town or using a line and sought to recover these sunk capital costs. More recently oil-fired generating plants, nuclear plants, and bypassed natural gas facilities have been abandoned. The variety of ways in which the state and federal commissions have accounted for these abandonments has ranged from disallowance to full recovery of investment. The recovery of sunk costs and stranded investment obviously is a major concern for all parties to the regulatory process.

Abandonment Criteria

Given the extensive experience that state and federal commissions have had in dealing with abandonment, particularly in the electric field, a fair amount of information and criteria exist that can be examined for applicability to telecommunications modernization investments. In the following sections commission standards as well as Financial Accounting Standards Board (FASB) standards for the recovery of the cost of abandoned plant are noted.

FERC Standards

The Federal Energy Regulatory Commission (FERC) has developed requirements that must be met if the cost of an abandoned plant is to be recovered. In order to qualify for recovery the utility must establish that:

1. The decision to go forward and to cancel were prudent.
2. The expenses were reasonably incurred.
3. The appropriate period is used for amortization of expenses.

Although these requirements are FERC standards, they do within limits, constitute a reasonable statement of general regulatory policy regarding abandonments. Individual states may, of course, have different policies, but these three requirements do substantially describe the position of many state commissions regarding the recovery of abandonment costs by jurisdictional electric utilities. State commissions tend to place some additional weight on the used and useful test, and some have specific state statutes governing other capital recovery aspects.

The FERC policy regarding the standard to be applied in determining whether costs incurred on construction of a subsequently cancelled or abandoned plant are to be recovered is in essence the "prudent investment test." It asks what would an ordinary, reasonable utility management have done, given the circumstances and information available to it at the time of the decision. It is a retroactive audit of the prudence of management decisions. For a telephone utility that seemingly prematurely abandons a productive asset in order to install modernized equipment, such as digital switching, the FERC policy may have some relevance in assessing the prudence of the modernization decision.

Financial Accounting Standards Board Abandonment Standards

Another area where developments in the treatment of abandoned utility plant may have some direct applicability to telephone modernization decisions is in the efforts of the Financial Accounting Standards Board

(FASB) to amend FASB Standard No. 71--Accounting for the Effects of Certain Types of Regulation.[1]

In 1986, FASB amended Statement 71 to require the future revenue that is expected to result from the regulator's inclusion of the cost of an abandoned plant in allowable costs for rate-making purposes to be reported at its present value when the abandonment becomes probable. If the carrying amount of the abandoned plant exceeds that present value, a loss would be recognized. Statement 71 previously required that asset to be reported at the lesser of the cost of the abandoned plant or the probable gross revenue.

Statement 90 also amends Statement 71 to require any disallowed costs of a recently completed plant to be recognized as a loss. Statement 71 previously required asset impairments to be recognized but did not specify what constitutes an impairment or provide specific guidance about how impairments should be measured. It further amends Statement 71 to specify that an allowance for funds used during construction should be capitalized only if its subsequent inclusion in allowable costs for rate-making purposes is probable.

Statement 90 applies to the recorded costs of previously abandoned assets, the recorded costs of assets for which future abandonment is probable or becomes probable in the future, previously disallowed plant costs, and disallowances of plant costs that are probable or become probable in the future (FASB, Statement of Financial Accounting Standards No. 90, FASB of the Financial Accounting Foundation, December, 1986, p. i).

This policy may have some application to telephone plant that is prematurely abandoned and replaced by a newer generation of telecommunications technology. The relevance is directly related to the outcome of the discounted present value analysis conducted. If the costs of an abandoned unit of telephone plant exceeded the present discounted value, then this excess arguably may have to be written off.

---

[1] The FASB is the official agency responsible for setting standards for the accounting profession to use in its work. Typically, its amended standards deal with areas of genuine contention within the accounting profession and address how conflicting or ambiguous practices, concepts, or policies may be resolved.

Anti-CWIP Recovery Statutes for Abandoned Facilities

In re Public Service Company of New Hampshire (60 PUR 4th, 1984, pp. 16-22), the state Supreme Court held that the state "anti-CWIP" statute as a matter of law forbids the recovery of costs associated with abandoned construction projects, unless and until the project is actually providing service to the ratepayers. It further found that the commission could not simply increase the rate of return for the purpose of producing the same revenue over the same time period. The court specifically left open the question of whether and to what extent the rate of return could be increased to reflect the risk the statute places on investors when a plant is abandoned.

Hope Natural Gas "End Result" Test

A recent court action that could have a significant impact on the recovery of a utility's capital in an abandoned plant occurred in Jersey Central Power & Light Co. v. FERC (No. 82-2004, February 3, 1987, D.C. Cir., 1987). In this case the U.S. District of Columbia Court of Appeals ruled by a 5-4 vote that the FERC must consider the "end-result" test established in the Hope Natural Gas case, even though the commission had an established policy of excluding certain investments in abandoned plants. It remanded the case to FERC for a determination as to whether its rate order constituted a reasonable balancing of the interests identified in the Hope case. The appeals court said that if on remand the FERC were to find that its order did not satisfy the requirements of the Hope case, it would have the flexibility to determine how it should be modified, "whether through enlarging the rate base, increasing the rate of return, or a combination of both."[2]

---

[2] It is not clear at this writing what the status of FERC's action is on this remanded decision. The dissenting opinion worried that,

> ...the commission [would be] constrained to take no interim action without first holding a hearing and making findings pursuant to the test formulated in FPC v. Hope Natural Gas. (Public Utilities Fortnightly, March 19, 1987, p. 44)

One way to assess the possible impact of this unresolved case for those involved in telephone utility regulation is to assume that the Circuit Court of Appeals majority opinion reaffirming the end result test is upheld by subsequent court cases or rate case proceedings. Unless a court were to decide that the disallowance of some or all of a telephone utility's modernization expenditures had caused the revenues and earnings of the entire company to fall below the minimum amount necessary for access to capital markets and to maintain its financial integrity, it seems unlikely that the far smaller size of the telephone investments would result in this legal principle being directly used. Should telephone utilities have a significant shift in basic transmission technology--a complete bypass of the local wire loop, for example--then utility capital investments might reach a level where access to financial markets and the company's financial integrity could be impaired by an adverse commission ruling, such that the reinvigorated Hope Natural Gas end result test could be applied. Present telephone utility investment levels should make this unlikely, however.

It may also be the case that the deft procedural maneuvers that Jersey Central Power & Light went through may not be so easily repeated now that commissions are sensitive to this application of the end result principle. A commission that can avoid having the end result of a modernization disallowance imperil the financial integrity of the utility, presumably would not be affected by this doctrine.

In theory a commission could completely disallow all modernization costs--based on commission rules--and offset this particular disallowance with, for instance, a higher rate of return. If the net effect did not impair the access to capital markets or hurt the financial integrity of the company, the disallowance could be acceptable under the Hope end result doctrine. This would not preclude the courts from applying other principles, such as used and useful or the prudent investment test, in adjudicating a subsequent court case.

<u>Prudent Investment Test</u>

The recovery of part or all of the cost of a partially constructed nuclear facility is dependent on the regulatory commission finding that the utility acted prudently during a commission-specified time period.

Depending upon the facts of the case, a commission can find (1) that the utility management acted imprudently by waiting too long to decide to cancel the unneeded facility and establish a date after which costs are to be disallowed, or (2) that the company's decision to cancel was prudent and that costs up to the time of that decision are eligible for some type of cost recovery. The finding of imprudence and the disallowance of some of the costs of a LILCO nuclear plant by the New York commission is a representative example of the former, and the Washington Utilities and Transportation Commission's decision in the Puget Sound Power and Light Company's abandoned Pebble Springs nuclear plant an example of the latter (NARUC Bulletin, August 27, 1984, p. 17, and Public Utilities Fortnightly, January 23, 1986, p. 47). Of course a commission can disallow all costs of an uncompleted plant as not being used and useful (Dayton Power & Light Co. v Ohio Public Utilities Commission, 4 Ohio St 2d 91, 447 NE2d 733, April 13, 1983 and; Cleveland Electric Illuminating Co. v. Ohio Public Utilities Commission, 4 Ohio St 3d 107, 447 NE2d 746, April 13, 1983).[3]

In the natural gas industry the prudence test has been applied mainly to gas purchasing practices and to the abandonment of facilities such as synthetic gas plants. In one representative case the FERC ruled against Columbia Gas Transmission Corporation's gas purchases on the ground that the pipeline had bought high cost gas when lower cost gas was available. Companies have responded to similar charges by saying that the purchases were not imprudent because they were made with the best available information and at a time when known gas reserves were declining and prices were increasing. In Iowa, a proactive procedure has existed since 1984 where the burden of persuasion that prudent gas purchasing practices are followed and the burden of going forward are on the utility, which must file a gas procurement plan and other information with the commission (Public Utilities Fortnightly, Oct. 25, 1984, p. 65).

---

[3] For a more thorough review see "A Survey of Regulatory Treatment of Plant Cancellation Costs," by Shippen Howe, Public Utilities Fortnightly 52, March 31, 1983.

Direct application of the prudence test to abandonment issues seems to be a widespread regulatory principle covering all utility sectors. As such it has relevance for equipment and facilities in the telephone utility sector that might be abandoned due to modernization.

Social Contract

The recent cluster of articles on the "social contract" in part springs from worries about deviations from the theme that as long as a capital expenditure was prudently incurred, a commission was obliged to approve and pass on these costs to the ratepayers (Kahn, 1987). Accordingly, if a plant was abandoned during or after construction, the relevant test was the prudence test and not, it was argued, the used and useful test. Opponents of this viewpoint argued that a rigorous application of both the used and useful test and the prudence test (particularly regarding the timing of the abandonment decision) more accurately represented the "terms" of the social contract, or "regulatory bargain."

