Nucor at a Crossroads

On December 7, 1986, F. Kenneth Iverson, chairman and chief executive officer (CEO) of Nucor Corporation, awaited a delegation from SMS Schloemann-Siemag, a leading West German supplier of steelmaking equipment, at his company's headquarters in Charlotte, North Carolina. Iverson had to decide whether to commit Nucor to a new steel mill that would commercialize thin-slab casting technology developed by SMS. Preliminary estimates indicated that the mill would cost $280 million, and that start-up expenses and working capital of $30 million each would push the total cost to $340 million, or nearly as much as Nucor's net worth.

Successful commercialization of thin-slab casting would let Nucor enter the flat sheet segment that accounted for half the U.S. market for steel. SMS's compact strip production (CSP) process was, however, just one of several competing, commercially unproven thin-slab casting technologies, all of which might be leapfrogged by the turn of the century. As Iverson wrestled with these trade-offs, he reviewed the state of competition in the U.S. steel industry in general and Nucor's position within it in particular.

The U.S. Market for Steel

In 1986, U.S. producers shipped 70 million tons of steel mill products. Subtracting exports of one million tons and adding imports of 21 million tons implied 90 million tons of domestic consumption of steel that year. Relative to the most recent peak year, 1979, domestic shipments had decreased by 30% and domestic demand by 22% (see **Exhibit 1**). The decline in demand derived from the stagnation of many steel-intensive industries, particularly automobile manufacture, efforts to use steel more efficiently and the emergence of substitute materials such as aluminum, plastics and advanced composites. There was general agreement in 1986, however, that the market would not decline further in the near term.

Although the market for steel comprised several thousand distinct products, they could largely be grouped into a few broad segments. Semifinished products were at least 8 - 10 inches thick and required further processing. Flat-rolling them yielded plates (more than 0.25 inches thick), or sheet and strip, thinner products that could be shipped in coils.[1] Other kinds of products that could

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[1] Sheet and strip were supposed to be of different widths, but were often lumped together.

Professor Pankaj Ghemawat and Research Associate Henricus J. Stander III prepared this case as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation. It is based in part on a field study by Sarah Hall, Takashi Nawa and Seiji Yasubuchi, all MBAs 1990.

be formed from semifinished steel included bars, which were typically less than one inch thick; wire rods, which were even thinner; a wide variety of structural shapes that were used primarily in construction and hollow pipes and tubes. Flat sheet was by far the most important of these segments: it accounted for about half of domestic shipments in 1986 (see **Exhibit 2**).

Shipments could also be classified by customer group. The four most important ones, ranked by volume, were service centers and distributors, the automotive sector, construction, and the appliance and equipment industries. Service centers and distributors were intermediaries that had increased their share of total domestic shipments to one-quarter by 1986, largely on the basis of secondary processing abilities that let them customize steel mill products to end-users' specifications and thereby take over a downstream processing niche vacated by integrated steelmakers. A significant percentage of the steel sold to service centers found its way to end-users in the automotive sector and the appliance and equipment industries. Taken together, these three customer groups accounted for half of total domestic shipments and three-quarters of the shipments of flat sheet. Service centers emphasized the most basic form of flat sheet, hot-rolled sheet, whereas the others' direct purchases were weighted toward cold-rolled and coated sheet that had been subjected to further primary processing. Construction accounted for another one-tenth of shipments of all steel mill products and of flat sheet.

Price, quality and dependability were the three most important buyer purchasing criteria. Uncompetitive pricing was probably the major reason U.S. steelmakers had lost ground to imports. Integrated steelmakers had been criticized, in particular, for charging excessive premia in periods of tight supply, pressing buyers to purchase higher-grade steel than they needed, requiring minimum orders that were too large for many buyers and arbitrarily favoring some buyers over others. Quality had several dimensions: internal quality, as determined by metallurgical structure and physical strength, which mattered most when durability was important; surface quality, which was a major concern in uses such as sheet metal for automobile exteriors and electrical appliance casings; and consistency from one shipment to the next. Dependable delivery was an additional requisite for doing business with certain buyers, particularly large ones such as General Motors and General Electric. While such buyers were sometimes willing to pay higher prices for quality and dependability, their exacting standards also led to higher shipment rejection rates.

U.S. Steelmakers

There were three groups of steelmakers in the United States in 1986: integrated firms with the capacity to produce 107 million tons of steel by reducing iron ore, minimills with 21 million tons of capacity to produce steel by melting scrap, and specialty steelmakers with 5 million tons of capacity to produce stainless and other special grades of steel. **Exhibit 3** compares integrated steelmakers' and minimills' production processes. The rest of this section describes integrated steelmakers' dominance of the U.S. steel industry and the challenge by minimills since the early 1960s.

Integrated Steelmakers

Integrated steelmakers had long operated as a stable oligopoly led by U.S. Steel. U.S. Steel was formed by merger in 1901 in a transaction that capitalized its value at $1.4 billion, or about 7% of U.S. GNP.[2] The merged entity pursued a policy of price leadership that brought stability to a cyclical industry and healthy profits to its shareholders. However, that policy also encouraged entry and

[2]Thomas K. McCraw and Forest Reinhardt, "Losing to Win: U.S. Steel's Pricing, Investment Decisions and Market Share, 1901-1938," *Journal of Economic History* (September 1989): 594.

expansion by other integrated steelmakers. By World War II, U.S. Steel's share of the U.S. steel market had slipped from two-thirds at the time of its formation to one-third.

In the aftermath of World War II, U.S. integrated mills as a whole accounted for about half of the world's raw steel production. They were mostly clustered in the Great Lakes region in order to optimize the distance between their main market in the Midwest and their sources of coal and iron ore in Ohio, Pennsylvania, West Virginia and Minnesota. They also possessed leading-edge technology, efficiently-scaled plants, and the lowest operating costs in the world. These advantages produced healthy profits through the late 1950s. Since then, however, integrated U.S. steelmakers' after-tax return on equity (ROE) had exceeded the average for U.S. manufacturing in only one year, 1974.

This decline in performance was attributed in large part to the failure of the integrated U.S. steelmakers to commit quickly to new technology (see **Exhibit 4**). They continued to invest in open hearth furnaces through the early 1960s despite the advent of the basic oxygen furnace, which reduced the cycle time for converting iron into steel from 10 hours to 30 minutes, and ended up, as one source put it, with 40 million tons of the wrong kind of capacity.[3] They also trailed in adopting continuous casting, a process that permitted molten steel to be cast into slabs ten inches thick, eliminating the intermediate steps of casting it into much thicker ingots that had to be reheated to be shaped into finished products. Continuous casting thereby reduced the cost of manufacturing basic steel products by about 15%. Conservative customers shared some of the responsibility for U.S. steelmakers' tardiness in adopting this innovation: they had, for example, resisted U.S. Steel's installation of its first continuous casters by explicitly ordering ingot-cast steel because of their concern about the relatively minute internal differences between steel cast by the two processes.

In the 1960s, less expensive and increasingly higher-quality imports began to erode the integrated mills' domestic market share. Import penetration was accelerated by poor management-labor relations which, after deteriorating throughout the 1950s, culminated in a 115-day industry-wide strike in 1959 by the United Steel Workers. That year, the United States became a net importer of steel for the first time in the twentieth century. Imports' share of U.S. domestic demand increased from 5% in 1960 to 17% by 1968 and fluctuated widely around the latter level through 1980 for reasons largely related to shifts in exchange rates and the imposition, removal and reimposition of trade restrictions. Since 1980, imports' share had edged up by another five percentage points. Their share of the flat sheet segment had been slightly lower, reaching 18% in 1986.

Integrated U.S. steelmakers initially responded to this surge in imports by increasing their investment rates and outspending their Japanese and European rivals in the 1960s and 1970s per ton of capacity installed or replaced. Much of their capital spending was absorbed, however, by "catch-up" investments such as basic oxygen furnaces and continuous casters; they continued to spend less of their sales on R&D. They also spread their capital expenditures thinly across existing plants instead of building new ones, locking into high electricity rates and creating "a mish-mash—100-year-old stuff fitted into two-year-old stuff."[4] The efficiency of their investments was also constrained by union contracts. The annual compensation premium for a U.S. steelworker relative to the average manufacturing worker increased nearly tenfold since the early 1960s, to $13,000 by 1979.[5] To make matters worse, inflexible work rules obstructed job redesign and technological innovation. Bureaucracy bore some of the blame as well: an integrated steelmaker might spend years studying an investment project and, if it decided to press ahead, another few months just processing the paperwork. Finally, rising debt-to-capital ratios curtailed and even choked off modernization

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[3]*Business Week* (November 6, 1963): 144-146.

[4]*The Wall Street Journal* (April 4, 1983): 11.

