

## The Introduction of Automatic Switching into the Bell System: Market Versus Institutional Influences

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In neoclassical economics, the postulated behavior of firm profit maximization is a comprehensive idea that subsumes important institutional details concerning management and organization. In accounting for the behavioral diversity of firms in the same industry, the common practice of deducing the incentive structure that decides the behavior of firms from the concept of market forces is ineffective.<sup>1</sup> Differences in the behavior of firms facing similar environments is strong evidence that institutional details are needed to account for why precisely defined factors located in the external environment do not uniquely determine the sensitivity of a firm to market stimuli.

An idea forcefully articulated by adherents of evolutionary economics is that firms operate in changing environments where there is no simple correspondence between having a goal (engage in activities valued by the market) and the myriad possible ways of achieving it.<sup>2</sup> According to Nelson and Winter [1982], the existence of firm-specific knowledge embedded in routines plays a major role in explaining differences among firms facing similar market parameters.

A key characteristic of routines is that knowledge is tacit. In evolutionary theorizing, the intelligence behind successful adaptations to changing environments is reflected in organizational capabilities that emerge from the practice of routines.<sup>3</sup> The

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relevance of organizational capabilities for explaining the success of vertically integrated enterprises is carefully articulated by Chandler [1990;1992].

The research of evolutionary theorists, along with that of Chandler, illustrates that the firm is not simply a passive reactor to market forces.<sup>4</sup> In this paper, we also adopt the perspective that firms shape markets. However, we do not view the creative energies of the firm as emerging automatically from a given technology, the practice of routines, or three-pronged investments in management, manufacturing, and distribution.<sup>5</sup> As Winter [1982] comments, "What is defensible is a conception of the firm as a significant and persistent but historically contingent entity, a repository of specifically organizational productive knowledge that is a reflection of its evolution. "Similarly, we view the firm as a cognitive entity where the explicit recognition of ideas is relevant for understanding how the firm shapes and responds to its environment.

In this paper, the intelligent and creative accumulation of experience reflected in the ideas of key personnel is used to explain the American Telephone and Telegraph Company's (AT&T) behavior toward a major innovation, automatic switching. Automatic switching, a technology that involves using machines to connect customers' telephone lines, was available for sale from electric manufacturers in the late 1890s. By the turn of the century, many of AT&T's competitors had deployed this new technology. However, the large-scale adoption of automatic switching by AT&T did not begin until 1919.

We argue that AT&T's utilization of the technological opportunity of automatic switching cannot be understood without reference to specific ideas that hastened the commitment of management attention to particular courses of action. We refer to such ideas as ideological presuppositions and conclude that when a multiplicity of actions appears reasonable, ideological presuppositions resolve some of the rationality issues firms face. For this reason, ideological presuppositions are an institutional achievement essential for the development and growth of productive knowledge within the firm.

The relevance of ideological presuppositions for understanding AT&T's reluctance to adopt the new technology of automatic switching is reflected in the fact that there were strong economic incentives for AT&T to adopt automatic switching earlier than 1919. The equipment was available, surveys showed that customers exhibited a strong preference for the technology, and it was deployed by rivals. The firm's delay in adopting automatic switching was criticized by the Federal Communications Commission in its 1939 investigation of the firm and by the Department of Justice in its 1949 antitrust suit against AT&T [Sheahan 1956, 263].<sup>6</sup>

Our explanation is that ideological presuppositions about the telephony needs and preferences of customers accounted for the delay. The beliefs that affected AT&T's appraisal of automatic switching emerged before the arrival of competition and were based on the critical vision of an early leader of the company, Theodore

Vail. Vail's slogan, "One System, One Policy, Universal Service," reflected crucial ideas about how to make the telephony market prosper and grow. Such ideas effectively served as the knowledge base for beliefs that affected the company's adoption of automatic switching. Thus, we find that key personnel within AT&T did not perceive that automatic switching would be ready for adoption by the firm until the equipment was (1) capable of rendering effective service in large cities, and (2) consistent with understandings within the firm regarding subscriber capability. When these two conditions were satisfied, the technological opportunity of automatic switching could be utilized within the constraints set by Vail's vision.

A crucial feature of our explanation is that we find no market forces that made it inevitable that Vail's vision emerge. Furthermore, the corresponding beliefs guiding the appraisal of automatic switching were not in any way predetermined by the environment. Such beliefs emerged because the challenges AT&T faced did not map only one path of response.<sup>7</sup> Since it was impractical for the firm to explore all the possibilities for developing its market, the demands of rationality were satisfied by conceptually anchoring the company to a specific path of market development. In the firm's intellectual setting, the vision of Vail received center stage—an accomplishment that served the company's long-term interests. Yet, we find that ideological presuppositions rooted in Vail's ideas about the market also acted as cognitive blinders that inhibited AT&T's behavior toward a major innovation. This suggests that the firm's environment was more forgiving than would be envisioned by a neo-classical perspective. In addition, a striking aspect of AT&T's behavior regarding automatic switching was the weak reliance placed on market parameters as transmitters of knowledge. In the conclusion, we discuss some broader issues this raises about the firm as a cognitive entity.

