# MEETING THE CHALLENGE:
# U.S. INDUSTRY FACES THE 21ST CENTURY

# THE BASIC STEEL INDUSTRY

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## Foreword

For over a decade there has been widespread and increasing concern that the ability of the United States to achieve sustained economic growth and long-term prosperity is adversely affected by declining industrial competitiveness. The President and Congress, in a bipartisan response, have introduced a wide range of programs and policies directed toward improving U.S. competitiveness.

Such polices, whether focused on building a 21st-century infrastructure, stimulating technological innovation and commercialization, improving the business climate for investment and growth, education and training, or promoting trade, start with assumptions, *often implicit*, about the competitive position of U.S. industry.

**"Meeting the Challenge: U.S. Industry Faces the 21st Century"** is a new series of studies, produced by the Department of Commerce's Office of Technology Policy, that develops an assessment of the competitive position of a number of major U.S. industries and the factors influencing their growth. Drawing principally from the experience and insight of the private sector, some 150 experts from over thirty organizations in industry, academia, and government have contributed to the drafting and review of the series. Overall, the studies provide a framework for government policy that is better informed and more accurately reflective of the shifting, and often improving, competitive position of U.S. industry.

This report on the basic steel industry discusses how advances in technology and industry restructuring have led to a U.S. basic steel industry substantially more competitive than ten years ago. However, the industry still faces challenges from less developed countries, from the continuing pressure of environmental regulations, and from pricing pressures related to surplus capacity. Within the industry, the integrated producers, with their high fixed costs and lingering costs of their large retiree population, face special challenges from electric arc furnace mills, which have been investing heavily in new production technology and have adopted new human resources practices to improve productivity.

Graham R. Mitchell
*Assistant Secretary of Commerce for Technology Policy*

## Executive Summary

This report is an overview of the competitiveness of the American basic steel industry. The industry is defined here as the companies that produce flat-rolled, structural, and tubular products from iron ore (integrated producers) or from scrap (electric arc furnace or EAF producers).

The industry has gone through wrenching changes over the past 10 to 15 years, but has now emerged in much better financial and operating condition. Downsizing and present economic conditions are allowing the industry to operate near capacity. These factors, combined with the substantial sums invested in modernization, have made the U.S. steel industry competitive for the U.S. market.

This report discusses the improvement in the industry's operation, the impact of the EAF producers, and the position of the U.S. industry with respect to the Japanese and the South Korean producers. A brief description of the financial performance of the industry is also included.

No industry operates in a vacuum. The steel industry's ability to grow and compete is modulated by constraints imposed by governments, the economy in which it operates, and its own decisions on priorities. The most important of the forces acting on the industry are discussed in this report and their impact on the future of the industry assessed.

The changing nature of the market for steel is illustrated by discussions of the automotive and home construction markets, among others. The automotive materials market is still dominated by steel, even though much is written of the rise of aluminum and plastics. The international steel industry, in cooperation with Porsche, has shown that a weight reduction of the order of 25 percent is possible in automobiles using steel—so the final outcome of the steel vs. aluminum vs. plastics competition is still unknown. The U.S. home construction industry presents a great opportunity. In 1993, the number of homes built using steel framing was 15,000. In 1994, it increased to 75,000. This rapid increase could indicate a large latent market.

The steel industry is much more competitive today than it was 10 years ago. Environmental requirements continue to have a major impact on the industry as a whole. The integrated producers must meet a special set of challenges: the growth of the EAFs, the relative inflexibility of the rules governing their labor force, the costs of pensions and other benefits for retired workers, and the inherent high capital expenditures associated with integrated production.

## Industry Condition

### The World Steel Industry

World steel consumption more than doubled in volume between 1960 and 1974. During this period, consumption grew at an average annual rate of 5.5 percent until suffering a decline of 8.2 percent in 1975. Consumption recovered and then suffered a second decline of about 40 million tonnes[1] in the 1980–82 time period (figure 1). The drop was particularly substantial in the Organization for Economic Cooperation and Development (OECD) countries, where a decline of 13.8 percent was reported in 1982, with steel consumption falling to its lowest level since 1967. From 1983 onward, growth in steel consumption resumed more or less uniformly, with a transient peak consumption of 650 million tonnes in 1989. In 1994, consumption was at about 620 million tonnes.

*World steel consumption more than doubled in volume between 1960 and 1974.*

The development of international trade in steel over the period has been somewhat different. World exports grew rapidly from 1960 to 1974 (9.4 percent annually) and somewhat more unevenly thereafter to reach a level of about 150 million tonnes today. As a percentage of world steel production, international trade in steel grew almost continuously from 1960 to 1984, from 11.7 percent to 23.4 percent. After falling from 1986 to 1989, the percentage rose again to today's value of about 25 percent of production (figure 1).

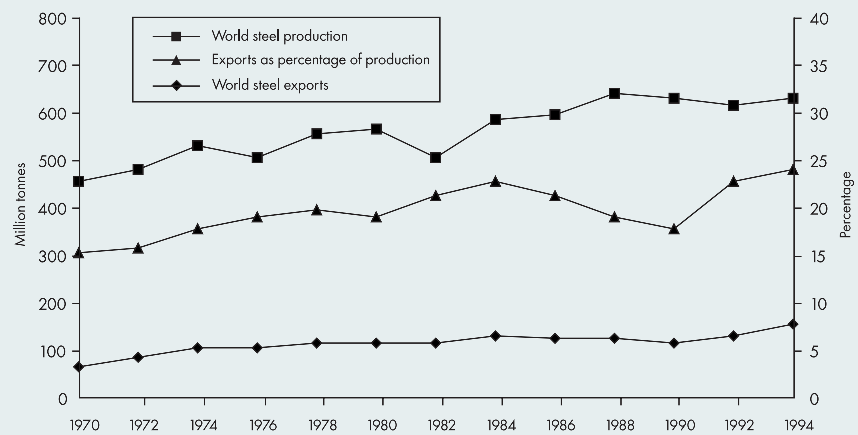
Over the past fifteen years or so, many changes have occurred in the world that have affected the world steel industry. The collapse of the Eastern Bloc trading system in particular brought to an end the steel trade flows among these countries. The difficult conditions encountered by these countries in the initial stage of their transition to market economies prompted them to search for new outlets for their steel in order to secure hard currency for their structural adjustment and modernization programs. The entry of Eastern Bloc steel producers had an adverse impact on established trade flows that, combined with sluggish world markets, led to a dramatic decline in steel prices for all producers.

*The entry of Eastern Bloc steel producers had an adverse impact on established trade flows that led to a dramatic decline in steel prices for all producers.*

The period also saw the emergence of dynamic new market economies with rapidly expanding steel-making capacity and output level; this development altered the pattern of trade flows, not only because by approaching or reaching self-sufficiency these countries imported less

[1] A metric tonne is 1,000 kilograms—approximately 10 percent larger than a ton (2,000 pounds). To convert metric tonnes to tons, multiply by 0.91.

**Figure 1. World Steel Production and Trade**



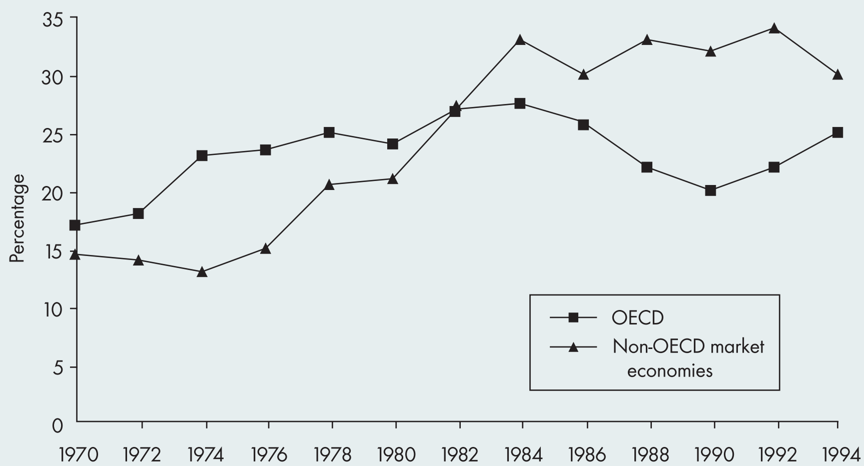

Source: *The Steel Market in 1994 and the Outlook for 1995 and 1996*, OECD, Washington D.C.

steel, but also because they became steel exporters in their own right, first at the regional level but ultimately at the world level (figure 2). Finally, the past few years have been marked by soaring growth in the demand for steel in China and South Korea, and this increase also had a significant impact on world steel trade (table 1).

The share of world steel production accounted for by the OECD nations has declined almost continuously since the early 1960s. This trend has also lowered the share of world steel exports accounted for by the OECD from 93.6 percent in 1960 to 66.8 percent in 1983. The decline continued until 1992, when the percentage share was 55.1 percent (table 2). Apart from 1993, when the downward trend was reversed as a result of increased imports by China, the OECD's market share in third world countries has steadily declined, from 17.6 percent in 1983 to 11.7 percent for 1990–92. Likewise, the share of steel produced and exported by OECD member countries fell from 27.7 percent in 1983 to 21 percent in 1990–92.

Since the volume of steel produced in OECD countries had not actually declined, this result was primarily due to increased production in the developing countries. However, the crude steel production capacity of the OECD did decline steadily from 1982 to 1993, falling from 565 million to 485 million tonnes per year, an overall reduction of over 14 percent, which to some extent allowed a better match between supply and demand.

**Figure 2. Steel Exports as Percentage of Steel Production**




Source: *The Steel Market in 1994 and the Outlook for 1995 and 1996*, OECD, Washington D.C.

This realignment of world production was accompanied by substantial reduction in worldwide industry employment. The only countries to escape the trend were those with emerging steel industries (table 3).

## The U.S. Industry Structure

The basic steel industry in the United States is composed of integrated producers and electric arc furnace (EAF) producers, both of which produce flat-rolled, structural, and tubular products (the companies in

**Table 1. Apparent Steel Consumption (Million Tonnes Product Equivalent)**

| | 1980 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|
| United States | 84.5 | 75.4 | 82.7 | 89.7 | 99.8 |
| European Union | 96.5 | 109.9 | 108.3 | 95.8 | 106.0 |
| Korea | 4.9 | 24.7 | 21.6 | 25.1 | 30.3 |
| Eastern Europe | 43.6 | 15.2 | 12.8 | 11.5 | 13.6 |
| China and North Korea | 38.0 | 68.0 | 75.7 | 107.3 | 95.9 |
| World | 558.1 | 618.5 | 610.2 | 622.2 | 621.6 |

Source: *The Steel Market in 1994 and the Outlook for 1995 and 1996, OECD,* Washington, D.C.

**Table 2. Changes in International Trade in Steel (Worldwide Exports)**

| | 1983 | Average over 3 Years 1984–86 | 1987–89 | 1990–92 | 1993 |
|---|---|---|---|---|---|
| **Origin as Percentage** | | | | | |
| OECD | 66.8 | 64.5 | 57.3 | 55.8 | 58.7 |
| Non-OECD market economies | 16.2 | 17.3 | 22.2 | 27.0 | 25.0 |
| Old Eastern Bloc | 16.6 | 17.9 | 20.1 | 14.8 | 15.4 |
| China and North Korea | 0.4 | 0.2 | 0.3 | 2.4 | 0.9 |
| **Exports from OECD to Third World Countries** | | | | | |
| In million tonnes | 49.0 | 50.2 | 38.7 | 36.4 | 52.1 |
| As percentage of market | 17.6 | 16.6 | 12.0 | 11.7 | 15.9 |

Source: *The Steel Market in 1994 and the Outlook for 1995 and 1996, OECD,* Washington, D.C.

table 4 are used as surrogates for the U.S. basic steel industry). An integrated producer is one that makes steel starting with iron ore and coal. An EAF producer is one that starts with scrap steel. Integrated producers tend to be firms that have been in the industry for a long time. They have not only integrated the steelmaking process, but to a great extent have integrated the other functions and requirements of the industry. For example, their maintenance tends to be done internally by workers with specific job classifications.

EAF manufacturers are often called minimills. Their manufacturing costs are normally significantly less than those of integrated producers, but they cannot produce all products. Their strengths tend to be in lower

**Table 3. Employment (Thousands)**

| Region | 1974 | 1994 | Change (%) |
|---|---|---|---|
| EU | 895 | 303 | (66) |
| U.S. | 610 | 234 | (62) |
| Japan | 324 | 183 | (44) |
| Mexico | 46 | 57 | 24 |
| South Korea | 63 | 66 | 5 |
| Total OECD | 2,183 | 980 | (55) |

Source: *The Steel Market in 1994 and the Outlook for 1995 and 1996, OECD,* Washington, D.C.

