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# LEADERSHIP, CAPABILITIES, AND TECHNOLOGICAL CHANGE: THE TRANSFORMATION OF NCR IN THE ELECTRONIC ERA

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*Scholars have advanced various theories to explain the common failure of market leaders in the face of revolutionary technological change. The history of NCR Corporation provides an instructive exception to that general pattern. This paper examines how NCR addressed the introduction of electronics to the field of business equipment and the advent of digital computers to widespread use. It describes NCR's entry into the computer industry in the 1950s and its commitment to evolutionary adaptation of its core products. It shows how persistence in old modes of practice led eventually to a crisis, which was resolved favorably when new management and fundamental organizational transformations reversed adverse trends and restored robust profitability.*

*While established academic theories can help to explain aspects of the story, no single theoretical perspective is sufficient to explain the path of NCR's behavior. NCR survived, we conclude, because new leadership provided the impetus to actualize latent dynamic capabilities.*


The 'digital revolution' pervades current headlines as 'e-business' transforms commercial practices and reshapes major industries. But the wellsprings of today's digital technologies surfaced more than a half-century ago, stimulating successive waves of change that repeatedly threatened the survival of well-established firms in home entertainment, electronic components, communications services, data processing, and related fields. Even the most dominant firms in the information industries have found themselves challenged to develop new strategies and new capabilities to cope with the incursions of new rivals exploiting new technologies.

The academic literature on innovation has repeatedly observed that mature, successful firms often fail to adapt successfully to revolutionary changes in technology (Cooper and Schendel, 1976; Foster, 1986; Christensen, 1997). Rather than analyzing patterns of failure, however, this paper traces the means by which one prominent firm—National Cash Register Company (NCR)—coped with radical changes in technology over four decades. We will examine in detail how NCR addressed the introduction of electronics to the field of business equipment and the advent of digital computers to widespread use. NCR not only survived but eventually prospered in the face of these powerful forces of change. Through this account of NCR's history from 1938 to 1978, we hope to illuminate the processes by which other firms threatened by similar fundamental change might cope successfully with the emergent threats.

Key words: capabilities; innovation; leadership; organizational change; technological change
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## ACADEMIC PERSPECTIVES

Scholars have advanced various theories to explain the failure of market leaders in the face

of technological change. One theme that is prominent in the literature is that the prospects for incumbents are contingent on the inherent nature of the technology and the proximate consequences of its innovative use. Studies have shown that 'architectural' changes in design and 'competency-destroying' innovations will be problematic for established leaders (Henderson and Clark, 1990; Tushman and Anderson, 1986). A web of implicit and explicit social commitments to employees, customers, and communities also can also impede adaptation to change (Sull, Tedlow, and Rosenbloom, 1997). Other studies suggest that when the greatest opportunities inherent in a new technology lie in novel 'value propositions' directed at new customers, its effects will be most disruptive to established leaders (Christensen, 1997). Economists have stressed the consequences of the asymmetry of incentives among differing sorts of firms facing the same technological opportunities (Henderson, 1993). They argue that small incumbents and new entrants will have a smaller stake in the current technology than will large incumbents, and therefore have less to lose from cannibalization of the established technology by the new. Similar logic leads to emphasis on the effect of irreversible resource commitments leading to persistence of strategies over time (Ghemawat, 1991).

In today's world, it seems inevitable that a firm will eventually encounter new technology that is disruptive in one or more respects and that its responses may be limited by financial disincentives and established managerial commitments. Some argue, nevertheless, that firms should be able to adapt successfully if they possess sufficient 'dynamic capabilities.' Dynamic capabilities are what enable a firm 'to integrate, build, and reconfigure internal and external competences to address rapidly changing environments' (Teece, Pisano, and Shuen, 1997: 516). Teece and Pisano (1994) suggest that a firm's dynamic capabilities are determined by three classes of factors:

- *processes*—managerial and organizational 'routines';
- *positions*—current endowments of technology, customer bases, and suppliers;
- *paths*—available strategic alternatives.

The ability to achieve new forms of competitive advantage is the essence of a dynamic capability. In the following account of NCR's history we shall seek to identify the extent to which its successes can be attributed to dynamic capabilities, and to characterize just what seems to constitute a dynamic capability.

## NATIONAL CASH REGISTER: ORIGINS AND TRANSFORMATION

NCR was founded in 1884 by John H. Patterson, a legendary salesman and business leader. A titan of early 20th-century industry, Patterson was an autocrat, paternalist, showman, and innovator (Friedman, 1998). Patterson created a multinational industrial giant that dominated its field. By 1911, NCR was selling 95 percent of the world's cash registers. The heart of the company lay in a sprawling complex of buildings on a huge site in Dayton, Ohio.

### Building competitive advantage

Technological prowess was a part of NCR's competitive strength. In 1900, Patterson hired Edward A. Deeds, a pioneering electrical engineer and inventor who later became a national figure in industry and aviation. In 1904 Deeds hired Charles Kettering to work in the 'Inventions Department.' Before leaving NCR in 1909 to concentrate on inventions for the automobile industry, Kettering's biggest contribution to NCR was to invent, at the prodding of Deeds, a practical electrical cash register.

John Patterson died in 1922, to be succeeded as president by his son Frederick, who left the running of the company in the hands of general manager John H. Barringer, a stellar salesman. Comptroller Stanley Allyn, a protégé of the senior Patterson, had been elevated to top management and a seat on the Board in 1917 at the tender age of 26.

NCR's scale advantages in manufacturing and selling protected it from attack in its base business while Barringer and Allyn broadened the product line to include accounting machines and adding machines. With the company in financial difficulty in the Depression, Patterson dismissed Barringer in 1931 and brought Deeds back as chairman, president, and chief executive. Deeds appointed Allyn to the number two spot, with the title of executive vice president, and enlisted

Charles Kettering as a member of the board of directors. In 1940, when Deeds turned 66, he passed on the title of president to Stanley Allyn. Although Deeds gradually withdrew to 'the perimeter of operations' he remained chairman until 1957 (Allyn, 1967: 67).

## RESEARCH IN ELECTRONICS

The transition to electronics at NCR began in 1938 with the establishment of an electronics research activity in the Dayton engineering organization. The initial commitment, sponsored by Deeds, who was being strongly encouraged by Kettering, had no immediate commercial motive. Deeds sensed that electronics would become important in the future of the business. Joseph R. Desch, who had worked on radio at General Motors, was hired to lead the effort. Robert E. Mumma, a younger colleague from GM, joined the company early in 1939.

The work of Desch's small group positioned NCR among the pioneers in computational research in the United States. Mumma soon designed a small machine that could add and subtract and started to develop a calculator that could also multiply and divide. He had figured out the design of the latter machine by mid-1941 and demonstrated its operation for addition, subtraction, and multiplication on April 24, 1942. As the nation began to prepare for war in 1941, the National Defense Research Council (NDRC) turned to NCR, along with Radio Corporation of America and Bell Telephone Laboratories, to apply its electronics capabilities to military fire control devices.

In 1942 NCR suspended all commercial activity to devote its resources entirely to wartime needs. The Naval Computing Machine Laboratory (NCML), established to design and build top-secret devices capable of breaking German codes, was located at NCR's facilities in Dayton, with Joseph Desch as its head. This decision by the government suggests the depth of NCR's prowess in computing at that early date. At the end of the war, the Navy wanted to continue the work of NCML, but NCR's management chose to focus entirely on reviving its commercial activities. Although Deeds and Kettering continued to encourage pioneering work in electronics, NCR's operating management dedicated itself to the task of meeting the pent-up postwar demand for its traditional mechanical products.

While NCR's earlier work earned it recognition as a technical leader in computational devices, its management did not seize the opportunity to define strategic directions responsive to the opportunities implied by the postwar emergence of the digital computer. Mumma's electronics group worked mainly on features—like punched-tape output—that could be added to traditional designs, and on printers and data storage devices that would later emerge as 'peripherals' for computer systems. As Mumma later characterized it, 'We were still considered outsiders in a mechanical factory' (Mumma, 1984: 18).

## DEVELOPMENTS IN COMPUTING

Early commercial progress in computers was stimulated by a few small entrepreneurial ventures, including the Eckert-Mauchly Computer Corporation (EMCC) in Philadelphia, founded by the principal designers of ENIAC, the first electronic computer in the United States, Electronic Research Associates (ERA) in Minnesota, and a few West Coast ventures associated with aviation and defense contracting. While the scientific value of digital computers was becoming clear, the cost-effective business applications of these expensive and bulky devices were far from obvious. Late in 1949, EMCC, fast running out of cash, sought to sell itself to one of the leading business equipment producers. NCR sent a delegation of seven men to visit EMCC in December, 1949, but wasn't prepared to move swiftly enough to meet the struggling firm's pressing needs; on February 1, 1950, EMCC accepted a buyout offer from Remington Rand.

