NUCOR CORP. AND THE U.S. STEEL INDUSTRY

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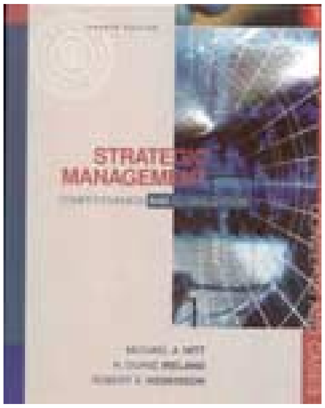


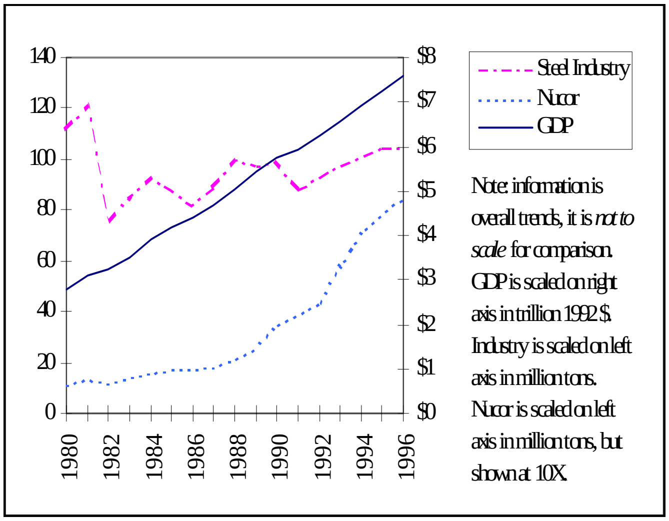
> Darlington, South Carolina, 1969. Making steel is a technically demanding, complex, and dangerous process. Nucor Corp.'s initial foray into steel production was the later. Instead of staffing with plant with seasoned steel veterans, Nucor hired farmers, mechanics, and other intelligent, motivated workers. Those employees along with company executives and dignitaries in attendance at Nucor's mill opening fled the plant as the inaugural pour resulted in molten steel pouring onto the mill floor and spreading toward the crowd. Onlookers and employees alike were left wondering if Nucor would ever successfully produce steel.[1]

The steel industry, a classic example of a market in the late stages of maturity, traces its roots to Colonial Era blacksmiths who forged basic farm and household equipment. The industry grew (and consolidated) rapidly in the first half of the 20th century, with world-wide demand growing throughout the 1960s. However, a series of shifts in market dynamics led to dramatic industry-wide declines in growth and profitability. The dominant players faced the same problems as did leaders of other mature industries -- Ford and General Motors, for example -- obsolete production facilities, bureaucratic management systems, heavily unionized workers, and hungry foreign competitors. The decline of the steel industry, due to its centrality in the economy, was cited by some observers as an indicator of the decline of the overall U.S. economic system.

While foreign competition played a significant role in changing the U.S. steel industry, an even larger factor emerged during the 1970s: minimill technology. Traditional "integrated mills" rely on large-scale vertical integration including integrated coke and ore production. "Minimills" used a new technology to recycle scrap steel and quickly stole most of the commodity steel market away from integrated producers. This enabled minimills to enter a geographic market with a distinct cost advantage: typically requiring a capital investment of $300 to $500 million or 5 to 10% of that required for an integrated mill. The minimill revolution has resulted in a dramatic dispersion of the steel manufacturers from the "rust belt" to the primary population and growth areas of the US. The impact of minimill's on the industry is best demonstrated by looking at the former industry leader US Steel (now USX Corp.). In 1966 US Steel controlled 55% of American steel market, in 1986 US Steel controlled only 17%.

Despite their inauspicious foray into steel, Nucor Corp. has become a benchmark for both the U.S. steel industry and U.S. industry in general. Nucor is one of the fastest growing and most efficient steel producers in the world. Despite declining demand for steel, Nucor's growth has been phenomenal, from pouring its first batch of steel in the 1960s to support in-house operations, the company has become one of the top five producers of steel in the U.S.. Without an R&D department, Nucor has repeatedly achieved technological feats other steel producers thought impossible. Their hourly pay is among the lowest in the industry, yet they have the highest productivity per worker of any steel producer in the U.S. and near zero employee turnover. How has Nucor achieved such phenomenal success? Can it continue to do so?

Figure I - Comparative Trends: GDP, Steel Industry Output & Nucor Output



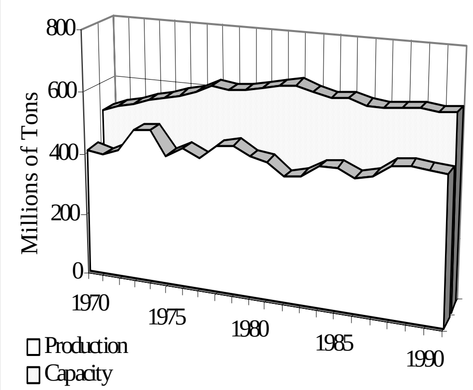
U.S. Steel Industry History

Steel has been a part of the domestic economic system since the Colonial Era when iron (the parent of steel) was smelted and forged. The early 19th century, with the advent of steam engines, cotton gins and farming combines, advanced iron as a commodity of progress. The addition of carbon to iron yielded a material with additional strength, elasticity, toughness and malleability at elevated temperatures. The Civil War provided the impetus for the industry to organize, consolidate, expand and modernize in order to supply the vast quantities of steel required for warfare.

Following the Civil War, the construction of new transportation systems, public works projects, automobiles, bridges, ships and large buildings all fueled a torrid expansion of the industry lasting through the turn of the century. Domestic economic expansion and two world wars maintained an unquenchable appetite for steel both in the U.S. and around the world in the first half of the 20th century. Even in the aftermath of World War II, America's steel industry prospered as it supplied an ever expanding domestic economy and the rebuilding of war-ravaged infrastructures. This windfall for the domestic industry was in actuality one of the root causes for it's eventual decline. U.S. plants, idled by the end of warfighting, were reactivated to support the Marshall Plan and MacArthur's rebuilding of Japan. The war-torn nations of the world, however, rebuilt their industrial facilities from the ground up, incorporating the latest production technology. Conversely, domestic producers were content with older, formerly inactivated facilities.

Global demand for steel expanded continuously throughout the 1960s, a demand domestic producers elected to not meet, choosing only to match domestic consumption requirements. This presented an opportunity for up-start foreign producers to rejuvenate and strengthen themselves without directly competing against U.S. producers. Throughout this expansion, the relationship between management and labor soured. In 1892, Henry Clay Frick's Pinkerton guards attacked striking workers, setting the stage for a contentious relationship between management and labor. Labor, represented by the United Steel Workers of America (USWA) and management began negotiating three year collective bargaining agreements beginning in 1947. These negotiations frequently collapsed and strikes following the third year of a contract became commonplace. Firms dependent on steel soon initiated a pattern of accumulating 30 day "strike hedge" inventories to feed operations during strike shutdowns. In 1959, the USWA walked out for 116 days. In 1964, another strike required presidential intervention. The impact of these strikes reverberated throughout the economy. Major customers began to look for stable supplies of steel from foreign producers who, in 1959, met only 3% of domestic demand. Fueled by excess capacity and strike induced demand, foreign producers were providing 18% of domestic demand by the time a long-term labor accord was reached in the early 1970s. Foreign producers currently supply 20-25% of the steel used in the U.S..

