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STRATEGIC PLANNING FOR TECHNOLOGICAL DISCONTINUITIES IN A CHANGING REGULATORY ENVIRONMENT

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Abstract

Discontinuous changes in technologically driven industries present challenges to business survival, particularly when coupled with the deregulation of a traditionally protected industry. Clearly, firms in this new deregulated environment will need to adapt to the competitive forces and quickly take advantage of new technological opportunities. Publicly available financial information can provide a glimpse of the structural response to technological discontinuities. This information would be useful to assess whether the industry is accepting new competitive paradigms, or reacting in the traditional way. This is important since competitive advantages can be realized by early introductions of new products and processes. However, it is difficult to analyze the data and assess the industry's traditional rate of technological diffusion.

This paper describes an approach to the analysis of publicly available financial data for individual industries. These methods enable the analyst to assess past practices and the historical rate of technological diffusion during the transition period of discontinuous technological change. This assessment can provide a basis of comparison for current changes in their industry. These methods are applied to small rural telephone companies during the period of 1960 to 1996. Annual data is presented detailing the change from aerial distribution cable to buried cable by the roughly 600 rural telephone companies financed through loans from the Rural Utilities Services, a branch of the U.S. Department of Agriculture. This change took place at a time when these companies were regulated public utilities. As such they were guaranteed profit and were not subject to competition.

With the passage of the Telecommunications Act of 1996, and the expectation of nationwide competition in telecommunications services, these firms will be faced with a much more volatile environment, in which firms can fail. Measuring past event through this approach can accentuate critical business practices. This analysis of longitudinal data can provide the rural telephone companies assessment of the change in technology diffusion based on the new competitive forces, and provide direction to management as it attempts to sail in this new uncharted territory.

I. Introduction

Changes in technology are common to all industries. New technologies can bring about changes in the way a product or service is delivered. In complex systems hardware and software are joined to produce output, and either may be the subject of change. The way in which companies, and entire industries, react to these changes, can provide insights into the companies, the industry and the technology being deployed.

This study examines changes in the type of cable used to deliver telephone service to rural areas of the United States. This change took place in the 1970's and 1980's, a time when system software did not play as great a role as is common today. The companies studied are regulated public utilities and, therefore, are not subject to many of the competitive market forces present in other studies of technology change.

II. Background

Technology lives, or cycles, have been characterized as phenomena that "...can be modified by careful management but not sidetracked..." [1]. Rogers' adopter groups illustrate technology lives based on the diffusion of technology through various user groups [2]. The work of Bass and others extends this knowledge to growth models leading toward long-range forecasting of diffusion life cycles [3] [4]. In the present study we observe the diffusion of new technology through the rural telephone company user group. The development of models for forecasting is left for future work.

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While companies cannot control change, each must select the strategies, structure, tools and techniques they believe will help them to survive and prosper [5]. Corporate strategies and visions evolve over time as companies and industries become aware of new technologies and begin to put them into use. Radical changes take companies progressively further from the operating environment, systems and skill sets they have come to rely upon. Dealing with changing technologies in the context of an organization's history can add stability and perspective to periods of turbulent change. While nothing moves backwards, a company's history is none-the-less a reliable point of reference and a measure of underlying values and goals which can provide direction in times of uncertainty.

The regulated telephone industry has a well-established history of providing dependable service. It has not been concerned with questions of profitability, competition or market share. New technologies have been approached cautiously and conservatively, and must meet strict quality and test standards before being deployed to provide improved or additional services.

Severe technological discontinuities cause established industries to change so drastically that they are essentially reborn. They may exhibit the characteristics of new, immature industries[6]. In order to gauge reactions and achieve some measure of the severity of a technological discontinuity, it is important to know what has changed and the magnitude of the change. New technologies may occur and effect operations at any point from the component level to the system level. Other ways to measure the magnitude of technical change include studying changes in competencies needed to employ new methods, physical changes in the product, changes in the character of the service, or changes in the relationship between price and performance (or revenue and expense).