Amortization and Write-off of Abandonment

While there is a broad body of regulatory principles and precedents (such as those presented above) to determine the correct treatment of abandoned facilities, commissions apply these principles and precedents on a case by case basis. The particular solution in a given abandonment case, accordingly, reflects the specific facts and circumstances of a utility's abandonment decision. Based on the facts before them, commissions have in some instances allowed the capital invested in abandoned facilities to be recovered through amortization over a period of years. In other instances, some or all of the capital invested in the abandoned facility has had to be written off as a loss to the shareholders. A range of representative examples of amortization and write-off treatments are presented below, in no particular order. These examples illustrate various principles and precedents that may be transferable to the abandonment portion of the telecommunications modernization equation.

Amortization

Amortization of Investment

In re Consumers Power Company (52 PUR 4th,pp. 536-617, April 12, 1983) a mothballed synthetic natural gas plant was found to be not used and useful and excluded from the utility rate base. Investors were permitted to recover their investment in plant through amortization of the undepreciated investment, although the plant would not be included in rate base (p. 536).

Amortization as an Alternative to Bankruptcy

In a proceeding concerning the Maine Public Service Company, the Maine Public Utilities Commission shortened the period of recovery of abandoned plant cost from 30 years to 44 months because of the company's precarious financial situation. The Commission weighed the bankruptcy alternative and determined that a shorter amortization was necessary and beneficial to ratepayers rather than pursuing a course that could lead to bankruptcy proceedings (Maine PUC, Order 85-212, July 9, 1986).

Amortization Adjusted for AFDUC

In re Pacific Gas and Electric Company (69 PUR 4th, p.1) before the California Public Utilities Commission, the commission issued an order allowing the utility to recover remaining net plant investment in prematurely retired nuclear plant. It ruled that a prematurely retired nuclear generating unit could not be included in the rate base as it is no longer used and useful, but that remaining net plant investment in the unit can be recovered from the ratepayers as long as there is no concomitant recovery of an allowance for funds used during construction accrued while the utility unsuccessfully attempted to modify and reopen the unit.

Amortization Prior to Abandonment

In Re Southern California Edison Co.(Docket Nos. ER82-427-000 and ER83-301-000, 34 FERC, S. 63,016) a FERC administrative law judge held that an electric utility may not recover projected costs of abandoned plant before abandonment actually occurs (Public Utilities Fortnightly, April 17, 1986, p. 62).

Amortization and Tax Write-Off

The Washington Utilities and Transportation Commission adopted a fifty-fifty sharing by ratepayers and shareholders through a five-year amortization with no return on the unamortized balance for Pacific Power and Light Company.[4] In a similar situation the North Carolina Utilities Commission decided to allow the return of investment, but not a return "on the investment" for Duke Power. This resulted in a ten year amortization without a return on the unamortized balance, with a cost sharing of 30% to ratepayers, 30% to shareholders, and 40% to taxpayers (Bower, 1987, p. 14).[5]

Write-Offs of Abandonment Losses

Write-Offs Against Earnings

Public Service Electric and Gas Company of New Jersey (PSE&G), abandoned two liquified natural gas facilities because of various licensing problems and delays. PSE&G's investment in the project was reported to be $69.6 million. As a result of the abandonment, PSE&G's investment, net of related tax savings, is expected to be written off over a seven-year period. The action may result in a reduction of approximately 5.4 cents per share of common stock.

Write-Offs Against Earnings to Avoid Uncertainty

Utah Power & Light took a one-time charge of 63 cents per share against its 1984 earnings for the $55 million spent on the cancelled 400 MW Hunter-4 coal unit. Earnings for 1984 were $1.78 a share, versus $2.39 in

[4] Pacific Power and Light Company Case No. U-84-65, August 2, 1985
[5] Duke Power Company Docket No. E-7, Sub 39, September 17, 1985.

1983. The decision to write-off this expenditure was done, in part, to avoid what the utility felt would have been "vociferous heated hearings" (Electric Utility Week, March 18, 1985, p. 1-3). The $55 million in costs associated with Hunter-4 were mainly for engineering and design, site preparation, and charges for cancelling equipment orders.

Write-Offs by Public Authorities

In 1986 the Tennessee Valley Authority cancelled four unfinished nuclear reactors and wrote them off as a $2.7 billion loss. Two of the reactors were at the Hartsville Nuclear Plant and two were at its Yellow Creek facility.

Write-Offs by Telcos

The leading long distance companies, US Sprint, MCI, and AT&T, have felt the financial strain resulting from their rapid modernization and extension of their facilities. Since 1986, US Sprint has reportedly spent more than $2.5 billion on optic and digital facilities and has written off (in 1986) more than $356 million, before taxes. MCI reportedly also spent $2.5 billion since 1985 and has written off losses of $448 million attributed to modernization and reorganization. AT&T spent $2.5 billion, in 1987 alone, modernizing and upgrading its facilities. All told, AT&T will have write-off $3.2 billion to cover "...32,000 redundancies, resulting from savings in manpower that new equipment allows, and to cover a corporate reorganization and scrapping of some old equipment" (The Economist, Oct. 17, 1987, p. 10).[6]

---

[6] In its effort to enter the computer market AT&T is thought to have lost approximately $1 billion, although it expects to be able to earn a profit on this by the end of 1988 (The Economist, Oct. 17, 1987, p. 13).

Applicability to Telecommunications Modernization

There are three sources of funds to pay for the undepreciated and unrecovered capital remaining in an old technology asset abandoned via a modernization investment: the ratepayer, stockholder, or the taxpayer. In a scenario where all parties see the cost savings in the new technology as sufficient to pick up both the cost of the abandoned asset as well as the cost of the new more efficient asset, few problems occur. The traditional regulatory capital recovery model works especially well in this circumstance. In a scenario where one or more of the parties forecast that the cost saving features of the new technology are not sufficient to also pick up the sunk cost of the abandoned facility, significant regulatory concern arises over the proper way to recover the capital invested in the abandoned, modernized asset.

Traditional regulatory principles and precedents cited above offer guidance about the appropriate capital recovery mechanism. If an asset is currently used and useful in producing services for monopoly ratepayers, then no serious capital recovery problem arises (other than in the proper design of rates). If an asset is abandoned, regulators ask (1) was the decision to build the facility or purchase the equipment prudent, and (2) was the decision to abandon the facility prudent.

If the commission finds that the decision to build the facility or equipment was prudent, then the likely course of action would seem to be to amortize the undepreciated investment over some period of time, but not to allow a rate of return on it.[7] If the abandoned unit is either fully depreciated or has a salvage (or resale) value equal to the undepreciated investment remaining in the asset, the regulatory problem is minor and is largely a record keeping issue.

If a finding of imprudence is made re the decision to abandon the asset, then amortization of some portion of the capital invested seems to be

[7] An "abandoned" piece of equipment may also be either reassigned or used as a backup or peak service facility. If this reuse of the equipment is regarded as being used and useful, it may stay in the ratebase and earn a rate of return.

the most frequently used capital recovery mechanism. If a utility waited too long to make a cancellation decision, say after the commission had presented what it felt was clear evidence of overcapacity, a commission might allow recovery for all costs only up to that point in time. A finding of some degree of imprudence usually results in the shareholder assuming a corresponding amount of the sunk cost in the asset.[8]

Amortization needs to take into account capital that has already been recovered, either as a depreciation expense, or CWIP, or AFDUC. In telephone capital construction, CWIP and AFUDC, while important, do not have the same financial impact on the utility as they do for electric utilities.

---

[8] Recovery of part of any loss through the tax code is not directly covered here, although the availability of amelioration through tax write-offs is an important feature of the deliberation by all parties to an abandonment proceeding.

CHAPTER 5

A REGULATORY MODERNIZATION FRAMEWORK

Introduction

In most standard economics, accounting, and engineering economics texts the concept of modernization is treated as a routine, primarily technical issue; one that can be handled by straight forward statistical and other analytical techniques. The application of these techniques is, of course, much more complex in a real world setting where the choice of assumptions, rates, and ratios may vary widely between analysts and the reliability of the data are unknown.

Both regulated and unregulated firms engage in modernization, but for an unregulated firm, the financial consequences of a modernization effort rest solely upon the shareholders. The financial consequences of a modernization investment for a regulated utility (like they are for most other important aspects of a utility's operations) are shared between the stockholders and the ratepayers.

In the following sections a qualitative model that provides a framework for modernization in a regulated industry is presented. In the first section, an overview of the framework is presented. In subsequent sections, parts of the regulatory modernization model are elaborated. In particular, the second section will focus on the replacement concept and the third on efficiency. The last section discusses the role of forecasting in making replacement decisions and the different forecasting results possible from different forecasting approaches.

Regulatory Modernization

To modernize means **to replace present technology with a more efficient technology**. For regulators it tends to apply exclusively to the replacement of a physical asset, such as a piece of equipment. Efficiency here is defined as either saving money or providing new or better services. In order to make a rational modernization decision, it is necessary to conduct an analysis sufficient to determine whether money would be saved and if a new or better service can be provided by the newer technology. This report and the modernization framework discussed below, do not directly deal with the assessment of the service features of new technologies. It accepts this information as given. However, the new or improved services must ultimately be justifiable economically. This analysis can be complicated for comparison purposes if the newer technology offers a significantly different array or quality of services.

The heart of the modernization model is that the investment decision analysis is based on the determination of the net future revenue stream of the newer technology relative to the technology being replaced. While the calculations are not simple and the reliability of the data used is problematical, the decision rule is relatively simple. If the net future revenue stream of the newer technology exceeds that of the older technology, then the decision should be to replace the old and modernize the asset. The choice of the analytical method and the data can cause different choices to be made.

Two key concepts underlying this model are examined below: replacement and efficiency.