Figure II - World Capacity, Production & Idle Capacity 1970-1991



Year	%Idle
1970	20%
1972	22
1974	13
1976	25
1978	24
1980	29
1982	39
1984	29
1986	31
1988	23
1990	23

Protectionists are quick to blame the Japanese for the decimation of American steel. However, other countries have an even stronger presence in the U.S. market: since 1991, for example, Canada has exported more steel to the U.S. than has Japan. By 1994, Europe and other regions accounted for the bulk of steel imports. While foreign producers maintain a strong presence in the U.S., the same cannot be said for American steel firms abroad. Exports by U.S. firms have traditionally been minuscule, 1% of production in the mid-1980s, but have grown to 3-5% of production during the 1990s.

While the labor accords reached in the 1970s stabilized the supply of domestic steel, the cost of living adjustments (COLA's) and automatic wage adjustments included in the accords would prove to be detrimental to the industry's cash position during periods of reduced demand for steel. Such a situation was experienced in the 1970s when the domestic auto industry, historically the largest consumer of steel in the U.S., began to decline. Domestic producers attempted to remedy the resulting cash flow crisis with lay-offs and price hikes, but the price hikes came at the expense of further market share erosion to low-cost foreign producers. While the industry claimed productivity improvements, these were often the result of lay-offs and shut-downs as opposed to process efficiency improvements.

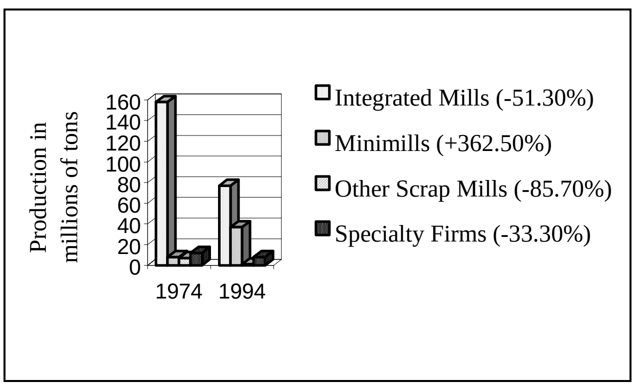
The slowdowns and closures of the 1970s set the stage for steels 'dark ages' – the 1980 to 1986 period when steel output declined from 115 to 80 million tons despite an increase in real GDP. The energy crisis lead to demand for smaller, lighter cars which require less steel, also resulting is less required tonnage. R&D in the steel industry led to stronger blends of steel. New materials, such as petroleum-based materials (plastics), organics (wood/pulp), and synthetic materials (fiberglass, epoxies) became significant threats in several applications customarily met by steel. Overall employment in steel fell from 535,000 in 1979 to 249,000 in 1986.

Despite this decline, this was also a period of shakeout and dynamic activity in the industry. Slowly, and with the help of the Federal government (primarily in tax and regulatory relief and enforcement of Uruguay Trade Agreements/ Voluntary Restraining Agreements), some firms were able to revitalize their operations by streamlining production, the selection of better markets, focused production (mini-mills), improvement of facilities, stabilization of labor contracts and the reduction of labor content by plant modernization, dollar devaluation and a reprieve from the onslaught of substitute materials. This gave the surviving firms opportunity to recover and prosper.

Historically, demand for steel fluctuates both in the U.S. and international markets due to its close ties to durable and capital goods, markets which suffer more acutely during austerity and are more prosperous during economic expansions. Economic swings notwithstanding, there has been little appreciable growth in steel demand between the 1950s and the 1990s. Current domestic production is approximately 100 million tons per year, far less than the 120 million tons of 1981. Decline in demand has led to substantial excess capacity. In 1980, for example, domestic producers had 25% idle capacity. While the industry now operates at 90% of capacity, this has come as a result of reduced capacity, not increased output: total domestic capacity declined by 30% between 1980 and 1994. Capacity reduction in the steel industry is expensive, particularly for integrated producers. USX Corp., for example, eliminated 16% of their capacity in 1983 at a cost of $1.2 billion. Still, by 1987, USX had 40% idle capacity.

While large scale, integrated producers such as USX were shedding excess capacity, a new type of competitor, "minimills" were entering the market. Minimill's utilize recycled steel (in the form of junk cars, scrap, etc.) as a primary ingredient. Unlike the integrated producers, minimills are less capital intensive, smaller, and have historically focused on producing low technology, entry level products. Unlike integrated mills which have seen production decline, minimills have seen explosive growth with numerous plants opening in the late 1980s and 1990s.

Figure III - U.S. Production: 1974 & 1994



Overall, the steel industry has all of the characteristics of a highly competitive market -- stagnant demand, excess capacity, and numerous global competitors. The ability of the largest firm to use its power to set prices is gone. Above average industry margins are quickly targeted by other firms. These factors are compounded by a largely commodity-like product which minimizes switching costs and customer loyalty. Not surprisingly, the profit performance of the industry has been weak: the industry as a whole lost money during much of the 1980s. In 1987, the first (albeit small) industry-wide profit in 8 years was posted. With the exception of the 1990-91 recession, domestic producers have gradually improved the return on assets to a value of 6.1% in 1994. A flurry of exits and Chapter 11 reorganizations led to an improved profit potential for remaining firms by the mid-1990's. The success is more pronounced in the minimill sector, although the integrated producers are presently healthy and now represent a new threat to the minimills.

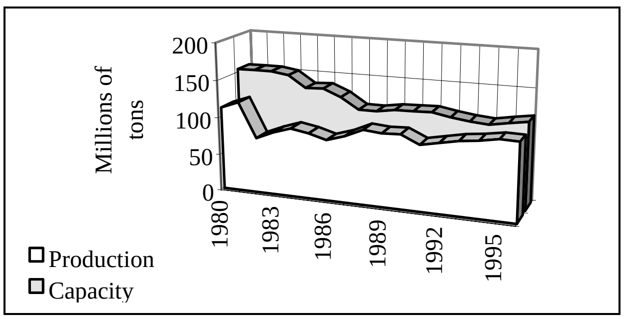
Emerging Industry Trends

While in many ways the industry appears to have stabilized, a number of emerging trends threaten to cause further disruption within the industry; disruption to both integrateds and minimills.

Minimill Overcapacity: Starting in 1989, only one company, Nucor, was capable of producing flatrolled steel using minimill technology. However, competing firms have started using similar technology and there were expected to be 10 new flatroll minimills online by 1997 adding 13 million tons of production capacity – about 10 percent of 1996 production, to the industry. This new capacity should become available just as steel consumption is expected to decline.

