CHAPTER 5: Chicago's Steel Minimills

Nationally, a new type of steel plant called a minimill has continually gained market share from large integrated steel mills. Concentrating on low value products, like rebar, and locating at the center of untapped regional scrap markets, minimills recycle steel by melting it in relatively small batches and selling to regional users, largely in the construction industry. Minimills now claim about 20% of the domestic market for steel, up from 3% in 1960.

This chapter presents our research findings on the growth and prospects for the minimill sector nationwide and in the Chicago region. It addresses the competitiveness of the minimill sector vis-a-vis both integrated mills and imports. Special attention is given to exploring the regional aspects of growth in the sector and unique aspects of the Chicago-region minimill industry.

We found that minimills are important to the Chicago steelmaking complex both as competitors to the larger mills and as local producers. Chicago's regional minimills are relatively older and are trying hard to upgrade facilities to compete. Minimills here confront higher labor and energy costs, but enjoy access to a skilled labor force, the country's largest scrap market, an excellent midcontinental transportation network, and proximity to some of the most important markets in the world.

We also found that domestic minimills' products have successfully competed with imports in recent years. As minimills move into higher value lines, expand their geographical markets, and face demands for just-in-time shipments, the advantages of Chicago as a site will be enhanced.
5.1 General Characteristics of Minimills

Amid the overall crisis in the domestic steel industry, one sector has grown steadily; this is the minimill sector. Between 1960 and 1984, the number of minimill plants grew from about 20 to 54, and total net capacity in the sector rose from about 4 million tons/year to nearly 20 million tons. This has meant an increase in minimills' share of the domestic market from 3% in 1960 to around 20% today. Moreover, recent estimates indicate that for certain steel products (bar, wire, and rod) minimills now supply 75% of the domestic market ("Has Justice Killed Steel?", 1984). Finally, some analysts estimate that import shares of minimill markets have decreased by nearly 10% since the early 1970s as compared to increases of around 7-8% in import shares for all steel products (Barnett and Schorsch, 1983).

Given the spectacular performance of the minimill sector, most analysts agree that mini steel plants are "here to stay". But, many observers also agree that minimills are not a panacea and are subject to losses and market place shocks as are integrated mills. In fact, one recent study suggests that minimills currently are in a period of "intense price competition" due to over capacity and a rising import problem (Marcus, 1984). The double-edged performance history of minimills suggests that the sector is diverse and that close attention should be paid to individual firm characteristics.

Given the diverse and dynamic nature of the minimill sector, it is important when discussing the industry as a whole to have a single, clear definition in mind. The Directory of Iron and Steel Plants, published bi-annually by the Association of Iron and Steel Engineers, for example, defines minimills primarily by size and only generally by product. Specifically, it counts "mini-plants" as "those companies
producing under 300,000 tons annually and 'midi-plants' as those producing between 300,000 and one million tons. The output of both categories is primarily carbon grade structural products." On the other hand, the Institute for Iron and Steel Studies defines minimills according to their primary raw material, namely "ferrous scrap or DR ore (direct reduced iron).

More comprehensive and more useful than either of the above definitions is the definition put forth by Barnett and Schorsch in their recent book, Steel: Upheaval In a Basic Industry. They maintain that distinctions between mini- and integrated mills are best measured along three dimensions: technology, product line, and market. It is helpful as well to include a fourth dimension in this matrix, that of management style. Each of these characteristics will be discussed briefly below.

Technology

Unlike the large integrated mills which are equipped with blast furnaces to melt coke made from iron ore, minimills use electric arc furnaces, which melt ferrous scrap. In addition, most minimills use continuous casters to pour the iron melt directly into billets or blooms which are then cooled and reheated before going to the rolling mill. Thus, a continuous caster eliminates the step of cooling and reheating ingots before they are formed into billets or blooms (integrated mills also make slab from ingots).

While continuous casters are not uniquely suited to the minimill configuration, they have been employed to a much greater extent in the minimill sector than in the domestic integrated mills. Rapid diffusion of the continuous casting technology among minimills has
resulted largely from the fact that most minimills were constructed after the advent of the continuous caster around 1960. Many observers, however, also attribute the more widespread use of continuous casting to minimills' entrepreneurial and competitive spirit, contrasted with the more reluctant capital investment posture among the older, integrated producers.

Product Line

Minimills produce low-value "commodity grade" products such as bar, wire rod, light structural bars, and hot-rolled bars. These products are heavily consumed by the construction industries. However, according to recent trade press accounts, minimills are beginning to penetrate new product lines, such as special quality bars, cold-finished bars, rails, structural bars, and seamless pipe ("Now the Slump," 1982). Some minimills also produce fence post and a variety of bar shapes.

As minimills increase their range of products, the lines of definition between mini- and integrated mills with regard to this characteristic begin to blur ("Minimills Vary Grades," 1982). However, a major difference in the product capability of the two types of mills continues to be the limitation on minimill technology for producing heavy structural bars and flat-rolled sheet, such as that used by auto and appliance manufacturers. Opportunities to move into the sheet market could open up in the not-too-distant future with the introduction of new technologies to continuously cast a thin slab, currently being researched both in the U.S. and abroad. According to a leading minimill firm, this technology may become commercially feasible within the next five years (Nucor, 1984).
Market

The third characteristic typically associated with minimills is their regional market orientation. Minimills are generally thought to serve geographic areas within a 300-400 mile radius ("Roesch, Iverson Stress," 1982). It appears that these markets have been based primarily on fast growing local industries, like construction, as well as on a variety of manufacturing sectors (U.S. Office of Technology Assessment, 1980; various company's annual reports). There is likely to be great diversity in market areas among minimills, however.

Management Style

Minimills are typically characterized by flexible management practices and a generally entrepreneurial character. Barnett and Schorsch (1983:93) compare U.S. minimills' management style to a Japanese management model, citing the following similarities: both are adept at riding learning curves; both are price takers and are therefore aggressive competitors over market share; both focus on long-term growth and on reinvesting their profits. In addition, these authors point to the "more flexible" labor practices among U.S. minimills, which often seek to develop a "team-oriented corporate culture and to provide profit sharing and employee stock plans."

While minimills' management practices have tended to enhance productivity and efficiency in the minimill sector, note must be taken that many U.S. minimills are non-union shops, operating in an historically highly unionized industry. Furthermore, even those minimills which are unionized tend to pay lower wages than integrated mills.
5.2 Competitiveness of Minimills

The characteristics of minimills outlined above have allowed minimills to compete effectively with both domestic and foreign integrated producers. As a result, minimills have, in the aggregate, enjoyed higher-than-average profit rates than the U.S. industry overall. Between the periods 1972-1976 and 1977-1981, for instance, the annual average return on equity for a sample of U.S. minimills rose 1.2% (from 15.8 to 17.0); this is in contrast to a decline of 3.5% (from 9.1 to 5.6) in average return on net equity for a sample of integrated mills and an overall industry decline of 2.2% (from 9.4 to 7.2) (Barnett and Schorsch, 1983). These profit margins, high both in relative and absolute terms, can be generally attributed to savings in four factor areas.