**Table 4. Sample Steel Firms (1994) ($ Million)**

| | Sales | Net Income |
|---|---|---|
| **Integrated Firms** | | |
| Armco Incorporated | 1,438 | 78 |
| Bethlehem Steel Corporation | 4,819 | 81 |
| Geneva Steel | 486 | (26) |
| Inland Steel | 2,488 | 54 |
| LTV Corporation | 4,529 | 127 |
| USX-US Steel Group | 6,066 | 201 |
| Weirton Steel Corporation | 1,261 | 35 |
| **EAF Firms** | | |
| Bayou Steel Corporation | 161 | (1) |
| Birmingham Steel Corporation | 703 | 22 |
| Chaparral Steel Company | 532 | 20 |
| Lukens Inc. | 947 | 22 |
| NUCOR Corporation | 2,976 | 227 |
| Oregon Steel Mills | 838 | 12 |
| Quanex Corporation | 699 | 19 |

Source: Compustat Database.

*Minimills have gained market share because of their lower costs and resulting lower prices.*

quality products, particularly bars and structural shapes. Recently they have also begun producing lower quality flat-rolled steel and have taken that market away from integrated producers. Minimills are generally considered world leaders in efficiency, human resource practices, and ability to implement new technology.

There is, however, some blurring in the distinctions between the two methods of production. Some integrated producers have stopped coke production, and one or two are building minimills. Some of the EAF producers will integrate back into direct reduced iron production and will probably also get into more complex finishing. So over time, the distinction between these two industry segments will probably become less clear.

In markets where minimills and integrated producers have competed, minimills have gained market share because of their lower costs and resulting lower prices. The integrated producers, in response, have shifted to producing higher quality, more complex products, and the industry tends to be divided in this fashion. The threat of the minimills improving their ability to produce higher quality, more complex products exerts a constant pressure on the integrated producers.

*Imports will always represent a competitive threat to U.S. producers because basic steel is a commodity – quality is important to some customers, but for most, price is the deciding factor.*

The steel industry's products are used in every sector of the economy. In 1994, the industry shipped 95 million tons of steel, whose main uses are depicted in table 5.

### The U.S. Industry Position in World Markets

In recent years, the American steel industry, especially the integrated producers, has increased its efficiency significantly and is now probably the lowest cost producer for its market. Sagging demand and international competition have resulted in a tremendous restructuring of the integrated producers. Many inefficient plants have been closed, workers have been laid off, and the workforce has been reduced permanently. Despite low profits during the past ten years, the industry has managed to invest, primarily in continuous casters and secondarily in refining. Because of the increased capital/worker ratio, productivity has also increased significantly.

As shown in figure 3, imports, which were 25 percent or more in the 1980s, dropped to 16 to 20 percent in the early 1990s. Import levels rose in the 1980s because the U.S. industry did not meet its customers' needs in terms of quality, and because steel buyers frequently want a diversity of suppliers to protect them against shutdowns in the American industry. Some of the increase in imports may have been due to unfair trading practices such as dumping or selling subsidized steel. In 1994, imports again rose to about 25 percent, not because of quality problems but

**Figure 3. Imports as a Percentage of Apparent Steel Supply**

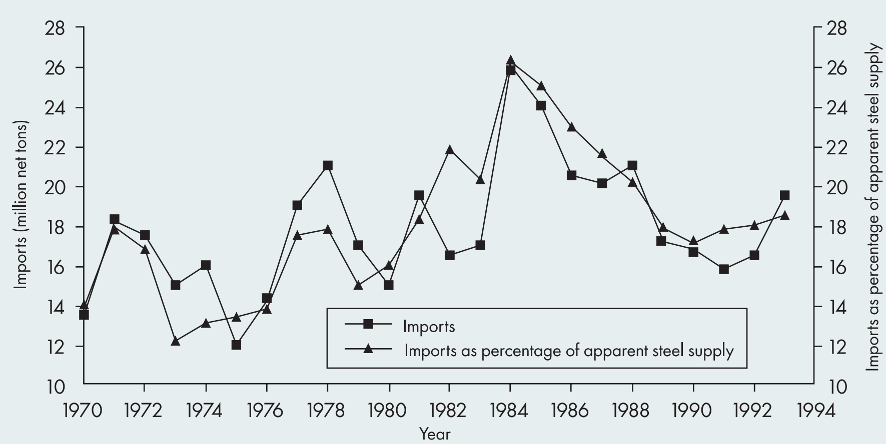


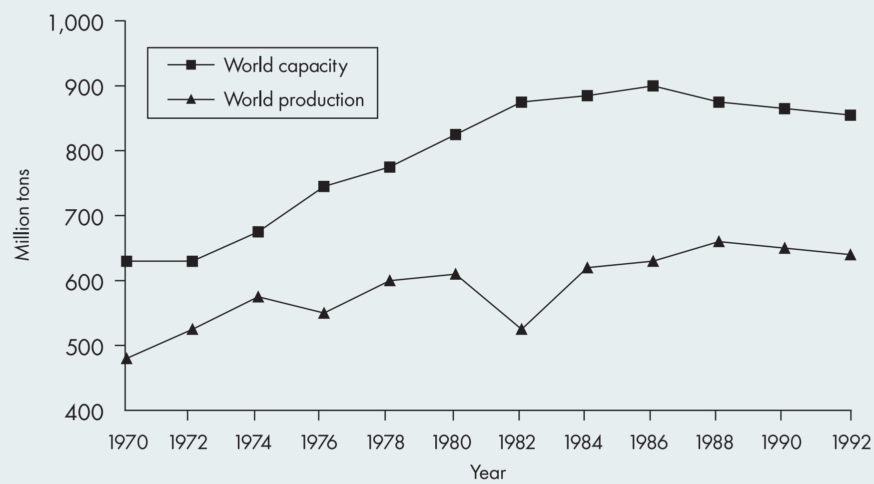
**Table 5. Markets/Products Matrix (1994) (Main Items Only)**

| Classifications | Products | Total Tons (million) | Percentage of Total |
|---|---|---|---|
| **Steel for Processing** | | | |
| Wire and wire products | Wire rods | 1.037 | 1.1 |
| Pipes and tubes | Plates, hot-rolled sheets, cold-rolled sheets | 3.065 | 3.2 |
| **Industrial Fasteners** | Wire rods, bars, hot rolled | 0.443 | 0.5 |
| **Construction Products** | | | |
| Pre-engineered buildings | Sheets, galvanized | 0.728 | 0.8 |
| General construction | Structural shapes, piling, plate, reinforcing bars, galvanized sheets | 7.551 | 7.9 |
| **Contractor Products** | | | |
| Building products | Sheets, cold rolled; sheets, galvanized | 1.737 | 1.8 |
| **Automotive** | | | |
| Vehicles, parts, and accessories | Bars, hot rolled; sheets, hot rolled; sheets, cold rolled; sheets, galvanized | 13.890 | 14.6 |
| **Rail Transportation** | | | |
| Rails and trackwork | Rails | 0.595 | 0.6 |
| Freight cars | Plates | 0.560 | 0.6 |
| **Oil and Gas Industry** | | | |
| Oil and gas drilling | Oil country goods | 0.569 | 0.6 |
| **Machinery and Equipment** | | | |
| Construction and general purpose | Plates | 0.879 | 1.0 |
| **Electrical Equipment** | | | |
| Power transmission/ distribution | Sheets, cold rolled; sheets, galvanized | 1.372 | 1.4 |
| **Appliances** | | | |
| Major appliances | Sheets, cold rolled; sheets, galvanized | 1.199 | 1.3 |
| **Containers and Packaging** | | | |
| Cans | Tin plate, tin free steel | 3.121 | 3.3 |
| Barrels and drums | Sheets, cold rolled | 0.497 | 0.5 |

Source: "Shipment of Steel Products by Market Classifications—Revised Final Year 1995," American Iron and Steel Institute, Washington, D.C.

*Dumping of steel on the market at below-production cost or by producers receiving large subsidies remains a problem.*

**Figure 4. World Raw Steel Capacity and Production**




because even at full capacity the U.S. industry could not produce all the steel required for the strong U.S. economy.

Imports will always represent a competitive threat to U.S. producers because basic steel is a commodity—quality is important to some customers, but for most, price is the deciding factor. For this reason, exchange rates will continue to have a major impact on the relative importance of imports in the U.S. market.

A significant amount of the imports was unfinished steel, such as slabs, which were finished in U.S. mills. The difficult economic conditions in the ex-Soviet countries and the European Community (EC) imposition of tariffs and quotas on imports from Eastern Europe have led to a surge of imports of semifinished and plate products from Russia and Ukraine.

Dumping of steel on the market at below-production cost or by producers receiving large subsidies remains a problem. In the early 1990s, the Commerce Department concluded that imports included a substantial amount of dumped steel or steel produced by subsidized firms, and applied tariffs in many cases. However, the International Trade Commission later ruled that in most cases there was no injury to the U.S. industry, and the tariffs were removed.

The long-term problem is that for the past fifteen years, worldwide capacity has exceeded production by 200 million tons, as shown in figure 4.

**Figure 5. U.S. Raw Steel Production and Capacity**

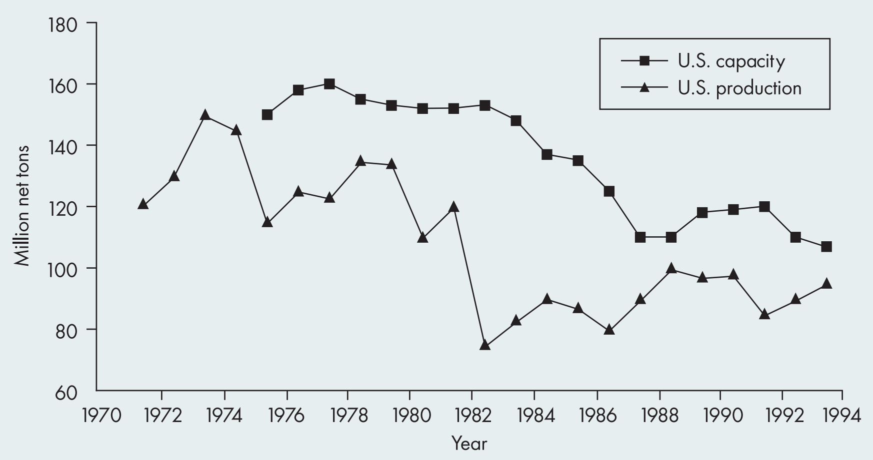



Figure 5 shows that, in contrast, U.S. production and capacity became more in balance during that period. There is some evidence that worldwide overcapacity will diminish in the next decade, but it will remain a major problem.

*South Korea is emerging to set a new standard for low-cost production, due to the fact it has new, highly efficient plants and relatively low wages.*

## Comparison of U.S., Japanese, and South Korean Companies

While the United States consumes more steel than any other country, it is not home to the world's largest producers. Japan, South Korea, and France have concentrated their industries, and thus have steel producers that are twice the size of any other countries' producers. Japan has the largest single producer—Nippon Steel (table 6)—and has set the standard for productivity in steelmaking for the past twenty years. However, South Korea is emerging to set a new standard for low-cost production, due to the fact it has new, highly efficient plants and relatively low wages. In this section, we compare the U.S. industry with the Japanese and South Korean industries.

In comparing the Japanese and American steel industries, it is logical to focus on productivity.[2] One commonly used measure of productivity is

[2] Marvin B. Lieberman and Douglas R. Johnson, *Comparative Productivity of Japan and U.S. Steel Producers, 1958–1993*, Working Paper of the Sloan Center for the Study of the Steel Industry, Carnegie Mellon University, Pittsburgh, 1994.

**Table 6. Raw Steel Production**
**Top 15 Producers (Million Tons)**

| Company | Country | 1984 | 1994 | Percentage Change |
|---|---|---|---|---|
| Nippon Steel | Japan | 32.4 | 28.1 | (13.3) |
| POSCO | South Korea | 10.1 | 24.4 | 140.7 |
| Usinor-Sacilor | France | 19.5 | 20.4 | 4.5 |
| British Steel | UK | 14.0 | 14.2 | 1.4 |
| NKK | Japan | 13.8 | 12.0 | (13.1) |
| Thyssen | Germany | 12.0 | 11.8 | (1.4) |
| U.S. Steel | U.S. | 15.1 | 11.7 | (22.7) |
| ILVA Group | Italy | 14.9 | 11.4 | (23.8) |
| Sumitomo Metal | Japan | 12.5 | 11.1 | (10.6) |
| Kawasaki | Japan | 12.4 | 11.1 | (10.9) |
| SAIL | India | 6.9 | 11.0 | 59.0 |
| Bethlehem | U.S. | 12.2 | 9.8 | (19.8) |
| BHP | Australia | 6.7 | 9.3 | 38.1 |
| Arbed Group | Luxembourg | 12.1 | 9.2 | (23.8) |
| Shougang | China | – | 9.1 | – |

Source: *Metal Bulletin Handbook*, 1985, Vol. 2: Statistics and Memoranda, p. 271, and *Metal Bulletin*, Feb. 23, 1995, p. 19.

"labor hours per ton of steel." A second is "value added" per employee. One problem with using these measures is that Japanese companies use many contract workers who do not appear in statistics as employees. Typically, contract workers make up 30 to 60 percent of the direct employees in Japan. In the United States, the use of contractors has grown, but it is still only about 10 to 25 percent.

In this study, labor input was taken as the total hours worked by a firm's employees during the year. In the early 1960s, the Japanese required 15 to 30 labor hours per ton. By the 1970s, the requirement was less than 5 labor hours per ton, and it remained fairly steady at that level through 1992.