### *Market Influences and Automatic Switching*

In 1894, with the expiration of Bell's patents, AT&T faced entry into its market. The newcomers, known collectively as the Independents, started primarily in small cities and towns in the Midwest but quickly spread out through the nation and into larger cities. Just when AT&T confronted competition from the Independents, the technology of automatic switching became available. Before the development of automatic switching, subscriber lines were connected by operators.<sup>8</sup> "The installation of the first Strowger prototype at the exchange in La Porte, Illinois coincided almost exactly with the establishment in the United States of 'independent' telephone companies not affiliated to the BELL system" [Chapuis 1982, 61]. Where automatic switching was installed by the Independents, the Strowger automatic system, called a step-by-step system, was the most commonly deployed [Chapuis 1982, 67].<sup>9</sup>

Experts from AT&T studied the step-by-step installation and commented: "The evidence seems to show that the La Porte, and perhaps other small exchanges, using and operating the Strowger Automatic Apparatus, at the present time works well and gives good satisfaction" [Baughman 1981, A-165]. There was other market information that favored the rapid deployment of automatic switching. In 1902, a sales representative for automatic switching commented to AT&T officials that, unlike manual switching, automatic switching was profitable for small exchanges. Therefore, the new technology could help AT&T in preempting the Independents who were entering the market primarily through small and medium exchanges.<sup>10</sup>

The Independents were not a force to ignore; by 1907, their market share was approximately 50 percent. The Independents' relative advantages were in the quality of their local service, their pricing, their greater responsiveness to the desires of customers, and their willingness to develop the markets outside large cities. By 1910, 200,000 of the Independents' customers were served by automatic switching machines [Chapuis 1982, 67].

Customers of telephony found appealing the privacy of communication and the immediacy of service of automatic switching.<sup>11</sup> A contemporary observer noted that major drawbacks to manual switching involved human error, unfriendly service, eavesdropping, and cost. "Hence, the automatic had its origin in the desire for secrecy, speed, accuracy, and uniformity in the telephone service and increased profits to the investor" [Smith 1911, 42]. Moreover, AT&T was aware of consumers' preferences for automatic switching. Its management learned about customer preferences through the collection of field data.

A typical study concluded that

Subscribers, in general, are well pleased with the constant service which the [automatic] system gives them; the rapidity with which a connection may be made, especially a toll connection, and the truthfulness of the busy test. They prefer this system to the old manual switchboard that was in use before the installation of the automatic exchange.<sup>12</sup>

AT&T's management was particularly concerned about the opinion of the business community. Business customers clearly expressed their preference for the automatic switching technology used by the Independents for local calls:

Business men say that they prefer the automatic system to the manually operated board as time is saved them in obtaining a connection, for the following reasons: it is not necessary to wait for the operator to answer; the operator requires that the desired number be repeated, in many instances; the automatic seldom gives the wrong number; "The busy test is reported truthfully"; and "the best feature," as explained by one prominent business man, "Is that a second connection may be made immediately, without waiting for the operator to take down a former connection."<sup>13</sup>

The descriptive reports received by AT&T's management were accompanied by results from customer surveys. As indicated in Table 1, the majority of those surveyed preferred automatic switching.

In evaluating these data, AT&T's management realized that other factors were also significant, such as price and the number of customers who could be reached. A survey undertaken in Chicago controlled for these other influences. In Chicago, the Independent only provided service in the downtown business district. Therefore, AT&T asked subscribers in the business district which telephone they would "prefer to use if both companies had the same number of subscribers, and the cost of service was the same?" Sixty-three percent of the respondents said that they preferred the automatic phone, 6 percent preferred Bell's manual telephone, while 31 percent showed no preference.

Although successful Independent exchanges using automatic switching were visible to AT&T as early as 1904, it was not until 1919 that step-by-step was "authorized for small multi-office and single-office cities of the Bell System" [Federal Communications Commission 1939, 261]. According to the firm's chief engineer in 1919, Bancroft Gherardi, the Bell Operating Companies facing the strongest competition from Independents had advocated an earlier adoption of automatic switching:

The company that has probably been the most anxious to introduce this new system has been the company on the Pacific Coast where, as you know, large automatic installations were made by competitors in such cities as San Francisco and Los Angeles and where at the same time, manual service conditions were as a whole satisfactory [Baughman 1981, A-230].