[5]William E. Fruhan, Jr., "Management, Labor, and the Golden Goose," *Harvard Business Review* (September-October 1985): 137.

programs in midstream. As a result, by the late 1970s, integrated steelmakers had only partially eliminated their cost disadvantage vis-à-vis imports, which were then being restricted by a system of trigger prices, and minimills which were rapidly expanding their share of domestic shipments.

As the 1970s ended, integrated U.S. steelmakers began a dramatic restructuring of their operations. They cut steelmaking capacity from 145 million tons in 1979 to 107 million tons by 1986, with the largest of them shouldering a disproportionately large share of the cutbacks. Their pattern of capacity reductions left them focused on flat-rolled products (82% of shipments in 1980), particularly flat sheet (75% of shipments). Over the same period, total industry employment declined from 450,000 to 175,000, while the compensation premium for steelworkers relative to manufacturing averages, after increasing from 72% in 1979 to 92% in 1982, fell to 62% by 1986. Labor productivity nearly doubled as a result. But integrated steelmakers' restructuring efforts continued to be hampered by some of the same factors that had previously constrained the efficiency of their investments as well as by linkages among their plants, political entanglements, and their desire to avoid write-offs that would wipe out their book equity. The seven largest integrated steelmaking operations lost $13 billion over the period 1982 - 1986. In 1986, their labor costs remained considerably higher than those of domestic minimills and competitors from newly industrializing countries: between $100 to $150 per ton of steel, compared to $35 to $70 per ton.

U.S. Steel, LTV Steel and Bethlehem Steel were the three largest U.S. integrated steelmakers in 1986, with 59% of total integrated steelmaking capacity and 49% of integrated flat-rolling capacity.[6] U.S. Steel was renamed USX to reflect its acquisitions earlier in the decade of Marathon Oil and Texas Gas USX modernized its integrated mill at Gary, Indiana, and started to do the same at Fairfield, Alabama. It also entered into a joint venture with Pohang Iron and Steel of South Korea to procure hot-rolled sheet for one of its other mills. Its steel operations suffered, however, from an on-going strike that began on August 1, 1986. LTV Steel was created in 1984 through a merger of Jones & Laughlin Steel, a subsidiary of the Texas conglomerate, LTV (which had absorbed Youngstown Sheet & Tube in 1978), and Republic Steel. The merged company sought protection from its creditors under Chapter 11 of the bankruptcy laws in July 1986. Bethlehem Steel refocused its operations more closely on steel in the 1980s. Its integrated mill at Burns Harbor, Indiana (the last "greenfield" integrated mill built in the United States in the 1950s), was regarded as relatively efficient, and the company was in the process of modernizing its other large integrated mill at Sparrows Point, Maryland, although that effort had lifted its debt-to-capital ratio to 65%. **Exhibit 5** summarizes some of the key operating and financial statistics for these three competitors in 1986.

Minimills

Although small, non-integrated steel plants had existed in the United States since the nineteenth century, plants constructed in the early to mid-1960s that used electric arc furnaces to melt scrap into steel were the first to be referred to as "minimills." In addition to adopting improvements in furnace and casting technologies, minimills took advantage of the declines in integrated steelmakers' demand for scrap as the latter switched to basic oxygen furnaces and, later, as their steel production fell. By eliminating coke ovens and blast furnaces, minimill technology reduced the minimal efficient scale of production by a factor of 10 (from millions of tons to hundreds of thousands of tons, or less), and the capital cost per ton of capacity by yet another factor of 10 (from $1,000+ to $100+). Minimills were typically built to last only 10 years, compared to 25-30 years for integrated mills.

The impurities in most scrap initially confined minimills to low-end structural products such as bars for reinforcing concrete, wire rod and small structural shapes. As a result, many got their start

[6]Specialty steelmakers also operated a small amount of flat-rolling capacity, equivalent to 2% of the total volume for integrated mills.

in the Sunbelt where construction had begun to boom. They began by pursuing regional strategies, locating within 200-300 miles of their markets, usually at sites with inexpensive electricity. Their modern technology, advantageous locations, cheaper and more cooperative labor, entrepreneurial management, and narrow product lines (which reduced the time required to reconfigure rolling stands), let them wrest share away from integrated steelmakers in the segments they served. Over time, they also reduced import penetration in those segments from above average to below average.

By the second half of the 1970s, the market for low-end structural products was beginning to reach saturation. Minimills responded by looking for new market outlets. The more aggressive ones expanded beyond their traditional 200-300 mile radii, typically by acquiring existing mills or by adding large new ones with up to several hundred thousand tons of steelmaking capacity. They also began to move into new product segments, such as higher-quality bars, larger structural shapes and pipes and tubes. Their geographic expansion had a more immediate impact than their efforts to expand their product ranges: minimills' profits shrank as the geographic insulation between them broke down and as year-to-year volume growth tapered off into single digits in the 1980s. Twenty-five minimills were closed or sold between 1975 and 1986.

In 1986, minimills continued to be shut out of flat-rolled and certain specialty products and to be confined to modest shares of the segments they had recently targeted, but they had nearly expelled integrated mills from low-end bars, wire rods and small structural shapes. They accounted for 16% of domestic steelmaking capacity, up from 7% in 1975, and a slightly higher percentage of domestic shipments. While 36 companies operated a total of 51 mini steel plants, 43% of all minimill steelmaking capacity was controlled by the five largest competitors: North Star (2.4 million tons), Nucor (2.1 million tons), Northwestern Steel and Wire (1.8 million tons), Florida Steel (1.6 million tons), and Chaparral (1.1 million tons).

North Star was owned by Cargill, a privately-held company primarily engaged in agribusiness. It operated five steel mills, four of which were in the Midwest and was upgrading the only mill it had built itself, which produced special-quality bar steel but had failed to perform as expected. It was also adding a seamless-pipe plant at an existing location at a cost of about $100 million. Northwestern Steel and Wire operated a plant in the Chicago area that produced mostly structural shapes, wire products and merchant bar. In 1986, it was reorganized after four years of losses ranging from $14 - $40 million per year. Florida Steel operated five plants in the Southeast, all but one of which it had built itself. It focused on traditional minimill products in which it held a very high regional market share. Chaparral was co-founded by Co-Steel, a Canadian steelmaker, and Texas Industries, a cement and construction company; the latter bought out the former in 1985. It operated a single plant in Texas, where it made a broad array of products, including wide-flange beams, of which it was the first minimill producer. Chaparral sold its products around the country and had a reputation for progressiveness that was exceeded, perhaps, only by Nucor's.

Nucor Corporation

Nucor's legal predecessor, Reo, was founded early in the twentieth century to manufacture motor cars. Nucor had since come to melt old cars and other sources of scrap back into steel. This section describes Reo's transformation into Nucor and the way the company was run in 1986.

History

Nucor's roots went back to 1904 when Ransom Eli Olds, resigned from Olds Motor Works, a company he had founded with the backing of venture capitalists five years earlier, to pursue his dream of manufacturing luxury motor cars instead of cheap Oldsmobiles. Olds disposed of his 10% stake in the Olds Motor Works and, with additional venture capital, founded the acronymous Reo

Motor Car Company. Reo Motor Car filed for bankruptcy protection in 1938, after years of losing money on luxury cars and only partly making it up on delivery trucks. It emerged from reorganization as Reo Motors, a manufacturer of trucks and, eventually, luxury lawnmowers. Reo Motors neither made nor lost much money. In 1954, it sold off all its assets, at a 15% book loss, and began to distribute the proceeds—approximately $16 million—to its shareholders.

Takeover prevented Reo from carrying out its plans for self-liquidation. TelAutograph Corporation won control of the company in a proxy fight and, in late 1955, merged one of its affiliates with Reo to form Nuclear Corporation of America. The company's vision of becoming the General Motors of various nuclear businesses did not, however, materialize: sales stagnated, and it lost money each year through 1960. In 1960, two large institutional stockholders, Martin Marietta and Bear, Stearns, installed a new president, David Thomas, who turned Nuclear into a small conglomerate. Friendly acquisitions took the company into semiconductors, steel joists (beams that support ceilings) and air-conditioning ducts, and it tried to diversify into aerospace, tin cans and plain-paper copiers through internal development. By 1965, bankruptcy loomed and the board of directors initiated a search to replace David Thomas. F. Kenneth Iverson was its less-than-unanimous choice to become president.

Ken Iverson, a metallurgist, was hired by Thomas in 1962 to run the newly-acquired Vulcraft steel joist business, and later put in charge of the air-conditioning duct business as well. Upon assuming the presidency, Iverson divested most of Nuclear's businesses (including air-conditioning ducts, the largest lossmaker) and focused the company on its most profitable operation, the Vulcraft steel joist plants in South Carolina and Nebraska. Within a year, Iverson moved Nuclear's head office, which consisted of himself and accountant Sam Siegel, to Charlotte, North Carolina, to be closer to the larger Vulcraft plant in Florence, South Carolina. And in 1968 - 1969, believing that the company could produce the steel bars that Vulcraft welded into joists more cheaply than it could buy them, Iverson bet the company by borrowing $6 million to build a small but modern minimill to make steel from scrap at Darlington, South Carolina.