Lower Capital Costs

According to several observers, electric furnace mills can be built at around an 80% savings over the construction of integrated mills -- $300-400/ton compared to $2000/ton for a greenfield integrated plant ("Has Justice Killed Steel?", 1984; Gold, et. al, 1984). Part of the savings accrues from the much shorter lead times associated with construction.

Some firms claim even lower capital costs. Nucor Corporation, for example, maintains that the average cost of building, improving, and expanding all four of its mills over the period from 1969 to 1981, came to only $150/ton of their current annual capacity (Nucor, 1984). However, some analysts note that the cost of constructing a minimill has grown considerably, in real terms, since 1960, due to greater equipment requirements needed to meet expanding capacity (Hogan, 1984).
Lower Materials Costs

Scrap, the primary raw material used in minimills, tends to be much lower priced than pig iron, iron ore, or blast furnace metal used in integrated mills. According to estimates by Barnett and Schorsch, materials costs for the production of a single product -- wire rod -- in 1981 were nearly 23% lower for minimills than for integrated mills ($93 compared to $114 per net ton shipped).

However, there appears to have been some debate in the industry, quieted for the moment, as to whether or not scrap will be in short supply in the future, and thus drive prices up. In a recent trade journal article, it was noted that for a short period between June, 1981 and April, 1982, minimill companies were scrambling to buy scrap companies. This phenomenon ceased, however, as minimill firms became convinced that there would be no scrap shortage, even in periods of peak demand. More recently, the trend in company acquisitions has reversed, as scrap companies have begun to buy up minimills to achieve some level of vertical integration( "Now Scrap Companies," 1984).

Lower Energy Costs

Cost data for 1982 indicate that on the average, minimills' energy costs were less than half of the energy costs facing integrated mills ("Roesch, Iverson Stress," 1982). Energy costs account for around 17% of operating costs for the average minimill (Barnett and Schorsch, 1983:95). In general, scrap-based furnaces are more energy-efficient than the large blast furnaces found in integrated mills.

Lower Labor Costs

Recent figures indicate that employment costs per ton of steel shipped for minimills are about $75-100 as compared to $195-295 for
integrated (Miller, 1984). Lower employment costs are basically the result of two factors: higher labor productivity and lower wages and benefits.

Generally, the long production runs required in minimills to produce a few simple products, with requiring relatively little re-tooling between runs, result in greater productivity. Consequently, minimills may require only half as many labor hours/ton as integrated mills (Gold et. al, 1984:738). Some firms may require even lower labor hours/ton, such as Chaparral Steel; in 1983 only 1.6 labor hours/ton were used in Chaparral minimill. This is far below the industry average for that year of 5-8 hours/ton ("Minimills Prosper", 1983).

Wages and benefit bills are generally lower due to lower unionization rates and greater worker wage concessions. Many minimills are non-union, although the United Steel Workers do represent nearly half (12,100) of all workers employed in minimills. Even in unionized mini-steel plants, however, average compensation, including benefits of $17.00/hour tends to be significantly lower than integrated mills' average of $22.50/hour ("Steel Workers Dig In," 1984.)

Other often-cited factors contributing to the relative competitiveness of minimills are lower transportation costs resulting from local/regional market orientations and the willingness to adopt the latest cost-savings techniques.

5.3 Growth and Regional Distribution of Minimills

Minimills represent a "process innovation" as well as a decentralizing trend in the steel industry. No longer are all raw steel products produced exclusively in huge integrated mills located in a
few "rust belt" states and employing thousands of people. Because minimills are also currently capturing large market shares for certain products, it is logical that policymakers are interested in minimills as potential economic development tools.

However, the minimill sector has developed in a different manner in different regions of the country. It is imperative that policymakers be aware of the historical growth and performance trends displayed by minimills in different parts of the country, as well as in the aggregate nationwide. In this section of the report, the aggregate growth trends are examined first, followed by an analysis of regional growth trends; the ability of minimills to compete with imported minimill products, one measure of performance, will be examined as well.

**Trends in Minimill Sector Growth Nationwide**

As cited previously, production of raw steel in minimills has risen from around four million tons/year in 1960 to around seventeen million tons/year in 1984. The number of minimill plants in operation has risen from about 20 to 54. While detailed data on minimills constructed before 1960 is not available, it is known that a few were in operation. Northwestern Steel and Wire which started up in the 1930s outside Chicago is often cited as the nation's first minimill. Most other mini steel plants operating before 1960 most likely did not start up until the late 1950s.

According to Barnett and Schorsch, the growth in the minimill sector during the 1950s and 1960s can be attributed primarily to three factors: (1) The technology for continuous casting became available in the early 1960s; this technology reduced capital cost requirements,
thus lowering barriers to entry for producing products made from billets. (2) The availability of scrap increased due to the shift among a significant proportion of integrated mills from open hearth to basic oxygen furnaces. Basic oxygen, or as it is more commonly referred to, BOP, uses a 30% scrap charge compared to a 50% charge in the open hearth. (3) Demographic shifts created new steel markets in the South and West, particularly for simple construction products (Barnett and Schorsch, 1983:86). It is likely that these same three factors continued to drive the growth in the minimill sector throughout the 1960s. By the early 1970s, then, the number of minimill plants operating had nearly doubled to about 36 and total annual capacity for minimills rose to about 8900 tons/year.

Since 1973, the number of minimill plants has continued to climb steadily (Table 5.1 and Figure 5.1). Despite the massive recession of the late 1970s and early 1980s, the number of minimills operating increased by eight from 46 to 54 between 1980 and 1984. This rate of increase in the number of plants was even slightly higher than during the more economically robust period of the early- to mid-1970s, when the number of minimills appears to have increased by 7 (from 36 in 1973 to 43 in 1977).