Despite knowledge from the market regarding customers' preferences for automatic switching, and the presence of competitors, AT&T did not act quickly to adopt automatic switching.<sup>14</sup> In the next two sections, we offer an interpretation as

**Table 1. Results From Customer Survey, 1904**

Which telephone do you prefer to use:	Dayton	Fall River	New Bedford
Automatic	63.3%	56.6	68.5
Bell	8.3	36.1	20.5
No preference	28.4	7.3	11.0

Sources: "Tests of the Strowger Automatic System in Chicago, Illinois," October 18th, 1904, AT&TCA file no. 11 07 01 02; "Tests of the Strowger Automatic Telephone System at Dayton, Ohio," November 3, 1904, AT&TCA file no. 11 07 01 02; "Tests of the Strowger Automatic System at New Bedford, Mass," September 28, 1904, AT&TCA file no. 11 07 01 02; "Tests of the Strowger Automatic Telephone System at Fall River, Mass," October 20, 1904, AT&TCA file no. 11 07 01 02.

to why these market incentives did not result in an earlier use of automatic switching.

### *Understanding AT&T'S Behavior Toward Automatic Switching*

Looking back over the early history of AT&T, the comments in 1926 by AT&T's chairman of the board, H. B. Thayer, reflect the firm's recognition that the existence of the telephony market presupposes a way of seeing it.

Telephone service was not created to fill a demand. Long line service between Boston and New York and then Chicago and Denver and San Francisco was not to fill a demand—the service creates the demand [American Telephone and Telegraph 1926, 11].

The importance that AT&T placed on providing long distance service emerged from the "vision" of Theodore Vail. Vail<sup>15</sup> perceived that telephony's value could be increased by connecting customers throughout the nation into one integrated network. The importance Vail attached to building a national network is reflected in his motto "One System, One Policy, Universal Service."<sup>16</sup> Vail's vision was established before any market information was available regarding the profitability of long distance telephony. Vail pointed out that "if in the early days the immediate and individual profit of the long-distance toll lines had been considered, it is doubtful if any would have been built" [Chapuis 1982, 104].

One reason the company had to originate its own path of market development, and therefore had a strong need for the creative ideas supplied by Vail, was that there were no providers of an identical product for AT&T to imitate. The most similar product to long distance telephony was telegraph service. Demand for this older technology seemed to provide an indication that long distance telephony could be profitable. Despite the absence of clear direction from the market, key personnel within AT&T perceived that there would be benefits from the provision of long distance service.<sup>17</sup>

The early leaders of AT&T envisioned telephone lines being used for inter-city business transactions. As the nation's industrial sector grew, there was an increased need to arrange business in other towns. The level of commercial activity, as reported in Dun's *Mercantile Agency Reference Book*, played an important role in deciding which cities should be connected to its long distance network. If the Dun's report showed a substantial amount of commercial activity, cities were tied into the long distance network. Since most smaller cities and rural communities did not receive a high ranking under these criteria, they were not linked into AT&T's network [Weiman 1992; Langdale 1987, 145; Fischer 1992, 41-2].

After long distance service started, AT&T undertook surveys to determine customer interest in long distance telephony. The surveys showed that the overwhelm-

ing majority of customers did not place a great deal of importance on it. As shown below, only a small percentage of the customers identified AT&T's superior long distance network as a reason to prefer Bell service to that of its rivals.<sup>18</sup>

The data show the percentage of subscribers who like the Bell System on account of its long distance business:

Dayton	Fall River	New Bedford	Chicago
4.4%	6.1	12.3	2.4

The low importance that most customers placed on AT&T's long distance network is consistent with other information received by the firm's management. In 1907, local calling made up 98 percent of the calls placed [U.S. Dept. of Commerce 1975, 2:783].<sup>19</sup> During 1903, 50 calls were the largest daily volume of calls between New York City and Chicago, and in 1905 on average, only 15 calls a day went between New York City and Cleveland. The AT&T Operating Company serving Ohio, Indiana, and Illinois studied customer calling habits about 1905 and found that "only about twenty percent of the exchange subscribers ever patronized a toll line at all, and only . . . three and a half percent . . . ever patronized a toll line over a hundred miles" [AT&T 1909, 30]. In 1906, after reviewing the evidence, a consultant for AT&T concluded that the long distance toll business was "but a trifling fraction of the entire traffic and affects but few subscribers."<sup>20</sup>

Despite evidence that few customers would use the service, crucial personnel within AT&T were committed to the goal of developing the market for long distance telephony. This focus on developing the long distance market influenced AT&T's adoption of automatic switching [Gabel 1989, 25-26; Lipartito 1991; Baughman 1981, A-207]. In 1910, an address given by the firm's chief engineer, John Carty, reflects how in the design of AT&T's network, beliefs about the telephony needs and preferences of consumers were paramount:

We must regard our plant as the landscape architect views the subject matter with which he works. He must plant his trees and shrubs not with a view to the immediate results, but he must have in mind the space which will be occupied and the shape and character of his plantation as it grows to maturity. He must leave room for his trees to grow and must have in mind at the beginning the total effect which he desires to produce. So it is with us. We are planning a magnificent park with its groves of trees and shrubs [Carty 1910, 13].