Nuclear Corporation of America held its corporate breath until Darlington eventually became profitable. The company was renamed Nucor Corporation in 1972 and expanded steadily through 1986. **Exhibit 6** summarizes Nucor's operating and financial statistics from 1972 - 1986 and **Exhibit 7** compares its stock performance with leading integrated and minimill competitors. The rest of this section describes the administrative principles and the operations and investment processes that underpin these numbers.

Administration

In 1986, Ken Iverson, by now 61 years old, was still Nucor's chief executive officer and had just been named the "Best CEO in the Steel Industry" by *The Wall Street Transcript*. Iverson chaired Nucor's board of directors, which included two other long-serving managers: chief operating officer David Aycock, who began his career as a welder at the joist plant in South Carolina in 1955, and chief financial officer Sam Siegel. The only "outside" director, Richard Vandekieft, had previously also been an officer of Nucor.

Nucor's top managers agreed that it knew how to do two things well: build steel plants economically and operate them efficiently. While they admitted that steel was not the best business in the world, they saw no future for Nucor outside it. Unlike top executives at integrated steelmakers and many other minimills, they supported free trade. Iverson, for example, published an op-ed article in *The Wall Street Journal* on August 21, 1986, with the subtitle "Protection Ensures Stagnation."

Nucor's top management also believed that the best companies had the fewest layers of management. In Iverson's words, "The fewer you have, the more effective it is to communicate with employees and the better it is to make rapid and effective decisions." Nucor had five layers of management, compared to a dozen or so at the typical integrated U.S. steelmaker: a chief executive officer, a chief operating officer, plant general managers (one per plant), department heads (an average of six per plant) and foremen (15 - 36 per plant). These layers supervised an average of about 275 employees per plant. Iverson appointed Aycock president and chief operating officer in 1984 to share his load of managing the company but resisted the idea of installing another management layer of group vice presidents. "That's the same old Harvard Business School thinking," he teased subordinates who pressed him on the point.[7]

To make this flat hierarchy work, Nucor decentralized as many decisions as the next layer down could manage. This meant, in practice, that all decisions except capital expenditures, major changes in plant organization, hiring and firing at the department head level (or higher), and pricing were made at the plant level. According to Iverson, "We don't do much here at Charlotte. That's not a joke. Except the cash. We handle the cash."[8] Headquarters handled the cash by demanding that each plant general manager achiev an annual contribution, before corporate overhead, of at least 25% of the net assets employed at his plant, or be able to explain why not. Although managers had been dismissed for failing to meet this target—at least one manager had been fired for meeting it by cutting back on investment and thereby compressing the asset base at his plant—exceptions to this target were made for new plants and for depressed market conditions.To compare the performance of its plants, headquarters received, in order of importance, monthly operating reports, weekly tonnage reports and monthly cash management reports from each of them. The monthly operating reports from each plant were shared with all plant general managers.

Because Nucor's top managers believed that "the best motivation is green," they complemented these controls with high-powered performance incentives. Base compensation began well below industry norms for officers (corporate and plant managers) and production workers, and grew linearly with group performance beyond thresholds with some built-in "stretch" and, except for production workers, was capped, although at a level so high that it rarely proved to be a constraint (see **Exhibit 8** and, for more detail on production incentives, the next subsection). Other incentive programs shared 10% of each year's pre-tax profits among non-officers, awarded non-officers discretionary bonuses in years when corporate performance was particularly strong, granted stock options to officers and other key employees, and offered all employees except officers a college education allowance for their children. Finally, an employee stock ownership program helped ensure that each employee held some of Nucor's stock. In 1986, Iverson's stockholdings amounted to 1.3% of the total shares outstanding, other officers' 4.8%, and all other employees' 3.9%. No other shareholder owned as much as 5% of Nucor's stock.

Apart from these monetary incentives, Nucor made strenuous efforts to minimize status-related differences among its employees. Everybody received the same insurance coverage and holidays. On the factory floor, everybody wore green spark-proof jackets and hard hats (unlike integrated mills, where different colors signalled different levels of authority). There were no assigned parking places or company cars, boats or planes. All air travel was in coach class and frequent flyer awards earned on business travel were redeemed for future business travel. Corporate headquarters still consisted of a rented suite of offices in the building Nucor had moved into in 1966 and Phil's Deli, across the street in a shopping center, served as the executive dining room. Iverson answered his own phone and along with the other officers promised to get an answer to any employee's question within 24 hours. Each year's annual report listed all employees on its cover in alphabetical order.

Nucor tried, in addition, to encourage both openness and risk-taking by emphasizing rather than denying the possibility of managerial mistakes. Iverson was particularly eloquent on this point: "We try to impress upon our employees that we are not King Solomon. We use an expression that I

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[7]Richard Preston, *American Steel* (New York: Prentice Hall, 1991): 35.

[8]Richard Preston, "Hot Metal, Part I," *The New Yorker* (February 25, 1991): 43.

really like, and that is, 'Good managers make bad decisions.' We believe that if you take an average person and put him in a management position, he'll make 50% good decisions and 50% bad decisions. A good manager makes 60% good decisions. That means 40% of those decisions could have been better. We continually tell our employees that it is their responsibility to the company to let the managers know when they make those 40% decisions that could have been better...The only other point I'd like to make about decision making is, don't keep making the same bad decisions."[9]

Operations

At the end of 1986, Nucor's steel operations, encompassing 16 steelmaking and fabrication plants at 10 locations around the United States, accounted for 99% of the company's sales (see **Exhibit 9**). By far its largest operating division was Nucor Steel, which that year produced 1.7 million tons of steel bars, angles, light structural shapes and alloys at steel mills in South Carolina, Nebraska, Texas and Utah. Nucor was ranked as the second most productive steelmaker in the world in 1985 based on its annual tonnage per employee (981 tons), behind Tokyo Steel but ahead of the largest U.S. minimill, North Star (936 tons), and the largest integrated steelmaker U.S. Steel (479 tons).[10] Nucor benchmarked its plants against its leading competitors, particularly Chaparral, as well as other Nucor plants in the same division. It had a policy of letting competitors visit its operations as long as they reciprocated.

Nucor Steel sold two-thirds of its output to external customers and one-third internally. Vulcraft, whose joist plants originally impelled Nucor to integrate backward into steelmaking, accounted for three-quarters of internal sales. In 1986, Vulcraft operated six plants, four of which were located very close to Nucor's four steel mills, and had sold 450,000 tons of steel joists—about 30% of the U.S. market—and 175,000 tons of steel deck. Vulcraft sourced 95% of the steel bars that it welded into joists from Nucor Steel, at a discount of $10 per ton relative to market prices that was justified on the basis of high volumes and the absence of credit and collections problems. Vulcraft purchased the flat sheet that it grooved and corrugated into deck from outside suppliers. The remainder of Nucor's internal steel sales were channeled to smaller downstream operations that made cold-finished bars, grinding balls, bolts, bearings and machined steel parts.

Nucor's dependence on external sales of steel had increased dramatically since the early 1970s, when they accounted for only 10% - 20% of total production. Although Nucor's four steelmills were geographically dispersed and each tried to maintain an inventory of 25,000 tons, they occasionally shared orders when they could not fulfill them alone. Service centers and distributors constituted their primary customers. Prices were set centrally on an F.O.B. (freight on board) basis, unlike the delivered cost prices quoted by integrated steelmakers and some minimills. Nucor did not allow discounts for preferred customers or, since 1984, on large outside orders. The elimination of quantity discounts reflected the computerization of Nucor's order-entry and billing systems, which reduced fixed order-processing costs, and Nucor's intention of differentiating itself, especially vis-à-vis imports, by letting its buyers maintain lower inventories and order more frequently. Nucor remained willing, however, to offer temporary discounts of up to $20 per ton when it started up a new steel mill.

Nucor tried to avoid haggling about prices on the input as well as the output sides by coordinating the purchase of steel scrap through an independent purchasing agent, David Joseph, Inc. Each mill was assigned a David Joseph representative who, upon receipt of an order for scrap, first checked other accounts to see if economies could be realized by pooling orders and then looked for sources within the region. Nucor paid David Joseph a fixed commission per ton of scrap.

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[9]F. Kenneth Iverson, "Effective Leadership: The Key is Simplicity," in Y. K. Shetty and V. M. Buehler, eds., *The Quest for Competitiveness* (New York: Quorum Books, 1991): 287.

[10]*Iron Age* (May 2, 1986): 58B1.