The business machine industry in the postwar years was highly concentrated, with more than 70 percent of industry revenues garnered by the four dominant firms: IBM, NCR, Remington Rand, and Burroughs. Despite the prewar stresses of depression and the postwar revolution in technology, industry structure remained highly stable. The four postwar leaders had been the largest and most profitable in 1928 and all would continue to rank among the top six in the computer industry in 1973. In 1949, NCR ranked second in revenues, close behind IBM and twice the size of fourth-ranked Burroughs (Cortada, 1993: 256, 258).

## NCR'S POSTWAR STRATEGY

In early 1950, despite the development of significant new capabilities in electronics and a fourfold increase in revenues, NCR was essentially the same company it had been a decade earlier. Three product lines still formed the core of National Cash Register's business: the eponymous cash register line, accounting machines, and adding machines. These products were all standalone electromechanical machinery, some quite complex in design and manufacture, made primarily in highly integrated facilities in Dayton, Ohio, and sold to users by a large and highly effective field sales force supported by a large service organization. The company's leadership, its culture, and its operating methods had changed little since the 1930s and would remain intact for another decade.

The requirements of marketing differed among the various lines. While cash registers faced little competition, accounting machines competed against similar devices offered by Burroughs, Remington, and Underwood, and also against the punched-card systems of IBM. More sophisticated salesmen, organized separately, sold the accounting machines. With the introduction of a new line in 1950, accounting machine revenues grew rapidly and NCR pulled ahead of Burroughs to lead the market (W. Anderson, 1991: 165–166).

Although it was an early mover in research on electronics for computing, NCR was the last of the 'big four' to choose a strategic path toward the new era, making what was in many ways the most cautious commitment. In 1947, Burroughs had launched a major research effort in electronics aimed at transforming its product line. In 1949, in a speech to IBM salesmen that also was circulated widely among customers, Thomas Watson Jr. had asserted that all of IBM's products would come to be 'based on electronics' within a decade (Usselman, 1993). Within a year, IBM was committed to market the Model 701 computer. Remington, having acquired EMCC in 1950, was the first to sell computers commercially.

In 1952, NCR management set its course for the transition to electronics. Allyn made an entrepreneurial commitment to add a fourth product line—digital computers—while defining the strategic guidelines that would govern the adaptation of the established lines to electronics. He declared that electronics should lead to 'evolutionary' change in the company's standalone products, which would increasingly be called upon to serve as data-entry devices for electronic data-processing (EDP) systems in which the newly emerging computer products functioned as a central element.

Although the investments in electronics R&D at Dayton were intensified to support movement along this new strategic pathway, no changes were made in the structure or work processes of the organizational units that developed, made, and sold NCR's core products. It remained the role of the Product Development Department to tell Research and Engineering 'what types of products are wanted' (National Cash Register Company, 1953: 1–3).

The contemporary reader, in an environment in which computers are ubiquitous, may find it difficult to grasp how speculative and uncertain the commercial prospects for digital computing appeared in 1952. The first commercial stored program computer, the UNIVAC, built by the Eckert-Mauchly division of Remington Rand, began operations for the U.S. Census in mid-1951; IBM's first computer, the Model 701, was announced in May 1952. These leaders in business data-processing systems using punched cards were natural first movers, IBM using internal capabilities and Remington relying on its acquisition of EMCC and later, in mid-1952, of ERA. The ultimate market potential for these 'giant brains'—room-sized and costing millions—was generally reckoned to be limited to a few dozens or, possibly, hundreds of installations. The first half-dozen UNIVACs and the full run (16) of the IBM 701 systems went to scientific users, mainly government agencies or defense contractors. It was not until September 1953 that IBM announced the Model 702 designed for business use and 1954 when the first commercial installations of UNIVAC occurred (Campbell-Kelly and Aspray, 1996).

## ENTERING THE COMPUTER MARKET

In 1952, Stanley Allyn, strongly encouraged by Joseph Desch, committed NCR to a new strategic direction by entering the nascent computer industry through acquisition of the Computer Research Corporation (CRC), located in Hawthorne, California. CRC was one of the handful of companies founded soon after the war to turn the new computer technology into a business; all of them soon were driven, like CRC, into the arms of a larger firm seeking to expand its capabilities.

The founders of CRC had worked at Northrop Aviation, where they had designed a Magnetic Drum Digital Differential Analyzer in 1949. The MADDIDA was a special-purpose compact computer intended to solve differential equations for airborne guidance applications. When top management at Northrop, struggling with financial woes, did not support continuation of their efforts, the group struck out on its own, incorporating CRC on July 13, 1950. As one of the founders later described it, 'this wasn't a "sandbox" for engineers; we were trying to build a computer business' (H. Sarkissian, personal interview, Newport Beach, CA, 7 March 1998).

The young firm attracted attention in the military services, hungry to exploit the nascent computer technology. One of the research contracts thus ensuing, from the Air Forces Cambridge (Massachusetts) Research Center, led to the design of CRC's first general-purpose computer, dubbed the CRC 102. Installed in Cambridge in January 1952, the 102 proved reliable and effective. Meanwhile, CRC's engineers adapted the design to create a standardized product, the Model 102-A, a general-purpose computer designed for volume production. Donald Eckdahl, one of the founders, was assigned to head manufacturing operations as well as engineering. He hired most of his staff from the aircraft industry, where learning curve effects dominated manufacturing practices. He later said that 'I learned manufacturing management mainly by doing it and from the people I hired' (D. E. Eckdahl, personal interview, Colton, CA, 19 March 1998).

But finding capital was an obstacle—today's robust venture capital industry did not exist—and prospective investors generally believed that there was a limited market for computers. In mid-1952, the founders of CRC—then primarily an engineering research and manufacturing organization employing 150 people—sold the business to NCR. Stanley Allyn intended that CRC's research activities should be integrated with those at Dayton, 'within the framework of [NCR's] overall product development program' (National Cash Register Company, 1953: 3). As new products emerged, Dayton would manufacture them.

Looking back on these choices, some four decades later, William Anderson, who became NCR's CEO in 1972, concluded that it had been an 'error' to assume 'that the computer business would simply be another "layer" on the cash register, accounting machine, and adding machine "cake". The theory was that to NCR's three departments ... a fourth would be added ... Seen by only a few was that eventually all of these businesses would tend to merge' (W. Anderson, 1991: 170).

## EVOLUTION IN THE CORE BUSINESS

NCR's *Annual Report* for 1953 devoted two pages (24–25) to defining the company's position in electronics. Three themes pervaded that statement and subsequent acts and utterances of management. The first was the company's commitment to participate in providing all elements of 'systems' for commercial record-keeping. With it came, as a second theme, management's conviction that changes in practice would come by 'evolution,' not revolution. Finally, they had a firm belief in the competitive advantages that NCR would enjoy in the new marketplace.

In the view of NCR's leaders, 'Most of the records business management requires are secured from an analysis of the many individual sales or other transactions.' Computers could process data at blinding speed, but were limited in productivity by constraints on input and output. Thus NCR was seeking 'to make the cash register or accounting machine the "input" mechanism,' transforming it into a 'link in an over-all electronic system rather than a machine which could be bought and used as a unit.' Hence, NCR was 'working toward an integrated system which will ultimately provide the three necessary elements ... input, computation, and output' (NCR *Annual Report*, 1953: 25).

Realization of this sweeping vision was believed to lie in the distant future since the utility of established products was expected to dominate for some time. As management repeatedly cautioned the shareholders:

> new developments are expected far too quickly ... The only sound development is that which moves forward step by step... (NCR *Annual Report*, 1953: 25)

> it becomes increasingly clear that the development of an electronics system will be more evolutionary than revolutionary... Important as electronics will be to the future of the business we must realize that there will always be a place for machines based on mechanical principles. (NCR *Annual Report*, 1955: 15)

Allyn and his associates approached the electronics era with confidence in NCR's advantages. Those included capabilities already in place in Dayton's research and engineering, and in 500 field sales and service locations. More fundamentally, they believed that NCR 'knew the needs of business from a systems standpoint.' Additionally, the 'long line of cash registers, accounting machines, and adding machines [could be] converted [by electronics] into ideal input devices' (NCR *Annual Report*, 1955: 15).

The effect of this new doctrine was to map a specific strategic pathway based on 'evolutionary' application of electronics to enhance its traditional products and to suit them to serve as input devices for computer systems employed by established customers. The organizational vehicles for this strategy were those already established in Dayton. Development and production of the traditional product line, and of the evolving electronic enhancements to it, remained in the hands of existing groups, which were dominated by staff whose experience was rooted in electromechanical technologies.