However, increases in the total annual capacity embodied in the minimill sector were considerably larger during the earlier period from 1973 to 1979 (about 54%) compared to during the more recent
FIGURE 5.1 Total Net Capacity of U.S. Minimills
1960-1984 (millions of tons)

Number of U.S. Minimill Plants
1960-1984

Source: Association of Iron and Steel Engineers, Directory of Iron and Steel Plants; Institute for Iron and Steel Studies, Steel Plants USA, 1960-1980

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Net Capacity (000 tons)</th>
<th>Number of Plants Operating</th>
<th>Average Plant (000 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1984</td>
<td>16,748 a+</td>
<td>54</td>
<td>335°</td>
</tr>
<tr>
<td>1982</td>
<td>15,773 a</td>
<td>48</td>
<td>329</td>
</tr>
<tr>
<td>1980</td>
<td>14,030 a</td>
<td>46</td>
<td>305</td>
</tr>
<tr>
<td>1979</td>
<td>15,830 b</td>
<td>46</td>
<td>344</td>
</tr>
<tr>
<td>1978</td>
<td>13,830 b</td>
<td>45</td>
<td>303</td>
</tr>
<tr>
<td>1977</td>
<td>13,730 b</td>
<td>43</td>
<td>319</td>
</tr>
<tr>
<td>1976</td>
<td>12,450 b</td>
<td>42</td>
<td>296</td>
</tr>
<tr>
<td>1975</td>
<td>12,100 b</td>
<td>41</td>
<td>295</td>
</tr>
<tr>
<td>1974</td>
<td>10,065 b</td>
<td>38</td>
<td>265</td>
</tr>
<tr>
<td>1973</td>
<td>8,900 b</td>
<td>36</td>
<td>247</td>
</tr>
<tr>
<td>1960</td>
<td>4,000 b</td>
<td>20</td>
<td>200</td>
</tr>
</tbody>
</table>

a Sources: Estimated from The American Iron and Steel Institute, Directory of Iron and Steel Works, 1984 and American Metal Market (various issues).


+ excludes capacity for 4 plants for which data was not available.

° average based on count of 50 to correct for 4 plants for which data was not available.
period since 1980 (about 20%). This contrast between the rates of
growth in the number of ministeel plants and their aggregate annual
capacity indicates a trend towards slower increases in the rate of
expansion of plant size. Such a trend is likely due to the tightening
of capital available for investment in plant in the more recent time
period.

Employment in minimills has also increased, albeit more
moderately. While comprehensive employment data for the minimill
sector is not available, we estimate that in 1984, minimills employed
35,000 workers, up from 13,000 in 1976.³

Regional Aspects of Minimill Sector Growth

While the growth in the minimill sector nationwide during the
last decade is readily apparent, closer analysis suggests considerable
diversity in the levels of growth across geographical regions. The
current location of minimill plants by geographic region and state is
presented in Table 5.2. As is indicated, the 54 minimills counted are
dispersed across 28 states. Texas, with seven minimills, houses the
greatest number of any one state. It is followed by Illinois,
California, and New York, with six, four, and three plants,
respectively.

Minimills have tended to locate near other steel producers
historically. However, this tendency is becoming weaker.⁴ If the
future reflects this trend, we should expect to find increasing
incidence of minimill siting in non-traditional steel locations.
However, as we shall see below, new minimill strategies may mitigate
against such dispersion.
### Table 5.2. Number of Minimill Plants By State and Geographic Region: 1984

<table>
<thead>
<tr>
<th>Great Lakes</th>
<th>New England</th>
<th>Midwest</th>
<th>Mid-Atlantic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ohio</td>
<td>Maine</td>
<td>Iowa</td>
<td>New York</td>
</tr>
<tr>
<td>Indiana</td>
<td>Vermont</td>
<td>Missouri</td>
<td>New Jersey</td>
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<tr>
<td>Illinois</td>
<td>New Hampshire</td>
<td>North Dakota</td>
<td>Pennsylvania</td>
</tr>
<tr>
<td>Michigan</td>
<td>Massachusetts</td>
<td>South Dakota</td>
<td>Delaware</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>Connecticut</td>
<td>Nebraska</td>
<td></td>
</tr>
<tr>
<td>Minnesota</td>
<td>Rhode Island</td>
<td>Kansas</td>
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<tr>
<td>10</td>
<td>0</td>
<td>2</td>
<td>7</td>
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</table>

<table>
<thead>
<tr>
<th>Mountain</th>
<th>Pacific</th>
<th>South Central</th>
<th>Southwest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Montana</td>
<td>California</td>
<td>Kentucky</td>
<td>Oklahoma</td>
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<tr>
<td>Idaho</td>
<td>Oregon</td>
<td>Tennessee</td>
<td>Texas</td>
</tr>
<tr>
<td>Wyoming</td>
<td>Washington</td>
<td>W. Virginia</td>
<td>Arizona</td>
</tr>
<tr>
<td>Colorado</td>
<td></td>
<td>Arkansas</td>
<td>New Mexico</td>
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<tr>
<td>Utah</td>
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<td>Nevada</td>
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<td>1</td>
<td>5</td>
<td>8</td>
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<td></td>
<td>1</td>
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<td>10</td>
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<table>
<thead>
<tr>
<th>Southern</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Maryland</td>
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<td></td>
<td></td>
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<tr>
<td>Virginia</td>
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<td></td>
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<tr>
<td>North Carolina</td>
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<td></td>
</tr>
<tr>
<td>South Carolina</td>
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<tr>
<td>Georgia</td>
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<td></td>
<td></td>
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<tr>
<td>Florida</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mississippi</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alabama</td>
<td></td>
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<td></td>
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<tr>
<td>Louisiana</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Sources: American Iron and Steel Institute, Directory of Iron and Steel Works, 1984; American Metal Market (various issues); Midwest Center for Labor Research, personal communication. Data does not include Alaska or Hawaii.)

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In order to more closely examine the geographic tendencies of growth in the minimill sector over time, all plants for which data were available were grouped according to their location in one of the four customs district categories (for which AISI reports shipments of imports) or in a fifth, inland group. As is evident from Tables 5.3 and 5.4, the proportion of annual minimill capacity concentrated in the Great Lakes Region relative to all other regions declined from nearly 50 percent during the mid-1970s to around 43% in the early 1980s. This relative decline has been coupled with a small absolute decline during the recent period in total capacity in that region's minimills, as evidenced by the negative growth rate listed in Table 5.3.

Still, the greatest proportion of total minimill capacity in any one region is concentrated in the Great Lakes Region. Additionally, this region is tied for first place in housing the greatest absolute number of minimill plants (about 15 in 1984). The Great Lakes Region, traditionally a major center for steel production by integrated mills, apparently continues to serve as an agglomerating center for smaller steel producers. However, the region appears to have played a less central role in the most recent stages of growth in the minimill sector (Figure 5.2).