Scrap Prices: Due to growing demand for scrap metal, its cost has become increasingly volatile in the 1990s. In 1994, for example, prices climbed as much as $50/ton to $165-170/ton while 10 million tons of American scrap were exported to offshore customers. In 1996 prices reached $200/ton, and were expected to climb, but instead declined to $170-180/ton by the end of 1997.

Figure IV - Domestic Capacity & Production



Euro Production: While growth has improved in recent years, demand for steel is still weak in much of Europe, particularly in Eastern European nations. Western Europe alone had 20 million tons of excess capacity in 1994, and Russian mills were operating at 65 percent of capacity. Additionally, many European mills are state-owned and subsidized. Faced with weak performance and idle capacity, many of these mills are aggressively pursing export opportunities in China and other parts of Asia. Russian steel exports approached $4 billion in 1993, double their 1992 level.

Antidumping Rulings: U.S. integrated steel producers filed 72 charges of dumping against foreign competitors -- primarily the Germans and Japanese. In 1993, the International Trade Commission concluded that there was some justification for these charges, but not for others and ruled that foreign steel caused no harm in 40 of the 72 cases. Stock prices for U.S. producers (in aggregate) declined $1.1 billion in the 90 minutes following announcement of the ruling.

Industry Economic Structure

The domestic steel industry, until recent technological changes, was essentially composed of two vertically integrated sectors. The first was the raw steel production sector which encompassed steel making operations from the unearthing of ores and coke to the basic ore reduction and smelting. The outcome or product of this sector was ingots, billets and slabs which are standard steel shapes. These products were then sent to finishing mills (the second sector) which conducted various heat treating and shaping processes to produce finished steel products such as bars, tubes, castings, forgings, plates, sheet and structural shapes. These two sectors were typically housed under a single facility but as two distinct operations in what was termed the "integrated" producer. Traditionally, steel manufacturers used batch processing which involved heating a furnace of steel, pouring the entire furnace full of molten steel into billets, ingots, and slabs. These intermediate products were then processed and the process repeated. The onset of continuous casting technology (a process in which ores are reduced and poured into final shapes without the intermediate production of slabs and ingots) in the late 1970s has blurred the classical two-sector demarcation. Most producers today use the continuous casting process for production of isometric shapes, but raw steel must still be shipped to finishing mills for manufacturer of more complex products.

The suppliers to the steel industry can be broadly assigned to three major classes: ore, energy and transportation. Since a preponderance of the final production cost is tied up in these input items, many producers have vertically integrate backwards by acquiring ore and coal/coke mining firms and transportation networks (rail and barge). The supply factors of production (transformation factors) are labor to operate plants, capital facilities, and land. Recent modernization has significantly substituted technology for labor in steel production.

Minimills are a significant force of change in the industry as their supplier and customer requirements differ from the integrated mills. First, ore supplies are, to differing degrees, replaced by a need for access to large quantities of scrap steel. Second, minimills, while still large consumers of electricity, consume far less power than their integrated mill counterparts. This, along with the lower output capacity of each plant, allows for placement of the mills closer to the third factor: the changing customer base. This has resulted in a radical shift in steel production in recent years from western Pennsylvania and Ohio to a much broader dispersion of steel mills throughout the U.S. By one estimate, steel mills can now be found in over half of the U.S. states.

The principal markets and customers for steel are the classical markets. Some sectors are on the decline while others are fairly stable. The automotive sector was historically the largest consumer of steel in peacetime. Construction materials is now the largest sector, followed by the auto and container industries, energy equipment, industrial machinery, farming equipment, car/rail production and various military applications. The reduced demand by the auto industry is the result of the lower steel content in a modern automobile; a trend steel producers are aggressively trying to counter by banding together to form the Steel Alliance which is running a $100 million advertising campaign targeted at consumers touting the advantages of steel for automobile design (and house construction).

Figure V - Steel Demand by Market Sector

	Automotive	Service Centers	Construction	Containers	Industrial Machinery	Energy/ Minerals	Rail/Rail Vehicles	Farm Machinery	Shipbuilding	Other
% of Demand 1972	23	20	17	9	8	4	3	3	1	12
% of Demand 1993	14	27	15	11	13	2	1	4	1	22

Service centers are playing an increased role in the industry, acting as major distributors and wholesalers for finished steel products to steel consumers (construction firms, shipbuilders, machine fabricators, etc.). With the exception of the auto and auto part manufacturers (who contract directly with producers), most finished steel is delivered to end users is via the steel service center, moving some of the inventory management burden to the service centers for a marginal mark-up to the end user. This presents a forecasting complication to planners and strategists as all demand for steel is a derived demand, the forecaster must be able to look into the macro forces affecting an economy and project steel's role in the broader economic system from which a consumer demand pattern could be ascertained.

Steel Production Technology

Any attempt to consolidate steel and steel production technology into a few paragraphs would be doing the topic a disservice. However, two major issues deserve additional attention: production factors and substitutes. Automation has improved the competitive position of the industry by reducing the exposure of the industry to volatile labor markets and labor costs. It has also increased the flexibility of producers to shift product output and lent to the incorporation of the continuous casting process. Closely related is the elimination of the old open hearth furnace in favor of the blast-oxygen furnace and electric arc furnaces which are far more efficient, more easily automated and require less manpower. These furnaces also reduce stack emissions, a critical environmental requirement (and a concern which many foreign producers do not face). While technology has been a driver of change, labor agreements and relations have not always made it possible to fully exploit the benefits of technological improvements.

The proliferation of substitute materials is an important issue. It is important to note, however, that while substitutes have made significant inroads into steel markets over the last 30 years, they will likely never replace steel as the commodity of choice for many applications. Steel will not be displaced (with very minor exceptions) as a material in strength applications: plastic is not strong enough, graphite-reinforced plastics and epoxies lack steels thermal resistance properties, wood is not as strong or environmentally resistant as steel, and titanium remains a rare, expensive, strategically controlled material. Furthermore, steel comes in many different compositions (stainless, tool, high-strength, galvanized). The industry’s R&D efforts have continued to evolve steel to meet the demands of customers. In short, steel remains and is likely to remain *the* material of choice in most applications.