The absorptive capacity of a firm has been defined as "...the ability to evaluate, assimilate and apply outside technological knowledge to commercial ends..." [7]. On a practical level, absorptive capacity is the firm's ability to find and acquire the technology needed to allow that company to progress with the balance of the industry and meet society's changing wants and needs. This new technology must be successfully integrated into current operations and compliment, or at least not degrade, existing capabilities.

The relationship of new technology to an industry's or a firm's knowledge or competency base can indicate how successfully it will be deployed and integrated [8]. New technologies that are "competency enhancing" build upon existing skills and improve product and service quality, and workers' efficiency. Changes that are "competency destroying" require new skills sets, new methods of operation, and new measures of performance quality.

The extent to which a new technology is disruptive, that is, does not work well with the installed base, is an important indicator of its success or failure [9]. Disruptions can be minimized by either isolating new technologies from those currently deployed, or by integrating them smoothly into the current environment. Disruptive technologies introduce a new set of attributes and capabilities; they may be far better or far worse depending on the performance measure [10]. Sustaining technologies, on the other hand, yield an improvement or addition to known attributes.

Often firms that are new entrants to an industry the most successful in deploying new technologies [11]. Natural resistance to change creates inertia within established firms. This can lead to difficulties in crafting a long-term corporate strategy that includes developing internal competencies to deal with changing technologies. The greater the magnitude of the change in technology the greater the variety in firms' responses within an industry.

III. Data

In the early 1930's the United States Congress established the Rural Electrification Administration (REA) within the Department of Agriculture. The goal of the REA was to provide low interest loans and other assistance to encourage private companies, or cooperatives, to extend commercial electric service to the unserved rural areas of the United States. In the late 1940's the REA program was amended to add the Telephone Loans Program. The objective of this new program was to complement REA's success in bringing electricity to rural areas with rural telephone service. During the 1990's the REA was reorganized under the newly formed Rural Utility Services (RUS). For simplicity, and since the activities which are the subject of this paper all took place prior to this reorganization, the program will be referred to as REA throughout this paper.

Since shortly after the beginning of the Rural Electrification Administration's Telephone Loans Program the U.S. Department of Agriculture has published the Annual Statistical Report, Rural Telephone Borrowers (REA Bulletin 300-4). These reports present income statements, balance sheets and subscriber data for each telephone company borrowing from the REA. In addition, the reports include an extensive compilation of summary data for all the companies. This is publicly available information. Accounting standards are prescribed by the REA and generally follow the rules for accounting for Class A and B telephone companies as set forth in Title 47 of the Code of Federal Regulations – Telecommunications. Over the years there have been changes in the accounting methods used. Most have been minor, but on occasion major changes have occurred.

This publicly available information is used to investigate the effects of a change in telephone cable technology that took place between the late 1960s and the mid-1980s. An accounting change in 1988 limits the use of the database to 1960 through 1987, but the technology change under study is well illustrated by the available information.

IV. Case Study

During the period when the technology under study was being deployed financial activity associated with different classes of outside telephone plant, including cable, was separated in the companies' accounts. Figure 1 illustrates the rate of deployment of new cable technology in terms of total investments in various types of cable. Table 1 shows account balances for the four types of telephone cable whose deployment underwent the radical change being studied. Changes in account balances between 1964 and 1987 show that buried cable, aerial cable and underground cable were being deployed and aerial wire was being taken out of service. The totals of these four accounts also show the amount of investment in new telephone cable by REA telephone borrowers during this period.

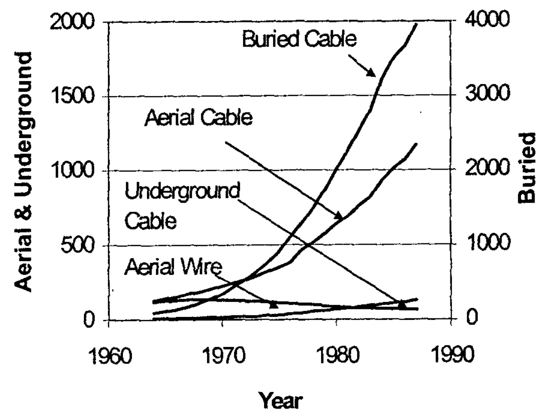

Fig. 1. Total Cable Investment by Type for REA Borrowers ($ million)

Prior to this technological change, virtually all telephone cables were mounted on poles above ground. Individual wires were wrapped in color-coded paper and encased in a lead sheath. The purpose of the lead sheath was to protect the individual conductors from weather, rodents, insects and other hazards. This type of cable was used in more densely populated areas. Many rural subscribers were served with unshielded, heavy gauge, copper-coated steel wire mounted on distribution poles and secured to glass insulators.