Nucor had long focused its operations on production rather than procurement or marketing. This focus had forced it over the years to think very hard about how it recruited, trained and motivated production workers. The results were widely acclaimed. In the words of investor Warren Buffett, "It is the classic example of an incentive program that works. If I were a blue-collar worker, I would like to work for Nucor."[11] Nucor attracted a large number of applicants for each job that it advertised. Iverson's favorite story involved eight new jobs that had opened up at the Darlington steel mill in 1985. By 8:30 a.m., the 1,300 applicants had created such a traffic jam that the state police had to be called in for assistance. Unfortunately, the police were short-handed: three of their officers were already at Nucor applying for jobs.

Nucor selected and trained all employees below the level of department head (accounting for about 95% of its total compensation budget) on a decentralized basis. Each plant general manager administered a psychological test to prospective employees that sought to identify goal-oriented, self-reliant people. Previous steelmaking experience was not, for most jobs, an important selection criterion. Once selected, production workers were trained by foremen to perform multiple functions. After a two-month training period, each employee was assigned to a 20- to 40-person production group that performed a discrete task, such as melting scrap into steel, rolling steel, or finishing steel by straightening it. On-going training was provided by the more experienced members of the production group. Most promotions on the shopfloor were made from within based on performance and peer evaluations. Production shifts were eight hours long, with an average workweek of 42 hours in a rotating pattern. Plants ran continuously for six days a week, with the seventh day reserved for maintenance.

Nucor's compensation systems were designed to reward production groups, rather than individual workers, for exceeding predetermined productivity and quality standards. The standards were typically based on experience rather than formal time studies and were not revised unless there was a major machinery change. Less than 5% - 10% of the standards were changed in any given year. No bonus was paid when equipment was idle. Since incentive bonuses could average 80% - 150% of base wages, cash compensation was slightly higher on average for Nucor's nonunionized production workers than for unionized steelworkers at integrated steelmakers, even though Nucor's base wage per hour was significantly lower. Nucor reinforced these rewards with stiff penalties: anyone late for a shift lost a day's bonus, anyone who missed a shift lost the bonus for the week, and if a group fell short of its productivity goal, all its members lost their bonuses for the week. It further reinforced the relationship between pay and performance by paying bonuses every week (with green checks) and by continually reminding workers of their progress. At the entrance to each plant hung a giant board that depicted each group's weekly productivity gain, their bonuses, the plant's performance relative to the target of 25% return on assets, the company's return on equity for the month, and the latest stock price.

Employee turnover at Nucor was about 1% - 5% per year, compared to an average of perhaps 5% to 10% for the U.S. steel industry as a whole. Turnover was highest among new production workers to Nucor but declined dramatically, with concomitant increases in productivity, after some quick departures. Nucor claimed that it never fired workers who performed their jobs up to reasonable expectations. Nor did it lay them off when demand dropped; instead, it shortened its work week as necessary. During a short week, production bonuses remained in place but might be based on one or two fewer days of work, reducing the average worker's total pay by 15% - 20%. Under the company's "Share the Pain" program, department heads' pay might fall by 30% - 40% at such times, and officers' by 60% - 70%. Between 1981 and 1982, for example, Iverson's compensation fell from $276,000 to $107,000, landing him near the bottom of the *Fortune* 500 on that measure. By comparison, the average compensation for CEOs of the seven largest integrated steelmakers dropped from $708,000 to $489,000 during the same period.

[11] *Fortune* (December 19, 1988): 58.

Although Nucor's operations were decentralized down to the plant level, there was considerable interplant communication. Some of this communication occurred through formal channels, such as the three meetings with corporate executives that all plant general managers attended each year and quarterly function-oriented meetings. Most communication, however, took place through informal channels, such as the one- to two-day visits that managers and workers frequently paid to other plants. Informal communications was encouraged by broad dissemination of data on the performance of individual operating units and by the incentive system, which motivated operating units to beat their performance targets and to take an interest in overall corporate performance as well. Some of the mechanisms used to ensure that information was transferred from old plants to new ones are described in the next subsection.

Investment

If operations determined the pace at which Nucor's productivity improved, investment defined the potential for such improvement. Nucor had invested steadily and heavily in upgrading its capacity, old as well as new: its Darlington plant, for example, had been thoroughly modernized three times since it was built in 1969. Since the early 1970s, Nucor had built or rebuilt at least one steelmaking or fabricating facility each year. Over that period, its investment levels averaged 2.9 times its depreciation charges, although that ratio had declined a bit since the early 1980s. The three largest integrated firms, USX, LTV and Bethlehem, averaged a ratio of 1.6 over the same period.

Nucor's heavy investment in facilities reflected its drive to embody technological advances. The company made a serious effort to monitor technological developments worldwide, particularly in Europe and, to a lesser extent, Japan: a metallurgist who reported directly to Iverson was responsible for scanning the scientific and engineering communities for new steel technologies. Nucor's own research was rather applied, and was conducted on the factory floor. While the Vulcraft division historically spent about $1 million annually on R&D, Nucor Steel had no dedicated R&D budget. Instead, it regarded capital equipment suppliers as its R&D labs, and treated the costs incurred while starting up a new plant or new equipment as its own process R&D investments.

Capital budgeting at Nucor was an informal, iterative process. Ideas for new investments were first evaluated at the organizational level at which they surfaced. The three senior officers, Iverson, Aycock and Siegel, had to approve all capital expenditures greater than $40,000 at Nucor's steel mills and $10,000 at its fabrication facilities. Their level of involvement in the approval process depended, however, on the size and the radicality of the commitment being contemplated. Relatively small incremental projects were routinely approved if they appeared to satisfy the criteria described below. But to evaluate a commitment such as the thin-slab caster being considered in 1986, the three senior officers formed a task force to which other Nucor personnel were deputed as necessary.

According to CFO Siegel, "We have only a few decision criteria that we use to reject capital projects. Will it perform technically as advertised? Will we be able to get the return on assets [ROA] that the vendor has advertised? And do previous capital expenditures constrain our ability to be 100% committed to the project under evaluation?" Most rejections were based on the first two criteria. The precise financial criteria applied tended to vary across projects. New plants were supposed to achieve a 25% ROA within five years of start-up, and projections about them were compared, whenever possible, to historical data on other plants. Investments in equipment at existing plants were evaluated on the basis of payback periods: longer payback schedules were allowed for investments that increased capacity than for those that reduced costs. The attention paid to previous capital commitments in making new ones reflected Nucor's policies of restricting its debt-to-capital ratio to less than 30% and not issuing new stock.

Nucor typically designed new plants as they were being built, with the intention of expanding them and in light of its informal rule of maintaining a ceiling of 500 employees per plant. New plants were located in rural areas with access to at least two railroads, low electricity rates and plentiful water. Instead of relying on a turnkey contractor, as was common in the steel industry, Nucor acted as its own construction manager. Contracting with individual suppliers tended to be quick and informal and typically involved fixed-price contracts. Exceptions were occasionally made for new, untried equipment: Nucor then tried to build in performance incentives for its suppliers.

Each construction project was managed by a core group of experienced engineers and operators drawn from other Nucor operations. A billboard at the entrance of each construction site proclaimed the number of days left until scheduled start-up. The farmers, clerks, students, and laborers hired locally to build plants were later retained to run them. These “veterans” might account for as much as 80% of each plant’s eventual work force. During start-up, the core management group worked side-by-side with them to forge close workplace relations and an intimate understanding of each plant’s physical character. In the past, Nucor had been able to start up its steel mills within 18 months of groundbreaking, well below the norms for other minimills of comparable capacity.

Nucor had not built any new steel mills since 1981 but had agreed earlier in 1986 to form a 51%/49% joint venture with Yamato Kogyo, a Japanese steelmaker, to produce wide-flange beams, a heavy structural product, at a new plant at Blytheville, Arkansas. The Blytheville mill was to have 650,000 tons of capacity, equal to about one-fifth of the U.S. market for wide-flange beams, and was projected to cost $175 million. Nucor would contribute its plant construction and management skills and Yamato Kogyo its “beam blank” technology, which permitted steel to be cast much closer to the final shape. Nucor hoped that this venture, which it did not consider very risky, would help establish a strong foothold at the high-end of the construction market.

Nevertheless, Nucor-Yamato only targeted another non-flat niche, and one that it would share with another minimill, Chaparral, and perhaps several others. Iverson thought that a major expansion of Nucor’s steelmaking capacity would require it to enter the flat sheet segment. Several barriers had prevented minimills from penetrating this segment in the past. Economies of scale pushed optimal capacity for a “greenfield” plant as high as three million tons per year and investment costs toward the $2 billion mark. High quality steel from Japan and Canada and cheap imports from newly industrializing countries were competitive threats at the high and low ends of this segment respectively, as was the 60% domestic capacity utilization rate. Given these constraints, Iverson was unwilling to enter the flat sheet segment with conventional steelmaking technology. Thin-slab casting looked, however, as if it might permit efficient entry on a much smaller scale.