The differences implied by electronics technology were little noted. The implications for sales and marketing were challenging. NCR's established business was based on selling many thousands of units at prices ranging from one to a few thousand dollars each. The new computer business, in contrast, was based on selling small numbers of systems at prices measured in hundreds of thousands of dollars. While the pace of change accelerated in the new marketplace, NCR's product development organizations retained the leisurely habits of an earlier era, in which they had set the pace (W. Anderson, 1991: 171).

The existing products were often very complex; the simplest register contained 1500 parts; some accounting machines used more than 20,000. Because NCR was a highly integrated producer, fabricating all required parts from metal stock, labor represented 80 percent of manufacturing costs (NCR *Annual Report*, 1956). The proportions were reversed in manufacture of most electronic machinery, for which components had to be purchased from specialized vendors. In the early 1950s, half of the company's 45,000 employees worldwide worked in manufacturing. Conversion to electronics would hold ominous implications for most of them.

In support of the new thrusts into electronics, management increased the intensity of R&D spending from a mere 1 percent of revenues in 1950 to a peak of 3.9 percent in 1958. Most of the increase was spent on evolutionary improvement of the traditional product lines and on creating the wholly new EDP line. But Allyn's actions to integrate computer research with product planning in Dayton and to press them to stay in touch with the expressed wants of customers, few of whom could have any sense of what electronics and computers could offer, would have the effect of limiting the pace of NCR's innovations in the new field.

The advent of electronics in the core business was signaled by the introduction of 'Sales-Tronic' and 'Post-Tronic' product lines. The latter was an accounting machine that could 'pick up' prior balances encoded in magnetic stripes on the back of a ledger card.[1] By 1954, Dayton engineering had developed a series of engineering models for the Post-Tronic in great secrecy. Although the product was straightforward technically, requiring a modest amount of electronic circuitry to add 'memory' to a standard electromechanical product, the weight of opinion in management was against commercialization. Some argued that it would soon be made obsolete by computers; others believed that cautious bankers would hesitate to adopt so novel a concept. Nevertheless, the head of sales for accounting machines decided to show the Post-tronic to some customers, whose enthusiastic response settled the issue. Sales of the machine surpassed $100 million within a few years; the resultant strong cash flow cushioned the burden of the costly venture into computers (Allyn, 1967: 159). The Sales-Tronic was a cash register that recorded transactions on punched paper tape that could be fed as input to central computers. Dayton also developed and sold optical scanners to read the punched paper tapes produced by Sales-Tronic registers.

NCR's early movement toward evolutionary

[1] In the days before computers, account transactions were posted to unit records called 'ledger cards,' which maintained a running balance in the account. For example, to record a deposit to a bank account, a clerk would read the prior balance on the card, enter it into the accounting machine, enter the deposit amount, and then have the machine update the balance and print it on the card. To ensure accuracy, some banks would have each transaction recorded twice by different clerks.

change in established products proved a successful strategic choice. For more than a decade, the company profited from evolutionary and incremental adaptation and enhancement of standard products, without any evidence of opportunities lost for failure to move more aggressively to innovate in the core product lines.

## FIRST MOVES IN COMPUTERS

In contrast to NCR's initial success with evolutionary change in the core, it proved to be difficult to find the right strategic pathway into the computer business and to create the organizational capabilities required to pursue it. The first approach was to let CRC follow its own path, although soon after the acquisition Allyn had replaced its president with an NCR sales and product planning executive, Robert Pierson, from Dayton. CRC had strong technological capabilities but lacked experience in marketing and administration.

CRC was an early leader in the design of inexpensive machines using magnetic drum memories. As noted earlier, while continuing to ship scientific computers and some peripherals, largely to government contractors and industrial research organizations, CRC's founders had developed the Model 102-A as a standard product intended for volume production. The new design, like its competitive counterparts, was compact and relatively inexpensive; sales prices—generally under $100,000—were equivalent to only a few months rental for the UNIVAC or IBM 701 computer systems then reaching the market. In late 1952, four of the other six firms marketing small drum memory computers were business machine producers.[2]

The drum machines competed in the markets for engineering and business applications with the IBM Card Programmed Calculator (CPC), introduced in 1949. In 1953 IBM announced the Model 650 magnetic drum computer, whose superior performance backed by IBM's marketing prowess eventually made it the dominant computer product of the 1950s.

The binary arithmetic and limited input–output (I/O) capabilities of the 102-A were well suited to scientific use, but appeared to the people in Dayton as obstacles to business application. As a senior engineer commented, 'when you talked about a binary machine, you scared our salesmen' (Rench, 1984: 26). There was also a certain disdain for the use of punched cards for I/O. IBM was anathema among managers in Dayton, who went to great lengths to avoid employing its products. Under pressure from Dayton, CRC designed the 102-D, using decimal arithmetic and punched paper tape for input and output.

The first unit of the 102-A was shipped to a customer in February, 1954; by August, a dozen systems had been shipped, with another 14 or so lined up for shipment in the next 12 months. By that date, CRC's staff had grown to 360 employees, 85 in engineering research and design, and 156 in manufacturing operations.

## SECOND THOUGHTS ABOUT COMPUTERS

In mid-1954, as CRC was building momentum in manufacture of its first standard product, and IBM and Univac were opening up the business market for computers, NCR's top management in Dayton was rethinking its strategy in the field. According to Donald Eckdahl, Allyn seemed to want CRC to produce 'business machines'—i.e., devices for a specified business function—in the tradition of the parent company's established strengths. CRC's principals perceived that he was 'afraid of electronics' (D. E. Eckdahl, personal interview, Colton, CA, 19 March 1998). Allyn chafed at the CRC engineers' commitment to building 'general-purpose' devices and they believed he failed to understand their utility. Allyn also seemed to expect that CRC could quickly become a profitable subsidiary. When losses persisted he began to get 'cold feet.' Abruptly, in mid-1954 he recalled General Manager Pierson to Dayton and instructed CRC to terminate production operations. All personnel in the manufacturing organization were laid off, some founders left the company, and the subsidiary was reconstituted as the Electronics Division of NCR, with Eckdahl as General Manager.

In one move, CRC's engagement with users was quenched and its manufacturing capability

[2] These were: Marchant Calculator, Monroe Calculator, Remington Rand (ERA Division), and Underwood (typewriters). A fifth, Electrodata, was acquired in 1956 by Burroughs (Pugh and Aspray, 1996).

extinguished. What remained was an engineering organization skilled in the design of general-purpose computers. They soon designed the Model 303, a small general-purpose digital computer still using vacuum tubes and drum memory—basically an improved version of the 102. An early version of the 303 was installed in a department store, but technical progress rapidly overtook the design. Progress in silicon transistor technology led to a decision to shelve the 303 and develop a version using semiconductor circuits and ferrite core memory—features soon to become universal. For the first time, product planners in Dayton collaborated closely with Eckdahl and his engineers to define specifications for what would emerge as the Model 304. A prototype was fully operational in 1956 and was displayed in the Division's Lobby in Hawthorne.

Electronics Division staff also collaborated with engineers in Dayton to design an accounting machine that fulfilled Allyn's vision of evolutionary adaptation. A console adapted from the Class 31 electromechanical accounting machine served as the interface for a small computer designed in Hawthorne that could serve a myriad of accounting applications. Known for a while internally as the National Electronic Accounting Machine, and finally introduced as the Model 390 in 1959, the machine sold well.

## ALLIANCE WITH GENERAL ELECTRIC

Meanwhile, Allyn struggled with NCR's options for entry into the mainstream of the computer industry. While management in Dayton had retained tight control of product planning for computers, and Hawthorne clearly was the only place where they could be designed, choosing the location for computer manufacture was vexing. Allyn's original idea that manufacture could take place in Dayton had quickly been seen as impractical. But he was reluctant to rebuild the capability in Hawthorne. Another senior executive later explained that Allyn lacked confidence in the company's ability to cope with production of such advanced technology (W. S. Anderson, personal interview, New York, January 19, 1989).

At the time, NCR was involved in computer innovation in banking because it had developed the technology for magnetic ink encoding (MICR), adopted by the American Banking Association to enable machine sorting of checks. As a consequence, NCR was drawn into the ERMA project, the first major bank automation endeavor at Bank of America. ERMA's computers were to be built by General Electric, then entering the computer industry. Allyn approached Ralph Cordiner, GE's chairman, to discuss what would now be called a 'strategic alliance.' What emerged was an agreement under which GE would build the central processor and memory units for both companies, and would buy high-speed card-readers, printers, and other peripherals produced in Dayton by NCR. The 1956 *Annual Report* (p. 13) cited the complementary nature of GE's experience in electronics and NCR's skills 'in the field of business systems.'