Nucor Corporation

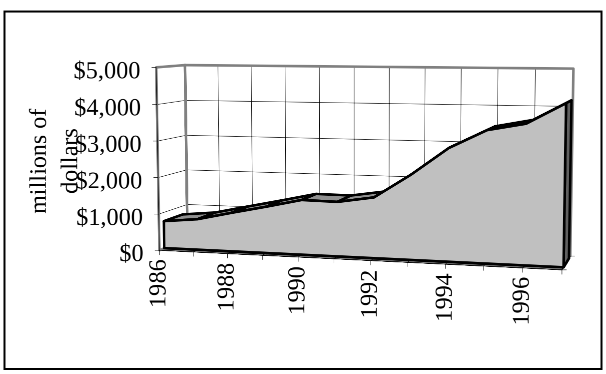
Nucor Corp. began life as the Nuclear Corporation of America. The latter was a highly diversified and marginally profitable company; their products included instruments, semiconductors, rare earths, and construction. One of their potential acquisitions was Coast Metals, a family owned producer of specialty metals. When the acquisition fell through, Nuclear hired one of Coast’s top engineers as a consultant to recommend other acquisition targets. The engineer – Ken Iverson – had strong technical skills (including a graduate degree in metallurgy from Purdue University) and general management experience. Based on Iverson’s recommendation, Nuclear acquired a steel joist company in South Carolina. Subsequently, Iverson joined Nuclear as a vice president in 1962. Nuclear built a second joist plant in Nebraska the following year. Iverson was responsible for supervising the joist operations as well as the research, chemical and construction segments. By 1965, the diversified company had experienced another string of losses; although the joist operations were profitable. The president stepped down that year and became president.

Recognizing that their most valuable skills lay in their joist operations, Nuclear became Nucor Corp. and divested non-joist operations. New joist plants soon followed, including one in

Alabama in 1967 and another in Texas in 1968. As a joist company, Nucor was dependent on American and foreign steel producers for their key input. Iverson decided to integrate backwards into steel making in the hopes of stabilizing supply and lowering input costs for their joist business. So, Nucor began construction on their own steel mill in Darlington, South Carolina – a location close to an existing joist operation. The Darlington plant used the then new minimill technology. The Darlington plant opened on October 12, 1969, the pouring of the first batch of steel resulted in molten steel cascading out of the mold and across the floor of the plant. Despite the mishap, Nucor quickly became adept at minimill technology. In addition to supplying their own joist operations, they began competing with integrateds and other minimills in the commodity steel business. Iverson and Nucor soon became recognized as the "Southwest Airlines" of steel: a simple, no-frills organization, with a unique culture, highly motivated workers, and the lowest cost structure of the industry. Some indicators of their success include:

- They are the only major player in the industry which can boast of 22 years of uninterrupted quarterly dividends (Nucor began paying quarterly dividends in 1973), and 30 years of continuous quarterly profits, despite numerous slumps and downturns in the industry.
- Between 1980 and 1990, Nucor doubled in size. In comparison, the six main integrated producers reduced their steel making capacity from 108 to 58 million tons during this period.
- In 1990, Nucor had six steel plants and a total annual capacity of 3 million tons. By 1995, they had added a seventh plant, and overall capacity nearing 8 million tons.
- In 1994, Nucor generated $1.50 in sales for every dollar in property, plant and equipment. The industry average was $0.95 before depreciation expenses. After depreciation, these ratios are $2.18 and $1.83 respectively).
- Nucor continues to be the industry leader in cost efficiency. In 1990, Nucor produced 980 tons of steel per employee each year, at a net cost of $60/ton compared to the industry average of 420 tons per employee at a cost of $135/ton. In 1994, Nucor's conversion cost was $170/ton, roughly $50-75 less than competitors.

Figure VI - Nucor Annual Sales 1986 - 1997



Nucor has primary mills located in Arkansas, Nebraska, Utah, South Carolina, Texas, Indiana, and South Carolina. Additional operating facilities located in Fort Payne, Alabama, Conway, Arkansas, Saint Joe and Waterloo, Indiana, Wilson, North Carolina, and Swansea, South Carolina, are all engaged in the manufacture of steel products. During 1997, the average utilization rate of all operating facilities was more than 85% of production capacity. Nucor competes in a number of distinct product segments and the emphasis on these segments has changed substantially in recent years. Historically, the largest segment was the Nucor Steel division, which produces bar and light structural steel products. In 1991, this was their largest segment (measured by product volume). However, by 1995 sheet steel, once considered to be an exclusive product of integrated producers, accounted for the largest production volume. Heavy structural beams from a joint venture with Yamato Steel of Japan was the third largest segment, followed by the Vulcraft joist division. Remaining products -- including grinding balls, fasteners, ball bearings and prefabricated steel buildings -- each account for relatively small proportions of total output.

Figure VII - Nucor's Principal Manufacturing Locations (1997)

Location	Size (ft^2)	Products
Blytheville-Hickman, Arkansas	2,880,000	Steel shapes, flat-rolled steel
Norfolk-Stanton, Nebraska	2,280,000	Steel shapes, joists, deck
Brigham City-Plymouth, Utah	1,760,000	Steel shapes, joists
Darlington-Florence, South Carolina	1,610,000	Steel shapes, joists, deck
Grapeland-Jewett, Texas	1,500,000	Steel shapes, joists, deck
Crawfordsville, Indiana	1,410,000	Flat-rolled steel
Berkeley, South Carolina	1,300,000	Flat-rolled steel

While Nucor's first experience with steel was the result of backward integration by the Vulcraft joist division - the manufacture of steel has become the central focus of the firm. That focus has broadened to include sheet steel (1989) and heavy structural beams (1988). The company has also extended their focus to several downstream products, including fasteners and ball bearings (both in 1986), and prefabricated metal buildings (1988). With the exception of the ball bearings mill, which was acquired, new business segments are developed internally. Roughly fifteen percent of steel output is used internally for downstream operations. More recently, Nucor has chosen to integrate backwards from steel with a plant in Trinidad. This backward integration is aimed at lowering production costs: the plant produces iron carbide, which is expected to become an alternative to scrap in the minimill process.

Nucor's Strategy

Nucor has chosen to avoid formalized planning processes which are typically found in *Fortune 500* firms. This lack of formalization also extends to the company's mission statement – non-existent but known to all employees. The company does not have a *formal* mission statement as management believes that most mission statements are developed in isolation, never seen or conveyed to employees, and have little in common with what the firm really does and how it operates. Nonetheless, all Nucor employees can tell you what their job entails and what the objective of the organization is – the production of high volumes of quality, low-cost steel.[2] Nucor and their employees recognize that all the steel produced must meet industry standards for quality. In fact, Nucor frequently exceeds quality standards. High levels of production per man hour result in low-cost and, subsequently, prices among the lowest in the industry.

Nucor's strategic intent is clearly known by employees, customers, and their competitors. Each year, the business review of the annual report gives this succinct description of their scope of operations: "Nucor Corporation's business is the manufacture of steel products." The annual letter to shareholders gives this picture of the company:

> Your management believes that Nucor is among the nation's lowest cost steel producers. Nucor has operated profitably for every quarter since 1966. Nucor's steel products are competitive with those of foreign imports. Nucor has a strong sense of loyalty and responsibility to its employees. Nucor has not closed a single facility, and has maintained stability in its work force for many years…Productivity is high and labor relations are good.[3]

As with the mission, goals at Nucor are equally streamlined. Iverson has noted that in some companies planning systems are as much ritual as reality, resulting in plans and budgets which are inappropriate and unrealistic.[4] Nucor has both long- and short-range goals. However, they are handled differently than at many firms. Short-term plans focus on budget and production for the current and next fiscal year. The plans are zero-based – created from actual needs and estimates for specific projects – not an updated copy of a prior years budget. Long-range plans are a combination of the plans of different divisions and plants – a bottom-up approach to planning. The long-range plans are seen as guides – not gospel. The plans incorporate relative goals instead of specific milestones which the firm expects managers to achieve. Division and plant manager's set their target goals knowing that they will be rewarded for meeting them, but not punished if for unexpected reasons they are not met.