Thin-Slab Casting

The idea of casting molten steel directly into a thin, continuous ribbon can be traced back to Sir Henry Bessemer, who built and patented a machine for that purpose in 1857. But when Bessemer attempted to operate his machine, it was bedeviled by “breakouts”: partially solidified strands of steel would rupture and molten metal at nearly 3,000° F would gush through the machinery, causing fires and, after cooling, welding it into a solid mass of steel. Breakouts were particularly likely to afflict attempts to cast steel in thin shapes because such shapes had a higher ratio of surface area to volume, increasing friction between the casting mold and the steel poured through it. As a result, for another century, molten steel continued to be batch-cast into ingots, typically about two feet thick, that were cooled and stored before being reheated and rolled into thinner shapes.

Continuous casting, which began to be commercialized in the late 1950s, marked an important step toward the goal Bessemer had set because it permitted molten steel to be cast into slabs that were only eight to ten inches thick. The efficiency of this process continued to be constrained, however, by the need to reheat slabs, the multiple rolling stands required to crush them hundredfold into flat sheet one-tenth of an inch thick, and the fact that slabs could only be processed one by one. Steelmakers continued, therefore, to hunt for better casting technologies. About 30 research programs on directly casting steel into sheet were being pursued around the world in 1986, but none were projected to yield a commercially viable process before the turn of the century. This projection fueled interest in the idea of casting thin slabs two or fewer inches thick to shrink the production chain from liquid steel to flat sheet by reducing reheating and rolling costs compared to conventional continuous casting.

The Hazelett caster was regarded as the most promising approach to thin-slab casting in the early 1980s, and was being tested at five pilot plants in 1986. Its design dated back to the 1950s and involved pouring molten steel between parallel water-cooled conveyor belts spaced one inch apart. The skin of the molten steel was supposed to solidify upon contact with the belts, which would then peel away from it, yielding a slab one inch thick. This twin-belt design assumed that high casting speeds, required for thin-slab casting to process tonnages comparable to conventional casting, could not be achieved with conventional fixed molds. But in trying to solve the problem of casting speed, it created new ones: the conveyor belts were very expensive and needed to be changed frequently, resulting in considerable down-time; steel poured between the belts was subject to turbulence, which marred product quality or, even worse, led to breakouts; and the large number of moving parts complicated breakout clean-ups and increased maintenance costs.

While experiments with Hazelett casters were yielding mixed results, SMS of West Germany, a leading designer of conventional casting and rolling equipment, began to promote another thin-slab casting technology that it called Compact Strip Production (CSP). CSP was less ambitious than Hazelett casting: casting slabs that were two inches thick based on just one major departure from conventional casting—the use of a lens-shaped rather than a rectangular mold. SMS set up a stationary device in 1984 to test the new mold and, encouraged by the results, spent $7 million in 1985 to build a pilot plant. Armed with data on the performance of this pilot operation, which was reported to experience breakouts only one out of every 10 casts, SMS began to promote CSP to as many steelmakers as possible. More than 100 companies sent engineers or executives to observe SMS's pilot thin-slab caster in operation. None of them, however, had yet contracted with SMS to commercialize CSP.

SMS's preliminary design for a commercial CSP installation envisaged a plant with 800,000-1 million tons of flat-rolling capacity at a capital cost of about $300-$400 per ton. Some of the predicted savings relative to conventional casting pertained to the casting operation, and some were based on the assumption that thin slabs would require only four rolling stands to be crushed into flat sheet instead of the 7-10 that were the norm for thicker slabs at integrated mills (see **Exhibit 10**). CSP was also supposed to lead to labor and energy savings and higher yields that would reduce operating costs below those of U.S. integrated mills, to the same level as state-of-the-art German ones (see **Exhibit 11**).

These were, of course, just projections. Because of space constraints, SMS's pilot thin-slab casting plant ran only seven minutes at a time and produced only 12 tons per charge. It did not, as a result, offer much of a basis for predicting the wear and tear that would result from continuous operation or how that might affect product quality. Continuous operation was important because the casting and rolling stages had to be coupled to handle thin slabs more than 100 feet long. Since a stoppage at any point could shut down the entire production process, its components had to operate with more than 96% reliability to be cost-effective. In addition the cost effectiveness of the CSP design was sensitive to scrap prices.

The Decision

Nucor started to scan its environment for thin-slab casting technology in 1983, a year after experiencing its first sales decline under Iverson. The initial search turned up a number of relevant projects but none seemed to be ripe for commercialization. SMS, which had supplied casting equipment to Nucor since it built its first steel mill at Darlington, approached Nucor in the summer of

1984 with the CSP concept but Iverson concluded that while it looked good on paper, it was still in an embryonic stage. Nucor ordered a Hazelett thin-slab caster instead and began to experiment with it at Darlington.

Nucor spent $6 million on its Hazelett caster through 1986 and developed a special nozzle for pouring steel into it that reduced turbulence. But over the course of the year, it became increasingly interested in CSP. SMS had returned in early 1986 with fresh performance data on its pilot CSP plant. Iverson recalled that these data impressed him and others because they improved on the company's own development effort. COO Aycock and top engineering and operations people from individual plants went to Germany in the spring of 1986 to take a closer look and were very enthusiastic when they returned. While uncertainties remained and some felt that SMS should be encouraged to resolve them by performing another round of experiments with a pilot plant of industrial scale, most members of the team agreed that CSP had more potential than other thin-slab casting techniques. "The most important aspect," concluded Iverson at the time, "is that we have seen nothing about the concept that tells us it is not viable."

In the summer of 1986, Iverson asked project teams from Nucor and SMS to study the feasibility of a CSP plant of commercial scale. The teams focused on defining the prospects for a CSP plant with close to a million tons of capacity at an unspecified site in the Midwest, close to the largest steel and scrap markets in the United States. Although most of the equipment for the plant was to be newly built, SMS located a second-hand cold-rolling mill in West Germany that was available for $1 million and could be renovated for $10 million. The evaluation of the prospects for a CSP plant with this configuration was anchored in the fact that Nucor had already used engineering companies' quotes for equipment and cost projections based on recent plants to put together a construction budget and profit-and-loss statements for a plant employing Hazelett casting. In order to assess the prospects for a plant based on a different thin-slab casting technique, it seemed sensible to begin by revising existing cost estimates for just that component of the project.

Nucor thought that as the first adopter of CSP, it might be able to secure a $10-$20 million discount off the $90 million SMS was asking as the supplier of core machinery and technical support. It would also try to make some of its payments to SMS contingent on performance clauses. Based on prior analyses, these assumptions and basic engineering by SMS, it appeared that the CSP plant would cost Nucor $280 million in total, take two-and-a-half years to complete, and two more years to reach rated production capacity. Nucor also projected the plant's start-up costs and working capital requirements to be an additional $30 million each. Its steady-state operating costs would be driven by the price of scrap and the level of labor productivity. Nucor felt fairly comfortable with its first-cut estimates of operating costs, less so with its construction cost estimates and least of all with start-up cost estimates. **Exhibit 12** summarizes a leading industry consultant's calculations of the construction and operating costs Nucor could expect to incur and compares them to estimates for a modernized integrated mill and an unmodernized one it might compete against in the flat-sheet segment.

Iverson was aware of this economic information. He also knew that the Nucor project team that prepared it was eager to proceed with the CSP plant. SMS had devoted six months to basic project engineering and was bound to press him for a commitment at the meeting that was about to begin. Iverson felt that it was time to make a decision. While he felt generally positive about CSP, he continued to wrestle with several issues.

First, pioneering the commercialization of a new technology was likely to entail "unknown unknowns" and to lead therefore to pioneering costs. Would the benefits of being the first adopter offset them? It was clear that Nucor could not lock up CSP by moving first: SMS owned the technology, was interested in diffusing it more broadly and would insist on the rights to observe process improvements at Nucor's plant and to show them off to prospective customers. Other minimills were known to be interested in CSP. Nucor might gain only a two-to-three year head start by being the first adopter if others decided to be fast followers. In addition, widespread adoption of CSP by other minimills intent on entering the flat-rolled segment might significantly increase the price of premium scrap. If scrap prices rose above $140 per ton, however, Nucor could probably shift to direct reduced iron (DRI, or iron ore that had been reacted with natural gas) as its principal raw material, although that would require substantial changes in its facility and operations.