AT&T's management believed that in order to realize the economic potential of its integrated network, the company had to provide superior service in large cities [Carty 1910, 13; Hall and Lowry 1919, 5].<sup>21</sup> There was expressed concern that automatic switching would not efficiently handle inter-office trunking in large cities. According to Carty, because of the limited memory built into step-by-step switch-

ing, the early machines could not handle the large trunk groups that connected different switchboards within large cities. High-level engineers and managers within AT&T proclaimed in a report that the firm should not install automatic switching until the trunking problem for large cities was solved.<sup>22</sup>

When we look outside the firm, it is unclear that such a perception of the trunking issue was the only possible way to view the problem. At an international conference of experts in 1910, most of the presentations offered a favorable assessment of automatic switching. As expressed by one participant, "Both large and small networks in continental Europe are now using automatic systems which have demonstrated their reliability and adaptability to technical requirements" [Chapuis 1982, 77]. A report on automatic switching published by the Electricians Press in 1911 states that "in a cosmopolitan city the advantage seems to be with the automatic as regards operating by the public" [Chapuis 1982, 148]. In addition, the Independents did not view the trunking problem as an insurmountable barrier that would prevent the deployment of automatic switching. The Independents were using automatic switching in some of our nation's largest cities such as Columbus and Los Angeles.

Another belief that shaped AT&T's behavior toward automatic switching is related to the perception of the proper role of customers in placing a call. Despite an abundance of information that customers preferred to dial on their own, a consensus was reached that in selecting technology, equipment should be selected that did not require customers "to do part of the service."<sup>23</sup> Although survey results suggested the opposite, AT&T's management believed that keeping customer involvement to a minimum would enhance the popularity of telephony [Mueller 1989, 545]. Thus, despite the favorable response toward automatic switching that was being reported in its surveys, the management of AT&T held on to the ideological presupposition that customers possessed limited capabilities for comprehending the steps involved in dialing a phone.

With manual switching, the subscriber's input was limited to telling the operator the name of the exchange she/he was calling and the three or four digits that identified the customer line. The operator for the telephone company controlled the connection of the subscriber lines. As Chapuis points out, it was only with the conception by one of AT&T's own engineers of three letters followed by four digits that an approach was developed that could accomplish the seven-digit dialing needed for big towns without abandoning the traditional names of big town exchanges. Leaving the traditional names of big town exchanges unchanged was considered essential for providing AT&T's subscribers with telephone numbers that were simple and easy to remember [Chapuis 1982, 84].

The new numbering system did not eliminate AT&T's concern about whether effective service could be rendered without operator assistance. In a 1919 statement, "Dangers of False Notions Regarding the Automatic Switchboard," management affirmed its commitment to delay the change from manual to automatic as fitting into



a larger vision. "From its foundation the company has continuously developed the whole telephone art of which switchboards are but a part." The statement clearly says that when operators are needed for effective service of the network, they will be provided [Kingsburg and Morna 1919, box 1].

### *AT&T Adopts Automatic Switching*

In 1919, a plan was issued by the company for deploying automatic switching.<sup>24</sup> In the larger exchanges, panel switching<sup>25</sup> was to be installed, while in the small and medium exchanges step-by-step automatic switching was to be deployed.<sup>26</sup> AT&T had acquired, in 1903, the patents for the Lorimer automatic system, and panel switching involved the modification of the Lorimer system by Western Electric to provide service for large cities. Thus, the panel switching deployed in large cities emerged from Bell's own research efforts [Chapuis 1982, 68].<sup>27</sup>

The perceived technical problems of automatic switching in large cities had dominated the company's assessment of the general feasibility of automatic switching. As Carty remarked 11 years before AT&T's use of automatic switching, "So important are these factors that it is safe to say that even if the annual charges on the automatic system were substantially less than those on the manual system, they would constitute such a serious objection to the automatic system as to bar its use" [Carty 1910, 115].

A striking aspect of the 1919 plan to use automatic switching was the decision to use step-by-step switching outside large cities. At that time, the step-by-step switch was still restricted to small-trunk groups; however, the firm ended up using step-by-step switches in the same manner in which the Independents had been using the equipment for a decade. Because AT&T deployed step-by-step switching outside large cities, Sheahan comments that the ". . . adoption of the [step-by-step] equipment for the medium sized Bell exchanges could probably have started much earlier than 1919; their requirements did not include the improvement which delayed its use in the large cities" [Sheahan 1956, 249].