Announcement of this move stunned the staff in Hawthorne. Eckdahl recalled that 'that was as close as I ever came to quitting.' In his view, the 304—then operating on display in the lobby—could have been put directly into production without further engineering refinement. Although GE did a 'good job' of production engineering, the real benefit of that was open to question in view of the small number of units to be produced. Furthermore, in his view, this decision by Allyn set NCR back 2–3 years in developing its own capabilities as a manufacturer of digital computers (D. E. Eckdahl, personal interview, Colton, CA, 19 March 1998).

The 304 design was released to GE in 1957. In the course of production engineering, according to D. E. Eckdahl (personal interview, Colton, CA, 19 March 1998), the Electronics Division 'taught GE everything it knew about computer design.' NCR began shipping 304 systems to government and retail customers in 1960. In that year, the Sales Division also opened Data Centers in New York and other major cities to train customer personnel, test software, and, as service bureaus, to process the punched tapes being produced by the new models of NCR cash registers and accounting machines. A modular mid-size system, the 315, was announced by NCR in 1960. Design and engineering for the 315 followed work on the 304 at Hawthorne, and this time Allyn authorized the Electronics Division to handle production engineering and manufacture. First units of the 315 were shipped in 1962.

In 1962, 60 percent of the company's 2000 R&D professionals worked in Dayton. Even then,

a decade after the company had entered the computer industry, the R&D effort remained centered amidst the traditions of 80 years of mechanical engineering. Although a small 'advanced development' group under Joseph Desch worked in Dayton on computer development, research and design for CPUs and mass storage was mainly at Hawthorne. In the late 1950s, to support expected applications for online transaction-oriented systems, the Hawthorne engineers developed a random access memory unit based on magnetic cards. The Card Random Access Memory (CRAM) functioned effectively in several bank installations in the early 1960s, but lost out to the disk drive design invented by IBM, which became dominant in the industry (Rench, 1984: 28). Nevertheless, NCR persisted in its aggressive stance toward the leading edges of computer technology. For example, NCR began development of integrated circuits in 1963 in order to be able to develop proprietary 'application-specific' integrated circuits (ASICS) and was an early user of metal oxide (MOS) technology (NCR Corporation, 1984: 20–24).

## GAINING A FOOTHOLD IN COMPUTERS

NCR had been a few years late in entering the market for computer systems and somewhat hesitant about its strategy. But it had the advantage of established relationships with numerous customers in the market segments it chose to address. The 304 and 315 systems successfully positioned the company as a supplier of small and medium-size systems used primarily by retailers and banks for recording transactions and issuing payrolls. RCA and GE, which had also entered late, chose to go head-to-head with IBM across a broad market, and failed. NCR's timing was not necessarily a handicap in its niches. While the potential opportunity for bank automation was large, it was not realized substantially until the late 1960s. In 1963, fewer than 20 percent of the nation's 14,000 banks reported that they either already used computers or had plans to automate. Even by 1969, barely 1000 had their own computers, and 6700 still had no plans to automate (Phister, 1979: Table II.3.11.6).

Computer sales grew slowly and were persistently unprofitable for NCR, as they were then for most computer manufacturers. In 1962, a decade after the decision to enter the business, NCR's computer revenues were only 2 percent of the company's total (NCR Corporation, 1984: 4). Because the Model 304 was a high-cost design, production was stopped after only 36 of the systems were sold.[3] The more successful Model 315 was eventually placed in more than 1000 installations.

The belief in 'systems' remained strong. NCR's display at the 1964 New York World's Fair featured the theme: 'NCR Total Systems—from original entry to final reports.' The view in technical circles, however, was that the words were not matched by deeds in marketing. As one manager noted:

> NCR's strength in the marketplace and (sales force) was deeply imbedded in the knowledge that the company had in selling accounting machines and cash registers in a distributive sense rather than in a systems sense. So the strength of the company might have been its weakness in its marketing efforts. (Rench, 1984: 22)

By 1963, NCR was shipping enough systems to place it in the middle of the 'seven dwarfs,' as the press came to call the group battling for the 30 percent of the market not claimed by IBM in the burgeoning new marketplace.[4] According to one analyst, the value of NCR's shipments that year represented 3 percent of the market, a level that would persist, with modest variations up and down, for a decade (Phister, 1979: Table II.1.31.1).

## MANAGEMENT SUCCESSION

A new generation of top management took command as NCR moved into the EDP market, but it brought no change to the traditions of its predecessors. Stanley Allyn, who had been catapulted into top management by John Patterson in 1917, retired as chairman on the last day of 1961. His successors were selected in much the same

[3] The initial commitment to GE had been for 24 systems; under pressure from the field, management in Dayton authorized another dozen, even though costs exceeded revenues (W. Anderson, 1991: 172).

[4] The 'Dwarfs', in order of size in 1963, were Univac, Burroughs, Control Data, NCR, Honeywell, RCA, and GE (Phister, 1979: Table II.1.31.1).

way as Allyn had been—chosen at a relatively young age and then groomed for the top. The first of them, Robert S. Oelman, was a native of Dayton and a *summa cum laude* graduate of Dartmouth College. After a year of graduate work in law and economics in Vienna, he had joined the company in 1933 as a file clerk. He moved rapidly into sales promotion and advertising responsibilities. In 1942, when Deeds and Allyn were looking for someone 'intelligent and of distinctly contagious personality and political astuteness' to understudy Allyn, they chose Oelman and brought him into the executive office (Allyn, 1967: 185). By 1950 he was executive vice president and was named president in 1957, succeeding Allyn as chairman in 1962.

Oelman's understudy was R. Stanley Laing. Trained in Mechanical Engineering at the University of Washington, Laing earned an MBA at Harvard in 1947. Allyn hired him that year as an assistant in the executive suite, and then moved him into a series of staff jobs in finance. By 1954, he was controller and in 1960 was named vice president, finance. In 1964, Oelman named him president.

Both Oelman and Laing were perceived as extremely intelligent, but with differing management styles. William Anderson, who succeeded Oelman as chairman, described him as 'essentially a consensus-type leader ... [who] always went out of his way to avoid conflicts and bruised egos.' Laing, in contrast, often seemed 'authoritarian,' inclined toward a style that implied 'this is what I've decided and this is what I want you to do' (W. Anderson, 1991: 217).

## Corporate culture

Despite differences in style, both Oelman and Laing were products of a strong corporate culture, shaped a half-century earlier by John Patterson and sustained by Deeds and Allyn. The prevailing style was described as 'formalistic and procedural' by a senior consultant who worked there in 1971. As he described it thus:

> If product development needed to coordinate with manufacturing engineering, a meeting would be scheduled, agendas prepared, notes taken, and yet often little would happen. There was no notion of teams. (S. P. Kaufman, personal interview, Melville, NY, 17 December 1998)

A senior manager who spent most of his career outside Dayton described the organization structure as a 'Byzantine labyrinth.' Management procedures lacked the 'give and take discussions' and formal checks and balances that would limit errors and excesses (W. Anderson, 1991: 180). Executives spent their careers within a single department, like manufacturing engineering; there was no tradition of rotation.

Nevertheless, as a reporter noted in 1962, 'NCR has long been noted for the togetherness of its executive family. Oelman and many of his top aides live in Oakwood, a Dayton suburb just beyond the NCR plant, and except on the coldest days of winter they meet on corners to walk in groups down the short hill to the plant' (*Business Week*, 1962: 106). Senior executives lunched together daily at the same table in the 'Horseshoe Room,' established in the 1930s as a common venue for managers and factory supervisors. Service began promptly at noon and a short educational or inspirational film was screened regularly at 12:40. The chumminess of this group bred what was later noted as a 'Dayton mentality' in which NCR staff in other locations were referred to as 'outsiders.' The press would later speculate that a certain myopia about electronics had been fostered by the daily sight of massive factories with their workers and machines chugging mightily to fabricate the familiar mechanical products.

## Core rigidities

In the 1960s, NCR's Dayton manufacturing organization, once a pillar of its competitive advantage, was turning into a handicap, mired in high costs and inflexibility. This was one of several instances in which long-standing core capabilities evolved into core rigidities as NCR faced the need for fundamental change (Leonard-Barton, 1992). Some 15,000 manufacturing workers and engineers worked at the massive Dayton facility. Labor costs were high; wages for relatively unskilled personnel were then three times the level at the Electronics Division in Hawthorne. Factory workers in Dayton were organized by a strong independent union, which followed the lead set by the local General Motors contracts. A piecework compensation system installed by NCR early in the century still governed factory operations. In combination with a strict union contract, it hobbled efforts to improve methods

and productivity. Many managerial practices were obsolete. Few in manufacturing management were university-trained; one executive later commented that NCR at that time 'did not have manufacturing managers; it had manufacturing supervisors' (W. Anderson, 1991: 184). Inventory, scheduling, and control systems were antiquated; foremen had wide discretion in determining parts quantities in any batch. Manual systems persisted in part because of management antagonism toward IBM punched card systems, which had long been used at Hawthorne (W. Anderson, 1991: 183). In contrast to the 'experience curve' doctrine advocated by Eckdahl in California, managers and cost estimators in Dayton assumed that costs would rise continually with inflation. The policy of vertical integration was carried to an extreme; NCR even made its own fasteners (with nonstandard threads). Costs of most components were eventually discovered to be as much as double what vendors would have charged (D. E. Eckdahl, personal interview, Colton, CA, 19 March 1998).