Similarly, even plans for specific projects are minimalist. For example, the company handles new mill construction largely internally. Many aspects of the plant design are done 'on the fly' to save time. The company does not create finely detailed construction plans for new plants. Instead, they use this experience as a guide for starting construction. They then fill in the details as construction proceeds.[5] This approach allows Nucor to construct plants both faster and at less cost than their competitors: the Hickman, Arkansas mill was completed six months ahead of schedule -- going from groundbreaking to first commercial shipment in a mere sixteen months.

By 1995, Nucor had become the fourth-largest domestic steel producer. CEO John Correnti targets annual growth between 15 and 18 percent – substantially above the one to two percent rate of growth for the industry. Given Nucor's size and the industry's maturity, growth for Nucor requires taking market share away from the integrated producers. Most experts agree that Nucor is well-positioned to achieve such growth and sustain profitability given their industry leading cost structure. Steel industry analysts attribute Nucor's ability to grow in a constricting market on the firms aggressive style of management, their innovative and revolutionary technologies, and a solid understanding of the dynamics and cost-drivers of the steel industry.

Nucor can trace its low cost position to a combination of three factors: *technological innovation,* continuous *process refinement*, and a strong *corporate culture*. Investments in any of the three alone is insufficient - the three elements must work together for the firm to be productive and successful.

Technological Innovation at Nucor

Historically, the main distinction between minimills and integrated producers has been the range of products offered. While minimill technology is less capital intensive, the production process is also limited to commodity steel products -- bars, angles, and structural steel beams. Integrated producers largely retreated from these commodity products and concentrated on sheet steel, which was presumably safe from encroachment by the minis. Strategically, though, Nucor more closely resembles the integrated producers versus other minimills in terms of product offerings. Innovative use of technology is key to this strategy.

A prime example of Nucor's innovation was their foray into sheet steel. By the mid-Eighties, Iverson had anticipated the coming shake-out among minimills: the lure of easy pickings from dinosaurs like Bethlehem Steel had drawn many firms into the minimill business and resulted in oversupply. Integrated mills produce steel sheet by starting with ten-inch thick slabs of steel and repeated processing the slab through rollers to reduce thickness and increase width. Multiple rolling machines result in a production line hundreds of yards long. Conventional wisdom said that it was impossible to produce the 10 inch thick steel slabs needed to roll sheet steel in a minimill: their small electric arc furnaces simply did not have the same capability as the blast furnace used by an integrated mill. Nucor carefully researched emerging technology. Rather than develop a proprietary system, they licensed and modified a new German caster and began a $270 million experiment. This new plant -- in Crawfordsville Indiana -- started up in 1987. The process was very different from making sheet steel in an integrated plant. Nucor's system involves the highly controlled continuous pouring of molten steel into a narrow mold and onto a conveyor belt to form a continuous two-inch thick ribbon of semi-solid steel – pouring steel much in the same manner as frosting an endless cake using a pastry tube. The process requires sophisticated computer technology and monitoring to ensure constant quality and avert costly and dangerous spills. This precisely sized ribbon of steel is then rolled to the specific thickness using a few, smaller sized rolling machines. This results in a much smaller and less expensive plant than a traditional mill for the production of sheet steel.

The technical challenges of producing steel using this methods are the basic requirements of entry into the minimill market. Profitability, however, is achieved through efficiency. Labor costs constitute a large portion of the cost of steel. Integrated producers can take up to 4-5 man-hours per ton to produce sheet steel, with 3 hours/ton a productivity benchmark. In comparison, Nucor's Crawfordsville took only 45 man-minutes per ton. Such efficiency gave Nucor a $50-75 cost advantage per ton; a savings of nearly 25 percent compared to their competitors. By 1996, Nucor had production time down to 36 minutes per ton with additional savings expected. A second sheet plant was added in 1992, and capacity was expanded at both plants in 1994. Production capacity was one million tons in 1989, and 3.8 million tons in 1995.

Not content with the sheet steel market, Nucor chose to enter a new strategic segment in 1995: specialty steel. The Crawfordsville plant was modified to produce thin slab stainless steel -- another "impossible" feat for a minimill. Through experimentation, they were able to produce 2 inch thick stainless steel slabs. They shipped 16,000 tons in 1995, 50,000 tons in 1996, and expect to hit a production capacity of 200,000 tons annually. Coincidentally, perhaps, their projected capacity mirrors the volume of stainless sheet imported to the U.S. – about 10 percent of stainless steel demand in the US.

Another example of technological innovation was Nucor's entry into the fastener steel segment. Fasteners include hardware such as hex and structural bolts and socket cap screws, and are used extensively in an array of applications, including construction, machine tools, farm implements, and military applications. Dozens of American fastener plants shuttered their doors through the 1980s, and foreign firms captured virtually all of this business segment. After a year of studying the fastener market and available technology, Nucor built a new fastener plant in Saint Joe, Indiana. Productivity was substantially higher than comparable U.S. plants, and a second fastener plant came on-line in 1995. The fastener plants receive most of their steel from the Nucor Steel division. With a production capacity of 115,000 tons -- up substantially from 50,000 tons in 1991 -- Nucor has the capacity to supply nearly 20 percent of this market.

A final example of technological innovation concerns upstream diversification. Scrap steel is a critical input for minimills. Quality differences in scrap types coupled with insufficient supply have led to large fluctuations in scrap costs. Frank Stephens, a mining engineer, had developed a technology to improve the efficiency of steel making through the use of iron carbide. Stephens had tried -- unsuccessfully -- to sell this process to US Steel, National Steel, and Armco, among others.[6] In comparison, to Nucor iron carbide appeared to be an opportunity to reduce its reliance on the increasingly volatile scrap steel market. After speaking with the inventor of the process and touring an iron carbide pilot plant in Australia, Nucor made preliminary plans to construct an iron carbide pilot plant.[7] The location selected – Trinidad – would provide the large quantities of low cost natural gas needed for iron carbide production. Nucor estimated that establishing the pilot plant would require $60 million. However, as the process was unproven, Nucor would, in essence, be making a gamble that would yield an industry revolutionizing process or be investing $60 million in a plant which would be virtually worthless. To Nucor, the investment constituted a measured risk – while the investment to determine the feasibility was significant, if the process failed it would not cripple the firm. In 1994, Nucor opened the iron carbide pilot plant at a cost of $100 million -- almost double expectations. At the end of 1995, the plant was operating at only 60 percent of capacity. Still, Nucor was betting big on this opportunity. Nucor estimates that the use of iron carbide would allow them to reduce their steel making costs by $50 per ton - a 20 percent reduction. Additionally, Nucor is working on a joint venture with US Steel to manufacture steel directly from iron carbide which could revolutionize the steel industry.