The second highest regional concentration of minimill capacity has been in the Atlantic Coast region, accounting for ground 22 percent of total minimill capacity in both the 1973-1977 and 1980-1984 period. This region experienced a relatively higher average rate of growth in minimill capacity during the most recent period (about 24%).
Table 5.3. Average Total Annual Steel Capacity in Minimills By Custom District Region: 1973-1977, 1980-1984 (000 tons)

<table>
<thead>
<tr>
<th>Region</th>
<th>1973-1977</th>
<th>% of total</th>
<th>Annual Rate of Increase</th>
<th>1980-1984</th>
<th>% of total</th>
<th>Annual Rate of Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>11,449</td>
<td>49.2</td>
<td>9.2</td>
<td>15,523</td>
<td>6,638</td>
<td>42.8</td>
</tr>
<tr>
<td>Great Lakes 1</td>
<td>5,638</td>
<td>13.9</td>
<td>21.3</td>
<td>3,160</td>
<td>20.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Gulf Coast 2</td>
<td>1,590</td>
<td>22.2</td>
<td>9.0</td>
<td>3,433</td>
<td>22.1</td>
<td>15.8</td>
</tr>
<tr>
<td>Atlantic Coast 3</td>
<td>1,196</td>
<td>10.5</td>
<td>8.2</td>
<td>875</td>
<td>5.6</td>
<td>4.7</td>
</tr>
<tr>
<td>Pacific Coast 4</td>
<td>486</td>
<td>4.2</td>
<td>7.4</td>
<td>1,417</td>
<td>9.1</td>
<td>43.7</td>
</tr>
</tbody>
</table>

*Source: Institute for Iron and Steel Studies, Steel Plants USA, 1978.*

*b* Source: American Iron and Steel Institute, Directory of Iron and Steel Works, various years.

+ average based on data for 1980, 1982, and 1984 only.

1 includes 8 states: Illinois, Missouri, Michigan, Mississippi, Ohio, Minnesota, Wisconsin, New Jersey; Plus: upstate New York.

2 includes 4 states: Texas, New Mexico, Alabama, Louisiana

3 includes 11 states: Massachusetts, Rhode Island, Connecticut, Pennsylvania, Maryland, Virginia, North Carolina, South Carolina, Georgia, W. Virginia, Florida; Plus: District of Columbia; coastal New York

4 includes 3 states: California, Washington, Oregon

5 includes 7 states: Arizona, Arkansas, Kentucky, Oklahoma, Nebraska, Tennessee, Utah.

6 excludes capacity for 2 plants for which information was not available.
Table 5.4. Imports of Four Minimill Products As A Percent of Apparent Supply: 1983 (Tons)

<table>
<thead>
<tr>
<th>Product</th>
<th>Shipments From U.S. Mills</th>
<th>Imports</th>
<th>Apparent Supply</th>
<th>Imports as % of Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire Rod</td>
<td>3,067,707</td>
<td>1,185,291</td>
<td>4,252,998</td>
<td>27.9</td>
</tr>
<tr>
<td>Structural Shapes (3&quot; and over)</td>
<td>3,364,079</td>
<td>1,444,721</td>
<td>4,808,800</td>
<td>30.0</td>
</tr>
<tr>
<td>Bars -- Hot Rolled, Including Light Shapes</td>
<td>6,717,310</td>
<td>457,094</td>
<td>7,174,404</td>
<td>6.4</td>
</tr>
<tr>
<td>Rebar</td>
<td>4,306,042</td>
<td>208,303</td>
<td>4,514,345</td>
<td>4.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>17,455,138</td>
<td>3,295,409</td>
<td>20,750,547</td>
<td>15.8</td>
</tr>
</tbody>
</table>


*Apparent Supply = Shipments + Imports
Minimill Plants in 5 Customs Districts

- N.E.C.
- Great Lakes
- Pacific Coast
- Atlantic Coast
- Gulf Coast

Year

Sources:


As defined for the purposes of this study, the Atlantic Coast region encompasses twelve states, as well as the coastal portion of New York. Interestingly, it is the older, industrial states in this region (PA, W. VA, NY-2) in which most of the recent growth related to new plant construction has occurred. However, most of the increases in regional minimill capacity from expansion of existing plants appears to have resulted from expansion among mills located in the region's southern states (NC, SC, GA, FL, VA). Nearly half this added capacity from expansion was from a single mill, located in Virginia (Roanoke Electric Steel). Three of the four other individual mills which recorded expanded capacities during this period are also located in this southern subregion.

The primarily "sunbelt" areas described by the Gulf Coast, Pacific Coast, and inland (N.E.C.) Districts together have accounted for only about 35% of total domestic minimill capacity during the period of 1980-1984, and currently account for about 44% of all minimill plants. But, growth rates for both plant and capacity during the last decade have been significant. Most dramatic has been the recent surge in minimill activity in the non-coastal area listed as "N.E.C." in Table 5.3. For the current analysis, this area includes seven primarily south-central and southwestern states. Since 1980, the number of minimills in this area has risen from five to nine, and average total annual capacity has risen by 44%. These increases are especially striking given that during the previous period, from 1973 to 1977, these non-coastal locations constituted the smallest and most slowly-growing segment of the minimill sector nationwide. Currently, these states have outstripped the Pacific Coast states in both the
number of plants and aggregate capacity. In addition, the number of
plants in this area is now equal to the number of minimills in the
Gulf Coast region. However, the Gulf Coast District continues to
account for the greatest average annual capacity of the three
"sunbelt" regions.

Minimills and Regional Import Substitution

The regional variations in the growth and robustness of the
minimill industry can also be gauged by the extent to which the
minimill sector bolsters the self-sufficiency of each region for
certain steel products. As was indicated earlier, import shares
nationwide of "minimill product markets" (wire rod, rebar, hot-rolled
carbon bar, and structural shapes) have been decreasing while import
shares of all steel products have risen dramatically. Still, for wire
rods and structural shapes, recent import levels remain relatively
high at 28% and 30% of apparent supply, respectively (Table 5.5). It
is likely that minimills in certain regions have greater capability to
displace imports of certain products than others. Such an ability may
have important implications for each region's development. For
instance, according to at least one industry source, imports in
structurals and wire rod products are reported heaviest in the Gulf
Coast and East Coast Port areas, and the toughest competition for bar
products is on the West Coast ("Some Minimill Turf," 1984).

As a first step toward evaluating regional variations in the
import-substitution capabilities for the minimill sector, we examined
the statistical relationship over time between changes in apparent
local minimill production and changes in imports of minimill products
into that region. We assumed that if regional minimill production is
Table 5.5. Relationship Between Apparent Minimill Production\(^a\) and Imports\(^b\) of Minimill Products for the Four Customs District Regions and Total U.S., 1973-1979

<table>
<thead>
<tr>
<th>Region</th>
<th>Direction</th>
<th>Relationship</th>
<th>Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>-</td>
<td></td>
<td>(r^2 = .33)</td>
</tr>
<tr>
<td>Great Lakes</td>
<td>+</td>
<td></td>
<td>(r^2 = .09)</td>
</tr>
<tr>
<td>Gulf Coast</td>
<td>-</td>
<td></td>
<td>(r^2 = .29)</td>
</tr>
<tr>
<td>Atlantic Coast</td>
<td>-</td>
<td></td>
<td>(r^2 = .38)</td>
</tr>
<tr>
<td>Pacific Coast</td>
<td>-</td>
<td></td>
<td>(r^2 = .13)</td>
</tr>
</tbody>
</table>

\(^a\)Apparent Regional Production was calculated as follows: Total minimill capacity for each region was multiplied by a constant coefficient of .85, the rate of capacity utilization suggested by Barnett and Shorsch, 1983:95.