In the mid-1960s, NCR was still pouring money into the old technologies. Pride in mechanical prowess was a strong element of the Dayton culture. When Charles Exley, then a vice president of arch-rival Burroughs, visited NCR in the late 1960s, he was shown around the plant and told proudly about plans to expand facilities like the automatic screw machine department, which was already the largest in the world. On his return to Burroughs, he told the chairman 'You can stop worrying about NCR. They're making more and more commitments to mechanical technology' (W. Anderson, 1991: 183). The new Class 5 cash register, first marketed in 1967, was an engineering triumph and an economic flop. It anticipated the imminent functionality of programmable logic in electronic point-of-sale equipment in the design of an electromechanical product that could be produced in hundreds of configurations through selective combination of thousands of standard parts. But the engineers' vision that salesmen would master the art of programming these devices to adapt to the customer's unique needs could not be realized in practice.

## THE END OF AN ERA

In hindsight, it is clear that the 1960s were the twilight years of the age of electromechanical technology for information processing. At the time, however, the signals were more confusing. Demand for mechanical cash registers was remarkably strong; steady 12 percent annual growth in volume throughout the 1960s was fueled by the sustained expansion of the American economy and enhanced by the rapid spread of suburban shopping malls. But, by the mid-1960s, the retail marketplace was rife with speculation about a revolution on the horizon: point-of-sale terminals, all electronic, and online.

### A retail revolution

In 1964, Singer Sewing Machine Company began to look for a vendor who could provide point-of-sale terminals for its retail stores. Told by NCR that neither the economics nor the technology would support such a product in the foreseeable future, Donald Kircher, Singer's CEO, gave the task to the Friden Company, a venerable producer of mechanical calculators that Singer had recently acquired. While Friden's engineers were fully as skeptical as NCR's, they couldn't refuse their new CEO.

Top management at some of the largest customers began to express their interest in machines that would feed data directly to their new computer systems. In 1965, a new entrant made the first move: Uni-Tote (a subsidiary of General Instrument Corporation) introduced the first electromechanical cash register with 'online' computer capability. In 1966, Remington Rand also introduced an 'online' product, the Point-0-S-Recorder. By 1970, Friden was marketing an electronic Modular Data Transaction System.

In the late 1960s, with multiple vendors in the marketplace, Penney, Sears, and other chains began to experiment with point-of-sale equipment, often with initially discouraging results. *Datamation* magazine (1966) advised retailers to wait for the price of point of sale [POS] machines and computers to drop in half before considering their purchase. In 1968, American Regitel Corporation, a start-up later acquired by Motorola, introduced an electronic cash register system for medium-sized and large department stores. By 1969, other competitors were field testing all-electronic machines for the retailing industry, notably Alpex (later acquired by Pitney Bowes), General Electric, and Singer's Friden Division. NCR responded to the POS challenge of new

rivals by upgrading its Sales-Tronic line, promoting new optical scanning wands and decoders for input, and designing a special line of low-cost electromechanical registers for retail use.

Critics would later fault NCR's management for its hesitant response. For example, a 1975 article in *Fortune* asserted: 'big retailers—J. C. Penney, Singer, Sears, Kroger—were pounding on NCR's door trying to get the company to experiment with computerized point-of-sale systems ... NCR failed to listen' (Martin, 1975). But in 1970 the signals from the marketplace remained very mixed. Corporate executives at the major chains foresaw the coming transition and pressed for action; but at the store level, operating executives—NCR's immediate customers—still preferred to buy the familiar (and still cost-effective) older products. Stanley Laing, NCR's president, speculated (in 1970) that 'cash registers will be around for some time to come ... Five years from now, maybe even ten, even the most advanced department stores will still be in the process of automating' (*Dun's*, 1970: 29) This, of course, was what customers were then telling NCR's salesmen (W. S. Anderson, personal interview, New York, January 19, 1989). According to a consultant who worked with NCR in 1971, its managers believed strongly even then that electronic registers would 'always' be too costly for the low end of the line (S. P. Kaufman, personal interview, Melville, NY, 17 December 1998). Laing believed that NCR had already accomplished a tremendous change with its new emphasis on entire business systems rather than individual business machines (*Dun's*, 1970).

Product development began in the late 1960s for a line of fully electronic terminals, targeted for market launch in the early 1970s. This was a challenging task. Engineers made the risky decision to base the line on MOS integrated circuitry, then still commercially unproven. In the end this yielded cost advantages over competitive bipolar designs, but the choice led to problems in development and schedule slippage of almost 2 years. As Carl Rench, head of engineering and product planning in Dayton, later said, this development required that they 'architect a whole new family of products from the ground up,' including design of ancillary elements such as printers, displays, keyboards, and communication devices (Rench, 1984: 58).

## EDP systems

Two fateful events signaled the future of the computer market in 1964: IBM introduced the 360 series, which set the pattern for mainframes and cemented its dominance of the field; and tiny Digital Equipment Corporation marketed the PDP-8, sparking the emergence of a distinct minicomputer segment. RCA responded by marketing a series of 'clone' systems to compete head-on with IBM at lower prices and GE differentiated its line by pioneering in time-sharing technology. Both strategies failed and the giants of electronics were forced to exit. The remaining 'Dwarfs,' now termed the BUNCH (Burroughs, Univac, NCR, Control Data, and Honeywell) sought security in niches in the few market spaces left open by IBM. NCR's intended niche was described by Stanley Laing as follows:

> We didn't want to be in the computer business just to sell computers, as IBM basically did. We wanted to sell terminal-oriented computer systems, because our two biggest clients were retailing and finance. We wanted to develop terminals whose outputs would be the inputs to the computers. We would basically offer a total system from input at the terminal level to output at the computer printer level. (R. S. Laing, interview, Delray Beach, FL, 3 May 1999)

In 1966, the NCR Electronics Division, still headed by Donald Eckdahl, was renamed the Data Processing Division. NCR spent $150 million to develop a third-generation computer system, the Century Series, introduced in 1968. Like IBM's System 360, the series featured a scalable design for the CPU, permitting users to upgrade readily as their needs increased. Unlike IBM, NCR's offerings would serve only a segment of potential users. At first, NCR offered Models 100 and 200, at the low end of the line; later a mid-range model, the 300, was added. In search of performance and cost advantage, NCR introduced highly innovative design features in the Century, including novel plated rods for main memory, to permit automated assembly, and a mass storage system using disk drives with a radically different head design. The new line made a strong debut in the marketplace; domestic orders for computers in 1968 were double those of the preceding year and, for the first time, exceeded those for either cash registers or accounting machines. But the Century's memory and disk drive technologies

had not been perfected. Customers became irate over repeated breakdowns. Over the years from 1968 to 1972, the Century series would drain another $150 million from NCR for redesign and repair.

The market for EDP systems, while growing rapidly throughout the 1960s, was also changing in character. One significant trend was the increasing importance of peripherals as a component of system cost. As demand grew, an OEM market for peripherals developed to serve the needs of the 'Dwarfs' and a 'plug-compatible' market emerged among IBM customers. NCR did not enter the plug-compatible segment and, despite its early moves (in the 1950s) to develop peripherals technology, failed to establish a strong position as an OEM supplier.