In the United States, the labor input in 1958 was between 12 and 23 hours per ton. By 1964, it had improved to 7 to 14 hours per ton. Productivity then stagnated for twenty years. In the 1980s it began to improve again, and it is now less than 4 hours per ton for many integrated producers and less than 2 hours per ton for EAF producers. New EAF thin-slab casting plants may use less than 0.5 labor hours per ton.

Value added per employee is a somewhat better measure. Value added is the difference between the firm's total sales and its purchases of raw materials and contract services. When these data are put into real terms for 1980 dollars and 1980 yen, the comparison is significantly in favor of the Japanese. Between 1958 and 1993, Japanese labor productivity increased about tenfold. For American firms the growth was slight, with stagnation from the mid-1960s to the early 1980s. U.S. labor productivity began rising again in the 1980s and had a major boost in 1993, when it increased between 2.5 and 3 times.

A more recent competitor in the world steel markets is South Korea. The South Korean steel industry is currently dominated by a single company, POSCO (Pohang Steel Company). South Korean steel production grew from 2.2 million tons in 1973 to 34 million tons in 1994, of which 24 million tons is manufactured by POSCO.[3] POSCO's capacity has nearly doubled in the past five years. The company has very modern plants with all the critical technologies. Its productivity in terms of labor hours per ton is 25 percent higher than that of the United States and Japan. Its workers average 54 hours per week, and wages are about $12.00 per hour, which is 50 to 65 percent less than wages in the United States and Japan.

Consequently, POSCO has relatively low production costs. For example, the estimated production cost for South Korean hot-rolled coil is about $350 per ton compared with $450 in the United States.[4] POSCO and other South Korean companies are continuing to invest heavily in steel production. They have been investing at a rate of $100 to $120 per ton of production, while the U.S. rate has been about $20 to $25 per ton, and the Japanese rate $40 to $60. Some experts predict that POSCO will be the largest steel company in the world by the year 2000 and that it will be the low-cost leader.

*South Korean companies have been investing at a rate of $100 to $120 per ton of production, while the U.S. rate has been about $20 to $25 per ton, and the Japanese rate $40 to $60.*

[3] Peter Marcus, et al. "World Steel Dynamics," a Paine Webber publication, #20, May 1994.

[4] Ibid.

## Financial Performance

In this section, the financial performance of the U.S. steel industry is illustrated and analyzed using sample companies as surrogates for the industry.

### Overview

Table 7 illustrates two of the key features of the U.S. industry over the past few years. The EAF producers have been able to maintain a steady growth in output, while the integrated producers have experienced a general decline in output and a volatile earnings history.

*U.S. EAF producers have been able to maintain a steady growth in output, while the integrated producers have experienced a general decline in output and a volatile earnings history.*

### Operating Ratios

Details of the sample firms and the data source are explained in Barber et al.[5] The computations of the financial ratios are displayed in figure 6.

Notice that firm-level data are aggregated to obtain a single value-weighted measure for each year from 1974 to 1993. Mean measures for each sample are in tables 8 and 9. Time-series plots in figures 7 and 8 compare selected performance parameters of integrated and EAF steel firms with that of the S&P 500.

**Table 7. Performance Overview (Sample Firms) ($ Million)**

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|---|---|
| **Sales** | | | | | | | |
| Integrated | 26,870 | 24,262 | 22,762 | 20,141 | 18,254 | 19,603 | 21,087 |
| EAF | 3,305 | 3,703 | 4,193 | 4,128 | 4,427 | 5,452 | 6,856 |
| **Income Before Extraordinary Items** | | | | | | | |
| Integrated | 564 | 1,381 | (162) | (1,979) | (1,207) | (415) | 562 |
| EAF | 244 | 220 | 213 | 139 | 155 | 178 | 324 |

Source: Compustat Database.

[5] W. Barber, Y. Ijiri, R. Trueblood, S. Kang, *Financial Analysis of the U.S., Japanese and Korean Steel Industry*, Sloan Steel Industry Study, Working Paper 25, Carnegie Mellon University, Pittsburgh, 1993.

**Figure 6. Computation of Financial Ratios**

The aggregate ratio ($R_t$) for year *t* is

$$R_t = \frac{\sum_{i=1}^{N} Xit}{\sum_{i=1}^{N} Yit}$$

Where *N* is the number of firms appearing in the sample in year *t*.

**Variable definition**

1. Return on Assets (ROA) =

$$\frac{\text{Income before extraordinary items + Minority interest + after tax interest}}{\text{Total assets of the preceeding year}}$$

2. Return on Sales (ROS) =

$$\frac{\text{Income before extraordinary items + Minority interest + after tax interest}}{\text{Sales}}$$

3. Asset Turnover (ATO) = $\frac{\text{Sales}}{\text{Total assets of the preceeding year}}$

4. $\frac{\text{Cost of Sales}}{\text{Sales}} = \frac{\text{Cost of Sales excluding Depreciation}}{\text{Sales}}$

***Return on Assets***

We use return on assets (ROA) (ratio of net income to the book value of assets) as a summary measure of profitability. Alternative measures of profitability based on operating cash flows do not alter the conclusion. We make adjustments so that ROA comparisons are unaffected by capital structure. Time-series plots and mean ROA measures for each sample are displayed in figure 7 and table 8, respectively.

During the past two decades, integrated steel producers have been generating a persistently lower ROA than EAF producers and other industrial firms. To understand the source of the difference in ROA, we decompose the ratio into two components: the product of the ratio of revenues to assets (asset turnover (ATO)) and the ratio of net income to revenues (return on sales (ROS)), where ROA = ATO x ROS. The reason for decomposing ROA is that ATO provides a measure of how effi-

**Table 8. Profitability Ratios of the U.S. Steel Industry (1975–1993)**

| | | Integrated Steel Firms | EAF Steel Firms | S&P 500 Firms |
|---|---|---|---|---|
| **ROA** | All periods | (.052) | 7.35 | 6.53 |
| | 88–93 | 0.10 | 7.04 | 5.27 |
| | 81–87 | (6.81) | 5.06 | 6.59 |
| | 75–81 | 4.33 | 9.57 | 7.59 |
| **ROS** | All periods | (0.74) | 5.30 | 5.59 |
| | 88–93 | (0.36) | 5.62 | 5.56 |
| | 81–87 | (6.07) | 3.94 | 5.54 |
| | 75–81 | 3.52 | 6.19 | 5.56 |
| **ATO** | All periods | 1.12 | 1.35 | 1.17 |
| | 88–93 | 1.01 | 1.23 | 0.94 |
| | 81–87 | 1.10 | 1.25 | 1.19 |
| | 75–81 | 1.24 | 1.54 | 1.35 |

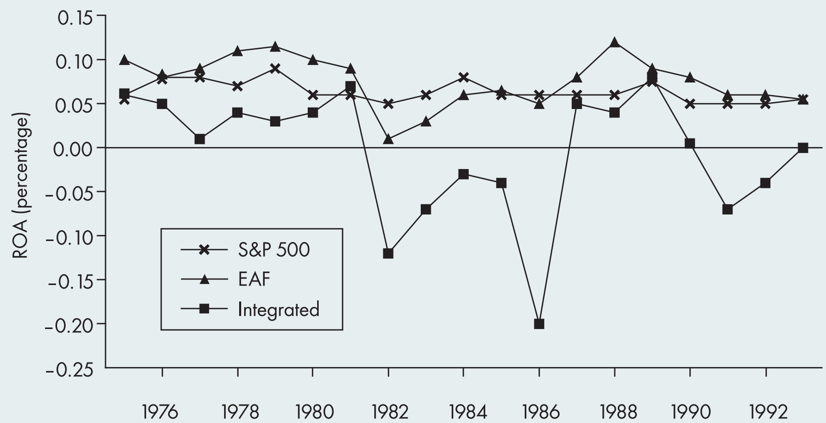
ciently the firm uses its assets to generate sales, while ROS indicates how much profit the firm recovers from its revenues.

Not surprisingly, the mean profit margin of the EAF producers is more than 5 percentage points higher than that of the integrated producers (table 8). However, this is not the only reason for the superior return: ATO of EAF firms has persistently exceeded that of the integrated firms (1.35 versus 1.12; table 8), suggesting that the EAF firms have generated more revenues relative to the size of their assets.

**Table 9. Breakdown of Expenses per Dollar of Sales (1975–1993)**

| | | Integrated Steel Firms | EAF Steel Firms | S&P 500 Firms |
|---|---|---|---|---|
| **Cost of Sales** | All periods | 89.10 | 80.70 | 72.20 |
| Sales | 88–93 | 89.90 | 81.30 | 70.00 |
| | 81–87 | 91.20 | 81.30 | 71.80 |
| | 75–81 | 87.50 | 79.60 | 74.30 |
| **Selling and** | All periods | 4.83 | 6.55 | 14.43 |
| **Administration** | 88–93 | 3.47 | 5.56 | 16.59 |
| Sales | 81–87 | 6.29 | 7.23 | 14.81 |
| | 75–81 | 4.74 | 6.81 | 12.24 |

Figure 7. Return on Assets (ROA)

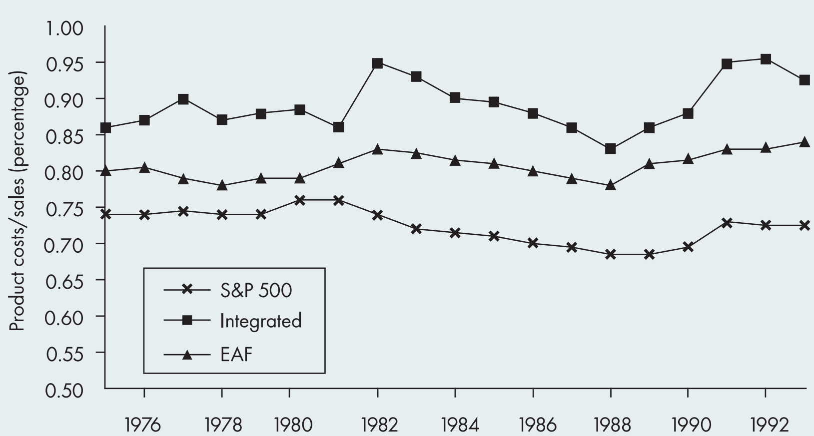



### *Cost Components*

The product costs/sales ratio (cost of goods sold deflated by sales) focuses on manufacturing costs. Table 9 indicates differences of 8 to 9 percentage points between integrated and EAF firms. The time-series plot in figure 8 reveals that these differences were persistent over the 1975–1993 period.

While the EAF firms have a product cost advantage of 8 to 9 cents per sales dollar over the integrated firms, their operating overhead (selling

Figure 8. Product Cost per Sales Dollar



and administration expense) is about 2 cents higher per dollar of revenue (table 9). As a result, the net cost advantage of EAF producers is about 7 cents per dollar. Since the average revenue per ton for the integrated firms is about $500, this cost disadvantage amounts to about $35 per ton, which accounts for a large portion of the lower ROA for the integrated firms. Both integrated and EAF firms were successful in reducing operating overhead during the past two decades. The operating overhead for integrated firms declined from 4.75 percent of sales in 1975 to about 3.5 percent of sales in 1993, and that for EAF firms declined from 6.81 percent to 5.56 percent.

*Both integrated and EAF firms were successful in reducing operating overhead during the past two decades.*

### Cash Flows and Capital Investments

Cash flow is the oil that lubricates the machinery of business. The integrated steel producers' well-publicized earnings problems over the

**Table 10. Cash Flow Data**
**Integrated Steel Producers (Selected Items) ($ Million)**

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Sums |
|---|---|---|---|---|---|---|---|---|
| **Operating Activities** | | | | | | | | |
| Income before extraordinary items | 564 | 1,382 | (117) | (1,868) | (1,196) | (393) | 616 | (1,012) |
| Depreciation and amortization | 1,179 | 1,069 | 1,023 | 934 | 1,040 | 1,091 | 1,087 | 7,423 |
| Deferred taxes | 235 | 157 | 565 | (237) | (581) | (173) | 115 | 81 |
| Funds from operations | 1,175 | (43) | 367 | 1,399 | 1,241 | (9) | 398 | 4,528 |
| Working capital changes | 730 | 218 | (221) | (420) | (55) | (651) | 744 | 345 |
| TOTAL "A" | 2,423 | 2,347 | 2,059 | 648 | 559 | 1,167 | 1,472 | 10,675 |
| **Investing Activities** | | | | | | | | |
| Capital expenditures | 1,406 | 1,618 | 1,851 | 1,795 | 1,218 | 1,106 | 1,432 | 10,426 |
| **Financing Activities** | | | | | | | | |
| Sale of common equity | 193 | 4 | 29 | 129 | 621 | 1,463 | 953 | 3,392 |
| Cash dividend | (214) | (245) | (245) | (157) | (128) | (179) | (189) | (1,357) |
| LTD-issuance | 273 | 466 | 786 | 1,162 | 745 | 827 | 292 | 4,551 |
| LTD-reduction | (2,247) | (1,917) | (788) | (210) | (608) | (1,571) | (638) | (7,979) |
| TOTAL "B" | (1,995) | (1,692) | (218) | 924 | 630 | 540 | 418 | (1,393) |
| TOTAL A+B | 428 | 655 | 1,841 | 1,572 | 1,189 | 1,707 | 1,890 | 9,282 |
| **DEBT/EQUITY (w/o LTV)** | | | | | | | | |
| Debt | 4,407 | 3,331 | 3,378 | 4,223 | 4,497 | 3,833 | 3,633 | |
| Total equity | 4,892 | 5,741 | 5,409 | 3,769 | 1,120 | 967 | 2,105 | |
| Debt/total equity | 0.90 | 0.58 | 0.62 | 1.12 | 4.02 | 3.96 | 1.73 | |

Note: LTD = Long-term debt
Source: Compustat Database.