Process Refinement at Nucor

Much of the business press focuses on the high-profile quantum advances made at Nucor, such as the creation of flat rolled steel in an electric arc furnace and the use of iron carbide as a substitute for scrap. However, an emphasis on continuous innovation is felt throughout the organization and is equally important. A manager from Nucor's Crawfordsville mill observed that most of the innovation comes not form management, but from equipment operators and line supervisors. The job of management, says the manager, is to make sure the innovations can be implemented.[8] For example, workers discovered that they could fine tune surface characteristics of their galvanized steel (a benefit valued by many customers) simply by making small adjustments to the air pressure of a coating process. Changes such as these do not require management review or approval. Instead, equipment operators and line supervisors are authorized to innovate and implement processes which improve production. Such innovation is routine enough at Nucor that management does not track individual improvements. Rather, Nucor tracks innovation by looking at the end result – reductions in the about of labor required to produce each ton of steel.

Employee innovation is driven by two factors. First, the company's bonus system means that any substantial improvements to efficiency will contribute to both the plant's performance and individual paychecks. Second, the corporate culture emphasizes how experiments – even failed ones – keep Nucor as the perennial benchmark for industry productivity. Experiments are conducted both at the time of mill start-up and on an ongoing basis. Typical of most mill start-ups, the start-up of Nucor's Hickman plant was fraught with problems. The high rate of the production line resulted in "breakouts" – bad pours – of the "ribbon" of steel for thin-slab casting. Though initially occurring at the rate of several per day, breakouts have been declining since the plant became operational. The high rates of production still result in two to five breakouts per week and Nucor continues to make modifications to the equipment to reduce this level.

Focusing on clean-steel practices, the melt-shop people are developing mold powders that can handle the high-speed, thin-slab casting. Mold powders insulate, lubricate, aid uniform heat transfer, and absorb inclusions - all of which makes for cleaner steel. Unfortunately, no existing mold powders can handle hot steel at the rate Nucor could potentially produce it - 200 inches a minute. To reduce inclusions (impurities in the steel), Nucor is working to standardize all operating practices in the two furnaces and two ladle furnaces.

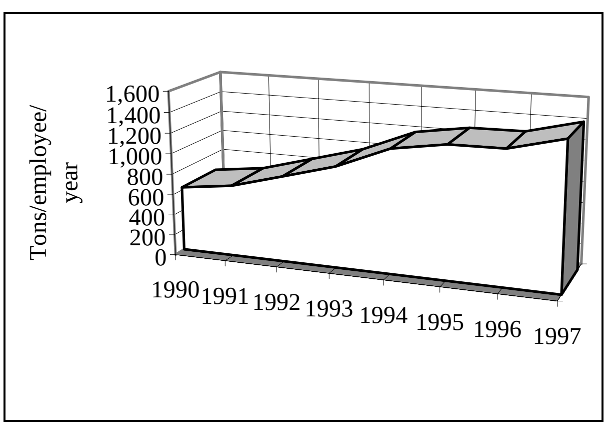
The Nucor philosophy toward innovation is that attempts at improvement will be accompanied by failures. Tony Kurley, a Nucor plant managers, recalls Nucor Chairman Ken Iverson expectation that success is making the correct decision 60 percent of the time. What's important isn't the mistakes that are made, says Iverson, but the ability to learn from the 20 percent that are truly mistakes and the 20 percent that are suboptimal decisions.[9]

This willingness to modify on the fly and "shoot from the hip," as one melt-shop supervisor puts it, makes Nucor an exciting place to work. The lean, flexible workforce is continually trying new things, doing different jobs. Employees continue to engage in risk taking because the company rewards success and does not punish for failures. The result is employees, from top managers to hourly personnel, being willing to take risks to achieve innovation and take ownership in their jobs.

At Nucor, the tolerance levels for failure are apparently high. In the 1970's, a Nucor plant manager was considering the replacement of the electric arc furnace in the plant with an induction furnace. At Nucor, the plant manager has the authority to select the type of furnaces used in his plant. There was no clearly right or wrong answer. A discussion yielded strong arguments in favor of the switch from some plant managers and equally enthusiastic arguments against the switch from others. The plant manger elected to make the switch at a cost to Nucor of $10 million. From the start, the new furnaces failed to live up to expectations and resulted in repeated shutdowns. Discussion shifted to the plusses and minuses of removing the furnace and within a year the furnace was removed. Upon telling Iverson of his decision, Iverson supported the manager saying he had made the right decision – no sense in having a leaving the reminder of a bad decision laying around.[10]

Despite the price tag on this particular learning experience, management was unfazed. Iverson's comment on this failure was that the true problem is people not taking risks saying that Nucor has a saying – don't study an idea to death in a dozen committee meetings, try it out and make it work.

Figure VII - Nucor Annual Worker Productivity



Through incremental advances, employees are continually able to streamline and refine the steel making process. The data suggests that Nucor employees have not come close to exhausting these enhancements. Productivity, as measured as tons produced per employee, doubled from 1990 to 1995 (626 tons/worker and 1,269 tons/worker respectively) and continues to climb. In 1997, productivity exceeded 1,400 tons/worker. How is Nucor able to realize such productivity gains in this mature industry? The following examples highlight incremental innovations.

Preventive Maintenance: Preventive maintenance is a crucial, but time-consuming task at a minimill. At Nucor-Yamato, a joint venture between Nucor and Yamato Kogyo, a Japanese steel producer, the plant had week-long shutdowns three times a year. During these periods, outside contractors – as many as 800 at a time – would strip, service, and replace worn machinery. The outages cold involve as many as 800 contractor personnel – a difficult task to manage. Further exacerbating the situation was the level of skill and low level of productivity of some contractor personnel. Aside from the challenges of hunting down missing contractors, the plant (and employees) suffered from the three weeks without production. The company addressed both of these concerns by eliminating the week long shutdowns, instead tackling specific areas of the mill in focused, 24-hour shutdowns. This new process has several advantages, including spreading the maintenance costs over a wider window, and being able to use a smaller in-house staff which operates continually. Some maintenance jobs are large enough to still require multiple day shutdowns, but the number of outside contractors has been reduced from 800 to 150. Through this program, downtime at the plant has fallen from 10 percent to near one percent. Some improvements are less dramatic, but significant nonetheless. A young engineer at a Nucor plant was concerned that too much was being spent to lubricate and maintain a series of supporting screws under a rolling line. He had a better idea. The screws, part of the original manufacturers design, were replaced with metal shims achieving an annual savings of over $1 million.