### Pressure on management

Throughout the 1960s, Stanley Laing struggled with sustaining NCR's profits in the face of adverse trends. As he described it:

> We had the P&L impact of the conversion to the rental business—the more we produced, the more we rented. It took a whack at our gross margins at the time when we couldn't afford to do it. And simultaneously, we were faced with a huge R&D problem of developing not only mainframes, but a huge array of peripheral gear which imposed a very substantial financial impact. (R. S. Laing, interview, Delray Beach, FL, 3 May 1999)

To alleviate these stresses, Laing initiated discussions with William Norris, head of Control Data Corporation (CDC) to explore cooperative measures in development and manufacture of peripherals. Relationships between the companies were warm, going back to wartime friendship between Joseph Desch and Norris (Rench, 1984: 45). CDC, like NCR, was under increasing financial pressure. In February 1972, the companies announced a broad cooperative program to coordinate their mainframe product lines and to rationalize development and manufacture of peripherals. CDC purchased NCR's disk drive engineering and manufacturing facility at Hawthorne and would supply NCR's needs for disk products. The companies formed a 50/50 joint venture to develop and produce other peripherals, including magnetic tape drives, punched-card equipment, and high-speed printers. NCR would supply CDC's needs for serial printers. In future CPU development, the companies would seek to achieve

> a high degree of compatibility ... between future small and medium-size computers developed by NCR and future large computers developed by Control Data ... NCR will be able to offer its customers an easy transition to more powerful systems. (*NCR Annual Report*, 1971: 5)

The task of selling the computer products created stresses for the field sales force, the heart of the company's traditional competitive strength. In NCR's early days in the computer field, the Model 315 had been marketed by a small cadre of people based in Dayton, assisted by a few specialists operating from the branch offices. As the business grew, instead of recruiting experienced computer salesmen, NCR retrained its own force and assigned both accounting machines and complete EDP systems to the same staff. In 1970, 80 percent of the staff selling the Century series were former cash register or accounting machine salesmen (*Dun's*, 1970). But it was hard to find a compensation scheme that worked well for both large systems and stand-alone machines. As one salesman grumbled, 'computers took 75% of your time and would bring in 25% of your income' (NCR Corporation, 1984: 5).

Top management debated alternative approaches to selling computers, especially the idea of 'vocationalizing' the sales force to create teams specialized according to the customer industry rather than NCR product. In 1965, top management went so far as to 'recommend' that foreign subsidiaries restructure along those lines. In Japan, William S. Anderson, who also initiated the development of an all-electronic cash register for his local market, implemented the idea in Japan in 1967. In 6 years, NCR's sales in Japan tripled with only an 11 percent increase in the sales force (*Business Week*, 1973).

One executive pointed to customer loyalty as the main factor behind the company's ability to succeed. He commented:

> We had amazing customer loyalty. Nobody had a longer history of caring for customers ... sons of customers remember us. We did everything for our customers. We sold a *system* to the customer, not just a machine. We became part of the customer's organization. They were reluctant to abandon us. (W. S. Anderson, personal interview, New York, January 19, 1989)

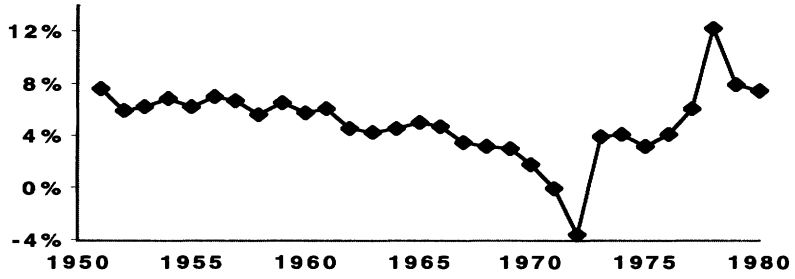


Figure 1. NCR return on total assets, 1951–1980

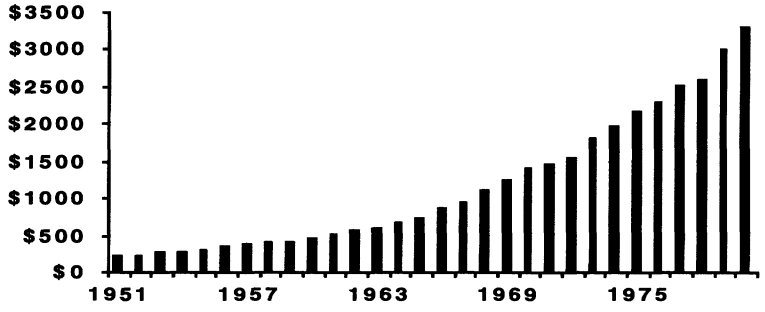


Figure 2. NCR revenues (in millions), 1951–1980

## CRISIS AND RESPONSE

The cross-currents of a technological watershed buffeted NCR's performance throughout the 1960s. Returns fell as assets grew more rapidly than revenues and productivity growth was sluggish (see Figure 1). Yet revenues nearly tripled over the decade as the computer business achieved significant scale and demand for traditional products boomed in the United States and abroad (see Figure 2). NCR expanded facilities while payrolls swelled; employment doubled, peaking at 102,000 in 1969. By 1968, EDP systems still accounted for only 11 percent of corporate revenues, but the installed base of systems represented 25 percent of assets on the balance sheet. The cash drain of leasing computers drove the debt/equity ratio steadily upward. In the late 1960s, NCR reaped an average of only $12,000 in revenue per employee (equivalent to $56,000 in 1999)—about two-thirds the comparable measure for Burroughs and half that for IBM. Internal controls were strained, and margins were squeezed as costs rose throughout the decade.

At the end of the decade, NCR was under attack in all its core businesses. By 1969, Burroughs Corporation, NCR's chief rival in the banking marketplace, had completed the transition from electromechanical to electronic machines, and was gaining market share. Revenues from accounting machine sales started to fall in 1970, declining by 16 percent between 1970 and 1972, but the company was slow to introduce new systems to halt the advance by Burroughs (Martin, 1975). In the retail market, although NCR was losing share, the buoyant market brought ever-increasing revenues through 1972. Despite success in selling the Century series of computers, NCR was still losing money in the EDP market. For the first time since 1962, profits declined substantially in 1970, a recession year, and then, burdened by a costly strike, NCR barely broke even in 1971. In the meantime, Friden had taken first place in the market for electronic cash registers, followed by Pitney Bowes-Alpex. IBM had an electronic register in field test, while both Litton's Sweda and Retail Systems divisions, as well as TRW, had development projects well under way.

In 1972, NCR began to ship its new electronic terminals: the 270 bank terminal and the 280 for retail point-of-sale. Encouraged by an order from Montgomery Ward for 1500 of its 280s, William Harris, NCR's director of department store marketing, predicted that NCR would have an 80 percent share of the market based on the strength of knowing their customers on a first name basis

and understanding their problems. Harris also predicted that the market wouldn't begin to grow rapidly until 1973, so 'it doesn't make sense to push a product until you can get sufficient volume to support a low price' (*Dun's*, 1971). The business press was calling the new market a four-way race between Singer's Friden, NCR, Litton's Sweda and Pitney Bowes-Alpex.

By 1972, Singer controlled 50 percent of the electronic point of sale market, followed in second place by Pitney Bowes-Alpex, with NCR third (*Wall Street Journal*, 1972: 1). The average price of an electronic cash register had declined, as *Datamation* had predicted, so that an electronic register, typically selling for $3400, cost only $200 more than an electromechanical model. The press forecast they would cost less than $3000 by 1976 (*Business Week*, 1972). NCR introduced two new models of freestanding electronic cash registers: the NCR 250 and NCR 230.

## Facing realities

In 1970, Donald Eckdahl was appointed vice president of operations for the corporation and moved to Dayton. Stanley Laing, he found, was well aware of the need to do something radical about the Dayton operation, but seemed unaware of the extent to which costs were out of line and management methods behind the times. In mid-year, Laing assigned Eckdahl to study potential uses for Dayton's three million square feet of factory space and nearly 15,000 production people as NCR moved from high-labor-content mechanical products to electronic technologies. With the aid of consultants from McKinsey & Company (and other firms), Eckdahl explored several options, some quite far from NCR traditions. The possibility, for example, of diversifying into the automotive aftermarket was discarded when studies showed that NCR's costs to make parts would be double those of other shops in Dayton. Analysis cast strong doubt on the feasibility of changing the structure, philosophy, and culture of manufacturing in NCR's Dayton operations to meet the needs of the future. The conclusion was that, despite their deep reluctance to do so, NCR management would have to let Dayton operations wither away, while building new capabilities in other locations.

Stanley Laing had recognized for some time that wrenching changes in manufacturing, engineering, and sales would be required to reverse the slide in NCR's fortunes. In the late 1960s, despite pressures on profits, he had increased investments in training and had moved to recruit MBAs to bring modern ideas into management. Eckdahl was moved from California for the same purpose. But Laing also believed that a number of senior people were unlikely to adapt and would have to be replaced. Oelman, loyal to his subordinates, resisted these moves and, in Laing's view, slowed down the pace of change (R. S. Laing, interview, Delray Beach, FL, 3 May 1999).

Battered by a strike and increasing competition in computers, terminals, and accounting machines, NCR saw its profits vanish in 1971, forcing the Board to cut the dividend in February 1972. The outside members of the Board of Directors had become increasingly concerned about the company's performance and its leadership and direction. One director, with a high opinion of Laing's intelligence and abilities, believed that he was more open to change than Oelman, who was more of a traditionalist (anonymous interview). But even this person believed that no one with deep roots in Dayton would have been able to implement the necessary cutbacks there. According to another account, 'also disturbing were reports that the relationship between the chairman and the president had become so strained that they were scarcely speaking to each other' (W. Anderson, 1991: 210). According to R. S. Laing (interview, Delray Beach, FL, 3 May 1999), he himself made the move that broke the stalemate at the top, going to Oelman to tell him 'that I just didn't think he knew where we were going and I thought he ought to step down,' adding 'if you don't step down, I'm going to leave.' Oelman's response precipitated Laing's resignation, effective May 17, 1972.