Replacement

Modernization of plant requires that the old equipment be taken out and the equipment representing the successor technology be installed to replace the old. Replacement is a key concept in understanding the modernization process. Replacement is the parallel substitution of the newer technology for the older, existing technology. It is not an exact substitution, in which case we would not be talking about modernization.

All capital equipment used by the utility can be characterized as to being either fully depreciated, or partially depreciated.[1] Equipment that is fully depreciated and is being replaced in a modernization effort with a newer technology, represents a relatively minor regulatory problem, as the original cost of the asset has by definition been returned to the utility.

A modernization decision where the equipment being replaced is not fully depreciated does have some of the same characteristics as an abandonment decision. If the modernization effort were directed at a geographical area where no equipment is in place, or for a service completely unsupported by any equipment now in the utility rate base, then there would be no direct parallel equipment substitution. Abandonment would not be a useful concept.

Equipment used for ratepayers in a geographical area or for a customer class that is currently receiving service may be abandoned, modernized, or kept in service. Existing equipment that is paired in a modernization decision or simply abandoned leaves behind an unreturned investment by the utility.[2] If the utility chooses to forsake the investment, for whatever reason, and does not seek to recover the investment in future ratepayer payments, then no issue arises. It is a standard policy for unregulated corporations to take write-offs, however reluctantly, for losses.

Regulated utilities are insulated somewhat from this write-off risk. For a utility to be forced to completely write-off the entire capital investment of a major facility against the shareholders, an investment would have to be judged as not being (1) used and useful, (2) prudent, (3) and large enough to deny it access to capital markets, or impair the financial health of the company. A further condition would likely be that no penalty be assessed such that the service to the ratepayers would be actually jeopardized. Utilities have been forced by state and federal

---

[1] Important distinctions made in telecommunications accounting practices between equal life groups and vintage groups, for example, are not discussed here.

[2] It is unreturned at this stage of the regulatory modernization process. The actual return of capital is unknown until the commission acts.

regulatory commissions to accept losses on facilities judged to be imprudent and not used and useful. In all cases, these losses have been muted in some way to avoid irreparable financial harm or bankruptcy of the utility. The line of reasoning in Jersey Central Power & Light Co. v. FERC, cited earlier, suggests that the Hope Natural Gas "end result" test may mean that commissions must take affirmative actions to ensure that service and financial viability are not impaired by any financial loss. Utilities, of course, see the avoidance of irreparable financial harm as a minimalist policy that may violate, at least, the spirit of the regulatory social compact.

Equipment that is not fully depreciated is abandoned when the new, more productive equipment is installed. If the equipment has a net positive salvage value and can be installed at another location or can be used to provide a different service at the same location, it is still considered to be part of a modernization decision. If the replaced equipment is not going to be used elsewhere to provide service to the utilities' customers, the replaced equipment is effectively the same as abandoned equipment and may be treated as such. All such modernization efforts have paired actions with each replacement having a corresponding abandonment. As technology may change over time, at an uneven rate, and often qualitatively, it can be difficult to identify the exact replacement pairs.

Both abandonment and modernization actions are preceded by an economic analysis to determine if it makes rational economic sense to abandon or modernize. If the analysis reveals that abandonment or replacement are not necessary, the concern of regulators is limited to that of regulatory oversight and a concern for the level and quality of service.

Efficiency

The decision to modernize is preceded by an economic analysis that indicates that a new generation of technology is more efficient than the specific technology being replaced. Efficiency is defined here as either saving money or providing new services. This view assumes that firms are interested in profit maximization and market share. Profit maximization is a short-term and long-term concept, as companies are concerned about their net profitability over time as well as for any given accounting period.

Market share also has short-and long-term features, as companies take specific actions in the short-term that are intended to preserve or increase the firm's share of the market. Telephone utilities seeking to provide various non-traditional information services are an example of a firm pursuing a market share strategy in order to maximize its long-term profits.

In replacing older equipment, a firm is deciding to increase its profitability and/or market share by improving its net future revenue stream, or by offering new services to its customers. While the analysis is often complex, the decision rule is simple, i.e., if the net future revenue stream using the new technology is greater than for the present technology, the decision should be to replace it with the new technology. Complexity in the efficiency analysis is due to the difficulty of (1) forecasting net future revenues, and (2) determining the appropriate treatment of the sunk cost of the abandoned, undepreciated asset.

Selected Forecasting Approaches

Demand forecasting is difficult. Earlier practitioners thought of it as a science, whereas there now is a growing recognition that it is, instead, an art. During times of stability with known relationships between key variables and proven assumptions, forecasting can be relatively straight-forward. Standard regression-type models can predict with good accuracy.[3]

The initial response of electric utility forecasters to the turbulent environment of the 1970s was to build even more sophisticated models and to seek forecasting solutions in statistical formulations, when the real problem was that the stability needed for forecasting did not exist. The Arab oil embargo, environmental concerns, double-digit inflation, a slowed rate in productivity improvements in electrical generation, regulatory

---

[3] Indeed, the present prestige that the economics profession enjoys today, it may be argued, can be directly traced to the economist's success in the 1960-1970 period in building sophisticated computer models that correctly forecast economic trends. From the 1970s to the present, however, forecasting has not enjoyed a success rate anything like the 1960-1970 decade.

changes, a shift to a post-industrial, information age economy, and a price and conservation-induced drop in demand all contributed to this instability. Forecasting models do poorly in periods of uncertainty because they forecast the future based on relationships that have changed in a way not accommodated for.

The problem of forecasting demand in the telecommunications field is no less difficult. Divestiture, de-regulation, competition, modernization, bypass, the blurring of the distinction between basic and enhanced services, and the internationalization of domestic markets all contribute to making forecasting difficult. Still, forecasts must be made in some way. Telecommunications utilities must responsibly plan major construction programs, financial markets need to assess future revenues and regulators need to assess and/or plan for change.

Two forecasting perspectives are sketched below. The decision analytic and the least cost planning approaches are presented as illustrations of how different forecasting approaches can produce different results. As all rational modernization programs are based upon data obtained through some kind of a forecast, and no forecasting method is perfect, regulatory policy makers may find it useful to require that more than one forecasting approach be presented.

Decision Analytic Approach

Assessing the value of future benefits is always difficult and the method chosen may influence the results obtained. For example, a recent study by Applied Decision Analysis, Inc. and Charles River Associates, Inc. for the Electric Power Research Institute contrasts the different outcomes possible using a decision analytic approach versus finance theory. They say,

> A complete decision analysis lays out every possible uncertain cash flow scenario and evaluates each separately using a risk-free discount rate. Financial analysis often uses a higher discount rate that is adjusted for risk and applies this risk-adjusted discount rate to a single expected cash flow." (1987, p.1-1)

The use of a single discounted cash flow is a powerful and widely used analytical tool. Given the many possible scenarios that could reasonably be used to describe the future structure of the various local, or intraLATA, or interLATA-intra-state, or interstate, or international telecommunications markets, the regulatory analyst may find it prudent to include the decision theory approach. From this perspective, a speciously accurate single cash flow that ignores the probability of placing an incorrect bet on the correct future scenario may be worse than no forecast at all.

The key initial problem for regulators is the reliability and validity of the forecast of future revenues by the utility. It is the dependence of many telecommunications modernization analyses on the emergence of a single forecasted future demand that causes concern for regulators. Accordingly, the explicit consideration given by the decision analytic approach to alternative future scenarios may help to address this concern.

Least Cost Planning Approach

Least cost planning (LCP) seeks to achieve economic efficiency through total cost minimization. It seeks to use all available resources to minimize price in a manner consistent with reliability concerns over a specified planning period. It has been used in the energy field to minimize cost by evaluating all demand and supply options by using the same economic criteria[4]. From a LCP perspective a home re-insulation option would be chosen over a base load capacity addition if the long-run cost minimization was greater. Traditionally utilities and utility commissions focused their attention on supply options such as whether to build a medium-size coal plant or a series of peak-load facilities. Least cost planning is a more comprehensive mode of forecasting and planning for future system needs by integrating both supply and demand considerations into the planning process.

The concept of LCP has not been used to the same extent and in the same way as has been the case in the electric utility and natural gas industry.

---

[4] See Wisconsin Public Service Commission, Order 05-EP-4, especially p.3, for one description of the least cost planning concept.

Some eighteen states have legislation for, and at least a third of these states have formally constituted, least cost energy planning programs. The common dimension of LCP that is relevant in both the power and telecommunications sectors is the concern that when telephone utilities modernize their equipment, cost minimization should be the goal. In addition to cost minimization the following objectives may influence telephone utility modernization expenditures: the protection of current market share, securing a competitive advantage, the desire to provide a comprehensive listing of telecommunication services (that is, the need to provide both comprehensive and ubiquitous service), the financial advantage of including modernization expenditures in the monopoly ratebase, and the lure of new technology. Utility commissions in a telephone rate case setting often judge whether capital expenditures of a utility are used and useful or prudent, but not necessarily whether they are cost minimizing.

Berry (1987, p. 4) has identified some publicly stated LCP goals for the regulation of electric utilities that provide a perspective on the applicability of the concept to telecommunications modernization, which are listed below (together with the commissions employing them).

* To determine the long-range needs for expansion of facilities for the generation of electricity (Indiana)

* To achieve the least cost supply of electricity (Massachusetts)

* To minimize revenue requirements through optimal selection of demand reduction programs and other supply resources based upon load forecast (Nevada)

* To meet the demand for energy services reliably and at the lowest possible cost (Ohio)

* To ensure the consideration of all possible impacts of supply-side and demand-side resource options and to ensure the development of least-cost resources (Pennsylvania)

* To assure that electric utilities are considering all available resources in their long-term planning and are implementing such plans in a manner that promotes the maximum effective conservation and use of energy and capital resources (Virginia)

While the conservation of resources theme is not directly relevant for telephone utility LCP, the other themes listed above may have relevance, such as long range needs, least cost supply, revenue requirement minimization, consideration of all available options, and meeting demand at the lowest possible cost.