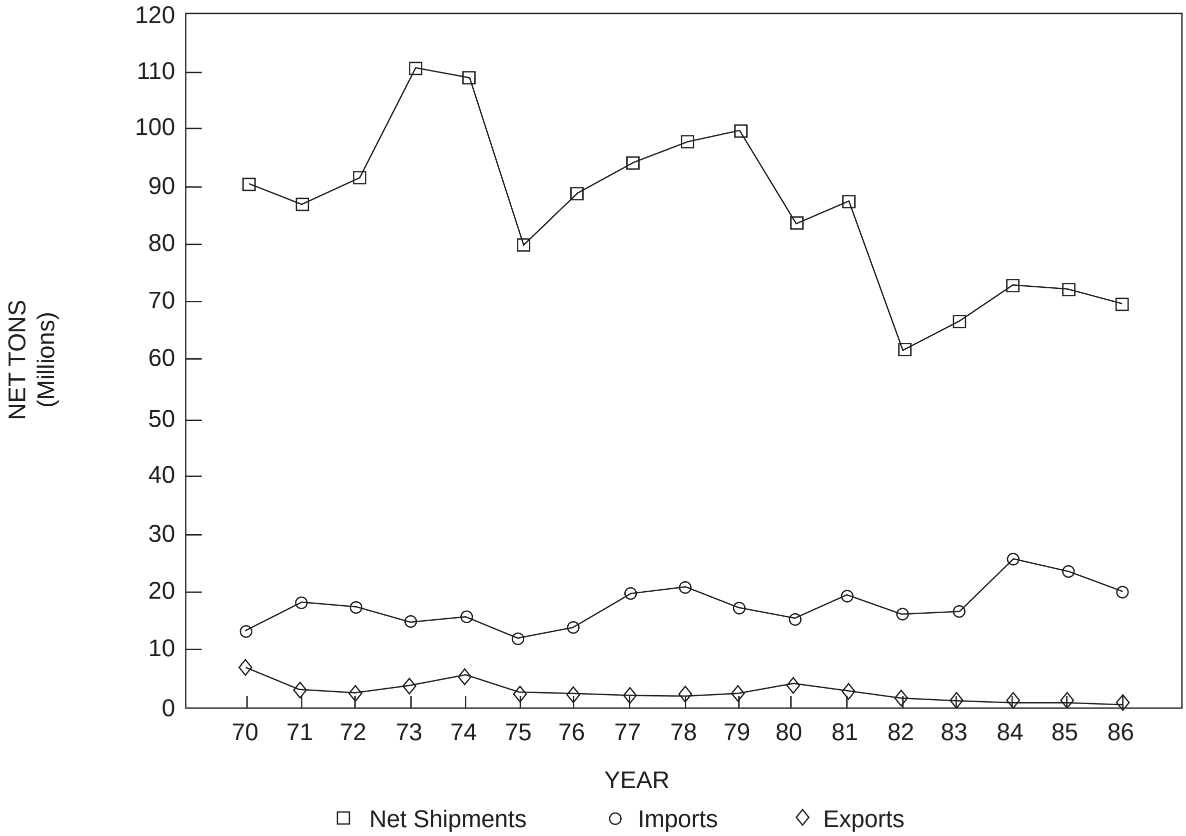
On the operating side, flat-rolled products presumed steelmaking expertise somewhat different from that required by non-flat products. Additionally, Nucor's policy of locating plants in rural areas might, with a plant larger and more complex than any it had built before, create an overwhelming operational challenge. It was also possible that integrated mills adopting CSP might be able to outpace Nucor on the basis of their cumulated experience at flat-rolled production.

As far as marketing was concerned, Nucor was confident that it would be able to penetrate the low end of the flat-sheet market, which consisted primarily of construction applications, where low price was the key to winning business. Nucor's own Vulcraft division could use about 100,000 tons of flat sheet each year to produce steel deck. While cheap imports were a force to be reckoned with in external sales to the low end, a measure of protection was provided by the fact that the CSP technology pushed U.S. labor costs down toward the level of ocean freight costs incurred by imports. The high end of the market was a different story. Products such as outer panels for appliances, and bodies and hoods for automobiles would be harder to penetrate because they required superior quality, reliable delivery of large quantities, and relationship-based marketing (including early involvement in product development). Although the first CSP plant's capacity could probably be filled with low-end business, Nucor would also have to target the high end if it brought a second or third plant on stream.

Resource constraints were also a cause for concern. The joint venture with Yamato Kogyo (to produce wide-flange beams) was already agreed upon. If Nucor took on the thin-slab project now the two projects would virtually coincide, stretching the company's financial and managerial resources. Allowing for expected start-up costs, Nucor would have to incur capital expenditures of about $100 million in 1987, $250 million in 1988 and a balance of $60 million or more in 1989 if it pursued both projects simultaneously. With yields on 10-year Treasury Bills and A-rated corporate bonds at 7.26% and 9.41% respectively, the cost of funding both projects would be substantial. Nucor did, however, have $185 million in cash and short-term securities on hand.

Technological leapfrogging was another major worry. While the Hazelett caster did not appear to be as efficient as CSP, other attempts to cast even thinner slabs were under way. For example, one of SMS's leading competitors, Mannesman-Demag, was promoting a process that would cast slabs that were only one inch thick—thin enough to be coiled and, consequently, to permit the decoupling of the casting stage from the rolling stage. Longer term, it was clear that thin-slab casting represented a step toward the ultimate goal of direct casting of sheet and strip. Did it make sense to invest in the former, knowing that it might become obsolete in 10 - 12 years? Although Iverson thought of these years as a window of opportunity, was the window wide enough to justify a full-scale strategic commitment to CSP?

Exhibit 1 Net U.S. Shipments, Exports and Imports: 1970-1986[a]



Source: American Iron and Steel Institute, *Annual Statistical Report*, various years.

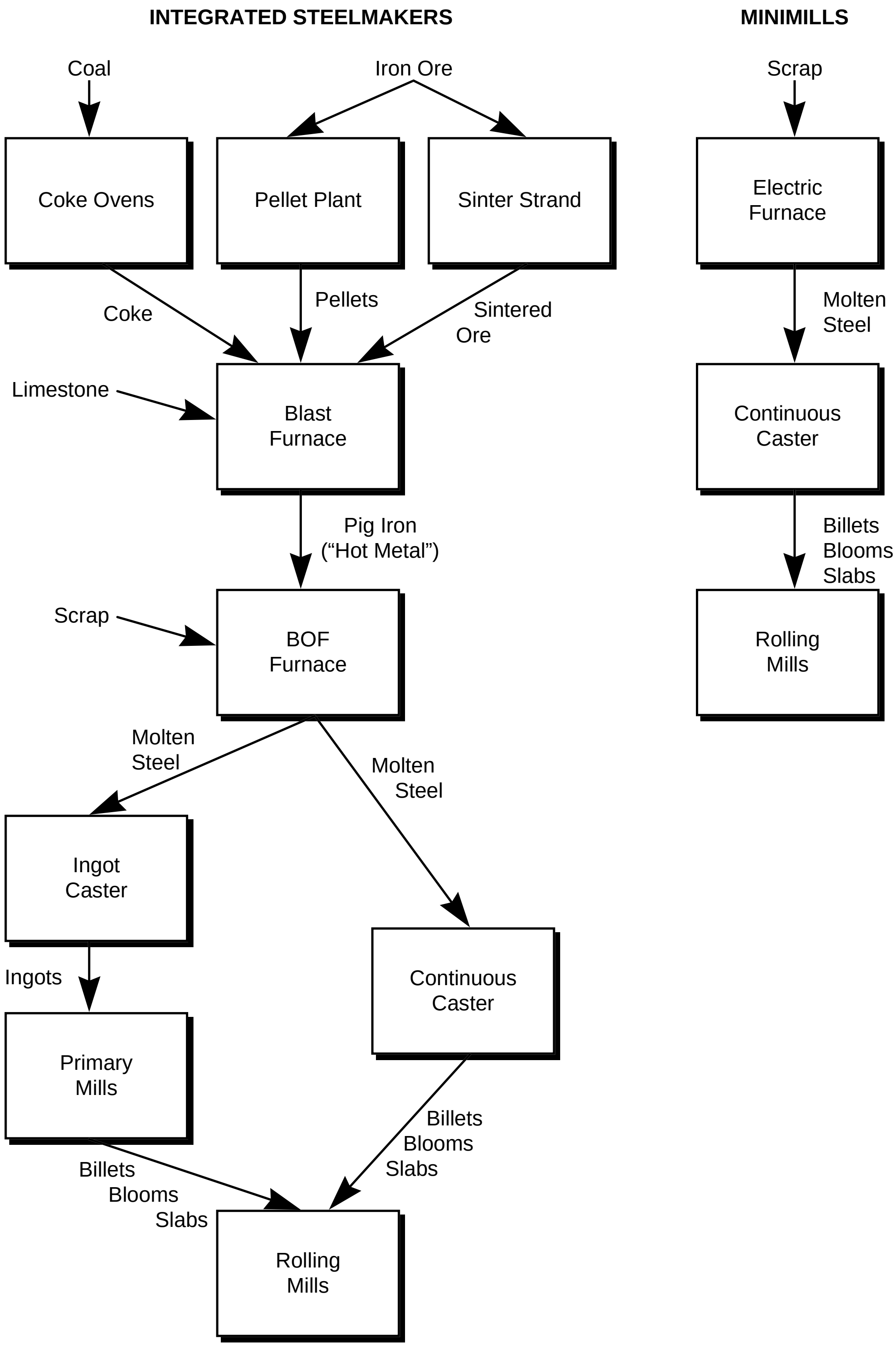
[a]Net shipments - exports + imports = apparent steel consumption.