Reduced Melt Times: At the Crawfordsville plant, workers made a series of small changes such as replacing an exhaust pipe and tinkering with the chemistry of the melt. By doing so, they reduced the melt time from 72 minutes to 65 minutes. While this may seem a small improvement, it meant that an additional 25 tons of steel could be poured in a single shift.

Revitalization of Outdated Equipment: When Nucor bought a casting line from a German supplier, an obsolete reversing mill, which is used to reduce the thickness of steel, was thrown in as an afterthought to sweeten the deal. The capacity of the reducing mill was rated as 325,000 tons a year by the supplier. Nucor employees immediately began fiddling with the mill, among the improvements and results:

- changing the way the steel was fed into the machine increased capacity from 360 to 1,960 feet per minute.
- changes reduced the time to thread the machine from five minutes to 20 seconds.
- Nucor changed the type and grade of lubricating oil and installed a bigger motor.

With these changes, Nucor processed 650,000 tons of steel during the first year the equipment was in operation – twice the machines capacity as rated its manufacturer. Nucor anticipates that an additional 10% increase can be achieved.[11]

New Galvanizing Line: At one point, Nucor decided to install a galvanizing line that coats finished steel to enhance its durability. Engineers from $17.8-billion USX Corp. visited the plant before the foundation for the line had even been poured, and Nucor engineers told them they'd have the line running by year's end. The USX visitors laughed as they had started building a similar line a year earlier and it still wasn't operational. The day after Christmas, USX ran its first coil through its new galvanizing line. Twelve hours later, Nucor's $25 million galvanizing line was operational. No other firm had constructed such a line for less than $48 million.[12]

Continuous Production: In most minimills, the conversion of scrap to a finished product is a discontinuous process. Scrap is converted to ingots, for instance, when are then stockpiled for further conversion. When building their new Hickman plant in the early 1990s, Nucor tried a new experiment: continuous production. All steps of the steel making process are coordinated, from picking up the raw scrap, to melting it, forming it, and laying down a finished coil. Continuous production is both faster (3-4 hours from inputs to finished product) and more efficient. The downside? This just-in-time approach eliminates all slack or buffers in the process – problems at any point in the production line shuts the entire operation down. How well has this new process worked? As with other Nucor plants, virtually all of their employees had never worked in a steel mill before. Still, plant performance within one year of start-up was competitive with more established mills: 0.66 man-hours per ton, and a 91 percent yield (percent of scrap converted to finished product, a measure of efficiency). In late July 1993, the Hickman plant shipped 8,804 tons – setting a new Nucor record for the most tons shipped from a single plant in a day.[13]

Culture at Nucor

A key ingredient in any effective corporate culture is people. It is not surprising that many organizations, especially manufacturing firms, have dysfunctional cultures given the fear and distrust experienced by many workers, frequent layoffs, and an 'us versus them mentality'. Executives of Bethlehem Steel, for example constructed a golf course using corporate funds – then built a second and third course for middle managers and employees respectively. Ken Iverson questioned how a company with a culture so dysfunctional as to require the construction of three golf courses to maintain the hierarchical distinction between executives, managers, and line employees could ever expect to improve their operations.[14]

Nucor differs dramatically from their competitors. At Nucor, 'us versus them' clearly implies management and workers united against competitors. Comments such as those by one melt-shop supervisor who described a sense of personal responsibility not only for his own job but also for the firm. He described his position at Nucor as being much like running his own company – a comment typical given the entrepreneurial environment Nucor has created. Decentralized authority and sense of individual responsibility are a key part of that structure. John Correnti explains that he does not what to micromanage the firms operations. Doing so, he feels, would result in employees placing blame when things go wrong instead of taking responsibility and finding solutions. This, Correnti feels, results in line personnel having a realistic ability to control their own job environment, increase productivity, and increase their pay[15]

Still, Nucor is anything but a 'workers paradise'. The standards for employee productivity are extremely high, and there are a number of painful reminders of this emphasis. For example, the steelworker who is fifteen minutes late loses his production bonus for the day – as much as half of the day's pay. Thirty minutes late and the bonus for the entire week is forfeited. Workers are not paid for sicknesses less than three days, or for production downtime due to broken machinery. However, by most measures, Nucor is the employer of choice. There is extreme competition for new positions. The Darlington plant has routinely received 1,000 applications from a single job posting in the newspaper. Similarly, the new plant in Jewett, Texas (population 435) received 2,000 applications. Employee turnover rates are among the lowest in the industry. For example, the Crawfordsville, Indiana plant lost a total of 4 employees between 1988 and

1994: two for drug use and two for poor performance. Nucor is a non-union shop with much of the opposition to unions coming from Nucor employees who feel that union rules would hurt productivity and subsequently their paychecks. According to company folklore, there has been one labor dispute outside the mill gates – plant supervisors had to protect union pamphleteers from angry employees!

How does Nucor achieve such levels of motivation and dedication? Iverson suggests that corporate America has confused the ideas of motivation and manipulation. Manipulation stipulates a one-sided relationship wherein management convinces employees to do things in the interest of management. Motivation involves getting employees to do things that are in the best interest of both parties. In the long-term, Iverson says motivation yields a strong company whereas manipulation destroys a company. With this in mind, Nucor has identified the following elements critical to effective employee motivation:

1. Everyone must know what is expected of them and goals should not be set too low.
2. Everyone must understand the rewards, which must be clearly delineated and not subjective.
3. Everyone must know where to go to get help. The company must have a system that clearly tells the employee who to talk to when confused or upset.
4. Employees must have real voices. They must participate in defining the goals, determining the working conditions and establishing production processes.
5. The company must provide a feedback system so that employees always know how they, their group and the company are doing.[16]

The approach appears to work. A long-time Nucor employee recalls when the Darlington, South Carolina plant could produce thirty tons of steel a day. The same plant now produces a hundred tons of steel *an hour*. The worker says that given the can-do attitude of employees and the focus on constant improvement, the 'sky is the limit' for additional improvements[17]

While Nucor is a merit-oriented company, they also make it clear that there are no 'classes' of employee. Top managers receive the same benefits as steelmakers, on everything from vacation time to health insurance. There are no preferred parking spaces, and the 'executive dining room' is the delicatessen across the street. Incidentally, the corporate headquarters is located in a dowdy strip mall in Charlotte, North Carolina. Not surprisingly, there is no corporate jet or executive retreat in the Caymans. Officers travel in coach class on business trips, and the organization is rife with legends of corporate austerity – such as Iverson traveling via subway when in business in New York City (true, incidentally). This emphasis on egalitarianism is an integral part of the Nucor culture. Iverson, wanting to eliminate even smallest distinctions between personnel, ordered everyone to wear the same color hard-hat. In many plants, the color of your hard-hat is a highly visible signal of your level in the company hierarchy. Even at Nucor, some managers thought that their authority rested not in their expertise and management ability, but in the color of their hat. This goal of egalitarianism has not been completely without problems. When it was brought to Iverson's attention that workers needed to be able to quickly identify maintenance personnel, Iverson admitted his mistake and at Nucor plants everyone wears green hard-hats except maintenance personnel who wear yellow so that they can be easily spotted.[18]