## Table 11. Cash Flow Data EAF Steel Producers (Selected Items) ($ Million)

| | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | Sums |
|---|---|---|---|---|---|---|---|---|
| **Operating Activities** | | | | | | | | |
| Income before extraordinary items | 244 | 221 | 212 | 139 | 155 | 178 | 327 | 1,476 |
| Depreciation and amortization | 135 | 162 | 186 | 205 | 235 | 274 | 320 | 1,517 |
| Deferred taxes | 6 | 11 | 13 | 0 | 17 | (2) | 2 | 47 |
| Funds from operations | 11 | 16 | 46 | 56 | 85 | 43 | 57 | 314 |
| Working capital changes | 53 | 88 | (49) | 131 | 130 | 11 | 309 | 673 |
| TOTAL "A" | 343 | 322 | 506 | 269 | 362 | 482 | 397 | 2,681 |
| **Investing Activities** | | | | | | | | |
| Capital expenditures | 483 | 273 | 346 | 377 | 567 | 593 | 534 | 3,173 |
| **Financing Activities** | | | | | | | | |
| Sale of common equity | 233 | 38 | 5 | 85 | 216 | 13 | 166 | 756 |
| Cash dividend | (105) | (40) | (51) | (53) | (60) | (70) | (73) | (452) |
| LTD-issuance | 113 | 190 | 186 | 143 | 622 | 128 | 359 | 1,741 |
| LTD-reduction | (165) | (160) | (262) | (38) | (319) | (47) | (575) | (1,566) |
| TOTAL "B" | 76 | 28 | (122) | 137 | 459 | 24 | (123) | 479 |
| TOTAL A+B | 419 | 350 | 384 | 406 | 821 | 506 | 274 | 3160 |
| **DEBT/EQUITY** | | | | | | | | |
| Debt | 408 | 504 | 426 | 566 | 863 | 1,005 | 969 | |
| Total equity | 1,257 | 1,430 | 1,661 | 1,826 | 2,059 | 2,128 | 2,583 | |
| Debt/total equity | 0.32 | 0.35 | 0.26 | 0.31 | 0.42 | 0.47 | 0.38 | |

Note: LTD = Long-term debt
Source: Compustat Database.

past ten years or so (our sample companies had a total of $1 billion in losses between 1988 and 1994) would seem to deny them the ability to invest in modernization. Yet our sample integrated firms invested over $10 billion in plant and equipment over that period.

A look at FASB #95 data (tables 10 and 11) for the surrogate firms illustrates how the integrated firms managed this feat and shows the fundamental economic differences between the integrated and EAF producers.

For the integrated firms, the $10 billion in capital expenditures was funded through a combination of depreciation charges, substantial equity sale, and the catch-all category of "funds from operations." This last category is made up mainly of the various accounting charges resulting from industry restructuring and accounting changes. The substantial equity sales are interesting in that during the period we are examining, investor sentiment was generally not favorable to the integrated firms, as shown in figure 9. Nevertheless, integrated producers were able to take advantage of more favorable recent (1992 onward) market conditions to sell more than $3 billion worth of new equity. Throughout the process, the integrated firms have maintained a very high debt/total equity ratio. The dividend payout testifies to the lean 1988–1992 period.

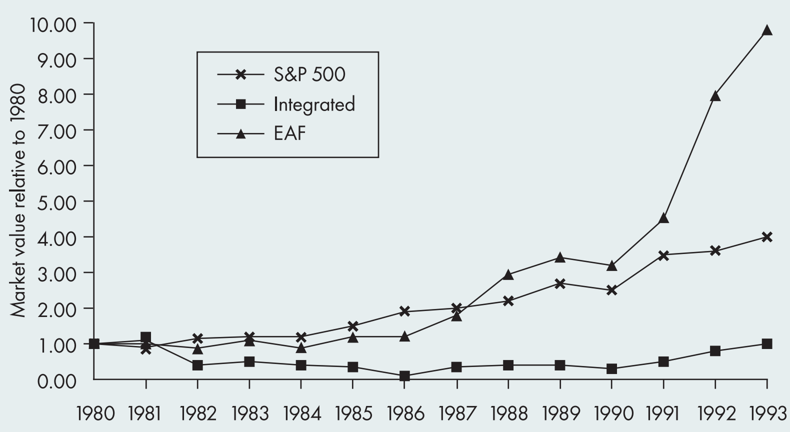
Data for the EAF producers exhibit a more classic business profile. Income and depreciation charges coupled with a more restrained sale of equity more or less cover modernization needs. The debt/total equity ratio is well behaved. Dividend payout is also well behaved (if a special dividend paid in 1988 is excluded from the data).

### Pensions

Pension costs are substantially higher for integrated producers than for EAF producers. The integrated firms are older and have an older workforce. In addition, the substantial rationalizing of operations of the integrated firms over the past ten years has resulted in their having a large ratio of retirees to active workers. For these reasons, the integrated firms tend to have larger relative pension expenses than the EAF firms. This disadvantage is especially acute for integrated firms (Bethlehem

*The substantial rationalizing of operations of the integrated firms over the past ten years has resulted in their having a large ratio of retirees to active workers.*

**Figure 9. Investor Sentiment**
**Market Value Normalized to 1980**



and LTV in our sample) that also have large unfunded pension liabilities.

In 1994, Congress passed new pension legislation that will have some impact on the industry's pension responsibilities. While the companies do not expect the new legislation to significantly increase their minimum annual contribution to their pension plans for the next several years, over time it will increase their annual premium to the Pension Benefit Guaranty Corporation.

## Industry Drivers

No industry operates in a vacuum, and the steel industry is no exception. Its ability to grow and compete is modulated by constraints imposed by governments, the economy in which it operates, and its own decisions and priorities. This section discusses the most important forces acting on the industry.

### Economic Climate

The current economic climate is excellent, and domestic steel production is nearly in balance with capacity. Prices decreased from 1988 to 1993 but are now back to 1988 levels. In the second quarter of 1995, a price reduction occurred in a few products. Integrated producers are currently making profits. They have been able to raise equity, and investment is strong. However, problems remain with pension plans, some of which are still underfinanced, although the companies have a number of years to bring them into balance.

There is a strong movement to use steel in new houses. Lumber prices have risen significantly, and the steel industry has done a good job of marketing steel as an alternative. The expectations for the future are high. The industry needs to develop training programs for steel housing construction, and it is doing so. In automobiles, there seems to be a continued strong demand. Aluminum does not seem to be making heavy inroads in the market. However, the steel industry must continue to improve quality and control costs. The automobile industry is continually looking for lower prices, but in the competition with plastics, steel seems to be holding its own. The beverage can market has been lost, but food cans continue to be made of steel.

Clearly, the steel industry depends on the general status of the economy; economic expansion benefits the industry. Demand is closely tied to the gross domestic product. Due to potential foreign competition and new capacity, prices will probably not exceed the 1988 level in terms of constant dollars.

*The steel industry depends on the general status of the economy; economic expansion benefits the industry.*

*With the anticipated coke shortage, many U.S. companies are using coal and natural gas injection in the blast furnace, which can reduce coke requirements by up to 40 percent.*

## Infrastructure

### *Technology Developments*

The two basic manufacturing systems for producing steel are shown schematically in figure 10. The integrated process uses ore and coal (coke) as its major raw materials, and the EAF process uses scrap as its major raw material. The integrated process is used by large plants producing 2 to 5 million tons per year and higher quality products. The EAF plants generally produce 0.5 to 2.0 million tons per year and generally produce lower quality, less complex products.

***Pellet and Sinter Plants:*** The United States industry primarily uses pellet plants, which are reasonably efficient. There has been significant overcapacity in pellet production.[6] Sinter plants, which are less common, generally prepare recycled materials, but they have significant environmental problems, and many have been closed in the past five to ten years.

***Coke Plants:*** Coke plants are highly capital intensive and have significant environmental problems. Several major companies (e.g., Inland, Rouge, and Weirton) no longer produce coke because of the high capital cost; they rely on purchasing coke. U.S. coke plants are relatively old, and many will have to be rebuilt or closed in the next decade. With the anticipated coke shortage, many U.S. companies are using coal and natural gas injection in the blast furnace, which can reduce coke requirements by up to 40 percent. In addition, there is a worldwide effort to develop a process to produce iron without coke. Such processes include the COREX process, which is commercially available for moderate-size production (0.5 to 0.8 million tons per year), and the AISI Direct Steelmaking, HIsmelt (Australia), and DIOS (Japanese) processes, which are under development.

***Blast Furnaces:*** Blast furnaces in the United States range from extremely large modern furnaces such as Inland #7, which produces 9,500 tons per day, and nearly comparable furnaces at U.S. Steel Gary Works and Bethlehem Sparrows Point, to relatively small furnaces (less than 3,000 tons per day). The best U.S. companies match world-best performances of total fuel rates (coke plus injected fuel) of 1,000 pounds per ton of hot metal and in productivity at over 10 tons per 100 cubic feet per day. While several U.S. companies (e.g., Inland Steel) are becoming leaders in coal injection, on average the United States is slightly behind Europe in this technology.

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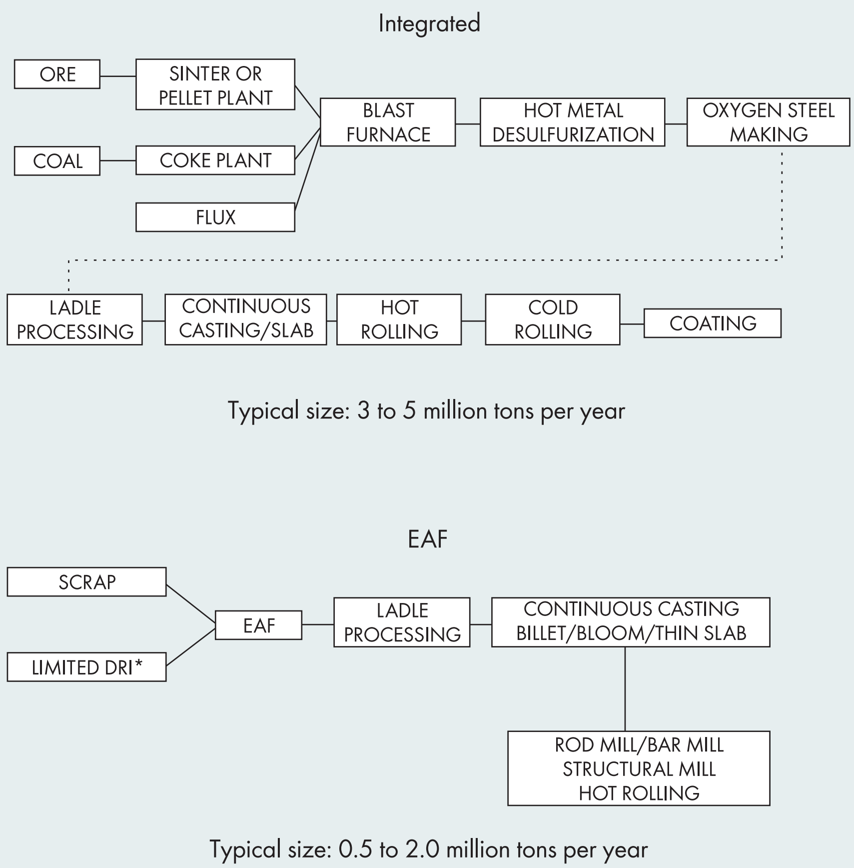
[6] *Metals Statistics 1994*, American Metal Market, New York, NY 1994.

**Figure 10. Basic Steel Manufacturing Process**




*DRI = direct reduced iron.

***Oxygen Steelmaking (OSM):*** Oxygen steelmaking (basic oxygen furnace, quick basic oxygen process, etc.) is a fairly mature, universal process. The last open hearth in the United States, at Geneva Steel, was closed in 1991. OSM in the United States is, in general, competitive with Japan and Europe with only slight differences.

***Ladle and Vacuum Processing***: Between 1975 and 1990 there was a large growth in ladle furnaces and in vacuum degassing. The U.S. industry lagged behind Europe and Japan in adopting vacuum processing for several reasons, including lack of capital and the misconception that it was not required. In the late 1980s, however, the U.S. industry invested significantly in this technology, and now most major integrated companies have such facilities. Currently there is adequate vacuum degassing capacity for normal operating levels. U.S. minimills were quick to adopt ladle processing technology. Most major plants have ladle furnaces or chemical reheating and carry out ladle processing.

***Continuous Casting***: The U.S. industry lagged behind Europe and, in particular, Japan in the installation of continuous casters. However, the United States has caught up and in 1994 continuously cast about 90 percent of the steel produced.