Berry found that the most common LCP functions for the electric sector are:

* to approve generation projects prior to construction;
* to improve staff or commission review of energy supply and demand factors in rate cases;
* to inform the commission of major issues in energy supply and demand; and
* to induce utilities to improve their long range planning.

Each of these activities has a reasonably similar functional equivalent in telephone utility regulation.

LCP is unlikely to be an important component of federal policy as telecommunications deregulation and pro-competition policies are pursued. The same may not be the case at the state level, especially for residential and single line business customers. The basic obligation of commissions to ensure that expenditures are prudently incurred and that cross subsidies not occur will continue. What is missing, however, is an impetus equivalent to that provided in the electric utility industry. Until such an impetus, like the energy crisis, occurs LCP concepts will likely not be in the forefront of telecommunications regulation.

The heart of LCP and the part that seems to have the greatest potential for transferability to telecommunications, is that a firm should use a cost minimization strategy that minimizes up-front investment costs as well as future operating and maintenance costs. If this strategy is not followed, a utility could have a "bad" production cost function because it is using the "wrong" mix of inputs to produce its outputs. For example, pursuing a territory-wide switch digitalization policy, when multiplexing or "switch hopping" technologies may be more economical, could produce an inefficient mix of inputs to serve what might be a low demand for digital services.

Conclusion

The qualitative descriptive model provides a simple framework from which to describe and analyze telecommunications modernization. It necessarily remains simple because an extensive modernization public record --like that produced through hearings and various publications for nuclear power plant construction--does not yet exist from which more detailed descriptions may be derived.

A decision analytic or least cost planning approach to forecasting may produce different modernization scenarios than those resulting from traditional forecasting approaches.

MODERNIZATION BIBLIOGRAPHY

"Access Issues and Answers." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, January 1986.

Accounting and Audits Division Report on Telephone Industry Depreciation, Tax, and Capital/Expense Policy. Washington, D.C.: Federal Communications Commission, 15 April 1987.

Accounting for the Effects of Certain Types of Regulation." Statement of Financial Accounting Standards No. 71. Stamford, CT: Financial Accounting Standards Board, December 1982.

"Accounting for the Effects of Regulation of an Enterprise's Prices Based on its Costs." Exposure Draft. Stamford, CT: Financial Accounting Standards Board, 4 March 1982.

Adkins, Robert S. "Utilizing Cost-Benefit Analysis to Establish the Management Prudence of Project Investment Decisions in the Utility Ratemaking Process." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Allesio, Frank J. "Market-Based Pricing for Carrier Access: A Minnesota Case Study." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Altman, Edward I. Corporate Financial Distress. New York: John Wiley & Sons, 1983.

American Bar Association Section on Public Utilities. Report of the American Bar Association Section on Public Utilities, (mimeo, 1987).

Anselin, Luc; Pike, Lynne M.; Smith, George L., Jr. "The Measurement of Electric Utility Performance: Preliminary Analysis." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Applied Decision Analysis and Charles River Associates, Inc. Evaluating the Effects of Time and Risk on Investment Choices: A Comparison of Finance Theory and Decision Analysis. Palo Alto, CA: Final Report Prepared for Electric Power Research Institute, January 1987.

Archibald, T. Ross. "Disclosure of Accounting: Some Empirical Data." Journal of Accountancy (April 1971).

Arthur Anderson & Co. Illinois Bell Telephone Company Capital Recovery Survey, Arthur Anderson & Co., March 1987.

Arthur Andersen & Co. Report to the Nebraska State Legislature on the Telecommunications Industry in Nebraska.

Arthur Young International. "Technical Change: Its Impact on Accounting." Proceedings of the Arthur Young Professors' Roundtable. Edited by Edward L. Summers, 1982

Basu, S. and Hanna, J.R. "General Price Level Adjustments and ROI." Financial Analysis Journal (January-February 1978): 55-67.

Baumol, William J. "Optimal Depreciation Policy: Pricing the Products of Durable Assets." The Bell Journal of Economics and Management Science (Autumn 1971): 638-56.

Baumol, William J. "On the Proper Cost Tests for Natural Monopoly in a Multiproduct Industry," American Economic Review, 67 (December, 1977): 809-22

Bedford, Norton M. "A Recapitulation of Technological Change: Its Impact on Accounting." Proceedings of the Arthur Young Professors' Roundtable. Edited by Edward L. Summers. Reston, VA (1982): 201-12.

Benedict, Louis. "Depreciation: What It Is and How It Is Computed." Public Utilities Fortnightly (September 1930): 286-92.

Bhatiol, Hasso. "A Plan for Investigation Into the Prudency of Power Plant Expenditures." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Bodenhorn, Diran. "An Economist Looks at Industrial Accounting and Depreciation." Accounting Review (October 1961): 583-88.

Bonbright, James C. Principles of Public Utility Rates. Columbia University Press: New York, 1961.

Bone, Jan. Opportunities in Telecommunications. Lincolnwood, IL: VGM Career Horizons, 1984.

Bower, Richard S. "Electricity's Unstable Regulatory Regime," in Public Utilities Fortnightly, June 25, 1987, pp. 13-19.

Brandon, P.S., Economic Depreciation, New Jersey, Bell Communications Research, September 21, 1987.

Brooks, F. Warren. "Accelerated Depreciation." Public Utilities Fortnightly (September 26, 1987): 433-41.

Brooks, John. Telephone: The First Hundred Years. 1st ed., New York, NY: Harper & Row, 1976.

Brown, Morton L. and Burkhardt, Daniel A. "'Baby Bells'--Still Going Strong." Public Utilities Fortnightly (January 9, 1986): 41-2.

Bullock, Clayton L. "Reconciling Economic Depreciation with Tax Allocation." Accounting Review (January 1974): 98-103.

Burns, Robert E.; Henderson, J. Stephen; Pollard, William; Pryor, Timothy; Chen, Yea-Mow. Funding Nuclear Power Plant Decommissioning. Final Report Prepared for the U.S. Department of Energy, Economic Regulatory Administration, Division of Regulatory Assistance. Columbus OH: The National Regulatory Research Institute, October 1982.

Burns, Robert E.; Poling, Robert D.; Whinihan, Michael J.; Kelly, Kevin. The Prudent Investment Test in the 1980's. Columbus, OH: The National Regulatory Research Institute, 1985.

Burns, Robert E.; Pollard, William; Pryor, Timothy; Pike, Lynne M. The Appropriateness and Feasibility of Various Methods of Calculating Avoided Costs. Columbus, OH: The National Regulatory Research Institute, June 1982.

Butler, Vincent. "A Social Compact to Be Restored." Public Utilities Fortnightly (December 1985): 17.

"Bypass Technologies." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, January 1985.

"Cable Television Networks as an Alternative to the Local Loop." Journal of Telecommunication Networks, 1984. In Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, September 1985.

California Public Utilities Commission. Minutes of the Meetings of the Staff Subcommittees on Communications and Cost Allocations. Washington, D.C., 30 March 1987.

Campbell, Philip A. "Fulfilling the Promise of Divestiture: A Call for Fair and Open Competition." Public Utilities Fortnightly (March 6, 1986): 13-17.

Canaday, Henry T. "Construction Cost Overruns in Electric Utilities: Some Trend and Implications." Occasional Paper No. 3. Columbus, OH: The National Regulatory Research Institute, November 1980.

Capitol Publications, Inc. "Joint Board to Decide Access Charge Issues; Full $2 Hike Considered Doubtful." State Telephone Regulation Report Vol. 5, No. 5 (March 12, 1987): 1, 8-11.

Capitol Publications, Inc. "Tax Windfall Bill Faltering in Congress; States Look at Tax Reform Impacts." State Telephone Regulation Report, Vol. 5, No. 5 (March 1987): 1-5.

Carduillo, J. Patrick and Moellenberndt, Richard A. ."The Cost Allocation Problem In A Telecommunications Company," Management Accounting, September 1987, pp.38-44.

Charles River Associates Incorporated. Analysis of Risky Investments for Utilities. Final Report Prepared for Electric Power Research Institute. Boston, MA: Charles River Associates, Inc., September 1983.

Chernick, Paul. "Power Plant Phase-In Methodologies: Alternatives to Rate Shock." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Chessler, David. "Regional Holding Companies." Columbus, OH: The National Regulatory Research Institute, 1986.

________. Strategies for the Evaluation of Telecommunications Investment Decisions. Columbus, OH: The National Regulatory Research Institute.

________. Proceedings of the Dartmouth College Conference. NARUC Telecommunications Committee, April 7-10, 1986.

Chessler, David and Constas, Anthonias. "Emerging Issues in Telecommunications Investment Decisions." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Comiskey, Eugene E. "Market Response to Changes in Depreciation Accounting." Accounting Review (April 1971): 279-85.

"Competition Takes Wing for British Telecom." The Economist (May 3, 1986): 77-8.

"Constant Dollar Accounting." Exposure Draft. Stamford, CT: Financial Accounting Standards Board, 2 March 1979.

Couts, Roddy L. Testimony Before the Public Service Commission. District of Columbia, 28 May 1986.

Cross, Philip S. "The Bypass of Local Telephone Facilities: How Serious a Threat?" Public Utilities Fortnightly (May 1, 1986): 49-52.

________. "The Hope Case and the 'End-Result' Test--A Reappraisal." Public Utilities Fortnightly (March 6, 1986): 50-2.

________. "Yellow Pages Revenues: A Benefit to Investors or Ratepayers." Public Utilities Fortnightly (July 10, 1986): 43-5.