Table 1. Effects of Technology Deployment

	12/64 Account Balance	12/87 Account Balance	Competence Destroying	Competence Enhancing
Buried Cable	88,500	3,943,600	X	
Aerial Cable	128,000	1,164,200		X
Underground Cable	7,500	130,800	X	
Aerial Wire	120,600	65,400	na	na
Total	344,600	5,304,000	na	na

Cable designed for direct burial in soil was a radically new technology. Buried cable is covered with polyethylene plastic. Beneath the plastic covering is a corrugated copper, or copper-coated steel, shield to protect the individual conductors from rodents, rocks or other physical damage. The individual conductors are 19 to 26 gauge copper wire coated with plastic. A single underground cable may contain over 1000 pairs of conductors or as few as two pairs. The earliest buried cable installations included a filling compound between the conductors within the center of the cable, but only in smaller pair sizes (50 pairs or smaller). This protective filling helps negate the problems of water in the underground environment and the difficulty of locating faults [12]. By the late 1970s all buried cables were filled.

Large buried cables are placed in open trenches and backfilled. Smaller cables can be buried by feeding the cable through a trough at the back of a thin metal blade, much like a knife cuts through butter. The blade is pulled through the ground with one or more heavy earthmovers or smaller machinery depending in the cable size and soil characteristics. At regular intervals during installation the buried cable is exposed above ground in metal enclosures, or pedestals. These access points allow maintenance, testing, subscriber connections and proper grounding; they are subject to mechanical and rodent damage. The numerous connections needed to bond conductors at these access points are accomplished with small waterproof connectors that can be quickly clamped into place.

Virtually all of the methods and technology involved in installing and maintaining buried cable were new to the industry. It was a competency destroying technological discontinuity. While the rural telephone industry, a regulated public utility, did not have to be concerned with loss of customer base or market share, or new competitors, they did have to absorb and employ a new knowledge base. The quality of the workforce, the active part that REA personnel took in informing and educating borrowers' staff, and the desire of the telephone companies to improve efficiency aided the acceptance and success of this new technology. The magnitude of the change can be seen not only in the dollars invested, but also in the length of time over which buried cable was deployed. This time span illustrates the variety of response to this radical change in terms of the period in time at which individual companies chose to deploy buried cable.

At the same time that obsolete aerial telephone plant was being removed from the rural areas, cities and towns were also upgraded to new cable designs. These cables continued to be installed above ground on poles. The expense involved in dealing with existing city utilities, multiple land owners, city streets and easements, and post-construction repairs to disturbed areas made burying cables in cities and towns cost prohibitive. This change was competency enhancing. It was an improvement on existing technologies and methods as opposed to a wholesale replacement as was the case with buried cable.

Underground telephone cable is placed within an empty pipe, or duct, rather than being directly buried in soil. This style of plant placement was in limited use during the study period. Except for the need to pre-install facilities in which to place the telephone cable, all other aspects of deployment of underground cable are the same as buried cable. Both were competency destroying technological changes.

Most new buried cable replaced aerial wire that had been in use since the beginning of the REA Telephone Loans Program. The change in costs since it was initially installed, and the relatively greater costs of multi-pair cables as compared to individual wires, account for the fact that the investment in aerial wire is so much smaller that the investment in buried cable. This work involved a nearly total replacement of telephone cable and wires. Therefore, there were only few cases where new and old technology had to interface. These were primarily in rural areas where aerial wire was retained due to costs. Connections between the new buried cable and retained aerial wire were satisfactory; the differing technologies interconnected without harm to the new cable or to service quality.

Strategies employed by the REA telephone companies were closely tied to their history and business structure. These locally owned companies were prone to be conservative but uncompromising in their primary goal of high quality service. They enjoyed the isolation from competition characteristic of public utilities, and support and guidance from the REA. Examination of operational data can help to develop insights into how typically or atypically this industry segment has reacted to technological change.