## A new leader

Meanwhile, the outside directors had concluded that new leadership was in order for the company. With Oelman's participation, they chose William S. Anderson, an Englishman born in China and educated in Shanghai, who had started his career with NCR in Hong Kong and eventually rose to become head of its large subsidiary in Japan. Although Anderson had spent his career with NCR outside the United States, he knew the country; he had married an American woman and

had visited the United States annually since 1951. Anderson moved rapidly to take charge, arriving in Dayton in June 1972. Oelman remained as chairman until 1974, and served as a director and chairman of the Executive Committee until retirement in 1980.

The board had looked for a market-oriented man to take NCR through what looked to be tough years of transition ahead. Charles A. Anderson, who had joined the Board in 1969, described William Anderson as 'smart and courageous ... a consummate salesman very good at high-level customer relationships' (C. A. Anderson, personal interview, Palo Alto, CA, 28 January 1999). Another director, asked to characterize William Anderson, mentioned 'a wonderful personality for meeting people' and a style that could be 'stern, very determined.' Overall, he found him 'straightforward, very honest, very open, a wonderful executive' (C. H. Hardesty, personal interview, Myrtle Beach, FL, 4 May 1999).

By 1972, NCR's previous strengths in sales and manufacturing had turned into obstacles to progress (see Leonard-Barton, 1992). Anderson quickly set out to break up the 'Dayton mentality,' reshuffling most of top management and restructuring manufacturing and marketing. He also attended to some necessary symbolic changes, including a new name—NCR Corporation—and a new corporate headquarters building. He quickly communicated the direction NCR was to take: 'The NCR of 1982 will be primarily an electronics company' he told the employees. 'Our principal products will be complete information processing systems' (National Cash Register Company, 1972: 16).

Anderson understood that the changes that NCR must make would have severe consequences for its employees in Dayton. Early on he told the Board that he was sure to experience severe pressure both from the union and from the Dayton civic leaders. To persevere he would need assurance of the directors' support. As one outside director said: 'The Board gave him that support; it was critical that they stood solidly behind him' (C. A. Anderson, personal interview, Palo Alto, CA, 28 January 1999).

### *Restructuring*

As Anderson was taking charge, Donald Eckdahl was working out the final elements of his plan for a radical restructuring of manufacturing operations. He would recommend the establishment of a series of self-contained, small to medium-sized plants across the country, each with its own general manager, engineering, finance, information systems, human resource management, quality control, and purchasing. All products currently made in Dayton would remain there; the transition to electronics in the marketplace would rapidly phase out those activities. Products still in development would be moved, with their engineering staffs, to the new locations where they would be produced. The new operations would be primarily for assembly and test. Most components would be purchased, reversing historic practices.

Anderson accepted the plan immediately, telling Eckdahl that it should be presented at the next board meeting. At the conclusion of the presentation, the directors applauded—'not for the presentation, but with relief' D. E. Eckdahl (personal interview, Colton, CA, 19 March 1998) recalled. As the product mix shifted, manufacturing at the Dayton plant was rapidly reduced from 80 percent of NCR's domestic production to 30 percent. NCR had been Dayton's second largest employer, after General Motors, employing approximately 15,700 factory workers at its peak in 1969. By 1976, NCR would have only 2000 factory workers remaining in Dayton. Throughout the company, the number of employees dropped from a 1969 high of 103,000 to 90,000 at the end of 1973. Within two more years, manufacturing had metamorphosed from being a high-precision mechanical parts fabricator and assembler to a high-quality assembler of purchased components.

Anderson shook the marketing organization from top to bottom, restructuring it along the vocational lines that had worked so well in Japan. All marketing and sales staff were identified with one of four 'vocational' customer segments: retailing, financial, commercial/industrial, and medical/educational/government. A shake-up among the senior marketing and sales managers occurred as promotions were made to new vocational vice president and regional director positions. A New York securities firm estimated that attrition from the restructuring might result in a 10–12 percent reduction in NCR's sales force. A new training program was established and backed by a 20 percent increase in the training budget to implement the restructuring

(*Business Week*, 1973). NCR's marketing efforts became heavily dependent on the field engineering force, so that by 1975 one in every four employees (18,000) was a field engineer.

Senior management was completely transformed. Five top executives took early retirement while another seven found new jobs outside of NCR. Seven more vice presidents were demoted or had their organizations eliminated. But almost all of the new appointees were also NCR veterans. Only two top spots, in R&D and finance, were filled from outside. The new chief financial officer was nearly an insider; Donald Macintosh had worked with the company for 11 years as the audit partner for Price Waterhouse. In 1973, when Anderson selected the marketing vice president from the Atlanta region to become senior vice president of marketing, non-Dayton people were in all the key spots in manufacturing, R&D, finance and marketing.

In NCR'S 1972 *Annual Report*, in contrast to the earlier emphasis on evolution, management noted:

> A technological revolution is now impacting on other types of free-standing business machines including the cash register, providing dramatic improvements in performance and flexibility. The transition of the business equipment industry into what will soon be essentially an all-electronic industry has presented many challenges.

The result of Anderson's immediate changes were write-offs of $135 million and an earnings deficit in 1972 of $59.6 million. Macintosh summed up the problem as follows: 'We didn't recognize early enough that market demand was moving much more rapidly than anticipated toward electronics. So we were caught two years behind the market' (*Forbes*, 1973a).

## Resurgence

NCR delivered thousands of its new electronic cash registers in 1973 and was poised to introduce a new machine once the food industry officially adopted the new Universal Product Code standards. At this point, all but one major NCR plant was producing the new generation of electronic equipment. NCR believed that it was 'neck-and-neck with Singer' in the point of sale market (*Datamation*, 1973). A significant market development occurred when Pitney Bowes-Alpex withdrew from the POS market, citing losses of $28 million over the previous 3 years. By 1974, capitalizing on the exit of Pitney Bowes-Alpex and with a new product line, NCR had captured 50 percent of the electronic cash register market; Singer was now second. By 1975, when NCR had a complete line of integrated point-of-sale systems, its market share rose to 61 percent, despite the added competition created by IBM's entry into the retail POS marketplace (*Forbes*, 1976). By the end of 1975, Singer, Bunker-Ramo and MSI Data had dropped out of the electronic cash register market.

NCR, having at last gone electronic in cash registers, had triumphed because of the power of its reputation and relationships, strengthened by the scope of its product line and the new systems orientation of its marketing force. As *Forbes* (1973b) reported, 'Customers would rather have a single manufacturer responsible for the entire system.' In 1973, NCR's revenues from computer systems and services ranked it last among the 'Bunch' but, for the first time, it earned a profit on system sales. The five firms then chasing IBM in computers were 'bunched' closely in revenues in 1973. NCR's $726 million was not far behind the $1.1 billion of Honeywell and Burroughs, the largest of the five (Flamm, 1988: 102).

1975 marked the last year that NCR produced mechanical cash registers in the United States. The market had evaporated with stunning speed. Stand-alone electromechanical products represented only 7 percent of equipment shipments in 1976, down from 66 percent 4 years earlier, while electronic terminals rose from 9 percent to 55 percent and computer systems from 25 percent to 39 percent. Equipment sales and rentals represented about 55 percent of total revenues—service and supplies providing the balance—in this period. NCR's revenues from traditional products (electromechanical registers and accounting machines) fell from nearly 40 percent of total revenues in 1972 to only 4 percent 5 years later (NCR, *Annual Report*, 1976; Foster, 1986: Figure 18).

By 1978 NCR had completed its transition from the age of mechanical registers to that of electronic systems. Revenues zoomed upward and profitability returned to peaks the company had last enjoyed in the gravy days of the early 1950s. And to lead it into the 1980s, NCR had a new Chief Executive: Charles Exley Jr, a 22-year

veteran of Burroughs Corporation recruited by Anderson to succeed him in 1976 as president and later as chief executive.

## DISCUSSION

The history of NCR is the story of only one organization among the many that were transformed in the mid-20th century by the gales of creative destruction that accompanied the coming of electronics to the office products industry. There are obvious limits to what can be inferred from analysis of a single historical case. But, the richness of detail available in this extended case should enable us to seek insights into some of the general propositions about adaptation to technological change that have gained currency in academic discourse.