Exhibit 2 Steel Mill Product Segments: 1986

	Tons	Percent
Ingots, Billets, Slabs	1,388,649	1.9
Plates	3,531,806	5.1
Sheet—Hot Rolled	11,993,239	17.2
—Cold Rolled	13,106,656	18.8
—Coated and Strip	11,148,806	16.0
TOTAL FLAT SHEETS	36,248,701	52.0
Bars	12,101,713	17.4
Structural Shapes	4,520,713	6.5
Wire Rod and Wire Products	4,573,954	6.6
Pipe and Tubing	2,836,458	4.1
Other	4,442,140	6.4
TOTAL SHIPMENTS	**69,644,134**	**100.0**

Source: American Iron and Steel Institute, *1986 Annual Statistical Report*.

Exhibit 3 Steel Production Processes



Source: Donald F. Barnett and Robert W. Crandall, *Up from the Ashes: The Rise of the Steel Minimill in the United States* (Washington, D.C.: The Brookings Institution, 1986): 4. © 1986 The Brookings Institution.

Exhibit 4 Capacity Incorporating New Technologies (in %)

	United States	Japan	E.C.	Canada
BASIC OXYGEN FURNACE				
1960	3.4	11.9	1.6	28.1
1965	17.4	55.0	19.4	32.3
1970	48.1	79.1	42.9	31.1
1975	61.6	82.5	63.3	56.1
1980	60.6	75.2	75.1	58.6
BASIC OXYGEN FURNACE PLUS ELECTRIC FURNACE				
1960	11.8	32.0	11.5	40.4
1965	27.9	75.3	31.5	45.1
1970	63.5	95.9	57.7	45.9
1975	81.0	98.9	82.6	76.4
1980	88.8	100.0	98.6	86.5
CONTINUOUS CASTING				
1971	4.8	11.2	4.8	11.5
1976	10.5	35.0	20.1	12.0
1981	21.1	70.7	45.1	32.2

Source: Donald F. Barnett and Louis Schorsch, *Steel: Upheaval in a Basic Industry* (Cambridge, Mass.: Ballinger, 1983): 55.

Exhibit 5 Summary Data for Three Largest Integrated U.S. Steelmakers: 1986

	USX	LTV	Bethlehem
Flat-rolling capacity (millions tons year)	12.4	12.3	6.5
Number of flat rolling rlants	4	3	2
Total steelmaking capacity (millions tons year)	26.0	18.0	16.0
Total number of mills	10	7	5
Capacity utilization (%)	36.6	60.5	65.1
Continuous casting (%)	26.5	31.0	58.3
Steel-related sales ($ billions)	3.7	4.5	4.1
Steel-related income ($ billions)	(1.37)	0.10	(0.11)
Total sales ($ billions)	14.9	7.3	4.3
Net income ($ billions)	(1.83)	(3.25)	(0.15)
Long-term debt-to-equity ratio (%)	50.0	74.0[a]	65.0
Steel sales by customer group (%)			
—Automotive	10.5	28.0	23.7
—Construction	12.4	9.0	20.0
—Service Centers	31.8	34.0	38.1

Source: Annual Reports and 10K reports.

[a]These figures are for 1985. In 1986, LTV filed for bankruptcy. Its unsecured debts of ($2.316 billion) were classified as pre-petition liabilities pursuant to Chapter 11 proceedings. Secured long-term debt amounted to $108 million. The book value of LTV's equity in 1986 was ($2.843 billion).

Exhibit 6 Summary Data on Nucor Corporation: 1972-1986

A) OPERATIONS	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**
Total number of plants	6	7	7	8	8	8	8	9	9	13	13	14	15	15	16
Steel capacity (000 tons)	200	400	400	600	600	700	950	1,200	1,250	1,700	2,100	2,100	2,100	2,100	2,100
Steel production (000 tons)	138	160	295	353	565	604	739	897	1,044	1,321	1,117	1,402	1,541	1,694	1,706
Employees	1,820	1,950	2,100	2,300	2,300	2,500	2,800	3,100	3,300	3,700	3,600	3,700	3,800	3,900	4,400
Man hours per ton	4.9	4.9	4.7	4.6	4.4	4.1	3.9	3.7	3.3	3.0	2.9	2.7	2.6	2.5	2.4
B) FINANCIALS (thousands of dollars)															
Sales[a]	$83,576	$113,194	$160,416	$121,467	$175,768	$212,953	$306,940	$428,682	$482,420	$544,821	$486,018	$542,531	$660,260	$758,495	$755,229
COGS	4,970	62,611	122,641	95,811	142,236	168,248	227,953	315,688	369,416	456,210	408,607	461,728	539,731	600,798	610,378
SG&A	11,452	15,703	17,068	12,483	14,745	19,730	28,660	36,724	38,165	33,525	31,720	33,988	45,939	59,080	65,901
Interest expense	625	1,545	1,938	1,491	2,291	2,723	1,878	1,505	(1,220)	10,257	7,899	(749)	(3,959)	(7,561)	(5,289)
Taxes	4,220	4,600	9,090	4,100	7,800	9,800	22,600	32,500	31,000	10,100	15,600	19,700	34,000	47,700	37,800
Net earnings	4,668	6,009	9,680	7,582	8,697	12,453	25,849	42,265	45,060	34,729	22,192	27,864	44,548	58,478	46,439
Capital expenditures	5,646	13,896	11,102	15,923	13,413	15,948	31,588	45,989	62,440	101,519	14,789	19,617	26,075	28,701	86,201
Depreciation	1,317	1,939	2,776	3,911	5,099	5,927	7,455	9,713	13,296	21,600	26,287	27,110	28,899	31,106	34,932
Current assets	30,166	38,510	44,850	44,545	61,816	61,155	101,110	117,362	115,366	131,382	132,543	193,889	253,453	334,769	295,738
Total assets	47,537	67,550	82,039	92,639	119,096	128,011	193,455	243,112	291,222	384,782	371,633	425,567	482,188	560,311	571,608
Current liabilities	11,664	19,264	24,025	17,877	30,902	30,302	55,833	63,536	66,493	73,032	66,103	88,487	100,534	121,256	118,441
Long-term debt	13,225	19,850	19,462	28,252	31,667	28,133	41,473	41,398	39,605	83,754	48,230	45,731	43,232	40,234	42,148
Stockholders' equity	20,930	26,620	37,104	44,550	54,085	66,295	92,129	133,258	177,604	212,376	232,281	258,130	299,603	357,502	383,699
Shares outstanding	17,588	17,576	18,428	18,753	19,448	19,702	20,065	20,262	20,550	20,891	20,988	21,135	21,242	21,473	21,131
Average stock price	$2.20	$1.86	$1.69	$1.68	$2.58	$3.32	$5.59	$10.12	$17.38	$21.88	$16.27	$24.30	$23.42	$28.92	$37.65
Producer price index for metals and metal products	39.6	42.6	55.2	59.6	63.0	67.2	73.0	83.3	92.1	96.5	96.9	98.6	101.6	101.2	100.0

Source: Nucor Annual Reports, various years.

[a]Fgure includes sales of the finished steel products listed in **Exhibit 9** and should not, therefore, be attributed entirely to steel production.