***Finishing***: While, the United States initially lagged in installing state-of-the-art equipment, its current equipment is nearly equal to the world's best, resulting in major improvements in quality and productivity (e.g., reheat furnace productivity is 300 percent higher, and energy consumption is a third of what it was a decade ago); further improvements will be relatively small. The United States still lags in the installation of continuous annealing, new developments in roll stands, and walking-beam furnaces. However, despite the lower capital investment, productivity and quality are competitive.

***EAF Steelmaking***: The scrap-based EAF producers have become highly efficient. The improvements in the major operational parameters have been significant, as indicated in table 12. These achievements were brought about by a series of improved technologies and management practices. The technologies included ultra-high-power furnaces, ladle furnaces, oxy-fuel burners, foamy slag practices, and high use of oxygen.

*Both the integrated and EAF producers have made significant improvements in ladle metallurgy and finishing, which have resulted in higher yields and better properties. The industry now delivers material with specific properties, not just steel.*

Since 1980, both the integrated and EAF producers have made significant improvements in ladle metallurgy and finishing, which have resulted in higher yields and better properties. The industry now delivers material with specific properties, not just steel.

In implementing new technologies, the U.S. steel industry was playing "catch-up" from 1985 to 1992. In general, it has caught up and is leading in a few areas.

**Table 12. Improvements in EAF Efficiency**

| Metric | 1970 | Current |
|---|---|---|
| Time to produce liquid steel | 180 minutes | 55 minutes |
| Electrical energy per ton | 600 kWh | 430 kWh |
| Electrode consumption per ton | 12 pounds | 4.5 pounds |
| Labor hours per ton liquid steel | 3 labor hours | 0.4 labor hours |

- Coal injection into blast furnaces has been or is being installed, and by 1996 several U.S. plants will be leaders in this technology.

- Continuous casting now includes over 90 percent of production.

- New thin-slab casting is up to about 4 million tons and could reach 18 million tons by the year 2000; the United States has and will continue to have the highest thin-slab casting capacity.

- All major producers have installed vacuum degassers to improve quality and extend markets.

- Direct charging of slabs is being implemented in a number of plants.

- Many new galvanizing lines, including electro-galvanizing, hot-dip lines, and other types of finishing lines, have been installed.

- Ladle metallurgical furnaces or other steel reheating capabilities have been nearly universally installed.

- Continuous annealing of sheets is being implemented.

- Statistical process control of rolling processes has been implemented, along with computer models and automatic control of variables, markedly reducing variations in properties.

- Advanced controls improved all dimensions except shapes.

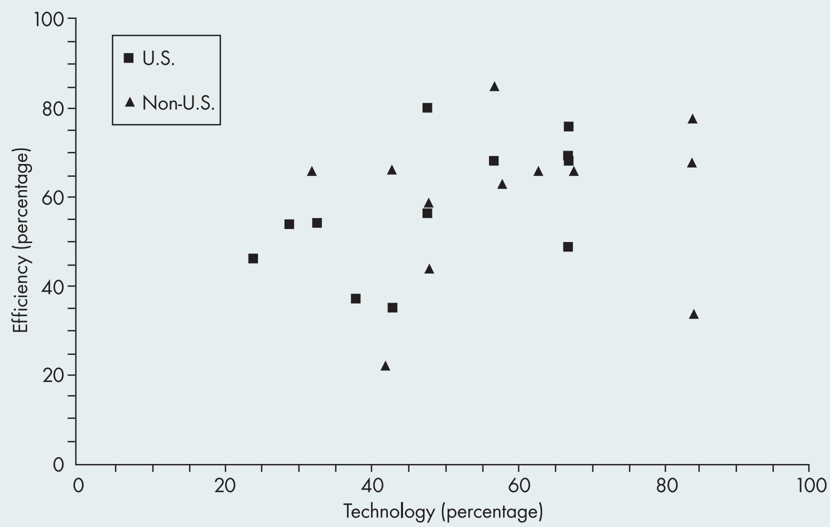
- Flat-rolled coil weights and sizes are much larger on average than ten years ago.

### *Technology Implementation and Efficiency*

As part of the Sloan Steel Industry Study, researchers at Carnegie Mellon University benchmarked the U.S. industry with regard to technology implementation and manufacturing efficiency.[7] More than twenty critical technologies and a similar number of measures of efficiency were considered for integrated and EAF plants. The results are shown in figures 11

[7] R. J. Fruehan, et al., *Iron and Steelmaker*, January 1994, p. 25.

**Figure 11. U.S. and Non-U.S. EAF Plants Efficiency vs. Technology**




*The U.S. industry in general has learned to do more with less and invested in the most critical technologies.*

and 12 for most major U.S. producers and several international plants, including the world's best. Although the U.S. plants do not have the same level of technology as the international best, they are nearly as efficient. The U.S. industry in general has learned to do more with less and invested in the most critical technologies.

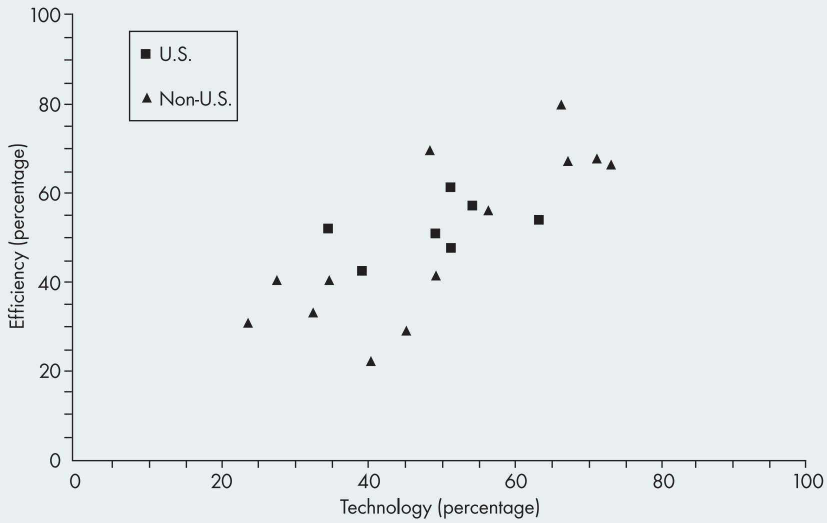
An interesting finding of the study was that some companies outperform others with similar levels of technology. This is due in part to better coordination of processes in the plant and better technical know-how, resulting in more production from the same equipment.

***Raw Materials***

The three major resources for producing steel are ore, coking coals, and scrap; currently scrap or scrap substitutes are the most critical.

***Ore***: The United States has large quantities of medium-quality domestic ore, which requires upgrading and pelletizing. Japan, South Korea, and Europe use imported ore (primarily from Australia and South America). But even with transportation costs, this higher quality material is similar in price to U.S. domestic pellets. For many years, U.S. companies were tied to long-term pellet contracts; in most cases this is no longer true, and pellet costs have decreased. In general, using domestic ore offers the industry no advantage.

**Figure 12. U.S. and Non-U.S. Integrated Plants Efficiency vs. Technology**




***Coking Coal***: Not all coals can be used for coking; special coals or blends are required. Coking coals cost about $10 more per ton than steam coals. At one time there was a concern about a possible future shortage in coking coals; however, this shortage will not be critical for a decade or more. The critical problem is in coke making, which has many environmental problems and high capital cost.

***Scrap***: There will be 10 million tons per year in new scrap-based EAF capacity in the next five years, primarily in flat-rolled steels, which require high-quality scrap. There is international concern about the future cost, availability, and quality of scrap, which has been the subject of several major studies. It is also being examined in detail by the Sloan Steel Industry Study.

*There is international concern about the future cost, availability, and quality of scrap.*

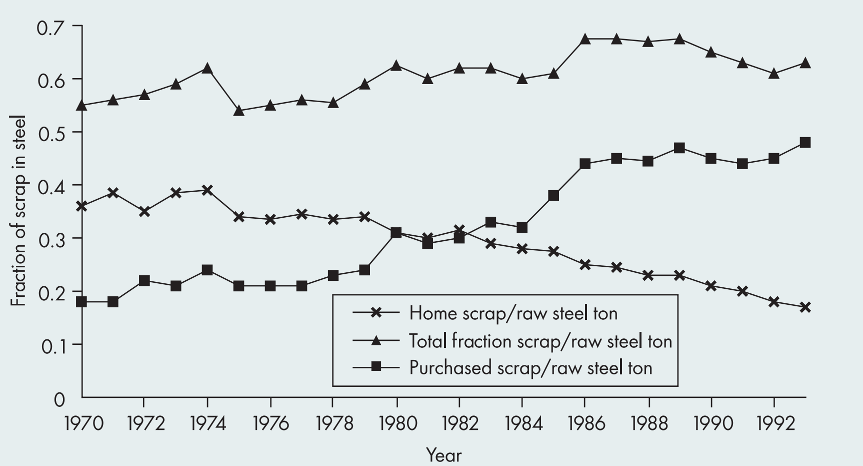
Scrap is classified as home, prompt, or obsolete. Home scrap is generated in the plant, and the supply has decreased significantly in recent years due to the implementation of continuous casting. Prompt scrap is from steel product manufacture (e.g., automotive stamping), and the supply is also decreasing. Obsolete scrap is postconsumer scrap such as shredded automobiles, appliances, etc. Home and prompt scrap are low in residuals and are of high quality. Obsolete scrap is high in residuals and cannot be used in large quantities for producing higher quality steels.

As shown in figure 13, the fraction of scrap used to produce new steel has increased to about 0.6; in other words, 65 percent of new steel comes from scrap. The fraction of home scrap has declined, causing a large increase in the use of purchased prompt and obsolete scrap. Furthermore, the amount of high-quality prompt industrial scrap has declined.

Pursuing the issue of the availability of scrap, we have made the following reasonable assumptions:

- an increase in steel production of 1 to 2 percent per year
- about 45 percent of steel in the United States produced in electric arc furnaces
- an increase in scrap recycle rates from 35 to 45 percent in the next decade
- a slight decrease in exports of scrap
- the availability of 3 to 5 million tons per year of scrap substitutes

**Figure 13. Types of Scrap in Steel**



From our own analysis and those of other studies, we reach the following conclusions:

- Sufficient obsolete scrap will be available. The price will fluctuate, but on average it will increase only moderately from today's relatively high prices.

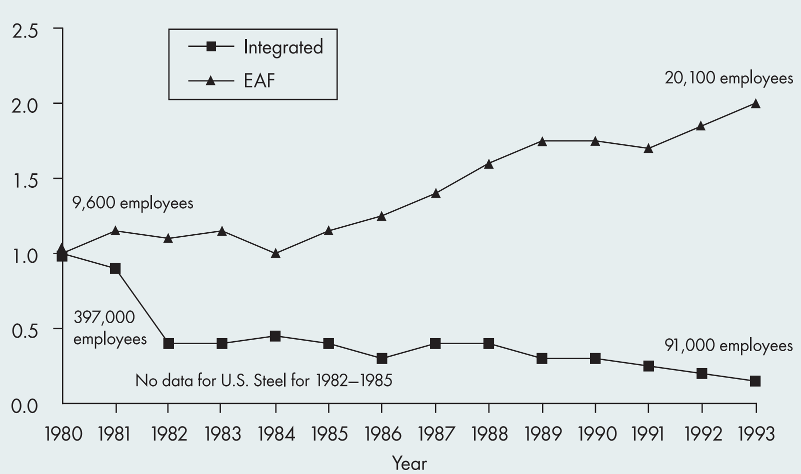
- There will be a shortage of prime residual-free scrap in the midterm. In the long term, scrap substitutes must fill the gap. In any case, scrap availability, quality, price, and substitutes will be a critical concern for the steel industry (see "Major Factors Influencing Competitiveness" for further discussion, page 51).

***Management and Labor***

Management in the steel industry has recognized the need to eliminate overcapacity and to develop more efficient operations. As a result, there has been an intensive effort to close inefficient facilities and to reduce the labor force. Employment has decreased by over 60 percent in the past fifteen years, as shown in figure 13. The integrated companies' employment is down by about 300,000, or 75 percent, while EAF employment is up by 10,000, or 100 percent. The aim is for each firm to develop a much lower break-even point; to do that, fixed cost must be reduced.

*There has been an intensive effort to close inefficient facilities and to reduce the labor force.*

**Figure 13. Employment Relative to 1980**




Source: Compustat Data.

*The integrated firms and the union have signed cooperative partnership agreements that promise a high degree of information sharing and consultation and spell out common objectives.*

In the human resources area, management has made significant progress. This area is extremely important because personnel costs, while varying greatly depending on whether the firm is integrated or not, account for 10 to 25 percent of the total cost of production.

The industry has made tremendous progress in improving labor productivity in the past ten years. Both integrated and EAF producers have increased the tons per worker year by nearly 300 percent, as discussed in the next section.

Labor costs in the integrated firms are still significant, since steel workers' wages are about 50 percent more than the average wages for manufacturing. The EAF firms generally are not unionized, but they pay comparable salaries. However, a large portion of their compensation is incentive based, which gives them flexibility in their labor costs. Since many of the other costs, such as capital, materials, and energy, are difficult to control, labor is one of the few major costs that can be reduced.