\(^b\)Source: American Iron and Steel Institute, Annual Statistical Report, Table 26, 1973-1979. Minimill products are defined as wire rod, rebar, hot-rolled bar, and structural shapes.
indeed serving as a substitute to imports of minimill products into that region, there would be a negative relationship between changes in import levels and local production.\textsuperscript{5} The results of the test\textsuperscript{6} described above are presented in Table 5.6.

For the U.S. as a whole and for all regions except the Great Lakes, we confirmed that local production by minimills have a negative relationship to imports of minimill products. In these regions, local minimills do seem to have replaced foreign-produced minimill goods in the local markets during the 1973-1979 period. As indicated by the $R^2$, the strength of this relationship is different for each of the three regions. The results suggest that the strongest import-substitution capability was for minimills in the Atlantic Coast region, and that the capability for minimills in both the Atlantic Coast and Gulf Coast regions to replace imports was stronger than in the Pacific Coast states.

The most ambiguous set of results from this test are for the Great Lakes District. The direction of the correlation between locally minimill-produced goods and foreign-produced minimill products is positive, suggesting that the rise or fall of imports during the 1973-1979 period was in tandem with the rise and fall in local minimill production. But, the strength of this relationship is extremely weak. The low $R^2$ implies that the level of imports of minimill products into the Great Lakes region has little to do with the output levels of local minimills. These findings might indicate that imports into the Great Lakes regions are more competitive with local minimills than in other regions or, on the other hand that local supply is simply not great enough to meet local demand.
Table 5.6. Minimills Located Within 300 Miles of Chicago

- A.B. Steel Mill; Cincinnati, Ohio
- Birmingham Bolt, Illinois Division; Kankakee, Illinois
- Calumet Steel Company; Chicago Heights, Illinois
- Continental Steel Company; Kokomo, Indiana
- Keystone Steel & Wire Company; Peoria, Illinois
- Laclede Steel Company; Alton, Illinois
- North Star Steel; Wilton, Iowa
- North Star Steel; Monroe Michigan
- Northwestern Steel & Wire; Sterling, Illinois
- Thomas Steel Corporation; Lemont, Illinois

Source: Compiled from existing directories and interviews. U.S. Steel's South Works is now also a minimill.
Minimills and the Steel Profit Cycle

As we have seen, steel production by minimills, though still concentrated most heavily in the traditionally "big steel" regions of the Great Lakes, Midwest, and Mid-Atlantic areas (roughly equivalent to the Great Lakes and half of the Atlantic Coast Customs Districts), has generally represented a decentralizing trend in the location of raw steel production. This trend has deepened since 1980, due largely to the construction of new ministeel plants in the South Central and Southwestern areas, as well as to expansion of existing plants in the more southern states along the Atlantic Coast.

To better understand the regional aspects of the growth trends in the minimill sector, it will be helpful to consider this sector more closely in the context of the larger steel industry. In her recent book Profit Cycles, Oligopoly, and Regional Development (1985b), Ann Markusen presents a useful model for analyzing this trend towards increased dispersion in the production of raw steel. Markusen maintains that the emergence of the minimill sector represents a shift from the "normal-plus" stage in the profit cycle, enjoyed by the big steel producers for over fifty years as a result of their oligopolistic market power, to the "competitive" or "normal-minus" state in the profit cycle. These latter stages are characterized generally by: moderate growth in output and size of firm; product differentiation, market penetration, advertising and sales; extensive vertical integration; and a corporate class or ownership. Moreover, Markusen argues that the competitive and normal-minus states of the profit cycle are characterized by "the propulsion of the industry towards low-cost locations," particularly those locations where a cheap, "deskilled"
labor force is available, and by pressures to "disintegrate" and diversify.

The evidence of increasing decentralization in the location of minimills to sunbelt and less urban places, driven to a large extent by the search for a labor force which is "innocent of the ways of industrial society", poses a clear challenge to organized steel workers and steel-based communities in older 'rust belt' locations. Such cities can choose to take aggressive stands to defend their interests and the interests of their manufacturing sector workers and siting of new mills. In relation to both retention of existing mills already, communities have begun to explore options for legislative and judicial remedies against plant closures, as well as new economic development opportunities for joint public/private ventures. Continued efforts on the local level, especially if couples with state and federal initiatives, may help to equilibrate the regional shifts in recent minimill growth.

5.4 Minimills in the Chicago Context

Having examined the historical growth trends of the minimill sector both nationwide and across broad regions, we can now turn to a more finely-grained analysis of the Chicago area minimill sector. The broad purpose of this part of the report is to examine the potential role of an existing or new minimill as an economic development tool for the City. By adopting an aggressive stance to build or expand economically viable manufacturing sectors, the City could enhance the industrial economic base already agglomerated in the region. It could also create much needed employment for displaced or unemployed workers. In order to help determine how viable an expanded minimill
sector in Chicago might be, it is necessary to look at the conditions of the sector as it exists currently in the Chicago area, the performance of existing minimill firms, the strength of consuming sectors, and the potential public policy options for the sector. These topics will be discussed below.

**Chicago's Existing Minimill Sector**

Table 5.6 lists names and locations of the ten minimills located within a 300-mile radius of Chicago, the generally accepted scope of minimill market area. Although only one of these (Calumet Steel) is located in Chicago's labor market area, all are located in the Chicago economic market area. For the purposes of this study, the three mills located nearest to the city were selected as an interview sample. Mill presidents were interviewed by the author in January, 1985, to obtain information on product lines, market area, economic performance, and perceptions about the industry.

**Size and Product Line**

A comparison of the three Chicago region minimills interviewed underscores the great diversity which exists among minimill producers. This finding of diversity underlines the need to examine firms individually and to avoid over-generalizing about the characteristics or performance levels of firms in this sector of the steel industry. The following contrasts are drawn from interviews with the presidents of the three independent minimill firms located in the Chicago region.