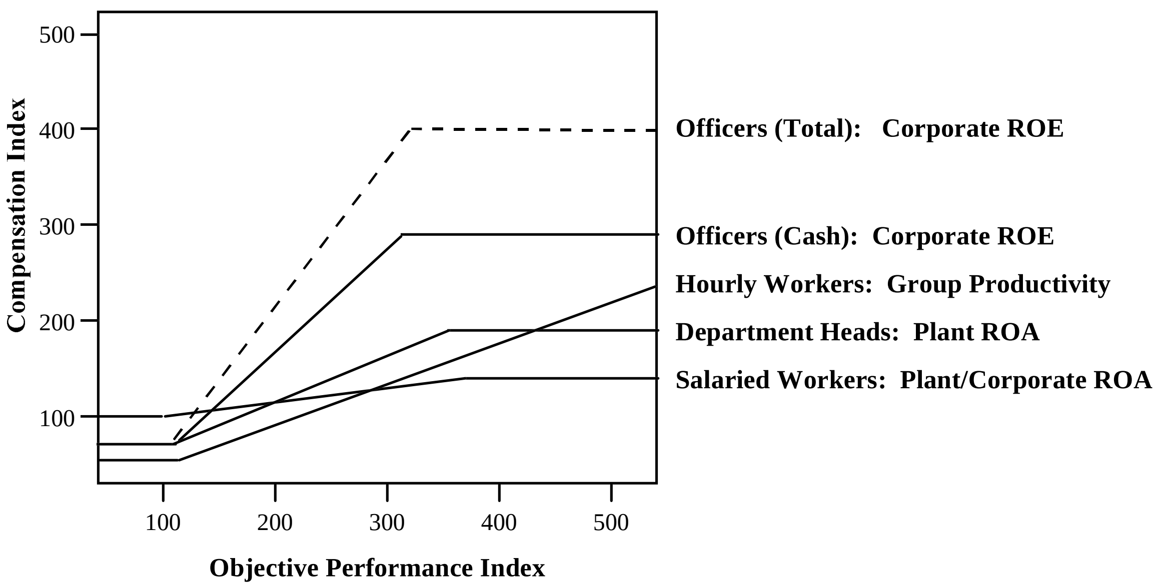
Exhibit 7 Stock Market Performance

Company	Price Range of Common Stock ($) 1976	1985	Average % Change 1976-1985	Average Market-to-Book Ratio, 1985
NUCOR CORP.	3.70-7.91	31.00-55.75	647.20	2.05
OTHER MINIMILLS				
Northwestern Steel and Wire Co.	27.50-36.10	38.00-14.50	-64.64	0.44
Florida Steel Corp.	4.88-7.44	12.63-19.88	163.80	1.08
Texas Industries[a]	11.00-15.38	25.75-34.38	127.94	1.33
INTEGRATED STEELMAKERS				
U.S. Steel Corp.	45.68-57.50	24.38-33.00	-44.39	0.63
LTV Steel Co.	10.00-17.70	55.25-13.25	-33.45	0.72
Bethlehem Steel Co.	33.00-48.00	12.50-21.13	-58.52	0.84

Source: Barnett and Crandall, p. 15.

[a]Parent of Chaparral Steel Company.

Exhibit 8 Incentive Compensation at Nucor



Source: Casewriter's estimates based on Nucor compensation schedules.

Exhibit 9 Locations of Nucor's Manufacturing Plants: 1986

NUCOR STEEL MILLS
Darlington, South Carolina
Norfolk, Nebraska
Jewett, Texas
Plymouth, Utah

NUCOR CORPORATE HEADQUARTERS
Charlotte, North Carolina

VULCRAFT
Florence, South Carolina
Norfolk, Nebraska
Fort Payne, Alabama
Grapeland, Texas
Saint Joe, Indiana
Brigham City, Utah

NUCOR GRINDING BALL
Brigham City, Utah

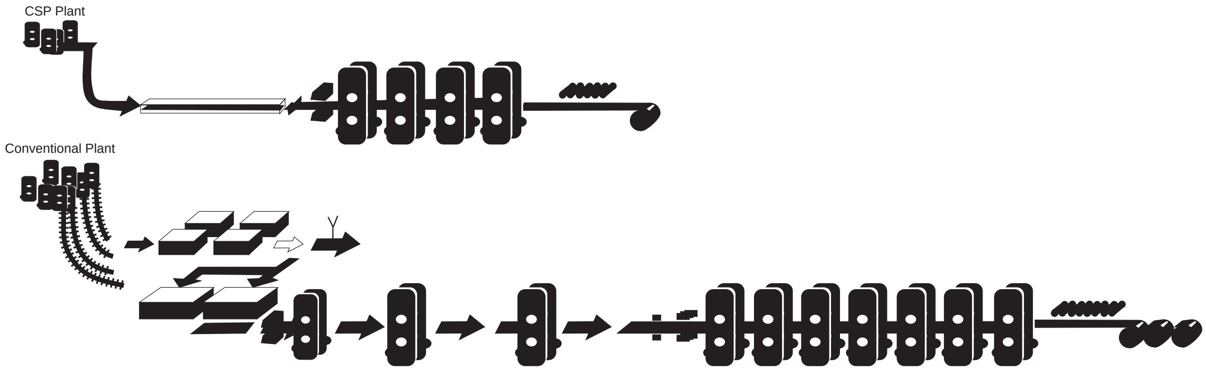
NUCOR FASTENER
Saint Joe, Indiana

NUCOR COLD FINISH
Darlington, South Carolina
Norfold, Nebraska
Brigham City, Utah

NUCOR MACHINE PRODUCTS
Wilson, North Carolina

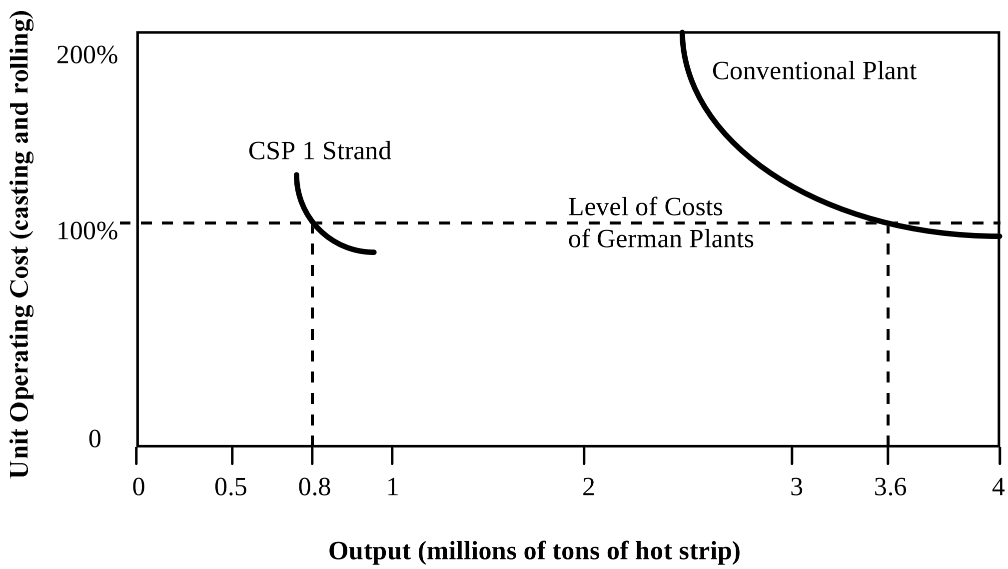
Source: The Nucor Story, Nucor Corporation.

Exhibit 10 Process Layouts: CSP and Conventional Plants



Source: Nucor Corporation.

Exhibit 11 Operating Costs: CSP and Conventional Plants



Source: SMS Schloemann-Siemag.

Exhibit 12A Construction Costs for Flat-Rolled Product Plants: 1986[a]

	Thin-Slab Minimill	Modernized Integrated Mill[b]
CONSTRUCTION COSTS ($ millions)		
—Melting stage	$120.00	$1,097.00
—Casting stage	28.00	168.00
—Rolling stage	132.00	608.00
Total construction cost	$280.00	$1,873.00
CAPACITY (millions of tons	1.00	4.20
SHIPMENTS (millions of tons)		
—Hot-rolled sheet (HR)	0.50	2.10
—Cold-rolled sheet (CR)	0.35	1.35
CONSTRUCTION COSTS PER TON SHIPPED ($)		
—Hot-rolled sheet (HR)	$236.00	$451.00
—Cold-rolled sheet (CR)	$450.00	$675.00

Source: Donald F. Barnett, Economic Associates, Inc., 1992.

[a]Costs do not include working capital or start-up costs.
[b]An unmodernized integrated mill does not, by assumption, require any additional construction expenditures.

Exhibit 12B Comparative Operating Data for Flat-Rolled Product Plants: 1986

	Thin-Slab Minimill		Modernized Integrated Mill		Unmodernized Integrated Mill	
	HR[a]	CR[a]	HR	CR	HR	CR
OPERATING ASSUMPTIONS						
Labor per hour ($)	20.00	20.00	23.50	23.50	23.50	23.50
Scrap per ton ($)	90.00	90.00	80.00	80.00	80.00	80.00
Man hours per ton (hrs.)	1.75	2.65	2.85	4.50	3.90	5.85
Capacity utilization (%)	90.00	90.00	90.00	90.00	75.00	75.00
OPERATING COSTS PER TON						
Labor	$35.00	$53.00	$67.00	$105.50	$91.50	$141.00
Ore	0.00	0.00	51.00	54.00	52.00	56.00
Coal	0.00	0.00	35.00	37.50	38.00	40.50
Energy	24.00	38.00	9.00	23.00	9.50	25.00
Scrap	100.50	102.00	13.50	9.50	19.50	15.50
Materials and supplies	56.00	72.50	71.00	93.00	72.50	95.50
Maintenance and repairs	10.00	17.50	15.00	26.50	17.00	29.50
TOTAL COSTS	**225.00**	**283.00**	**261.50**	**349.00**	**300.00**	**403.00**
REVENUES PER TON	**$306.50**	**$390.50**	**$326.00**	**$454.50**	**$325.00**	**$453.00**

Source: Donald F. Barnett, Economic Associates, Inc., 1992.

[a]Cold-rolled sheet (CR) is hot-rolled sheet (HR) that has been subjected to further primary processing.