These developments in labor costs have not been lost on the integrated firms or their union, the United Steelworkers of America (USWA). Management and labor have developed a much more cooperative attitude over the past ten years or so than previous history would have indicated. Union representatives now sit on the boards of more than thirty steel companies, including all the major integrated firms. The major steel companies and the USWA are jointly funding and managing an Institute for Career Development for steelworkers. More than 25,000 workers are presently taking advantage of the courses offered by the Institute, whose 1995 budget was $19.1 million. Finally, the integrated firms and the union have signed cooperative partnership agreements that promise a high degree of information sharing and consultation and spell out common objectives aimed at improving the profitability and competitiveness of the companies, thereby preserving and enhancing workers' jobs.

Management has done a good job of introducing new technologies, thereby substituting capital for labor. Management has also been alert to new human resource (HR) practices, and firms putting these practices into use have improved productivity significantly. A number of integrated plants have reduced the labor hours required to produce hot-rolled steel from about 10 to about 3. NUCOR, a scrap-based EAF producer, has used thin-slab casting to reduce labor hours to less than 1 per ton. The company also has made good use of pay incentives to improve productivity.

### *High-Performance Workplace*

The U.S. steel industry has improved the productivity of its workforce by nearly 300 percent in the past decade in terms of labor hours per ton of steel. This dramatic improvement has been the result of many factors, including capital investments in new technologies, investments in technical know-how, reduction in overhead, changes in culture, and improved productivity through modern HR practices.

The U.S. industry has made smaller capital investments than its international competitors and achieved greater improvement. The U.S. industry carefully chose to invest in only the most critical technologies and purchased technical know-how from overseas companies. The United States has made vast improvements in these areas but is now caught up, so further improvements from these sources will be limited. Some companies have changed their corporate culture by streamlining management and decision making. Layers of management have been removed, reducing overhead costs and allowing decisions to be made closer to the production process.

Innovative HR practices have also led to many improvements. As part of the Sloan Steel Industry Study, researchers used site visits and questionnaires to gather data from twenty-six steel plants for a specific comparison of production processes.[8] They factored in influences other than HR practices to isolate the effect of these practices. Their results clearly show that although isolated HR practices do not necessarily improve productivity, clusters of such practices do improve it significantly.

*The use of multiskilled workers and fewer job classifications is critical to a high-performance workplace in the steel industry.*

One of the major innovative HR practices is the use of work teams with multiskill training and responsibility. In particular, the use of production workers for routine maintenance reduces the need for specialized maintenance workers, who are often underutilized. The use of multiskilled workers and fewer job classifications is critical to a high-performance workplace in the steel industry. To a great extent, the EAF producers are more advanced than the integrated producers in developing a high-performance workplace.

[8] C. Ichneowski, K. Shaw, and G. Prennushi, Working Paper 15, Sloan Steel Industry Study, Carnegie Mellon University, Pittsburgh, 1994.

*The major U.S. companies have about 20 researchers per million tons of production versus 30 for the selected foreign producers.*

***Social Costs***

High social costs such as pensions and health care remain a major factor for the steel industry. The cost of pensions and health insurance for the major integrated companies is in the range of $30 to $65 per shipped ton, or an average 7 percent to 15 percent of the selling price. Some of the older integrated companies have a ratio of retired to active workers of four or more to one.

Many of the new EAF firms have lower social costs since they have fewer retired workers, and they employ younger workers whose health insurance is less expensive. Many international competitors have much lower social costs since these costs are the responsibility of the government, putting U.S. companies at a disadvantage.

***Research and Development***

The steel industry of the future will require new technologies to reduce capital costs and environmental concerns. But the U.S. industry spends less on research than many of its international competitors.[9]

***Industry spending*:** In figure 15, the research and development (R&D) expenditures, as a percentage of corporate sales, are compared for the major U.S. and international producers. Nippon Steel and Usinor Sacilor are the two largest producers, and BHP (Australia) plans to expand significantly, as does POSCO, the South Korean producer. The major U.S. companies have about 20 researchers per million tons of production versus 30 for the selected foreign producers. With few exceptions, the U.S. EAF producers do little or no research.

***U.S. government support*:** Under the Metals Initiative of 1988 (Public Law 100-680), the Department of Energy jointly funds research projects with the American steel, aluminum, and copper industries to increase their competitiveness and energy efficiency. Through fiscal 1994, the department had committed $102 million to these programs, about $95 million of which was for past and present projects with the steel industry. Through September 1994, the following projects were funded:

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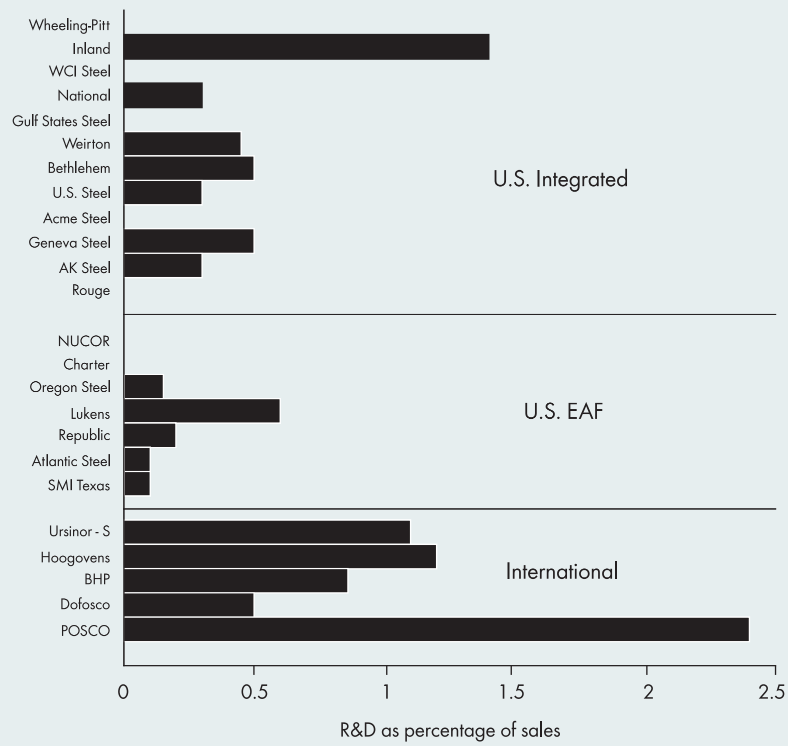
[9] The data in this section are from R. J. Fruehan, research in progress, Carnegie Mellon University. Sloan Steel Industry Study, Pittsburgh.

**Figure 15. Research Budgets (as percentage of sales)**




- Direct steelmaking

  a) Direct steelmaking/ironmaking with the American Iron and Steel Institute

  b) Waste oxide recycling with the American Iron and Steel Institute

- Near-net shape casting

  a) Spray casting with Chaparral Steel, Air Products and Chemicals, and seven other companies

  b) Direct strip casting with Armco Steel

*In the long term, the lack of R&D could be a problem for the U.S. industry, although it can be argued that technology can always be purchased, making R&D less critical.*

- Raw materials beneficiation

  a) Electrochemical dezincing of steel scrap with Metal Recovery Industries, Inc.

- Advanced computer applications

  a) Rapid analysis of molten metals with Lehigh University and a consortium of steel companies

  b) Advanced process control for the steel industry with the American Iron and Steel Institute, National Laboratories, private companies, and universities.

In the long term, the lack of R&D could be a problem for the U.S. industry, although it can be argued that technology can always be purchased, making R&D less critical. Collaborative research could make the use of R&D resources more efficient. A recent report published by the American Iron and Steel Institute and the Steel Manufacturers Association,[10] recognized the need to accomplish continuous improvements in the following areas of technology:

- Production efficiency—to seek improvements in energy efficiency to reduce pollution, control production costs, and limit exposure to fluctuating energy costs.

- Recycling—to increase the use of steel scrap and the recycling of plant solid wastes.

- Environmental engineering—to reduce air and water emissions and the generation of hazardous wastes and to develop processes to avoid pollution.

- Product development—to achieve flexibility in production capabilities, to implement advanced process controls and sensors, and to produce higher strength steels with improved weldability, fabricability, and toughness characteristics.

[10] "Steel: A National Resource for the Future," American Iron & Steel Institute, Washington, D.C., May 1995.

***Education and Training***

The U.S. steel industry is behind its competitors in Japan and Europe with respect to training and the number of qualified engineers with specific knowledge of the industry. Greater skills will be needed, as the future industry will be more automated, rely more heavily on advanced control systems, and will need to be more flexible in both production and products.

Specifically, the U.S. industry does not have as skilled a workforce as its competitors.

- Germany has a highly developed, state-supported apprentice program that trains individuals for three years in plants.
- Japan has over twice as many graduate engineers per ton of steel produced as the United States.
- Europe and Japan still have university programs devoted to the production and products of steel. U.S. universities, in general, have abandoned education in this area in favor of so-called advanced materials.
- European companies have a more structured continuing education and training program than the U.S. industry.

In the future, the U.S. industry must develop processes and manufacturing systems that require fewer, but more highly skilled, workers while continuing to provide education and training to increase the capabilities of the reduced workforce.

## Government Regulations

For the past twenty years, the steel industry has been influenced by a growing set of government regulations and initiatives—not only regulations restricting its own practices, but regulations covering steel end uses. Penalties for violations of environmental regulations have increased significantly and include criminal enforcement measures. A list of the major regulations affecting the industry in the order in which they became effective is given below.

*Penalties for violations of environmental regulations have increased significantly and include criminal enforcement measures.*

***1970 Occupational Safety and Health Act:*** This act set standards for safety and health in steel plants. Coke ovens became a major concern in

*Future legislation or consumer demand for greater fuel efficiency could lower the steel content of cars.*

the mid-1970s, after a large increase in lung cancer risk was documented. The industry made major investments to improve worker health and safety.

***1970 Clean Air Act:*** This act established National Ambient Air Quality Standards and technology-based emissions standards. The industry curtailed emissions of sulfur dioxide, particles, and toxic releases.

***1972 Clean Water Act:*** This act and subsequent amendments established water quality standards and technology-based discharge standards. Water pollution control standards are set by the states, making it difficult to compare U.S. standards with those of other nations. Nonetheless, the standards appear to be broadly comparable.

***1975 Energy Policy and Conservation Act:*** This act required an increase in fuel efficiency for the average new car sold from 14 miles per gallon (mpg) to 27.5 mpg. As a result, the average new car has shed about 1,000 pounds. The amount of steel in a car has declined primarily because of lower total weight and, to a lesser extent, through the substitution of competing materials. In recent years, the percentage of steel in automobiles has held relatively constant and has even increased slightly. However, future legislation or consumer demand for greater fuel efficiency could further lower the steel content of cars, and, as will be discussed, the industry is responding.

***1980 Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund):*** This act established joint and several liability for cleanup of existing toxic waste sites.

***1982 Resource Conservation and Recovery Act (RCRA):*** RCRA established cradle-to-grave regulation of toxic materials to prevent the generation of new toxic waste sites. RCRA covers generation, transportation, storage, use, and disposal of hazardous material. In the steel industry, dusts, sludge, and some slag are of particular concern. EAF dust is loaded with heavy metals and therefore is a hazardous waste. According to the International Trade Commission, the largest difference among nations is in disposal of hazardous waste and treatment of toxic waste dumps.

***1986 Superfund Amendments and Re-authorization Act (SARA):*** SARA revised requirements and funding. Title 3 requires reporting environmental discharges of plants.

***1990 Clean Air Act:*** This act set stringent emissions standards for toxic pollutants.

Carcinogens are a particular focus of the legislation, resulting in stringent standards for benzene and coal tars (coke plants) and heavy metals (blast furnace, basic oxygen furnace, and EAF steel making).

Concerns with tropospheric ozone are leading to concerns over emissions of volatile organic compounds (VOC) and oxides of nitrogen. The northeastern states are setting stringent standards for emissions of nitrogen oxides and VOC.

A risk analysis in the year 2000 will determine whether the reductions are sufficient to lower the risks of cancer to one in 1 million. If not, still more stringent standards will be required. Benzene from coke ovens is a particular concern. According to the International Trade Commission, national air pollution standards are "broadly comparable between industrialized nations."

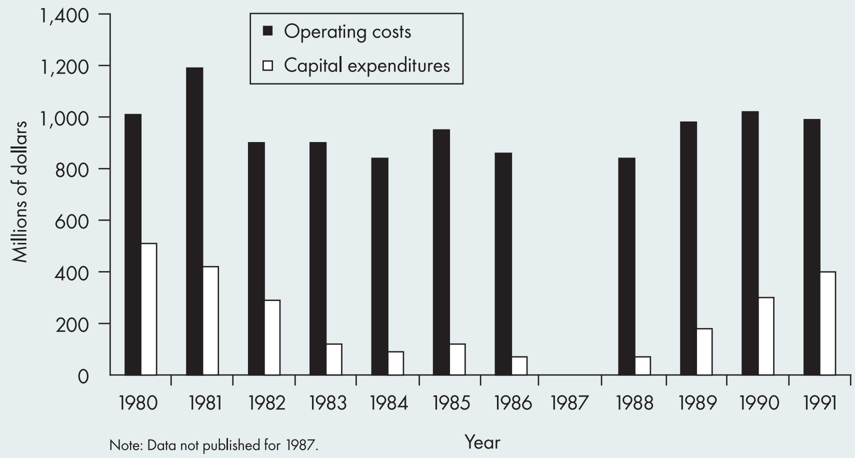
***1994 Rio Protocol:*** The Rio accords committed the United States to reduce greenhouse gases. A carbon tax would severely hurt the steel industry. A carbon tax of $100 per ton of carbon is estimated to raise the cost of steel by more than $100 per ton.