Postponing the development of step-by-step switching until key personnel accepted that the equipment would be compatible with the technology developed for large cities was not the only conceivable option. Another possibility was to install the step-by-step switch system in the medium and small exchanges and then to either design, or wait for others to manufacture, a compatible switch for the central nodal points that met the needs of the firm.<sup>28</sup>

Management held steadfastly to its view of how to proceed, and apparently there were no market influences they would recognize as warranting a change toward automatic switching. As pointed out in the FCC investigation, "Investments in manual central-office equipment at locations suitable for unattended dial operation were made by the Bell System companies during the fourteen years after the unattended

automatic exchange equipment was available on the open market" [FCC 1939, 261]. Most important, we believe that if the firm had been willing to listen to customers' definitions of quality, the rate of deployment of automatic equipment would have been speeded up. Instead, because manual switching was perceived as satisfying the service objectives established within the firm, management did not believe that it needed to learn from customers about what customers wanted.<sup>29</sup>

AT&T's management discounted information about automatic switching that did not fit with specific ideas regarding how the market should be developed.<sup>30</sup> Since there were clearly revealed incentives for an earlier installation of automatic switching, we are unable to understand AT&T's delay in the deployment of automatic switching without reference to beliefs that emerged within the company regarding the development of the long distance market.<sup>31</sup>

AT&T's reluctance to install automatic switching was not due to financial restrictions. Throughout the era under consideration, the Bell Operating Companies were frequently reconstructing their exchanges.<sup>32</sup> Carty stated in 1910 that AT&T has been so conservatively financed and our administration

has been so keen to adopt new improvements, that ample depreciation funds have been accumulated so that just as soon as it is demonstrated that a better switchboard system is available, we are prepared to begin its installation and proceed with the utmost practicable speed to make the change. All of this could be done without the slightest disturbance in our financial arrangements [quoted in Baughman 1981, A-206].

Instead, the deployment of automatic switching was controlled by an emphasis on the needs of the central nodal points perceived as crucial for the achievement of the long-term goal of a national integrated network.

We do not consider AT&T's emphasis on providing service for the small proportion of customers who made long distance calls as the inevitable result of specific influences emanating from outside of the company. There were no external forces that we can identify as the "reason" the firm had to act as it did. AT&T's approach was internally generated in that the creative energies of key personnel played a critical part in shaping the market these same personnel sought to dominate.

The view within AT&T that a few markets should decide the needs of the entire network was not the only reasonable perspective on developing the telephony market. By focusing on a small share of the market, AT&T created an opportunity for potential competitors to develop a network that connected with more customers. A competitor could increase the attractiveness of its own network by increasing the number of customers who could be reached [Rohlf's 1974]. In particular, by bringing residential customers to the network, the attractiveness of the network to the business community would increase, because the business community would perceive a larger group of potential customers for its products. Indeed, when Independent companies petitioned for franchises to serve large cities, they often stressed

that they had developed the market in the smaller cities and towns surrounding places like Chicago, and that the metropolis would benefit by having an Independent telephone company that interconnected with these towns [*Milwaukee Free Press*, July 27, 1906; *Milwaukee Sentinel*, July 27, 1906]. Thus, by focusing their development efforts on large- and medium-sized cities, AT&T created opportunities for competitors to develop the very areas that AT&T had ignored and to use these areas to enter larger cities. AT&T responded to entry by developing the markets outside large cities, and it appears that this conduct was more costly for the firm than it would have been if it had preempted its competitors [Nix and Gabel 1993].

### *Concluding Comments*

Ideological presuppositions served as a potent institutional influence affecting AT&T's behavior toward a major innovation, automatic switching.<sup>33</sup> The need for a set of beliefs to guide behavior is rooted in the requirement that to be successful, a firm must anchor and give authority to ideas that identify goals and restrict options.<sup>34</sup> A firm must accomplish purposeful intent.

The ideas that gained credibility within AT&T regarding how a network should be built and developed were of limited plasticity. While such ideas played a crucial role in AT&T's long-term success, these same ideas inhibited the firm's behavior toward automatic switching. We conclude that the lack of plasticity associated with Vail's vision enabled AT&T to focus its efforts on a specific path of development. However, the benefits AT&T accrued from having articulated intentions that represented intelligent and creative approaches to the company's environment should not be taken to imply that ideological presuppositions always produce optimal adaptations.

We believe that there are strong grounds for broadening the cognitive dimension ascribed to the firm beyond that of a simple sensitivity to market signals, technology, or broad investments. Environmental stimuli undergo an internal constructive process within firms that is based on idiosyncratic cognitive frames. The knowledge incorporated into such frames is not simply transmitted by technology, the monitoring of throughput, or market forces. The intelligence and creativity of key individuals serve as an important source of ideological presuppositions that produce differences in firms' productive knowledge. Such differences are needed to explain the presence of behavioral diversity among firms facing similar environments.<sup>35</sup>

### *Notes*

1. For a detailed discussion of this point, see Nelson [1991].
2. The absence of a deterministic environment is a key difference between evolutionary and neoclassical theories. As Nelson [1991, 69] comments, "A basic premise of evolutionary

theory is that the world is too complicated for a firm to comprehend, in the sense a firm understands its world in neoclassical theory."