________. "Progress of Regulation Trends and Topics: 1985 - The Year in Review." Public Utilities Fortnightly (January 9, 1986): 48-51.

Czamanski, Daniel Z.; Henderson, J. Stephen; Odle, Curtis J.; Witkind, Vivian. Regulation as a System of Incentives. Columbus, OH: The National Regulatory Research Institute, 1981.

Datapro Research Corporation, "Fiber Optic Communications: Issues and Trends," Datapro, October 1987, pp.101-112.

________. "Telecommunications Predictions for the year 2000," Datapro, September, 1987, pp. 101-105.

________. "ISDN - Betting on the Future," Datapro, February, 1986, pp. 101-118.

"Demonopolising is Tricky." The Economist (November 23, 1985): 8.

"Digital Network Strategies." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, October 1985.

Dingell, John D. "Washington and the Utilities: Elements of a Progressive National Telecommunications Policy." Public Utilities Fortnightly (December 12, 1985).

Dobrovolsky, S.P. "Depreciation Policies and Investment Decisions." American Economic Review Vol. 41, No. 5 (December 1951): 906-14.

Dugan, Dennis J. and Stannard, Richard. "Barriers to Marginal Cost Pricing in Regulated Telecommunications." Public Utilities Fortnightly (November 28, 1985): 43.

Dopuch, Nicholas. "The Impact of Technology on Accounting Research - Past, Present, and Future." Proceedings of the Arthur Young Professors' Roundtable. Edited by Edward L Summers. Reston, VA (1982): 175-99.

Dunlap, David. "It is Time for a Change." Public Utilities Fortnightly (March 27, 1975): 25-6.

Dunn, Ed. Untitled Handout. San Francisco, CA: Telecount Engineers, Inc. Prepared for NARUC, 23 February 1987.

"Economic Depreciation and the New Tax Survey." Public Utilities Fortnightly (September 1, 1960): 323-29.

"Europe's Markets Marking Time." The Economist (November 23, 1985): 20-28.

Edgar, Edward C. and Faust, G.R. "System Growth and Obsolescence--Their Effect on Depreciation." Public Utilities Fortnightly (February 15, 1968): 15-28.

Edelstein, H.M. and Bernstein, P.L. "The Case Against Accelerated Depreciation." Social Research (Winter 1961): 491-96.

"Effect of Rate Regulation on Accounting for Regulated Enterprises." FASB Discussion Memorandum. Stamford, CT: Financial Accounting Standards Board, 31 December 1979.

Electric Utility Week, "S.C. PSC Allows 50% of Carolina P&L's Harris Nuclear Unit in Ratebase," Electric Utility Week, September 21. 1987, pp. 7-8.

Ely, Owen. "Financial News and Comment." Public Utilities Fortnightly (August 2, 1962): 161-64.

Ernst & Ernst, Study of Common Carrier Depreciation Rate Practices and Policies, Ernst & Ernst, July 29, 1977.

Ernst and Whinney. Review of Depreciation Policies and Procedures in Selected Industries. Prepared for the U.S. Telephone Association, 9 December 1986.

"The Evolution of U.S. Standardization Activity." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, April 1986.

Faber, Anne F.; Homick, Robert; Hyman, Bruce. "A Rating Agency's New Look at the Telephone Industry." Public Utilities Fortnightly (October 2, 1986): 28.

Fanara, Philip Jr. and Gorman, Raymond. "The Effects of Regulatory Risk on the Cost of Capital." Public Utilities Fortnightly (March 6, 1986): 32-6.

Federal Communications Commission, Accounting And Audits Division Report On Telephone Industry Depreciation, Tax, And Capital/Expense Policy. FCC: Washington, D.C., April 15, 1987.

Ferguson, John S. "Methodology and Mythology of Equal Life Group Depreciation." Public Utilities Fortnightly (January 6, 1983): 30-7.

________. "The Remaining Life Concept in Modern Depreciation Analysis." Public Utilities Fortnightly (June 23, 1977): 19-22.

Fisk, Hayward D. "The Impact of Tax Reform on the Telecommunications Industry." Telematics Vol. 4, No. 2 (February 1987).

Florida Public Service Commission. Florida Residential Demand for Local Telephone Service. Tallahassee, FL: Division of Communication; Division of Research, April 1986.

Fogarty, Joseph R. "Telephone Company Capital Recovery: Crisis and Dilemma Persist." Public Utilities Fortnightly (February 6, 1986): 23.

Foley, Frederick W. "Access Charges Paid by the Cost Causer." Proceedings of The Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Foley, Michael. "Proposed Reforms of Accounting Standards--A Cure Worse Than the Disease?" Public Utilities Fortnightly (May 29, 1986): 19-25.

Fraser, Jane M. and Posey, Jack W. A Framework for Replacement Analysis. West Lafayette, IN: Purdue University School of Industrial Engineering, January 1986.

________. "Modernization Investments" (unpublished mimeo, 1987).

Fraser, Jane M. and Rees, Rachelle E. Decision Analysis with Competition. West Lafayette, IN: Purdue University School of Industrial Engineering, May 1985.

Freiss, Robert E. "Evaluating Microwave Systems for Bypass Configurations." Datapro Management of Telecommunications (May 1985).

Fritz, Jerald N. "The Regulatory Burdens of the Bell Operating Companies: Are They Needed?" Public Utilities Fortnightly (April 3, 1986): 25-8.

Galil, Uzia. "The Impact of Technology on Industrial Organization." Proceedings of the Arthur Young Professors' Roundtable. Edited by Edward L. Summers. Reston, VA (1982): 69-83.

Gallagher, Daniel J. "Separate Subsidiaries as a Regulatory Tool in Telecommunications." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: the National Regulatory Research Institute, September 1984.

Gantz, John. "Telecommunication: An Industry in Transition." Telecommuncations Products & Technology, 1984. In Datapro Management of Telecommunications (February 1985).

Garnet, Robert W. "The Vail Years: Organizing for the Universal Network." The Telephone Enterprise, 1985. In Datapro Management of Telecommunications (January 1986).

"Gas Rate Order Remanded." Public Utilities Fortnightly (February 14, 1980): 69-70.

Gaylord, Gloria. "Presentation at Capital Recovery Policy Issues Panel," USTA Capital Recovery Seminar: Arlington, Virginia, September 21-22, 1987.

Gehrlein, William V. and Tiemann, Thomas K. "Optimal Depreciation Policies for Regulated Firms." The Engineering Economist Vol. 25, No. 2, (Winter 1980): 79-89.

"The Giants Circle." The Economist (November 23, 1985): 34-40.

Gilbreath, Robert D. Forward Thinking. New York, NY: McGraw-Hill Book Co.

Goldberg, Victor P. "Regulation and Administered Contracts." The Bell Journal of Economics, Vol. 7, No. 2 (Autumn 1976): 426-48.

Gransee, Marsha. "Progress of Regulation - End of the Year Review." Public Utilities Fortnightly (January 6, 1983): 50-55.

________. "Progress of Regulation Trends and Topics - A Year of Regulatory Decisions in Review." Public Utilities Fortnightly (January 5, 1984): 51-55.

Grant, Eugene L.; Ireson, W. Grant; Leavenworth, Richard S. Principles of Engineering Economy. 7th ed., New York, NY: Wiley, 1982.

Green, David Jr. and Sorter, George H. "Accounting for Obsolescence - A Proposal." Accounting Review (July 1959): 433-41.

"The Greening of America." The Economist (November 23, 1985): 10-17.

Griffith, Mark C. and Robinson, Terence D. "Economic Value and Capital Recovery: A Regulatory Model." Public Utilities Fortnightly (July 11, 1985): 30.

Gunter, Richard T. "Contributions-In-Aid-Of-Construction." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Hall, Mary D. "From Universal Plain Old Telephone Service to a Universal Information Network System: The Basis for New Communications Policy." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

________. "Telecommunications Policy for the Future: A Model State Plan." Public Utilities Fortnightly (January 10, 1985): 15.

Hasbrouck, H.C. "When Should Depreciation Be Deducted to Find the Rate Making Value of Public Utilities." Cornell Law Quarterly (June 1925): 471-86.

Helein, Charles H. Summary and Report on ONAF-2, Los Angeles March 31-April 2, 1987. Washington, D.C.: Dow, Lohnes & Albertson, May 1987.

Helman, Leonard A. "Inventoried Capacity: An Innovative Approach to Ratemaking." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Hill, Steve. "The Market Risk Premium and the Proper Interpretation of Historical Data." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Hiser, Michael L. and Proudfoot, Paul A. "An Examination of Income Deferral as an Alternative to Conventional Regulatory Treatment of Utility Plant Investment." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

"A History of the Telecommunications Regulatory Environment." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, February 1986.

Hlavac, Paul; Meadows, Steve; Robert, Frank. "Bypass: The Threat That Keeps Changing." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Hodges, Ray L. GTE Florida Exchange Network Evolution and Capital Recovery Plans. General Telephone of Florida, 1987

Horne, Adlancy. An Application of Regulatory Strategic Planning to Local Exchange Company Key Financial Variables, Part I. Public Service Commission of Wisconsin, March 1986.

Horning, John S. Public Policy Towards Rural Telephone Service, 1945-1981. Unpublished Ph.D. dissertation, M.I.T. (Cambridge, Mass., 1982).

Huber, Peter W.: As a Consultant to the Department of Justice; Funded by the Antitrust Division. The Geodesic Network, 1987 Report on Competition in the Telephone Industry, January 1987.

Huhta, R.A., Capital Recovery In The Local Exchange Network. New York: NYNEX Service Company, September 1987.

Hyde, J. Edward. The Phone Book: What the Telephone Company Would Rather You Not Know. Chicago, IL: Regnery, 1976.