***Recycling:*** Many local governments have recycling laws for steel cans and other materials. More than 70 percent of the steel in cars is recycled, as is a large part of the steel in refrigerators and other "white goods." This percentage is likely to rise in the future, although there is not much room for improvement.

The costs associated with pollution abatement regulations have been substantial (figure 16). Although capital expenditures have fluctuated over the past decade, they have remained significant. Costs have risen because of increases in the administrative cost of complying with regulations and permits and because of fines and litigation resulting from lack of compliance. In 1992, steelmakers paid almost $25 million in environmental fines and litigation costs. The cost of operating and maintaining equipment associated primarily with environmental control is estimated at between $10 and $20 per ton of steel shipped. Total pollution abatement operating costs were $981 million in 1991. Over the past two decades, the industry has invested approximately $6 billion in pollution control systems.

*Over the past two decades, the industry has invested approximately $6 billion in pollution control systems.*

**Figure 16. Pollution Abatement Operating Costs and Capital Expenditures**




Note: Data not published for 1987.
Source: Bureau of the Census data.

## Evolving Markets

One thing that is clear in the steel industry is that consumers are requiring better quality and improved products. These more stringent requirements require new steelmaking processes and products. Although the industry has greatly improved its competitive position in the past decade, it still faces tremendous challenges to maintain or increase its share in the evolving markets of this country and the world. Some of the major markets in which the steel industry must participate are described below, along with some of the problems associated with each.

*Although the industry has greatly improved its competitive position in the past decade, it still faces tremendous challenges to maintain or increase its share in the evolving markets of this country and the world.*

**Automotive**

This is a major and very competitive market still dominated by steel, even though much is written of the rise of aluminum and composites. The chairman of General Motors said recently that it is steel's market to lose, and made it clear that nothing less than continuous improvement will be acceptable.

Aluminum has attractive features, such as lighter weight and corrosion resistance, but it also has drawbacks in a high-volume manufacturing operation, such as lack of weldability and limits on formability. It is making headway as a cast material in engine blocks, much of it from recycled aluminum. With a relatively fixed world aluminum production (approximately 20 million tons), aluminum sheet for autos will have to compete with other uses (e.g., containers and aircraft), and the relative profitability becomes relevant.

The great unknowns for competitiveness in the auto market in the medium term relate to many external factors (e.g., corporate average fuel economy, "guzzler" tax, fuel price at the pump, and recyclability). Downsizing of automobiles (by 10 to 25 percent) appears likely regardless of materials and will influence flat-rolled products of all types.

One of the goals of a cooperative project formally called "The Partnership for a New Generation of Vehicles," is to develop a midsize "green" vehicle that will have fuel economy in the range of 80 miles per gallon and meet customers' needs and preferences in safety, performance, utility, and affordability. The target is a concept vehicle by 2001 and a prototype by 2005. The car would have a mass reduction approaching one-half that of today's models. Not all of this reduction will necessarily come from reducing the density of the materials of construction. While aluminum and fiber composites meet the density criterion, they cannot be substituted directly for steel and still meet manufacturing, productivity, recycling, safety, and cost criteria. However, for the project to become a reality, these other materials will certainly occupy a larger place in the automobile. The effect on steel consumption would be in the range of a few million tons per year.

*The steel industry can retain more of the automobile market by being innovative in holistic design and by accepting the need in some areas, such as safety and recycling, to work cooperatively with suppliers of other materials.*

The steel industry can retain more of the automobile market by being innovative in holistic design and by accepting the need in some areas, such as safety and recycling, to work cooperatively with suppliers of other materials. The international steel industry, in cooperation with Porsche, has shown that a weight reduction of about 25 percent is possible in an automobile using steel. To the degree that formability for aesthetic reasons becomes less important, steel can be favored because of the reserve of potential strength in ferrous systems, even those that must be welded. The true tradeoff between the competing materials awaits an analysis that will take into account the above parameters and the life cycle costs of energy, pollution, and recyclability.

### Construction

The home construction industry is a great opportunity. In 1992, about 500 homes were built with steel. In 1993, the number was 15,000, and in 1994, it increased to 75,000. The steel industry's goal is 250,000 homes by 1997. Steel could displace large amounts of wood because of an insufficient supply of high-quality wood. The market for steel in the housing industry is suppressed by lack of familiarity on the part of installers, lack of specifications and codes, inadequate standardization, and thermal properties that can be improved. The steel industry is developing programs with "how-to" manuals and seminars on steel housing construction.

For large structures, steel and concrete will continue to compete with each other, with no trends apparent to cause a major shift in material choice. One possible growth area for steel is in short-span bridges.

### Appliances

Some inroads into this market have been made by plastic liners, but the modules of steel and the enameled finish possible will keep it competitive. Some switch back to steel has already occurred. New, more efficient horizontal-rotor washers being offered will favor steel.

### Containers

Competition among steel, aluminum, and various paper and polymer macrocomposites is vigorous. Beverage cans have long since gone to aluminum in the United States, costing steel a 2- to 3-million ton market at the current number of over 100 billion cans per year. Food cans seem likely to remain steel; competition in other food packs may depend on recycling issues. Steel recycling historically has handled far more scrap than its nearest competitors—some 65 percent, or about 50 million tons per year, is recycled. The "retail" scale recycling from individual consumers is now much more active and may soon be competitive with aluminum. Polymer recycling techniques are not making the progress needed to permit economic recycling levels. There is an outside chance that steel may regain a foothold in the beverage can market, especially if detinning facilities continue to improve.

### Oil and Gas

The number of drilling rigs has been reduced by some 80 percent from the high point in 1982, with a major reduction in pipelines. A combination of factors including low energy prices, cuts in exploration budgets, and offshore environmental restrictions has reduced the number of new finds. Large tankers are being scrapped; the growing demand for double hulls will provide demand for a currently indeterminable new volume of plate.

*The growing demand for double hulls will provide demand for a currently indeterminable new volume of plate.*

Although exploration activities have decreased from their 1982 high, there has been an increase in shipment of steel products for the oil and gas industry over the past few years—to 2.6 million tons in 1995.[11]

[11] "Shipment of Steel Products by Market Classification," American Iron and Steel Institute, Washington, D.C., 1996.

## Major Factors Influencing Competitiveness

### Technology

Technology affects competitiveness in two fundamental ways:

- Competitive advantages in the choice of manufacturing technology system: scrap- versus ore-based production.
- Competitive advantages within an industry segment due to technology.

As discussed in the section on capital considerations, the scrap-based EAF producer has a significant competitive advantage in capital costs over the ore-based integrated producer. Also, as will be demonstrated, at historical scrap prices, the scrap-based producer has an advantage in production costs. However, at high scrap prices, like those in 1994, the integrated producer is competitive.

Within the steel industry, technology and know-how are readily available at a cost. In most cases, a company cannot sustain a competitive advantage for long by installing or developing new technologies. If the return on investment is attractive, the technology will be duplicated elsewhere. As part of the Sloan Study, the effect of technology on efficiency and quality was examined. Where there was a positive correlation, other factors dominated in many cases.

A few technologies (see figure 11) that have not been universally implemented do provide some competitive advantage with respect to cost or quality. They include the following:

***Thin-Slab Casting***

In 1995, only three U.S. plants (two NUCOR plants and Gallatin Steel) had this technology, which greatly reduces the cost of producing flat-rolled steel. It is estimated that by the year 2000, five to seven more plants will have this technology.

***Ironmaking***

The coke oven-blast furnace method of producing iron is highly capital intensive and relies on coke, which is expensive to produce and has extensive environmental problems. Most major U.S. companies are installing pulverized coal injection equipment to reduce coke require-

*In the long term, however, a method of producing iron that uses only coal and is less capital intensive will be required.*

ments. Several plants are using 300 pounds of coal per ton of metal, reducing the coke requirement to 700 pounds; eventually, up to 500 pounds of coal will be used. In the long term, however, a method of producing iron that uses only coal and is less capital intensive will be required. Processes such as AISI Direct Steelmaking (ironmaking), the Japanese DIOS process, and the Australian HIsmelt show promise, but they are at least five years from commercialization. Direct reduced iron (DRI), hot briquetted iron (HBI), and iron carbide require natural gas and will be primarily produced outside the United States and used as supplementary feed to the EAF producers.

***Electric-Furnace Steelmaking***

Scrap preheating technologies such as Consteel and the Fuchs Shaft Furnace are emerging. Direct current furnaces are being widely implemented. The bottom or return electrode requires innovative approaches to reduce costs. Methods of reducing dioxin formation are required. A major long-term problem associated with EAF production is the cost of disposal or recycling of EAF steelmaking dusts, which are classified as hazardous wastes. Several technologies have been developed for treating the dust and recycling the iron portion. However, these processes are not economical in all cases, and optimized or new processes are required.

***Vacuum Degassing***

The installation of vacuum degassing allows for the production of higher quality flat-rolled steels. Most major Tier I (quality) producers have such facilities, but Tier II (merchant-quality) producers do not.

***Continuous Annealing***

This technology reduces cost, but it is not clear whether the capital can be justified. Several plants have this capability.

There are many other examples of new technology, such as ultra-high-power EAFs, walking-beam furnaces, and advanced coatings. If a plant can justify the capital, these technologies are available.

### Capital-Economic Performance

*The capital costs associated with new manufacturing facilities are a major driver in selecting technologies.*

The steel industry is highly capital intensive. Capital costs vary greatly depending on the manufacturing system and product, but range from 20 to 35 percent of the total cost of producing steel. Therefore, the capital costs associated with new manufacturing facilities are a major driver in selecting technologies. In particular, the capital cost for the integrated production of steel from ore and coal is extremely high, and consequently much of the new production capacity installed in the past twenty years has been scrap-based EAFs. The capital costs associated with conventional slab casting and subsequent rolling, along with the large capacity requirements for economic operation, were a driving force in the development and implementation of thin-slab casting.

*Much of the new production capacity installed in the past twenty years has been scrap-based EAFs.*

Tables 13 through 15 roughly estimate the approximate capital costs for new and rebuilt integrated production equipment, along with those for EAF production. The figures given are only crude estimates, since capital costs are very site-specific and depend on the actual equipment used. Nevertheless, they do illustrate the importance of capital when selecting technologies.

Although these costs are only approximate, it is clear that if new capital is required, scrap-based EAF has significantly lower capital cost. It should be noted that scrap-based EAF production cannot produce all grades of steel. For example, exposed automotive steels can be produced only by the ore-based process and conventional casting. Therefore, although the capital cost for EAF production is significantly lower, it cannot be used exclusively.

**Table 13. Capital Cost for Liquid Steel Production in an Integrated Plant (3.0 Metric Tonnes Annual Production)**

| Facility | Production (metric tonnes per year) | Capital ($ million) | Cost of Output ($/tonne per year) | Cost of Steel ($/tonne per year) |
|---|---|---|---|---|
| **New Greenfield Site** | | | | |
| Coke plant | 1.0 | 300 | 300 | 100 |
| Blast furnace | 2.5 | 600 | 240 | 200 |
| Steelmaking | 3.0 | 550 | 183 | 183 |
| Totals | 3.0 | 1,450 | – | 483 |
| **Rebuild and Update Existing Facility*** | | | | |
| Coke plant | 1.0 | 200 | 200 | 67 |
| Blast furnace | 2.5 | 400 | 160 | 133 |
| Steelmaking | 3.0 | 200 | 67 | 67 |
| Totals | 3.0 | 800 | – | 267 |

NOTE: Costs for hot metal are $360 per annual tonne for new plants and $240 for rebuilt plants.
*Site-specific costs would vary depending on the degree of rebuilding.

*The major areas that will drive the industry to develop new technologies or restructure include reduction in nitrogen oxides, sulfur oxides, VOC emissions, and recycling of in-plant wastes.*

**Table 14. Capital Cost for Liquid Steel in an EAF Plant (1.0 Metric Tonnes Annual Production)**

| Facility | Production (metric tonnes per year) | Capital ($ million) | Cost of Steel ($/tonne per year) |
|---|---|---|---|
| **New Greenfield Plant** | | | |
| **Scrap Only** | | | |
| EAF refining | 1.0 | 160 | 160 |
| **Scrap plus DRI/HBI*** | | | |
| EAF refining | 1.0 | 160 | 160 |
| DRI/HBI | 0.2 | 35 | 35 |
| Total | 1.2 | 195 | 195 |

*DRI/HBI assumes 20 percent of 1 metric tonne per facility costing $175 million.

The large difference in capital costs between integrated and EAF production has been partly responsible for the increase in production by EAFs from less than 20 percent to 38 percent. The cost difference between conventional and thin-slab casting has helped drive the recent decisions to install nearly 18 million tons of thin-slab casting capacity by the year 2000.