3. As Nelson [1991, 68] explains, "The notion of a hierarchy of organizational routines is the key building block under our concept of core organizational capabilities."
4. In Chandler's seminal research, most recently *Scale and Scope* [1990], the importance of firms in shaping markets is carefully articulated with reference to the history of the United States, Britain, and Germany. As Teece comments in his review, "His [Chandler's] thesis is not that markets shape business organization as is commonly supposed in economic theorizing; rather it is that business organizations shape markets. The implication of this tour de force is that much of what is in the textbooks in mainstream microeconomics, industrial organization, and possibly growth and development ought to be revised, in some cases relegated to the appendices, if economic analysis is to come to grips with the essence of productivity improvement and wealth generation in advanced industrial economies" [Teece 1993, 199].
5. In accounting for the achievement of sustained market leadership on the part of first movers in the United States, Britain and Germany between 1880 and 1940, Chandler places paramount importance on such "three-pronged" investments [see especially Chandler 1990, 91].
6. In addition, after reviewing the early history, Chapuis comments that "the companies of the Bell system were allergic to the automatic telephone" [1982, 67].
7. The idea that the inter-firm differences matter and that such differences do not result from a choice process dynamics where alternatives are "given" for firms to pick according to a well-defined objective function is found in the research of Nelson and Winter [1983] and Nelson [1991]. Additional reasons for relaxing the choice framework of neoclassical economics is found in the research of James March [March 1981, 1987; March and Romelear 1976; March and Shapira 1982].
8. "All the early [manual] switchboards were of the single unit type manned by a single operator. As the number of subscribers grew, an additional unit and operator had to be placed beside the first operator. The operators made interconnections between their boards by reaching across in front of each other. One operator could handle the calls for one hundred to two hundred subscribers at the most. When the number of subscribers increased so that three operators became necessary, the operator in the middle could reach lines on both sides but the two outside operators had great difficulty in making the cross connections. At first cords were passed across by the middle operator but later so called 'transfer' trunks came into use. These trunks or tie circuits connected each operator's position with positions otherwise out of reach. Connections were made by one operator calling out the subscriber's number desired to the distant operator, who replied with the number of the transfer trunk to be used" [Jewett as quoted in Baughman 1981, A-158].
9. The name is based on using a "step by step sequence to make connections" [Baughman 1981, A-163]. ". . . The vertical and rotary motions of the shaft were controlled by electromagnets actuated by impulses sent from the subscriber station" [Hill, as quoted in Baughman 1981, A-164].
10. R. D. W. McKay, New England representative of the Globe Automatic Telephone, 1902, AT&TCA, file no. = 11 07 01 02.
11. As Chapuis points out, the need for privacy was the propelling reason leading A. B. Strowger to invent the step-by-step exchange [1982, 60]. The extent of his accomplishment is evident in the fact that as late as 1978, "the Strowger system continued to be one of the most extensively used exchange systems throughout the world" [Chapuis 1982, 68].
12. A Report on the 100-line automatic exchange at Peshtigo, Wisconsin, February 24, 1905; file no. = 11 07 01 02.
13. A Report on the 100-line automatic exchange at Peshtigo, Wisconsin, 2,24,05; file no. = 11 07 01 02.