With regard to capacity and product mix, the sample of three minimills spans the industry spectrum. The smallest of the three mills has a current annual raw steel capacity of 120,000 tons. This capacity is also small relative to the industry average of about...
335,000 tons per year. At the other extreme, lies Northwestern Steel and Wire, which has a current annual raw steel capacity of 1.5 million tons. The third mill interviewed falls in the middle, with an annual capacity of 250,000 tons. Both of the relatively small producers are exclusively bar mills, producing various bar sizes and light structural shapes. Northwestern Steel and Wire, on the other hand, has a much more diversified product line. It produces a wide array of hot-rolled products, including wide flange beams, light structurals, rods, and bar shapes. In addition, about 20% of this mill's total annual output is from its wire division, which is a fabricating unit. In terms of both size and product line, then, Northwestern Steel and Wire resembles a cross between a minimill and an integrated producer.

**Market Area and Customer Mix**

All of the three minimills interviewed described their market area as "regional", but there is a some variation among the three nonetheless. For instance, the smallest mill described its market area as within a 300 mile radius, but explained that it will ship its lowest value-added products, such as angles, only within a shorter range; on the other hand, this mill produces a high-value custom-order product for a Texas firm, which lies well beyond its typical 300 mile radius market area. Both of the larger two mills define their market areas as somewhat broader. The middle-size mill ships to the ten or eleven states surrounding Illinois, and sometimes as far south as Texas. The largest mill describes its current market area as bounded roughly by the Smokies to the East and the Rockies to the West. Until 1980, however, this mill's market area was national.
There is considerable variation among the three firms' customer mix, as well. Although the two smaller mills are both primarily bar mills, about 90% of the output for the middle-sized mill is sold to the construction industry (either directly or indirectly through fabricators) whereas the smallest mill sells only about 10% of its output to the construction industry directly. However, the smaller mill sells nearly one-fourth of its output to Steel Service Centers, which may in turn sell to construction firms. The remainder of this latter mill's output is sold to a variety of consuming sectors, including the agriculture machine and tool industries and railroad car manufacturers.

As would be expected, the largest of the three mills, Northwestern Steel and Wire, serves a somewhat more diverse customer mix than the other two firms interviewed. This diversity stems largely from the fact that this mill's wire products are for consumer use. They are sold to large wholesalers who service job shops, contractors, and farm stores. A majority of Northwestern Steel's raw steel output (60%-65%), however, is sold to Steel Service Centers; information on the end-user consuming sectors, then, is not available. However, our contact at this mill indicated that a variety of industries including construction, heavy equipment and agricultural machine manufacturers use the steel produced by his mill. Two of the mills interviewed indicated that their customer mix usually follows the "80/20" rule, which is to say that 20% of their customers purchase 80% of their output. This indicates a level of dependence on a relatively small customer base.
Economic Performance

While minimills have, for the most part, registered higher levels of performance than integrated mills during the early 1980s, the performance results of minimills have been mixed. A review of net income and profit levels in 1983 for a sample of eight minimills located in various regions (including one of the three Chicago-region mills interviewed) has led at least one professional financial analyst to caution that, "a minimill does not automatically translate into a profitable or financially strong company" (Hageman, 1984). Additionally, according to a Value Line Investment analysis, the minimill sector is currently faced with overcapacity due to rapid expansion. This has resulted in tough competition among minimills. This view was corroborated by our contact at one of the Chicago area mills. He commented that on the whole, minimills throughout the U.S. are "hurting" in the current period and that as a result, some are up for sale or filing for bankruptcy under Chapter 11.

Since our interviews, the situation for minimills has worsened. In 1985, three minimills shutdown, none in the Chicago area: Marathon Steel (Tempe, Arizona), Soule Steel (Carson, California) and Kentucky Electric (Ashland, Kentucky). In each case, overcapacity and weak prices were cited, and in two of the cases, strike difficulties. Yet another mill, Marion Steel of Columbus Ohio, has just emerged from Chapter 11 reorganization. Analyst Donald Barnett expects more minis to "fall by the wayside" (Russell, 1985:6). Competition is chiefly coming from other minimills, as geographical market boundaries widen. "Our competition isn't the integrated steelmakers or foreign producers, its other minimills" reports Kenneth Iverson, the chairman of Nucor Corp (Russell, 1985:6).
Although specific income and profit data were not made available by two of the three Chicago-area minimills interviewed, other indicators suggest that these mills have posted a mixed performance record over the last four to five years. One indication that these firms may be operating at less than optimal levels is their current rate of capacity utilization. Both the smallest and largest mills interviewed revealed that their current utilization rates are relatively low, at 65% and 60%, respectively. These rates are not much higher than rates for integrated producers, which, during 1984, operated at an average of 55% of their total capacity (AISI, Annual Statistical Report, 1984). For the middle-sized of the three minimills, the current utilization rate is considerably higher. Its rate of 80% approached, and may even surpass, the average utilization rate for the entire minimill sector of the industry.

A further indication of less than favorable performance levels for the minimills interviewed is the decrease in their employment levels during the last decade. The largest of the three mills decreased its workforce by nearly 30%, from approximately 3500 to 2500; the middle sized mill by about 25%, from 500 to 370; and the smallest mill by nearly 65% from 670 to 240. These reductions in workforce are due in large part to the adoption of labor-saving technology, though at least one of the mills indicated that its reduction in workforce resulted primarily from the permanent cutback from three shifts per day to two shifts.

For one of the three firms, Northwestern Steel and Wire, more precise information regarding its financial performance is available, given that it is a publicly-traded firm. For the past three years,
the company has registered losses, and currently, the owners are having difficult meeting the minimum net worth requirements specified in their loan agreements. Formerly, the mill was considered a consistently profitable "backbone" firm in the industry. A combination of operating costs, competition, and poor labor management relations resulting in a lengthy shutdown due to a strike in 1982-1983 have all affected the firm adversely. In addition, the firm initiated an ill-timed $235 million modernization program to install a continuous caster and two new rolling mills beginning in 1978, just prior to the recession of the early 1980s. Overall, then, Northwestern is experiencing acute financial difficulties, due to a combination of both market and company-specific factors. However, Wall Street analyst William Stewart believes that Northwestern is positioned for a comeback, having taken the steps necessary to become "one of the low-cost producers in the country" (Spivak, 1985).

While it is not possible to ascertain the precise performance levels and company-specific factors affecting those performance levels for the two other, privately-held Chicago area minimill firms, information provided in our interviews does help to illuminate some of the market and locational factors affecting performance. One difficulty perceived in common is, simply, competition. All three interviewees indicated that their primary competition is from minimills located in other regions, though two of the mills interviewed indicated that imports are also a sore source of competition. For Northwestern Steel and Wire, an additional source of competition has been from the burgeoning numbers of independent wire fabricators. According to our contact at this mill, the wire fabricating industry has grown
tremendously since about 1974, and currently, nearly 16% of all wire marketed domestically is produced in such fabricating shops. These firms are often able to undercut the prices of mills which produce wire, largely as a result of lower labor and overhead costs.