Inan, Czatdana and Lannon, Larry. "Carriers Plan $24 Billion Outlay in 1986." Telephony's Directory (1987): 701-05.

________. "World Telecom Spending Moves Ahead Again After Down Period." Telephony's Directory (1987): 769-73.

"Integrated Services Digital Networks (ISDN): An Overview." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, March 1986.

Irby, William. "Allocating and Recovering Jointly Used Local Loop Telephone Costs." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Irwin, Manley R. "The Demise of State Telecommunication Regulation?" Telecommunications (December 1986): 70-7.

"ISDN--Betting on the Future." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, February 1986.

"Issues in Telecommunications Planning." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, January 1986.

Jackson, Charles L. and Rohlfs, Jeffrey, H. "Improving the Economic Efficiency of NTS Costs Recovery." Proceedings of the Fifth NARUC Biennial Regulatory Informaiton Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Jaffee, Bruce L. "Depreciation in a Simple Regulatory Model." The Bell Journal of Economics (Spring 1973): 338-42.

________. "Depreciation in a Simple Regulatory Model: Reply." The Bell Journal of Economics (Spring 1974).

Jarrett, Jeffrey E. "An Abandonment Decision Model." The Engineering Economist Vol. 19, No. 1 (Fall 1973): 35-46.

Jensen, Susan D. "Presentation at NARUC Capital Recovery Panel Simplification and Reform," USTA Capital Recovery Seminar: Arlington, Virginia, September 21-22, 1987.

Jeynes, Paul H. "What Others Think, Depreciation Methods and the Consumer's Interests." Public Utilities Fortnightly (March 30, 1978): 37-41.

Johnson, Orace. "Two General Concepts of Depreciation." Journal of Accounting Research (Spring 1968): 29-37.

Jones, Douglas N. A Perspective On Social Contract And Telecommunications Regulation (1987). The National Regulatory Research Institute: Columbus, Ohio.

Journal of Taxation. "ABA Tax Section Rejects Most Proposed Depreciation Changes." Journal of Taxation (October 1960): 232-33.

Kahn, Alfred. The Economics of Regulation: Principles and Institutions. John Wiley & Sons, New York, 1972)

Kahn, Alfred. "Keynote Address" at USTA Capital Cost Recovery Seminar, Arlington, Virginia, September 21-22, 1987

Kalbach, Lisa. "Transmission Alternatives for Bypass Users." Datapro Management of Telecommunications Vol. 3, No. 2 (February 1987): 1-37.

Kamien, Morton I. and Schwartz, Nancy L. "Market Structure and Innovation: A Survey." The Journal of Economic Literature Vol. XIII, No. 1 (March 1975): 1-37.

Kasper, Raphael G. Technology Assessment: Understanding the Social Consequences of Technological Applications. New York, NY: Praeger Publications, 1972.

Kaufman, Alvin; Kelly, Kevin; Hemphill, Ross. Commission Treatment of Overcapacity in the Electric Power Industry. Columbus, OH: National Regulatory Research Institute, September 1984.

Keenleyside, Anthony H.A. "There is More Than One Side to A Social Compact." Public Utilities Fortnightly (April 3, 1986): 47-49.

Keiser, Bernhard E. and Strange, Eugene. "Digital Techniques in the Telephone Network." Digital Telephony and Network Integration, 1985. In Datapro Management of Telecommunication (December 1985).

________. "Evolution of the Public Switched Telephone Network: From Analog to Digital." Digital Telephony and Network Integration, 1985. In Datapro Management of Telecommunications (November 1985).

Kennedy, Jim "For Whom The Bell Toil: Decisions That Companies Make In The Next Six Months Will Determine Their Futures" in ONA Opening The Network: How Far? How Fast?, a magazine supplement of Communications Week: Manhasset, New York, pp 10-22.

________. "Microwave Transmission." Digital Telephony and Network Integration. In Datapro Management of Telecommunications (July 1986).

Keucken, John A. Talking Computers and Telecommunications. New York, NY: Van Nostrand Reinhold Co., 1983.

Kiefer, Donald W. The Tax Reform Act of 1986: The Effects on Public Utilities. Congressional Research Service, 18 March 1987.

Kimball, Bradford F. "The Failure of the Unit-Summation Procedure as a Group Method of Estimating Depreciation." Econometrica Vol. 65 (1945): 225-44.

Kleinfeld, Sonny. The Biggest Company on Earth: A Profile of AT&T. 1st ed. New York, NY: Holt, Rinehart, and Winston, 1981.

Kolb, Burton A. "Risk Technological Change and Long-Term Financing Public Utility Versus Industrial Firms." Financial Analysts Journal (November-December, 1965): 141-46.

Kraus, Alan and Huefner, Ronald J. "Cash-Flow Patterns and the Choice of a Depreciation Method." The Bell Journal of Economics and Management Science (Spring 1972): 316-34.

Lawton, Raymond, and Davis, Vivian Witkind. Commission Regulation of Small Water Utilities: Some Issues and Solutions. The National Regulatory Research Institute, Columbus, Ohio, 1983.

Lebowitz, Joel L.; Lee, Chong Ouk; Linhart, Peter B. "Some Effects of Inflation on a Firm With Original Cost Depreciation." The Bell Journal of Economics (Autumn 1976): 463-77.

Lenz, Ralph C. and Vanston, Lawrence K. Comparisons of Technology Substitutions in Telecommunications and Other Industries. Austin, TX: Technology Futures, Inc., 1986.

Levin, Jack S. and Adess, Melvin S. "The Income Forecast Depreciation Method; Its Current Usage: Problems and Outlook." The Journal of Taxation (February 1974): 70-6.

Levin, Stanford L. "Theoretical, Practical, and Policy Issues in Telecommunications Cost Recovery." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Levy, Paul F. and McCarren, V. Louise. "Free the Local Telephone Companies." Public Utilities Fortnightly (July 10, 1986): 13-15.

"Liberalized Depreciation - Accounting Methods Used by 112 Electric Utilities." Public Utilities Fortnightly (September 29, 1960): 472-3.

Lindstrom, Lance. "Connectivity: The New Utopia." Datapro Management of Telecommunications Vol. 2, No. 11 (November 1986): 1-4.

_________. "Packet-Switched Voice." Datapro Management of Telecommunications Vol. 3, No. 2 (February 1987): 3.

_________. "Tax Reform: Good News." Datapro Management of Telecommunications Vol. 3, No. 11 (November 1986): 2.

Linhart, Peter B. "Depreciation in a Simple Regulatory Model: Comment." The Bell Journal of Economics (Spring 1974): 228-34.

Liqukas, Spyros K. "Factors Affecting Capital Retirement: Evidence From Capacity Decommissioning Plans in a Publicly Owned Corporation." The Journal of Industrial Economics Vol. XXVIII, No. 3 (March 1980): 241-54.

Littleton, A.C. Accounting Evolution to 1900. New York, NY: American Institute Publishing Co., Inc., 1933.

Litzenberger, Robert H. "On the Competitive Structure of the Cellular Service Industry and the Implications for Regulation." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Lowe, Howard D. "The Essentials of General Theory of Depreciation." Accounting Review (April 1963): 293-301.

Lubow, Howard E. and Harptser, Gary C. "Regulatory and Accounting Implications of Phase-In Plans." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

McCarren, V. Louise and Levy, Paul F. "The Mandatory Carrier Common Line Pool Should Go." Public Utilities Fortnightly (March 19, 1987): 23-7.

"Making Sense of New Private Line Tariffs." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, February 1986.

Mansfield, Edwin; Rapoport, John; Romeo, Anthony; Villani, Edmond; Wagner, Samuel; Husic, Frank. The Production and Application of New Industrial Technology. New York, NY: W.W. Norton & Co., Inc., 1977.

Marston, Anson; Winfrey, Robley; Hempstead, Jean C. Engineering Valuation and Depreciation. New York, NY: McGraw-Hill Book Co., Inc., 1953.

Massella, Ines M. "Progress of Regulation Trends and Topics: 1984 - The Year in Review." Public Utilities Fortnightly (January 10, 1985): 46-51.

Matthews, Douglas T.; Kraemer, Joseph S. "What Others Think." Public Utilities Fortnightly. (October 2, 1986): 42.

Milks, William W. and Lum, Patricia. "A Strategic Perspective on Hawaii's Future Telecommunications Demands and Suppliers." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Miller, Bennet R. "The Current Agenda of the U.S. Telephone Industry." Public Utilities Fortnightly. (October 2, 1986): 11.

Miller, Edythe S. "Back to the Future: A Comment." Telematics Vol. 4, No. 3 (March 1987): 1, 2, 14-16.

________. "FCC Preemption, State Telecommunications Deregulation, and the Public Interest." Paper Presented at the 7th Annual Conference of the Institute of Public Utilities, Michigan State University. Williamsburg, VA, 9 December 1985.

________. "Ideology, Jurisdiction, and Deregulation of the Telephone Network." Public Utilities Fortnightly (October 2, 1986): 14.

Mitchell, Cynthia K. "Application and Utilization of Cost-Benefit Test in the Evaluation of Competing Resources." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Mount-Campbell, Clark, Neuhardt, John, and Lee, Baumin. A Descriptive Study Of Telephone Usage In Ohio. The National Regulatory Research Institute: Columbus, Ohio, 1987.

Morrison, Thomas A. and Buzby, Steven L. "Effect of the Investment Tax Credit on the Capitalize - Expense Decision." Accounting Review (July 1968): 517-21.

NARUC Depreciation and Subcommittee of the Committee on Engineering, Depreciation, and Valuation. Public Utility Depreciation Practices The National Association Of Regulatory Utility Commissioners: Washington, D.C., 1968.

The National Regulatory Research Institute Quarterly Bulletin. "Telecommunications Issues: Depreciation and Capital Recovery - California PUC." Columbus, OH: The National Regulatory Research Institute (January 1986): 69-70.