This approach appears transferable and the motivational effects contagious. Iverson recalls when Nucor purchased a plant and immediately sold the limousine and eliminated executive parking spaces in favor of a first-come, first-serve system. Iverson greeted employees on their way into the plant and recalls one employee who parked in what was the boss's reserved spot and commented that the simple changes in the parking system made him feel much better about the company he worked for.[19]

Compensation & Bonus System Leadership by example can only induce so much behavior; one of the more visible aspects of Nucor's culture is it's compensation system, particularly the prominent bonus system. "Gonna make some money today?" is a common greeting on the plant floor, and discussion of company financials is as common in the lunchroom as basketball scores. The bonus system is highly structured, consisting of no special or discretionary bonuses. The company is divided based on the production teams of 25-50 individuals who are responsible for a complete task (such as a cold rolled steel fabrication line, for example). The group includes everyone on that line from scrap handlers, furnace operators, mold and roller operators, even finish packagers. Managers get together and, based on the equipment being used, set a standard for production. This standard is known to everyone in advance and doesn't change unless the company makes a significant investment in capital equipment. With the standard in mind, employees make whatever changes they see fit to increase production. A bonus is paid for all production over the standard and there is no limit as to how much bonus can be paid. The only qualifier is that the production must be good – that is of sufficient quality for sale. No bonus is paid for bad production. At the end of the week, all the employees on a particular line get the same production bonus which is issued along with their weekly checks.[20]

With bonuses, Nucor employees typically earn as much as their unionized counterparts in the integrated plants. Weekly bonuses have, in recent years, averaged 100 to 200 percent of base wages. Typical production workers earn $8 or $9 in base pay plus an additional $16 per hour in production bonuses and averaged $60,000 in 1996 making them the highest paid employees in the industry. Since Nucor locates their plants in rural locations, employee salaries are well above the norm for any specific area, making Nucor jobs highly desirable.

Nucor also offers several other benefits to help motivate and retain employees. In the 1980s, they shifted to a work week of four-12 hour days. Workers then take four days off, and then resume another intensive shift – a practice borrowed from the oil industry. While this practice results in a lot of expensive overtime – Crawfordsville alone paid out an extra half million dollars in 1995 due to the compressed work week – management feel that the ensuing morale and productivity gains pay for themselves. The company has also disbursed special $500 bonuses (four times in the last 20 years) in exceptionally good years. They also provide four years worth of college tuition support (up to $2,000/year) for each child of each employee – excluding only the children of corporate officers.

Job Security Listening to Nucor managers, it is difficult to determine which fact they are most proud of – 30 years of uninterrupted quarterly profits, or 20 years since they have last had to lay off an employee. Nucor locates in rural areas and there are often few other employment opportunities, let alone other jobs at similar pay scales, so Nucor feels a strong responsibility to keeping workers employed, even during economic downturns.

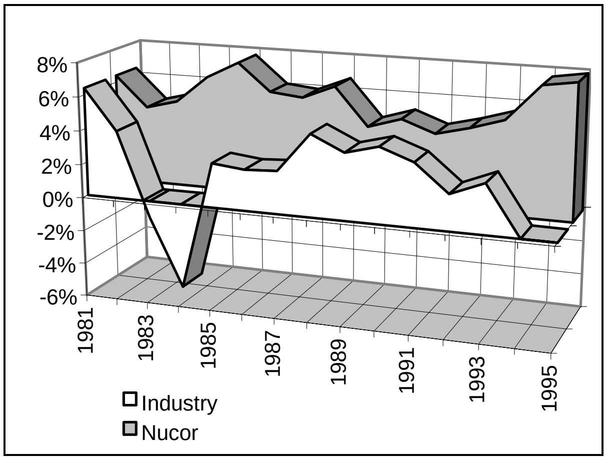
Popular impressions aside, Iverson is clear to note that Nucor does not have a no-layoff policy. He cautions that Nucor will layoff employees as a last resort if the survival of the company is at stake.[21] But during prior downturns, the company has chosen to ride out slowdowns with their "Share the Pain" program involving reduced workweeks and plant slowdowns instead of layoffs. What is most unusual with the program is the brunt of poor performance is felt most heavily at upper parts of the organization, particularly as long-term compensation is an integral part of the executive pay system. During a period of reduced demand for steel, the plants reduce their operations. For line personnel and foreman, this reduces their income by about 20 percent. For department heads, who are covered by a bonus plan based on the profitability of their plant slowdowns result in , a reduction of about one-third of their pay. Nucor's top managers have their pay based largely on return on stockholders equity – the measure most important to shareholders. This is hit the hardest and top managers see their pay decline the most – as must as two-thirds or three-quarters of their income is lost.[22] This structure serves a number of purposes. First, the line personnel don't feel that they are bearing the brunt of a downturn. Second, there is a great deal of motivation to further reduce the cost per ton so that Nucor can underprice any other producer and keep their mills active even during an economic downturn. Lastly, while the shareholders may not be happy with a reduced ROI, they at least know that management has an incentive to improve company performance. As an example, Iverson notes that in 1961 – a good year – he made $460,000 including bonuses. In 1982, though, Nucor fell shy of its eight percent return on equity and Iverson earned only $108,000.[23]

Summary

How important is the corporate culture to Nucor's success? Management is free to point out that their advantage does not stem from proprietary technology. After all, most of their innovations – including thin slab casting and the use of iron carbide, are based on technology developed by other firms. While they pioneered the modifications to make thin slab casting possible, numerous other minimills are hot on their heels in this product segment. Nucor's plants are open to firms seeking to benchmark their operations – including other steel producers. When other firms tour a plant they may see the same equipment as in their plant. Many comment on the culture of the plant. One visitor from an integrated producer commented that at his plant the culture is adversarial, management versus employee, with no trust between the parties. Us versus them refers to workers versus management and production. In contrast, at Nucor workers are see striving together as a team, helping each other, and working toward a common goal – the production of a high volume of low-cost, quality steel.[24]

Iverson explains Nucor's success as being based on a combination of the technology used and the culture of the organization. He's unsure if technology is 20, or 30, or even 40 percent – but he's sure it is less than half of the formula for Nucor's achievements. The culture that Nucor instills is focused primarily on the long-term health of the organization. For example, debt is avoided, start-up costs are not capitalized but rather are expensed in the current period, and depreciation and write-offs lean towards the detriment of short-term earnings. Iverson is adamant about not bowing to short-term pressures to manage earnings or spread dividends evenly over a quarterly basis. He refuses to do it. He compares companies that try endlessly to meet short-term projections at the expense of a long-term approach to dogs on a leash – trying to make perform a trick to satisfy the stock market. He admonishes short-term stock speculators to stay away from the company. He compares Nucor to an eagle and invites long-term investors to soar with the company.[25]

Figure IX - Nucor Profitability vs. Industry



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