### Environmental Regulations

Environmental concerns and regulations on discharges will be one of the major future forces behind developing new technologies. Government regulations could also significantly affect demand for steel. The industry will be more proactive and less reactive in the future, particularly in the area of recycling scrap and plant waste materials. These materials will be considered man-made resources for producing new steel. Current and potential government regulations will require new technologies and capital.

The major areas that will drive the industry to develop new technologies or restructure include reduction in nitrogen oxides, sulfur oxides, VOC emissions, and recycling of in-plant wastes such as basic oxygen furnace dust and especially EAF dust.

**Table 15. Capital Cost for Casting and Finishing to Hot Band**

| Facility | Production (metric tonnes per year) | Capital ($ million) | Cost of Steel ($/tonne per year) |
|---|---|---|---|
| **New Greenfield Plant** | | | |
| Conventional slab rolling | 3.0 | 1,000 | 333 |
| Thin-slab rolling* | 1.0 | 200 | 200 |
| Conventional slab stickel mill | 1.0 | 250 | 250 |
| **Rebuild and Update Facility** | | | |
| Conventional slab rolling | 3.0 | 500 | 167 |

*Thin-slab rolling has only a finishing train.

### Scrap Availability, Price, and Substitutes

As discussed in the section on raw materials, there are major issues related to the availability and price of scrap. Historically, scrap prices have been lower than the cost of producing hot metal, giving EAF producers an advantage in the cost of production in addition to their lower capital cost. However, scrap prices have risen significantly recently because of high demand. Also, integrated producers have cut the cost of producing hot metal and steel. Although the cost of producing steel is site-specific and may vary significantly from plant to plant, a reasonable comparison between the cost of production for EAF scrap versus integrated ore-based production demonstrates the effect of scrap price.

Table 16 shows the cost of producing steel for both processes at scrap prices of $100 and $150 per ton. At the low historic price, the EAF producer has a cost advantage, but at the high peak price, the integrated producer has a slight advantage. The high-priced scrap is for an EAF plant producing higher quality products such as flat-rolled steel. For producing lower quality long products, such as reinforcing bar and constructional shapes, the scrap costs are lower and the EAF producer will almost always have a significant advantage, and EAF producers have indeed captured that market.

There is expected to be a great increase in thin-slab flat-rolled production, from about 2 million tons per year in 1992 to more than 10 million and possibly 18 million by the year 2000. This increase will put tremen-

**Table 16. The Effect of Scrap Price on the Cost to Produce Liquid Steel (Per Ton of Liquid Steel)**

| | EAF | | Integrated | |
|---|---|---|---|---|
| **Scrap Price per Ton** | **$100** | **$150** | **$100** | **$150** |
| Scrap | $110 | $165 | $25 | $37 |
| Ore | – | – | 41 | 41 |
| Coke/Coal | – | – | 33 | 33 |
| Electricity | 20 | 20 | 5 | 5 |
| Labor | 10 | 10 | 20 | 20 |
| Other | 28 | 28 | 30 | 30 |
| Capital | 25 | 25 | 65 | 65 |
| Total cost | $193 | $248 | $219 | $231 |

dous pressure on the availability and cost of high-quality scrap, which will significantly affect the relative competitive position of the two steelmaking processes.

Part of the demand for low-residual, higher quality scrap will be met with scrap substitutes such as pig iron, DRI, and possibly iron carbide and liquid hot metal. Several plants to produce DRI and carbide are being built or planned for the near future (NUCOR's iron carbide plant in Trinidad is expected to produce about 300,000 tons per year when it is fully operational). In the meantime, imported pig iron is being used to fill industry needs. The availability and price of scrap substitutes are still relatively uncertain and will greatly affect competitiveness.

*The availability and price of scrap substitutes are still relatively uncertain and will greatly affect competitiveness.*

Scrap substitutes such as DRI, HBI, and possibly in the near future, iron carbide, will be commercially available in reasonable amounts. The availability of these materials could put a limit on high-quality scrap price increases, but as of 1995, the quantity available does not significantly affect scrap prices.

### Foreign Competition

The profitability of U.S. steel producers will continue to be subject to the influence of subsidies to foreign producers and the strategic investment policies of foreign governments. The U.S. government can be expected to continue seeking free and fair trade in international markets, but there is uncertainty concerning the effect of U.S. monetary policies on international exchange rates. As a consequence of these forces, U.S. steel producers will continue to be concerned about the impact of imported steel.

*Subsidies have been the rule rather than the exception in the world market for steel.*

***Subsidies***

In the past, foreign competitors sustained strategic investment programs, gained access to new markets, and won long-term advantage with government support. Subsidies have been the rule rather than the exception in the world market for steel. The steel industry often plays a critical role in a nation's economic development plans, as attested by Japan's success in the 1960s and 1970s or by the success of steel producers in Brazil, South Korea, and Taiwan in more recent years. Even when steel firms are privately held, many, if not most, outside of the United States have recourse to government aid in times of crisis.

Under the General Agreement on Tariffs and Trade (GATT), three specific types of subsidies are allowed: R&D, assistance to affected regions, and assistance to meet new environmental standards. As discussed under R&D, subsidies in this area could give companies a long-term advantage, and assistance to affected areas could reduce the social costs for subsidized producers.

***Imports***

The profitability of all U.S. steelmakers is linked directly to import penetration, and therefore, their ability to implement and sustain investment strategies hinges on how easily foreign steelmakers can sell their goods in this country.

The competitive pressure on U.S. steel producers from imports is likely to be unabated. However, the rules governing steel trade are subject to change under several new international agreements. The North American Free Trade Agreement provides for tariffs to be reduced in stages for trade among the United States, Canada, and Mexico. Similarly, the Uruguay Round of GATT, which was signed and approved in 1994, provides for the elimination of tariffs between the United States and a number of other countries over a ten-year period. The countries involved in both of these agreements account for at least three-quarters of all U.S. steel imports and exports, as measured by the value of trade (USITC Pub. #2759, April 1994, p. 9).[12] Further, because of the most favored nation

[12] "Steel Semiannual Monitoring Report," U.S. International Trade Commission, Washington, D.C., 1994.

*The enhanced trade flows that are likely to result from the lowering of tariff barriers will continue to put pressure on U.S. steel producers to maintain efficient operations and reduce costs in order to remain internationally competitive.*

provisions of the GATT/WTO, the elimination of steel tariffs in the United States and a number of other countries will allow duty-free access for all World Trade Organization (WTO) members, not just those eliminating tariffs.

At a minimum, the enhanced trade flows that are likely to result from the lowering of tariff barriers will continue to put pressure on U.S. steel producers to maintain efficient operations and reduce costs in order to remain internationally competitive. Free trade also has the effect of encouraging more specialization in product lines. Integrated producers in the United States have become more specialized in recent years, owing primarily to competition from domestic minimills, and lower tariff barriers should promote this trend. On balance, if the new trade agreements are enforced, the U.S. steel industry will benefit.

***Foreign Exchange***

Changes in the value of the dollar on international markets are driven by policies here and abroad, and it is difficult to predict exchange rates. Exchange rates can significantly affect the profitability of steelmakers by making imports more (high dollar) or less (low dollar) attractive.

The anti-inflation policy of the Federal Reserve Bank has been a major determinant of import penetration in the U.S. steel market in the past decade. Inflation was controlled in the U.S. economy by restricting the money supply in the early and mid-1980s, and this forced real interest rates up to unprecedented levels. The inevitable consequence of this policy was a strengthening of the dollar, and a surge of imports resulted.

The general price level in the United States now appears to be relatively stable, but the Federal Reserve is vigilant in its battle, and could once again pursue tight money policies. The dollar is firming at the moment, making imports more attractive, but predictions of the direction and extent of changes in its value are uncertain.

Thus, U.S. government policies that cause large temporary changes in exchange rates can have long-lasting effects on U.S. steel producers, in part because some foreign governments may continue to play an active role in supporting steel exports.

## Conclusions and Possible Future Directions

The U.S. steel industry is certainly more competitive than it was ten years ago. Management has lowered costs significantly by reducing much of its excess labor and upgrading its technology. In addition, there have been some modifications in product portfolio, with firms concentrating on products in which they have a comparative advantage. For the integrated producers, these are products at the higher end in terms of quality and sophistication.

At the same time, environmental regulations continue to have an impact on the industry. For example, a number of firms are importing slabs from Europe, Asia, and South America and then rolling and finishing them in this country. While this is due, in part, to current domestic demand exceeding U.S. companies' production capacities, it is also due to U.S. environmental regulations coupled with old, inefficient production technologies that would need to be replaced to meet current environmental standards. As a result, it is cheaper for these U.S. firms to import slabs rather than produce them domestically. This displaces pollution from the United States to other nations, forfeits potential domestic jobs, and essentially results in the importation of ore and energy. For EAF producers, the most critical environmental concerns are the disposal or recycling of EAF dust and emissions from the furnace.

In the early days of steel, integration of the supply and production chain was a major corporate strategy. There was concern, for example, that the supply of iron ore might be inadequate to maintain steel production. Thus, US Steel bought iron mines in Northern Minnesota to guarantee its supplies. Others formed consortia to guarantee the availability of a supply. Today, it appears to be advantageous not to be integrated vertically in this manner.

Today, many of the so-called integrated mills are purchasing slabs and coke on the open market—previously manufactured as part of the integrated production process—to reduce their costs. In fact, several major firms no longer produce coke, finding it cheaper to buy coke pellets on the open market than to produce it to meet their own requirements.

In a similar fashion, a number of companies are "contracting out" for labor to reduce costs associated with their high level of integration. As steelworkers' wages have risen faster than those in manufacturing as a whole, integration has become a curse rather than an advantage. Companies not contracting out for labor are paying more than is necessary for operations such as maintenance. This is due to work rule restrictions that reduce the flexibility of individual workers.

In general, integrated steel firms have three major challenges. The first is the growth of the minimills. Most observers expect that the minimills will gradually improve quality and be able to produce a full product line that is competitive with that of the integrated mills. At the same time, a number of minimills are moving into ironmaking to guarantee a supply of iron for their electric furnaces. An example is NUCOR's iron carbide plant in Trinidad. As indicated, the distinction between the two types of firms will gradually become blurred. At least one integrated firm (LTV) is building an EAF thin-slab minimill.

*As labor and management become aware that productivity must be increased, ...we expect to see greater changes in the work rules as well as an increase in contracting out.*

The second major challenge is labor and pension costs. The minimills have shown they can pay wages equal to those of unionized steelworkers and get higher productivity from them. The keys are the lack of work rules, and in some cases the management culture. The integrated mills' problem is not the high wages of the steelworkers, but rather the work rules under which they operate. These rules result in a decrease in flexibility for the integrated mills and a decrease in productivity. As labor and management become aware that productivity must be increased to guarantee the survival of the integrated mills, we expect to see greater changes in the work rules as well as an increase in contracting out. This will give the management of the integrated mills the flexibility they need.

A related problem for the integrated firms is the lack of flexibility in compensation, leading to high fixed cost. In contrast, a large percentage of the labor compensation in minimills is linked to production and profits, making labor costs flexible—increasing or decreasing with the companies' economic performance. The older integrated producers also have large pension costs. Several firms have two to five retired workers for each current employee. This puts a tremendous burden on their financial performance.

The third and possibly most critical problem is the high capital costs associated with integrated production. If conventional technologies are used, these costs will increase further because of complex environmental regulations. In the long term, the steel industry must develop processes to convert ore to steel that require less capital. Many believe these processes should be coal based because of the abundance of coal available.

The existing processes must be combined and the overall process made more continuous.

The U.S. steel industry has greatly improved its competitive position in the past decade by closing inefficient plants, improving productivity and quality, investing in crucial technologies, and being more customer oriented. It is the low-cost producer for the U.S. market. However, to prosper in the future, the industry must manage a number of difficult issues:

***Additional domestic capacity:*** In the next five years, an additional 15 to 20 million tons of new flat-rolled capacity will be installed. This will cause further competitive changes and restructuring, perhaps causing some marginal producers to leave the market. While this adjustment will be very painful for some companies and individuals, it is expected to result in a more competitive industry and lower steel costs to consumers.

***Evolving markets:*** The industry must maintain its position in the automotive market in the face of efforts to reduce the weight of automobiles through material substitution. The industry also must increase its penetration of the housing market through cost reduction, innovative design, and customer training.

***Technology:*** Until recently, U.S. industry has employed a fast-follower strategy, acquiring technical know-how from international companies and investing only in the most critical technologies. Further improvement from these sources will be limited. In the future, the U.S. steel industry will require new technology to reduce capital costs and address environmental concerns.

***Capital requirements:*** Integrated producers have extremely high capital requirements. In addition, many long-established producers have large pension liabilities. Several have two to five retired workers for each current employee, placing a tremendous burden on their financial performance.

***Imports:*** The profitability of U.S. steel producers will continue to be subject to the influence of the current world production overcapacity, subsidies to foreign producers, the strategic investment policies of foreign governments, and fluctuation in global currency exchange rates. As a consequence of these forces, and in spite of the U.S. government's continued support for securing free and fair trade in international markets, U.S.

steel producers will continue to be concerned about the impact of import penetration on the domestic industry.