Nash, L.R. "Depreciation Reserves as Affected by Property." American Economic Review Vol. 6, No. 1 (March 1916): 69-87.

Nellis, Richard E. "What Others Think: Depreciation - 'Economic' or Otherwise." Public Utilities Fortnightly (October 17, 1985): 53.

Nelson, Sharon L. "Washington State's New Regulatory Flexibility Act." Public Utilities Fortnightly (January 9, 1986).

Nowick, Stephen P.. " For Openers...Sure ONA Is Confusing. But It Doesn't Need To Stay That Way." In ONA Opening The Network: How Far? How Fast?, a magazine supplement of CommunicationsWeek: Manhasset, New York, pp 4-22.

"Off the Hook: Fiber Optics." Telematics Vol. 4, No. 2 (February 1987).

"One to Watch: Judge Greene and ONA." Telematics Vol. 4, No. 2, (February 1987).

"Open Systems Interconnection: A Review and Status Report." Journal of Telecommunication Networks. In Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, September 1985.

"Optical Fibres Straddle the Globe." The Economist (March 22, 1986): 84-85.

Ostergren, C.N. "What Others Think: Depreciation - What's Going on Here?" Public Utilities Fortnightly (May 25, 1978): 41-3.

"Other Recent Rulings." Public Utilities Fortnightly (January 5, 1984): 58.

"An Overview of Transmission Facilities." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, September 1985.

Pelton, Joseph N. "Telecommunications in the Information Society." Telecommunications Issues and Choices for Society, 1983. In Datapro Management of Telecommunications (March 1985).

Perrine, George R. "Coping with Today's Regulatory Problems." Public Utilities Fortnightly (February 18, 1960): 217-226.

Persinger, Gordon L. Presentation on Capital Recovery to the NARUC Staff Subcommittee on Communications. Manuscript, 28 July 1986.

Pflaum, Christopher C. and Zumwalt, J. Kenton. "Investment Risk Evaluation: The Special Case of the Regulated Firm." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Phillips, Almarin. "Humpty Dumpty Had a Great Fall." Public Utilities Fortnightly (October 2, 1986): 19.

Phillips, Charles F. Jr. "The Changing Structure of the Public Utility Sector." Public Utilities Fortnightly (January 9, 1986): 13-20.

________. The Regulation of Public Utilities: Theory and Practice. Arlington, VA: Public Utilities Reports, 1984.

"Planning a Successful Private Network." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, January 1985.

Pollard, William. Rate Incentive Provisions: A Framework for Analysis and a Survey of Activities. Columbus, OH: The National Regulatory Research Institute, 1981.

"Poor Connection." The Economist (January 26, 1985): 69.

Poth, Harry A. Jr. "Regulatory Treatment of Accelerated Depreciation." Public Utilities Fortnightly (June 9, 1960): 830-47.

Preinreich, Gabriel A.D. "Annual Survey of Economic Theory: The Theory of Depreciation." Econometrica (July 1938): 219-41.

________. "The Principles of Public Utility Depreciation." Accounting Review (June 1938): 149-65.

"'Price Level.' Depreciation for Full Replacement." Public Utilities Fortnightly (December 22, 1960): 971-74.

Priest, A.J.G. "Major Public Utility Decisions in Perspective: Virginia Law Review Vol. 46, No. 7 (November 1960): 1327-44.

Prigmore, Donald G. "Creating Long-Distance Competition at the State Level: What's Needed." Public Utilities Fortnightly (October 31, 1985): 43.

Primeaux, Walter J., Jr. and Nelson, Randy A. "The Impact of Competition of Distribution Costs and Electricity Consumers."

Proctor, Michael S. "Rate Treatment for Cancelled Plant." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Profozich, Russell J.; Burns, Robert E.; Hess, Patrick J.; Kelly, Kevin. Commission Preapproval of Utility Investments. Prepared for the U.S. Department of Energy, Economic Regulatory Administration, Division of Regulatory Assistance. Columbus, OH: The National Regulatory Research Institute, December 1981.

"Progress of Regulation." Public Utilities Fortnightly (January 3, 1952): 60-6.

"Progress of Regulation." Public Utilities Fortnightly (January 7, 1954): 60-6.

"Progress of Regulation Trends and Topics - Allowance for Funds Used During Construction." Public Utilities Fortnightly (September 25, 1975): 51-3.

"Progress of Regulation Trends and Topics: Are Revenues from 'Yellow Pages' Publication for the Benefit of Telephone Investors or Ratepayers?" Public Utilities Fortnightly (July 10, 1986): 43.

"Progress of Regulation Trends and Topics: The Bypass of Local Telephone Facilities: How Serious a Threat?" Public Utilities Fortnightly (May 1, 1986): 49-52.

"Progress of Regulation Trends and Topics: Issues of Definition, Jurisdiction, and Charges for Shared Tenant Services." Public Utilities Fortnightly (December 12, 1985): 52.

"Progress of Regulation Trends and Topics: A Re-Appraisal of the Supreme Court's 1944 'End-Result' Test." Public Utilities Fortnightly (March 6, 1986): 50.

"Progress of Regulation Trends and Topics - Recent Cases on Depreciation Reserve." Public Utilities Fortnightly (February 27, 1975): 48-56.

"Progress of Regulation Trends and Topics: Regulatory Adjustments of Purchased Utility Asset Costs." Public Utilities Fortnightly (October 31, 1985): 58.

"Progress of Regulation Trends and Topics - 1979: The Year in Review." Public Utilities Fortnightly (January 3, 1980): 44-8.

"Progress of Regulation Trends and Topics: 1985 - The Year in Review." Public Utilities Fortnightly (January 9, 1985): 48.

"Progress of Regulation Trends and Topics: An Update on the Financial Need Standard for Rate Base Treatment of Construction Work in Progress." Public Utilities Fortnightly (November 28, 1985): 62.

"Proposed Amendments to FASB Concepts Statements 2 and 3 to Apply Them to Nonbusiness Organizations." Exposure Draft. Stamford, CT: Financial Accounting Standards Board, 7 July 1983.

Pryor, Timothy M. "The Technological Basis of Natural Monopoly and Its Implications for Telecommunications Industry Pricing." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Pryor, Timothy M. and Weaver, Carl G.K. "The Future of Competition in the Telecommunications Industry." Public Utilities Fortnightly (March 5, 1987): 28-32.

"The Public Utility." 1984 Survey of Financial Reporting and Accounting Developments. New York, NY: Price Waterhouse, 1984.

"The Public Utility." 1985 Survey of Financial Reporting and Accounting Developments. New York, NY: Price Waterhouse, 1985.

"The Public Utility." 1986 Survey of Financial Reporting and Accounting Developments. New York, NY: Price Waterhouse, 1986.

"Qualitative Characteristics: Criteria for Selecting and Evaluating Financial Accounting and Reporting Policies." Exposure Draft. Stamford, CT: Financial Accounting Standards Board, 9 August 1979.

"Qualitative Characteristics of Accounting Information." Statement of Financial Accounting Concepts No. 2. Stamford, CT: Financial Accounting Standards Board, May 1980.

Quirmbach, Herman C. "The Diffusion of New Technology and the Market for an Innovation." Rand Journal of Economics Vol. 17, No. 1 (Spring 1986): 33-47.

Raby, William L. and Loveday, Paul M. "Depreciation and Economic Life." Taxes - The Tax Magazine (August 1961): 84-6.

Racster, Jane L.; Wong, Michael D.; Guldmann, Jean-Michel. The Bypass Issue: An Emergency Form of Competition in the Telephone Industry. Columbus, OH: The National Regulatory Research Institute, December 1984.

Radford, Bruce W. "Progress of Regulation Trends and Topics - 1980: The Year in Review." Public Utilities Fortnightly (January 1, 1981): 47-51.

________. "Progress of Regulation Trends and Topics - 1981: The Year in Review." Public Utilities Fortnightly (January 21, 1982): 61-5.

________. "Tinkering at the FERC." Public Utilities Fortnightly (April 2, 1987): 4-7.

Rao, K. Venkata. "Depreciation Methods." The Chartered Accountant (India), May 1966. In The Accountant's Digest (September 1966): 16-18.

Reece, William S. "Federal Telephone Policy and Universal Service." Working Paper 86-8. Baltimore, MD: Loyola College, September 1986.

"Regulated Enterprises - Accounting for Abandonments and Disallowances of Plant Costs." Statement of Financial Accounting Standards No. 90. Stamford, CT: Financial Accounting Standards Board, December 1986.

"Regulated Enterprises - Accounting for Phase-In Plans, Abandonments, and Disallowances of Plant Costs." Exposure Draft. Stamford, CT: Financial Accounting Standards Board, 19 December 1985.

Reinbergs, Modris. "Pricing Excess Electric Capacity." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Reinganum, Jennifer F. "Market Structure and the Diffusion of New Technology." The Bell Journal of Economics (Autumn 1981): 618-24.

"Review of Current Cases." Public Utilities Fortnightly (February 27, 1975): 50-6.

"Review of Current Cases." Public Utilities Fortnightly (March 13, 1975): 52-8.

"Review of Current Cases." Public Utilities Fortnightly (September 25, 1975): 53-59.

"Review of Current Cases." Public Utilities Fortnightly (January 3, 1980): 49-56.

"Review of Current Cases." Public Utilities Fortnightly (January 1, 1981): 51-4.

"Review of Current Cases." Public Utilities Fortnightly (January 21, 1982): 65-8.

"Review of Current Cases." Public Utilities Fortnightly (January 6, 1983).

"Review of Current Cases." Public Utilities Fortnightly (January 5, 1984): 55-7.

"Review of Current Cases." Public Utilities Fortnightly (January 9, 1986): 51-3.