Diffusion curves normally show sales or revenues from operations, over time. Figure 2 shows the change in total operating revenues. The steady growth over the period during which this new cable technology was deployed is typical of the deployment of a successful new technology. In a competitive environment increasing revenues would be the result of sales of new products or services. In the case of a regulated public utility the increased revenues result from a combination of adding previously unserved customers, rate increases and normal growth. It is also reflective of improvements in the price/performance relationship of the service offered. Figure 3 shows the change in long-term debt incurred by the study group as this new technology is deployed. As discussed previously this additional debt could be tolerated due to the associated increase in revenues.

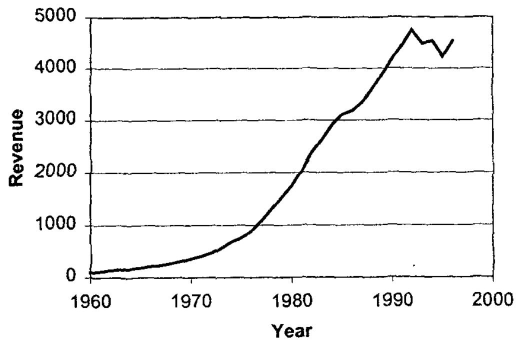

Fig. 2. Total Operating Revenues of REA Borrowers ($ million)

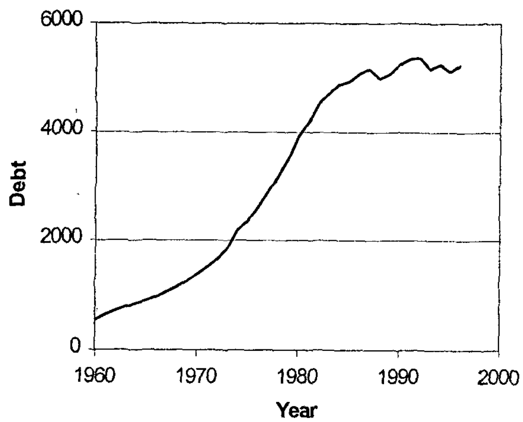

Fig. 3. Total Long-Term Debt of REA Borrowers ($ million)

While it is desirable that new technologies add to operating efficiencies, it is not always true. In this case maintenance expense continued to increase from year-to-year as shown in Fig. 4. However, in the mid-1980's, as deployment of new cables was nearing completion, maintenance expenses decreased. Maintenance expenses include the costs of maintaining all parts of the system. New cable technology was able to decrease the overall expenses for a short period only to be overshadowed by increasing expenses in other areas of the companies' operations, notably aging electromechanical

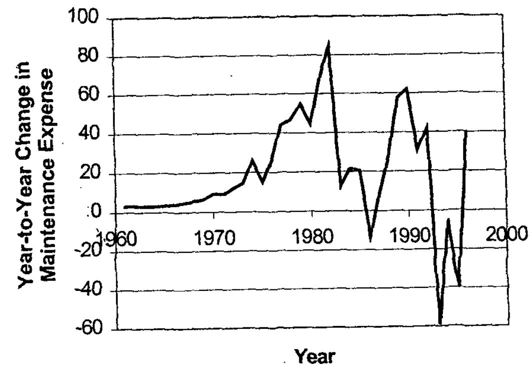

Fig. 4. Year-to-Year Change in Maintenance Expense of REA Borrowers ($ million)

switching equipment. (The replacement of switching equipment was the next major change in the industry and is outside the scope of this paper.)

An abrupt and continuing decrease in the number of employees per subscriber needed to provide service is shown in Fig. 5. This clearly illustrates an increase in operating efficiency that began with the replacement of obsolete cable and wire, and continued through later technology updates, such as the switching equipment referred to above.