14. AT&T had a mixed history of responding to competitors. We have argued elsewhere that the firm was slow to adopt its rate structure and levels prior to actual entry into a market [Nix and Gabel 1993]. On the other hand, after entry AT&T responded aggressively—the firm often reduced its prices and realigned its rate structure [Gabel 1993]. Furthermore, in order to secure markets, it built up its long distance network and, in some areas of the country, improved the quality of its local service.
15. Alexander Graham Bell invented the telephone in 1876. National Bell emerged in 1879 from the original Bell Company and New England Telephone Company. American Bell Telephone Company was formed in 1880. In 1885, AT&T began as a subsidiary of American Bell. In 1900, this structure changed with AT&T becoming the parent company of the Bell system [Danielian 1974, 11-12].
16. American Telephone and Telegraph Company, *Annual Report: 1909*, p. 18. Vail's vision of the importance of long distance telephony may be explained, in part, by his experiences with telegraphy. In the last quarter of the nineteenth century, the telegraph was used mostly for long distance information transmittals; the demand for local telegraph service was weak and consequently unprofitable. Furthermore, Western Union had used its own long distance telegraph network as a strategic tool to limit the growth of Bell. During the years 1878-79, Bell Telephone and Western Union battled for control of the telephony market. Western Union refused to provide telegraph service to locations that used the Bell telephones. Brock points out that this exclusionary practice "effectively prohibited Bell installations in hotels, railways, and newspaper offices that depended on Western Union service" [Brock 1981, 94]. Vail may have foreseen that by Bell constructing its own national network, the likelihood would be reduced that a competitor, such as Western Union, could harm Bell by leveraging its control over a more complete network. In 1879, AT&T and Western Union signed an agreement to end competition in the telephony market. Western Union agreed to yield the market to AT&T in exchange for royalty payments and an agreement that AT&T would not compete with Western Union in the provision of telegraph service. AT&T did retain the right to develop long distance service. The agreement reflects the emphasis Vail placed on creating and controlling a national network [Reich 1985, 134]. The impact of Vail's vision on AT&T's research activities is found in Wasserman and Reich [1985, 134]. The effects of his vision on the organizational structure of AT&T are found in Chandler [1977], 200-04], Langdale [1978], Smith [1985], and Garnet [1985].
17. AT&T perceived three types of benefits from the development of long distance services. First, the firm anticipated that the demand for the service would eventually become strong and therefore, on its own merits, investments in the long distance market would become profitable. Second, by linking together different cities, the demand curve for access to the network would shift out [Sharp to French, July 30, 1901, General Manager's Letter Books, Vol. 631, AT&TCA]. Third, the leaders of AT&T envisioned that an integrated network would also offer formidable protection from competition when its patents expired in 1894. Competitors might be able to establish service in a city or a region, but AT&T was skeptical that entrants would be capable of constructing a nationwide network. This qualitative difference would provide Bell's local exchanges with an important competitive advantage.
- One of the early leaders of AT&T, E. J. Hall, argued that once Bell's initial patents expired, ". . . the continued success of the local exchanges will be largely in proportion to their ability to connect satisfactorily with our [toll] lines" [Hall and Hudson 1888, box 1011, AT&TCA].
18. "Tests of the Strowger Automatic System in Chicago, Illinois," October 18th, 1904, AT&TCA file no. 11 07 01 02; "Tests of the Strowger Automatic Telephone System at Dayton, Ohio," November 3, 1904, AT&TCA file no. 11 07 01 02; "Tests of the Strowger Automatic System at New Bedford, Mass.," September 28, 1904, AT&TCA file no.

- 11 07 01 02; "Tests of the Strowger Automatic Telephone System at Fall River, Mass," October 20, 1904, AT&TCA file no. 11 07 01 02.
19. In 1905, long distance toll revenue accounted for 23 percent of AT&T's total revenues [AT&T 1909, 30].
  20. Testimony of Horace Hill, in *Read et al. v. Central Union Telephone Company* (hereafter "Read"), Superior Court of Cook County Illinois, Chancery General Number 299,689, tr. 3037-8 (first quote), 3537; George Anderson, "The Telephone Situation: Its Causes and its Future," October 12, 1906, at 83-4 (second quote); Dickson [1905, 41].
  21. AT&T also expressed its concern that the equipment would add additional cross-talk and induction that would lower the quality of long distance connections [Baughman 1981, A-170, A-207].
  22. As Carty [1910] stated: ". . . Automatic switching was not that developed so as to be satisfactory for use in large cities."
  23. "Report of the Meeting of the Switchboard Committee," March 15-18, 1892, pp. 117-18, AT&TCA.
  24. Carty [1910, box 6]. AT&T took an active stance regarding the management of the public's reaction to the firm's deployment of automatic switching. "Great care must be exercised, therefore, in any matters of publicity, not to dwell on improvements in service to be effected through its use, as otherwise a demand may be created which it is undesirable and impracticable to meet" [Bancroft Gherardi, Report to the Presidents of the Operating Companies, "Reasons for Adopting Machine Switching at the Present Time," cited in Baughman 1981, A-237].
  25. "In the panel system the fundamental switch is one which has a vertical movement only, the selector moving over contacts arranged in a flat bed or panel, from which is derived the name of the system" [FCC 1939, 262].
  26. The introduction of panel switching did not eliminate manual switching from either Bell's short- or long-term network plans. At the same time AT&T made plans to deploy step-by-step switches in some medium and small cities, it had plans to maintain and expand the use of manual switches [Carty to Jewett, and Ghardi to Thayer, March 19, 1923, box 6, "Automatic Exchange Switching"]. As late as 1933, a majority of AT&T's subscribers were still being served by manual switching machines [Chapuis 1982, 287].
  27. The Federal Communications Commission, in its 1939 investigation of AT&T, and Sheahan [1956] comment that AT&T was reluctant to adopt technologies developed outside of the firm. The firm's focus on internal evaluations of technology is reflected in an address made to the Bell Operating Companies in 1916: "The true way to judge the capabilities of such a system is not what could it do when it is in the hands of those that are not quite up to the mark, but what could it do if it were developed by people who understood more about it. So for many years, we have been studying with conscientious care the automatic problem to see what the truth of the matter was, and what the answer would be" [Baughman 1981, A-212]. Carty emphasized the need for AT&T to conduct an internal evaluation of the technology. His 1916 address should not obscure the fact that a leading historian of technology concluded that "the modern automatic exchange really came into being in 1907," which was nine years before Carty's talk [Chapuis 1982, 67].
  28. As pointed out by Sheahan [1956, 263], the British waited to deploy automatic switching in its largest exchanges until automatic came out with a switch suitable for its largest exchanges.
  29. Carty appeared to have his own view of what should matter to customers. For example, in his 1910 speech, he argued that "the difference in speed of connection between [manual and automatic switching] was so small as not to constitute a practical factor, the time elapsing between the start of the call and the answer of the called subscriber being in the case of the automatic system 19.2 seconds and in the case of the manual system 21.7 seconds." Some officials within AT&T argued, without success, that customers' announced