For all three firms interviewed, competition from minimills in other regions is linked largely to the disparity in the age of plant for the Chicago area mills relative to their competitors. The two smaller Chicago area mills began operations as minimills in 1959, and one of them had been operating even earlier as a re-roller mill. Northwestern Steel and Wire is even older than the other two, having begun operations as a minimill in 1936. These plants are considerably older than other mills located in the 300 mile greater Chicago area radius, as well as most of the minimills located in the nearby Great Lakes and Atlantic Coast regions. In general, older plant requires greater investment for maintenance and upgrading, and is usually less efficient than new, state-of-the-art equipment.

In addition to older plant age, the Chicago area mills interviewed may be at a competitive disadvantage due to higher operating costs. When asked to compare their operating cost structure with regards to labor, energy, and scrap with national averages for all minimills, all three mill owners indicated that their energy costs account for a higher proportion of total operating cost than the national average of 17%. In addition, two of the owners identified high energy costs as the greatest disadvantage of operating a minimill at their current location. All of the owners attributed their relatively higher energy costs to what they consider to be the unreasonable rates charged by Commonwealth Edison. A comparative
examination of industrial electrical power provided per dollar of revenue by utility companies in Illinois does bear out that Commonwealth Edison provides "the least for the money" of any company in the state. We will return to the energy issue in greater depth in Chapter 8.

Two of the three mills also identified high labor costs as a locational disadvantage. All three of the mills interviewed are union shops, with the hourly employees represented by the USW. However, there appears to be considerable disparity in wages among the three. For the two mills interviewed which supplied information on the average employment cost per employees (wages and benefits), there was a full $6.50/hr. differential ($13.50/hr as compared to $21/hr.). The discrepancies at these mills point out that even among unionized minimills, employment costs may vary considerably.

Plans for the Future

While the current performance levels of the three minimills interviewed may be less than optimal, the minimill sector in the Chicago region is not likely to "go belly up". There is considerable evidence that managers at several of the mills are pursuing aggressive corporate strategies. These approaches include continuing to invest solely in their existing plants and to explore new market and production strategies.

Of the three firms interviewed, the medium-sized one is taking a particularly aggressive investment strategy. Currently, the owners of this mill are installing a continuous caster, which will be operational by the summer of 1985, and are discussing installing a new rolling mill to supplement their single, existing 14 inch mill.
Furthermore, the approximately $15 million in other improvements we scheduled to go in over the next few years.

While Northwestern Steel and Wire has no plans for new capital improvements for the near future, due to its tenuous financial position, the extensive improvements discussed earlier have been completed. Also, the firm's president indicated that once the mill returns to a level of profitability, additional improvements would be considered.

That at least two of the three Chicago-area minimills interviewed are planning (or have recently completed) major capital improvements indicates that although there may be some perceived disadvantages to operating a minimill in a Chicago region location, there is also a healthy degree of faith in market conditions and in the ability to produce profitably at the existing plants. It is clear that this positive outlook is enhanced by several attributes of these mills' location near the Chicago markets. When asked to indicate the advantages of operating a minimill in their current location, all three mill spokesmen indicated that proximity to markets is the greatest advantage. Other advantages indicated by all of the respondents are good availability of scrap and access to a skilled labor pool. Two of the three also mentioned proximity to good transportation as an important locational advantage.

5.5. Prospects for Retaining and Expanding Capacity in Chicago

As mentioned above, all three minimill presidents interviewed stressed that operating in the Chicago region affords great access to markets. Because most minimill products are relatively low-value, shipping costs for more distant mills to Chicago region customers may
still present some barrier to competing in Chicago markets. However, both the deregulation of trucking and price competition in order to capture market share have undoubtedly shaved Chicago area minimills' locational advantage.

Prospects for Selected Consuming Sectors

The health of both existing and potential new Chicago-area minimills will be tied to the health of those sectors that consume minimill products. As many minis continue to diversify their product lines, they are selling to an increasing variety of capital goods and heavy machinery industries, chiefly construction, construction machinery, and agricultural machinery, sectors whose current difficulties were discussed in the previous chapter.

Although the continued health of some of the major consuming sectors of minimill products is threatened, the Chicago and Midwest markets will continue to be attractive to minimill producers. In the capital goods sectors like farm and construction machinery, for which production is concentrated in the Midwest, macroeconomic forces like the strong dollar, competition from imports and shrinking demand are resulting in restructuring and cutbacks in production. In the long run, however, strong firms in these industries will survive, and they are likely to remain concentrated in the Midwest.

For the construction industry, the largest consuming sector of minimill products, the outlook is good for the medium and long run. Even though the Midwest region accounts for a declining share of certain kinds of new construction nationwide, public construction, funded with revenue from the Federal gasoline tax hike, will rise. The Build Illinois Program, as well as Chicago's recently approved
public works improvement program will provide additional demand for
minimill products as well.

**Competition from the Periphery**

Despite the important locational advantage for a new Chicago
minimill of proximity to markets discussed above, it is impossible to
ignore the fact that the minimill industry is becoming increasingly
cost and price competitive, at least in the more standardized product
lines. The old view, based on location theory, purports that mini-
mills easily maintain regional market monopolies.

But, this theory is oversimplified, failing to capture the recent
trends and developments in the structure of the industry. Some of
these trends include:

1. Rapid growth in the sector is resulting in overcapacity,
especially in low-value product lines.

2. Reduced transportation costs resulting from the deregulation
of truck and rail freight rates are contributing to in-
creased interregional competition.

3. There may be an increased threat from imports of minimill
products above current rates if the dollar remains strong.

4. A more competitive environment is resulting in increases in
price discounting and the use of "innovative" price struc-
tures in to capture market share.

Many of the factors described above are similar to those facing the
steel industry overall, diminishing the special 'shining star' status
which the minimill sector has often been afforded.

But still, many minimills do continue to be profitable, to
expand, and to provide tax revenues and jobs for the communities in
which they are located. In discussing the role a new minimill might
play in Chicago's economic development, then, it will be useful to
take a brief look at the strategies which analysts are predicting and

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advocating for the minimill sector in its increased competitive environment.

Minimill Strategies in a Competitive Environment

One strongly-urged strategy for minimills striving to remain competitive and profitable is to upgrade their product mixes, and particularly to expand into special-quality bars and medium-sized structural (Marcus, 1984). For many mills, then, this means diversifying their product mix, and no longer relying simply on rebar and other low-value products.

A complimentary strategy to product diversification would be seeking market niches. This would entail concentrating on product specialization and filling custom orders. Pursuing a product niche strategy might, however, necessitate trimming the diversity of products in the mix.