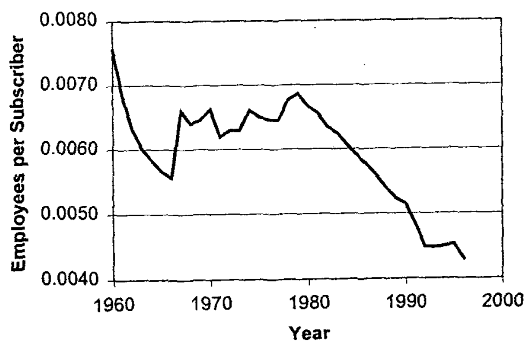

Fig. 5. Average Number of Employees per Subscriber for REA Borrowers

An illustration of the effects of the diffusion of this new technology on the rural telephone companies' subscribers is seen in the change in the percent of rural telephone subscribers with private lines. The graphs in Fig. 6 are broken down by residential and business subscribers. Historically, business subscribers were located in the most densely populated areas served by rural telephone companies and it was these areas in which private line telephone service was initially available. Residential subscribers, on the other hand, were spread much more evenly throughout the service areas and, therefore, were more likely to be on multi-party lines. Multi-party lines were historically deployed in more sparsely populated areas. As this new technology was deployed it was the goal of the REA program to eliminate multi-party service throughout all of the operating areas of all borrowers. The graphs illustrate the success of this initiative.

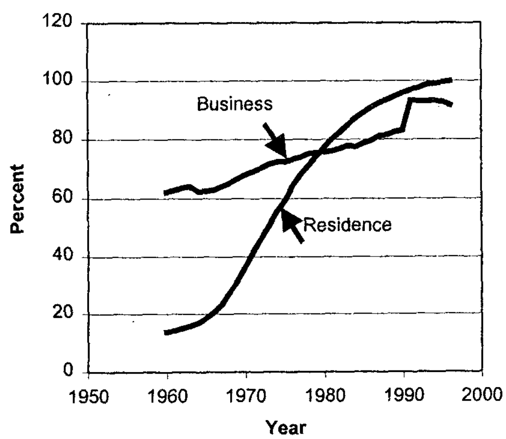

Fig. 6. Percent of Subscribers by Class with Private Lines

Despite the differences in the business environments of regulated public utilities and competitive industries the data shows that the REA borrower group successfully deployed radically new technology. The increased income, efficiency and number of customers are typical of a successful new product or service introduction in a competitive business environment. New competencies were developed and new technology was successfully deployed. And, despite the magnitude of change the industry displayed no evidence of any setback, or "dematuring", as a result of these changes. Yet the fact remains that these activities were carried out virtually without risk. Even the laudable goal of eliminating party lines was not a matter of subscriber choice. As new cables were installed party lines were no longer available.

V. Conclusions

Freedom from competition, and the obligation to provide service, have been the primary goals of regulated public utilities. The rural telephone companies have pursued these goals in the context of local ownership and accountability. Their business practices are generally conservative but also strongly customer service oriented. The additional benefits of REA guidance and an acceptance of the need for improved service buffered, or negated, most of the destructive effects normally associated with radical technological change. The companies were able to incur large amounts of debt from the REA and simultaneously increase revenues to service that debt. REA guidance and the quality and dedication of rural telephone company employees made the adoption of new methods and attainment of new competencies a much easier task than would be expected or possible in other industrial environments. The competencies that were destroyed, such as the skill to repair lead cable or climb poles, were gladly forgotten. Customers readily accepted the extra cost of a dependable private line. Buried cable and private lines were early steps toward technologies and services that are still being deployed today. The service life of buried filled telephone cable, baring physical damage, has yet to be determined.

In recent years the integration of digital electronics, semiconductors and fiber optics has moved this industry into the mainstream of advancing technology. The promise of a competitive business environment caused by the Telecommunications Act of 1996 adds to the disruptive effects of changing technologies. New technologies, products and services must be managed as rapid changes tend to decrease their useful lives. Increased emphasis is needed on market research, test marketing and gaining a greater understanding of changing customer needs and wants. The outcome of this work can help drive profitable new ventures.

In a competitive environment, no advantage can be overlooked. The rural telephone companies have the advantages of the insider's knowledge of the industry and an in depth understanding of their customers. This can aid companies in recognizing product and service opportunities. Coupling this knowledge with an understanding of the finite and ever decreasing lives of new products and services may can aid the rural telephone companies in shaping competitive posture to meet an uncertain future.

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