As we noted at the outset, the thrust of most academic discussion of the impact of transforming technological change is to explain why it leads to the failure of dominant incumbent firms. NCR serves well as a counter-example; it was one of the dominant firms in its industry in 1948, and it unquestionably did not 'fail'—in 1978 it maintained leadership in its principal market segments and was highly profitable (see Figure 1).[5] Yet, while it was not a 'failure,' neither would it be judged by most observers as a 'success' in these transitions. The company did not exploit computer opportunities as fully as might have been done and it endured a painful crisis in the adaptation of its core product line. But it survived, and even regained its prosperity, with a significant position in computers and a leading position in transaction terminals by the late 1970s. Survival in the face of a technological transition as strong as this one is no small achievement; many firms that had strong positions in specialized fields of business equipment in the 1950s were severely diminished or had vanished from the scene by 1975—e.g., Smith-Corona (typewriters), Marchant and Monroe (calculators), and Addressograph-Multigraph (reprographics).

Given this detailed, complex, and decades-long story of adaptation and survival, different readers will undoubtedly come to different interpretations about its larger meaning. The author's view is that this story offers qualified support for each of the varied theoretical perspectives identified at the outset. Incremental change in product designs, competence destruction, new value propositions, and threats to long-standing social commitments all appear as consequences of new technologies deployed by NCR and as factors shaping its behavior. Each of the propositions about the significance of such characteristics of an innovation is useful in explaining part of NCR's experience in the transition to electronics.

For example, the successful 'Post-tronic' accounting machine enhanced the value to users of existing designs through incremental design changes that built on established competencies. In contrast, inherent in the technology of the Model 102-A drum computer, launched in the same year, but later aborted by Stanley Allyn, was an opposite set of consequences. Implicit in the emergence of small general-purpose computers in the 1950s was a wholly different value proposition, at first not well understood by either producers or users, but potentially a replacement for accounting machines and hence destructive of those established competencies. In the first case electronics was sustaining and enhancing; in the second it would be disruptive and destructive. One was embraced by top management, the other rejected.

The logics of economics do not help to justify some of the most important investment decisions in this story. The foundations of the requisite new technical capabilities in electronics were laid down by Desch and his associates, beginning in 1938, and by the acquisition of CRC in 1953. The first of these investments was made nearly 20 years before NCR's first electronic products reached customers. Net profits from the second were not realized until the 1970s.

In the postwar years, the founders of the entrepreneurial start-ups were probably more highly motivated to invest in computers than were the established leaders in office equipment, but IBM, Remington, Burroughs, and NCR were not unwilling to invest and were better able to access the requisite capital. Financial constraints appear more evident in the 1960s, when the continuing squeeze on margins did limit NCR's investments in its computer line. Furthermore, the reluctance to restructure ('vocationalize') the field sales organization, or to change its incentive system, was clearly rooted in the concern that change might disrupt the flow of current revenues and profits.

[5] Anita McGahan (1999: 78) shows that this kind of turnaround from chronic low profitability is a rare event.

Several other kinds of commitments stand out as influential in NCR's story. The company's manufacturing prowess and heavy investment in people and equipment would be rendered null by a 'revolutionary' (as opposed to 'evolutionary') shift to electronics technology. Management's long-standing commitment to the masses of factory workers and to the city of Dayton hindered the implementation of changes that were essential to adaptation. On the other hand, another long-standing commitment—to help customers meet their needs—served the company well in making the transition to the new era.

As the foregoing indicates, the established theoretic perspectives do offer some explanatory power when applied to specific aspects of the story. The necessary qualification, however, is that no single theoretical perspective is sufficient to 'explain' the path of NCR's behavior in a more general sense. Neither specification of the characteristics of specific innovations, nor generalization about asymmetric incentives, social commitments, and the like, will by itself sum up the story. Hence we conclude by raising some broader questions which might be addressed in future research.

## Waves of change

As is evident in the story, the task facing NCR's management was not simply one of coping with a particular innovation; the company participated in a revolution in technology that played out over decades and comprised multiple innovation opportunities within two major waves of change. The first wave led to the practical possibility of using electronics, rather than mechanics, to register and to process financial information; the second led electronics into the age of semiconductor integrated circuitry. Each of these waves presented the potential for numerous innovations with varied consequences.

Seminal inventions, like ENIAC or the first integrated circuits, open new frontiers of technological opportunity. Pioneering investments to develop their capabilities and explore their applications are usually required before significant innovations can be commercialized. NCR's stance on the frontiers of technology changed over time. In the 1930s, it was a technological pioneer in electronic calculation but it was not among the first to bring the technology to market. In the 1960s, it was an early mover in the applications of semiconductor technologies pioneered by others. The company, however, survived both waves of change; its revenues grew consistently and, although profitability suffered during the 1960s and it endured an acute crisis in the early 1970s, it emerged in the mid-1970s more profitable than ever. This suggests that it would be useful to formulate and test theories that can explain the changes in the fortunes of firms in the face of aggregate changes in technology, as well as with respect to specific innovations.

## Dynamic capabilities

Looking at the NCR story from the 'dynamic capabilities' perspective, the significance of organizational processes stands out. Organizational processes within NCR were strong, in the sense that they were long-standing, robust, and influential. Yet they were weak in the sense that they proved to be poorly suited to the new era. The established processes for product development, product delivery, and marketing were hierarchical, ineffective at integration, and slow. They had been sufficient to sustain a near-monopoly position in markets where needs and technologies changed slowly—even encouraged by that environment. But electronics changed all that, destroying entry barriers and creating rapid change in the customers' sense of their information needs and in the products available to them. New processes were required to integrate marketing and product development, so that the latter could be driven by customer needs rather than the preferences of 'expert' product planners. Teamwork was needed to bridge formal boundaries and speed response to change. The established culture was a barrier to meeting these new needs. Learning was not an inherent element of processes at NCR. The company had had no experience with reconfiguration or transformation of structure and processes in what was, until 1972, a highly centralized organization.

## The role of leadership

NCR regained prosperity when new leadership provided the impetus for a required transformation whose nature was clear to all whose vision was not clouded by commitments to an earlier order of things. Because it possessed strong capabilities in the new technologies plus

strengths in sales and distribution that could serve well, with some adaptation, to bring new products to old customers, the organization was able to move rapidly in the new directions. But the value of these capabilities would have been dissipated without the action of leaders to enable the transforming changes that made that possible.

The central role of NCR's leaders over the decades was both to make new commitments and to break old commitments. Hesitancy in both respects acted to limit success. Creation of new capabilities, by Deeds in 1938, by Allyn in 1952, and by Anderson in 1972, were essential to the long-run outcome. On the other hand, the postwar decision to focus on core products and restrict electronics work to 'research' foreclosed strategic paths that might have been open to NCR. For example, in a retrospective on the early days of the industry, a computer historian speculated on what he called 'an intriguing industrial "might-have-been."' Noting the prewar inventions at NCR, he suggested that

> this machine could have become the first commercial electronic computer had the company wished to pioneer in this field. However, NCR management was not interested in automatic computing, *per se*, but only in improving its existing line of office equipment. (Tropp, 1974: 76)

In 1954, another strategic path was closed off by the decision to shut down drum computer sales by CRC.

The *position* of a business can be partly defined, as Teece and Pisano suggest, by the firm's current 'endowments,' but it also is determined by choices made about which *paths* to follow. Important choices of strategic *direction* were effected by Deeds' decision to invest in electronics research and Allyn's acquisition of CRC. But the capabilities thus added to NCR's endowment left open a range of opportunities along a range of potential strategic paths. The more concrete choices to pursue certain pathways and eschew others were more determinative of long-run results.

What stands out is that creation of some essential capabilities implied a corresponding willingness to break commitments and take risks. Anderson criticized his predecessors for treating computers as 'a fourth department', in effect, assuming that new paths could be followed successfully without transforming the old ones. The leader's main role, perhaps, is to own responsibility for the breach of commitments.

This brings us to our final observations, on the role of leadership. One dimension that was conspicuously influential in the NCR story, individual leadership, is rarely mentioned in the academic sources cited at the beginning of this paper. It deserves closer examination and may well be a central element in dynamic capability.

Some organizations may have the capacity to transform themselves to adapt to changes in strategy or in the environment. Robert Burgelman (1994) has described how Intel's established processes for resource allocation redistributed the application of its critical assets from memory to microprocessors, a move eventually ratified by its top executives. Early in this century, as Alfred Chandler (1962) has shown, middle-level executives at DuPont took the lead in moving the organization to a decentralized structure as a creative adaptation to the requirements of a new strategy of diversification. At NCR, which lacked the culture of learning and adaptation, decisive action by the top executive was necessary to resolve the problems that arose in the 1960s. The roles and functions of the Chief Executive should probably figure more prominently in our theorizing about adaptation to change.

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