"Review of Current Cases." Public Utilities Fortnightly (January 8, 1987): 48-53.

"Review of Current Cases." Public Utilities Fortnightly (March 19, 1987): 43-4.

Revsine, Lawrence. "Technological Changes and Replacement Costs: A Beginning." The Accounting Review Vol. LIV, No. 2 (April 1979): 306-22.

Richardson, William R. Jr. "BOC Acquisition of Nonwireline Cellular Systems: What is the Commission's Role?" Telematics Vol. 4, No. 2 (February 1987): 3-6.

Rivera, Henry M. and Helein, Charles H. Memorandum - Re: FCC's Report and Order Joint Cost Proceeding CC Docket No. 86-111 [Adopted December 23, 1986; Released February 6, 1987 FCC 86-564]. Washington, D.C.: Dow, Lohnes & Albertson, June 1987.

Rohlfs, Jeffery. "Presentation at Capital Recovery Economic Issues Pannel." USTA Capital Cost Recovery Seminar: Arlington, Virginia, September 21-22, 1987.

Romano, Richard A. "Non-Traffic - Sensitive Telephone Costs: Examining the Components." Public Utilities Fortnightly (November 27, 1986): 18-21.

Rosen, Dr. Richard A.; Low, Dr. Donald A.; Molin, Brian J. "Risk Sharing, Excess Capacity and the 'Used and Useful' Criterion." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

"The Rules of the Game." The Economist (November 23, 1985): 33-34.

Russo, J.G. and Cowles, H.A. "Revalidation of the Iowa Type Survivor Curves." The Engineering Economist Vol. 26, No. 1 (Fall 1980): 1-16.

Schneider, Claudine. "Least-Cost Utility Planning: Providing A Competitive Edge." Public Utilities Fortnightly (April 17, 1986): 15-21.

Schray, Frank. Small Company Depreciation Practices. Paper presented at the USTA Capital Cost Recovery Seminar, Arlington, Virginia, September 21-22, 1987.

Schwartz, Gail Garfield. "A New Deal for Telecommunications." Public Utilities Fortnightly (November 27, 1986): 13-17.

"The Shinto Shake-Up." The Economist (November 23, 1985): 17-20.

Shipman, William D. "Who Should Pay for Overpriced or Abandoned Power Plants." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Shooshan, Harry M. Disconnecting Bell: The Impact of the AT&T Divestiture. New York, NY: Pergamon Press, 1984.

Shooshan & Jackson, Inc. The Negative Effects of Tax Reform on the Telephone Industry: Making Up the $15 Billion Difference. A White Paper Prepared for the U.S. Telephone Association, January 1987.

________. Primer on Capital Recovery, Regulatory Treatment of Taxes and Cash Flow Financial Analysis. Prepared for the U.S. Telephone Association, January 1987.

Smartt, Lucien E. "Pages with the Editor." Public Utilities Fortnightly (July 19, 1984): 5-8 .

Smith, Charles W. "What Concept of Depreciation for Fixed Assets is Most Useful Today?" Journal of Accountancy (August 1951): 166-74.

Sponseller, Diane. "Accounting for Gains on the Sale of Utility Property." Public Utilities Fortnightly (May 16, 1985): 49-52.

________. "Progress of Regulation Trends and Topics: 1986 - A Year in Review." Public Utilities Fortnightly (January 8, 1987): 43-8.

Southwestern Bell Telephone. ONA Planning Handout. No further information available.

Stanford Law Review. "Regent Decisions. Liberalized Depreciation and Public Utility Rate Regulation." Stanford Law Review (May 1961): 610-16.

Stanley, Willard F. "Liberalized Depreciation After Five Years." Public Utilities Fortnightly (September 10, 1959): 401-11.

"The State of Long Distance, 1986." Datapro Managment of Telecommunications. Delran, NJ: Datapro Research Corporation, September 1986.

Statistics of Communications Common Carriers. Washington, D.C.: Federal Communications Commission, 31 December 1971.

Statistics of Communications Common Carriers. Washington, D.C.: Federal Communications Commission, 31 December 1972.

Statistics of Communications Common Carriers. Washington, D.C.: Federal Communications Commission, 31 December 1974.

Statistics of Communications Common Carriers. Washington, D.C.: Federal Communications Commission, 31 December 1977.

Statistics of Communications Common Carriers. Washington, D.C.: Federal Communications Commission, 31 December 1981.

Stella, Mark E. and Wood, Paul J. "Integrated Resource Management: A Process to Enhance the Prudence of Decisions on Plant Modernizations." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

Sterzinger, George J. "Telephone Ownership Since Divestiture." Public Utilities Fortnightly (October 2, 1986): 25.

Stoltz, Michael G. . Overview of March 1987 Support Assets Capital Recovery Survey Performed By Illinois Bell Telephone Company. Presentation at the USTA Capital Recovery Seminar, Arlington, Virginia, September, 22, 1987.

"Strategic Planning in Telecommunication." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, March 1986.

Studness, Charles M. "Electric Utility Issues A Year From Now." Public Utilities Fortnightly (March 20, 1986): 49-50.

________. "Financial News and Comment: Electric Utility Stock Valuation in an Era Without Major Plant Construction." Public Utilities Fortnightly (March 20, 1986): 49.

Survey of Current Business. "Alternative Estimates of Corporate Depreciation and Profits, 1965-1970." Survey of Current Business (January 1972): 34-5.

Sussman, M. Richard. "Depreciation Revisited." Public Utilities Fortnightly (February 26, 1970): 31-35.

"Telecommunications Survey," The Economist, October 17, 1987, pp. 1-34.

Telecom Publishing Group. "On The Road To ISDN: A Status Report On The BOC Field Trials," (mimeo). Telecom Publishing Group, Alexandria, Virginia, March 1987, pp. 1-4.

"Telephony: A Primer." Telecommunications: Concepts, Development, and Management, 1985. In Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, September 1985.

Temple, Barker, & Sloane, Inc. Project Risk Analysis: A Case Study of Plant Life Extension. Final Report Prepared for Electric Power Research Institute. Lexington, MA: Temple, Barker, & Sloane, Inc., March 1987.

Thayer, Rufus G. and Wilson, Lionel B. Concurrent Opening Brief of the Public Staff Division on Certain Results of Operations Issues Designated by the Commission. In the Matter of the Application of Pacific Bell. Public Utilities Commission of California, 20 March 1987.

"Theory of Ratemaking." Telecommunications: Concepts, Development, and Management, 1985. In Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation.

Tunstall, W. Brooke. Disconnecting Parties. Managing the Bell System Break-Up: An Inside View. New York, NY: McGraw-Hill, 1985.

"The Unknown Unknowns." The Economist (November 23, 1985): 40.

Updaw, Nelson, J. "Potential Relationships Between Changing Depreciation Methodology and Plant Average Service Life." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

U.S. Government. Report and Recommendations of the United States Concerning the Line of Business Restriction Imposed on the Bell Operating Companies by the Modification of Final Judgement. United States v. Western Electric Co., Inc., 1987.

USTA Capital Recovery Methods User Group, 1987 Authorized Depreciation Methods and Amortization Treatment Report, Washington, D.C., September 8, 1987.

USTA Engineering Depreciation Subcommittee, 1987 USTA Depreciation Data Base Major Telephone Companies, Washington, D.C., April 15, 1987.

USTA Engineering Subcommittee on Depreciation, 1987 Activity Report, Washington, D.C., September, 1987.

U.S. Telephone Association. Phonefacts. Washington, D.C.: USTA, 1986.

Vial, Donald. "Civil Rights for the Marketplace?" Public Utilities Fortnightly (January 22, 1987): 11-14.

Von Auw, Alvin. Heritage and Bell Destiny: Reflections on the System in Transition. New York, NY: Praeger, 1983.

Wald, Haskell P. "A Regulatory Economist Looks at Computer Services." Public Utilities Fortnightly (July 8, 1971): 25-29.

Weiler, Thomas N. "The Accounting Dilemma: Should Book Depreciation Conform to Tax Depreciation?" The Journal of Taxation (May 1963): 264-66.

Weiss, David H. "Telephone Plant Utilization." Proceedings of the Fourth NARUC Biennial Regulatory Information Conference. Edited by Raymond W. Lawton. Columbus, OH: The National Regulatory Research Institute, September 1984.

Weiss, William L. "The Department of Justice in Telecommunications: Time for a Change." Public Utilities Fortnightly (November 14, 1985): 15.

"While Waiting for ISDN: Applying Evaluation Techniques to the Convergence of Technology." Datapro Management of Telecommunications. Delran, NJ: Datapro Research Corporation, September 1985.

White, P.E.. Trends in Telecommunications Transmission Technology. Bell Communications Research: Morristown, New Jersey, 1987.

Wilkerson, Mark. "Concepts in Streamlining the Depreciation Study Process." Florida Public Service Commission.

Williams, Frederick. The Communications Revolution. Beverly Hills, CA: Sage Publications, 1982.

Wiley, Joe M. "Barriers to Integrating Voice and Data." Data Communications, March 1983. In Datapro Management of Telecommunications (January 1985).

Wilson, John W. "Telephone Access Costs and Rates." Public Utilities Fortnightly (September 15, 1983): 18-25.

Winn, Michael. "Multi-Tenant Services." Datapro Management of Telecommunications (October 1985).

Woerner, George. "Put Decommissioning Costs Where They Belong." Proceedings of the Fifth NARUC Biennial Regulatory Information Conference. Edited by Robert E. Burns. Columbus, OH: The National Regulatory Research Institute, September 1986.

"The World on the Line." The Economist (November 23, 1985): 5-8.

Wright, F.K. "Towards a General Theory of Depreciation." Journal of Accounting Research (Spring 1964): 80-90.