- desires should be given greater weight. For example, in 1895 the firm's patent lawyer, Thomas D. Lockwood, wrote that "while I am convinced that this apparatus is neither an improvement from the good service point of view nor a saving, if people want it and are willing to pay for it, we should be prepared to supply it, . . ." [Lockwood and Hudson, quoted in Baughman 1981, A-167].
30. Chapuis and Lipartito have pointed to the importance of rising labor costs and other labor problems in explanations of AT&T's adoption of automatic switching in 1919. But, as pointed out in the FCC investigation, "the original decision to adopt panel type, full mechanical equipment was made before the serious employment difficulties developed, and the first installations were not completed until after the emergency passed." In addition, as officials within AT&T recognized, the labor shortage was temporary and there were pricing strategy changes that would have helped control labor costs. "The ending of the war and measured rates instead of flat rates should relieve many of the bad situations" [Sunny and Thayer 1919]. Based on the analysis of automatic switching by Gherardi contained in a 1917 memorandum prepared for Carty, Baughman comments "for Gherardi, the critical factor was not one of costs . . ." [Baughman 1917, A-218].
  31. Lipartito's explanation of AT&T's behavior toward automatic switching emphasizes a change in paradigms. "The combination of an enterprising strategy and a strong monopoly position gave AT&T an abiding commitment to a particular technological paradigm, one which, as we shall see, initially had little room for new devices like automatic switches. The end of the company's monopoly eventually forced some important revisions of that strategy, and led to a revised paradigm which provided a means of dealing with departures like automatic switches" [Chandler 1990, 22]. As we see it, AT&T's fundamental strategy of developing a national, integrated network did not change over the period examined. Our explanation emphasizes that automatic switching would not be deployed until it was perceived as consistent with the crucial assumptions AT&T employed in the design of its market. In addition, we believe that the incentives Lipartito attaches to the provision of universal service such as ". . . placating customers who wanted new products and services quickly while avoiding disruption of existing service as the new technology was introduced" [Chandler, 1990, 42] were present during the period in which AT&T delayed its deployment of automatic switching.
  32. See, for example, *1910 Annual Report of the Wisconsin Telephone*, Wisconsin State Historical Society.
  33. The comments of Temin [1987] regarding AT&T's slow offering (relative to the competition) of a digital PBX (private branch exchange) reflect the continued influence within AT&T of internal evaluations of the proper course to take in response to technological change. "This orderly progression made sense to managers concerned with the networks' long run capabilities. It did not make sense to customers who wanted a digital switch at once . . . They [engineers] were the custodians of the network, and they knew what was best" [Temin and Galambos 1987, 64].
  34. We believe that even if the specifics of AT&T's case did not lend themselves to further generalization, there are benefits from understanding AT&T's behavior. As Simon comments: "Biologists have described millions of species of plants and animals in the world, and they think they've hardly started the job. Now, I'm not suggesting that we should go on out and describe the decision making in a million firms; but we might at least get on with the task and see if we can describe the first thousand. That doesn't immediately solve the aggregation problem, but surely, and in spite of the question of sampling, it is better to form an aggregate from detailed empirical knowledge of a thousand firms, or five, than from direct knowledge of none. But the latter is what we have doing in economics for too many years" [Simon 1992, 20].
  35. The importance for firm effectiveness of having a productive conceptual orientation that identifies constructive approaches toward technologies is reflected in the current uncer-

tainty about the best approach for dealing with the technologies that transmit high speed data, voice and video. As one key decision maker commented, "Distinguishing among opportunities, challenges and just plain problems in the digitizing world is no small task . . ." ["Two Studies . . ." 1995, D7]. The environment is not uniquely determining the optimal approach toward digital producing technology.

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