Some industry spokespeople, including one of the mill presidents interviewed in Chicago, have suggested that in the longer-run, in order to remain competitive, minimills may move into next-day delivery of structural and other products. This would be modeled on the emergence of just-in-time response for which many integrated producers are increasingly developing the capability, pioneered by agreements worked out between steel and auto producers for same-day delivery of sheet.

In the even longer-run, there is likely to be a radical change in the industry if and when the technologies for casting a thin slab and/or direct reduction of iron ore are perfected. Slab-casting would allow minimills to enter the sheet market and could result in even tougher competition among integrated mills and those minimills which
will be able to adopt the new technology. As was mentioned in Section II however, these developments seem to be several years in the future.

Minimill Strategies in a Competitive Environment: Chicago's Options

Given the increasingly competitive and quickly changing nature of the minimill sector described above, is it feasible or desirable for the City of Chicago to pursue a new and/or refurbished minimill for economic development purposes? Furthermore, if the answer from a policy perspective is affirmative, then what might these mills look like? Clearly, these questions are complex; providing complete answers would require indepth feasibility analyses. However, it will be helpful to outline a few of the general considerations and directions which could be pursued.

Two types of minimill expansion can be envisioned. One is the planning for and recruitment of a leapfrog minimill which would include an experimental component -- either slab casting, or direct reduction of iron ore, or both. Special financing from the federal government, could be sought for this type of mini-pilot plant. It could be tied in with existing steel process research in the region. Chicago would be the best site for this type of facility because it is situated at the heart of steel distribution networks and has some of the nation's best engineering talent in metallurgy located within the area.

A second type would be a minimill concentrating on the higher value-added lines, such as customized rod or bar, special structurals, or flat-rolled products with state-of-the-art technology. To the extent that minimills are moving up into these lines, the advantages to them of locating at the heart of the distribution system become
more attractive, without incurring the disadvantage of a tight regional scrap market. Several partially closed and idled mills in the area could serve as the basis for new start-ups in these market niches. The growing emphasis on just-in-time shipping will enhance the advantages of Chicago sites over those in more remote regions, and can help to offset somewhat higher labor and energy costs. At least one entrepreneur is reportedly seeking a site in either Illinois or Indiana for a pioneering flat-rolling minimill (Collier, 1985).

While the city has a clear interest in attracting investors for a new or refurbished minimill venture, it could also explore an arrangement whereby some equity position were maintained for the city itself, or for steel workers and the city together. In such a case revenue bonds and pension funds might figure into the overall financial package. Other arrangements, such as a worker buyout of an existing facility could be explored as well.

Care must be taken in any city effort that newly engendered minimill production not unfairly handicap the ability of existing minimills and integrated steel mill lines to compete. Only when it is clear that a market need is not being met should a new venture be undertaken. If possible, existing idled plant and labor pools should be targeted for receipt of new minimill expansion. Since Chicago offers special agglomeration advantages, in terms of proximity to both transportation networks and major steel consuming sectors, it should not be necessary for the city or its steelworkers to make concessions which will undermine the resulting tax base and incomes generated from this project.
CHAPTER 6: Future Technologies and Investment Opportunities in Steel

The U.S. steel industry has undergone many severe shocks over the past two decades, but not until the 1980s did it respond by developing several new investment strategies. As we have seen in previous chapters, foremost among the integrated mills' strategies are rationalization of steel production, restrictions on new steel-making investments, centralization of production into the Midwest, and diversification out of steel. All firms have engaged in these four strategies in varying degrees. But while Bethlehem and Wheeling-Pittsburgh, for instance, have continued to invest heavily in new steel production lines, U.S. Steel and LTV are entering product markets unrelated to steel. In contrast, the leading minimills are all following a similar course -- the expansion of their product line through new investments.

This chapter's analysis of specific steel-making investments over the past five years confirms these general observations. Expenditures on the "hot end" of steel production -- coke ovens, blast furnaces and basic oxygen furnaces -- have been very limited, while more remunerative investments such as continuous casters and electrogalvanizing units have been commonplace. It is clear that most integrated companies are concentrating new investment in steel sheet, slowly yielding up billets, bars and rods to the minimills. Production of "heavy" steel goods, such as rail, structural and plate, is slowly being consolidated into a handful of integrated steel facilities.

From an analysis of current trends and promising technologies, three potential patterns of future steel-making investments emerge:
(a) the concentration of integrated mills will continue, as massive plants located in the Midwest become the rule;

(b) technological innovations such as direct reduction will decentralize steel production, and smaller plants will be established across the nation;

(c) steel production by both integrated and minimills will dwindle as imported steel comes to dominate the market.

In this chapter, we use these scenarios to classify emerging steel technologies, according to whether the new processes will promote centralized or decentralized steel production.

These scenarios can help us identify which steel-making technologies could be most beneficial to the Chicago area. Centralized steel production would be ideal for Chicago, as several of the major plants doubtlessly would be located nearby. But if the revolutionary decentralized -- or "leapfrog" -- technologies prove feasible, the U.S. steel industry will change rapidly. The smaller mills will be able to locate anywhere in the nation, and are likely to gravitate to wherever pilot "leapfrog" plants are located.

This analysis suggests that, in the short run, the City should seek to encourage investments which restore the viability of local mills and preserve the jobs of Chicago steelworkers. Steel companies should be urged to renovate blast furnaces and coke ovens, to purchase continuous casters, to continue to invest in facilities for cold-rolling and finishing flat-rolled products, and perhaps to make strategic investments in carefully selected "heavy" steel goods.

When it comes to supporting research, however, the City should be more flexible. The Keyworth Initiative, which primarily will support research of decentralized technologies, should be promoted and a pilot "leapfrog" plant sought for the region. At the same time, promising
centralized technologies should be studied, particularly those where a modest research effort could produce significant results. The City might sponsor several joint research projects involving steel companies, university engineering departments, production workers and steel-utilizing industries. Among the most promising technologies for such a research project are ladle metallurgy, horizontal continuous casting, electrogalvanizing, computer networks and coke production.

6.1 Investment Strategies: Integrated Mills

Industry observers have identified three major strategies that characterize the investments of the integrated steel companies in recent years. Not all receive the same emphasis in every firm, but as will be apparent from the examples in the following section, all steel companies are employing these methods.

Rationalization

The most visible trend in the past five years has been the rationalization of U.S. steel production (See Chapter 4). Steelmakers, finding their control of steel prices vanishing, have energetically strived to cut costs. This has meant the whole or partial closing of many plants, the increased coupling of steel facilities, and mergers of whole steel companies, and agreements to buy foreign steel. The steel industry is becoming through these steps a smaller and much less flexible part of the economy (McManus, 1983d:MP-10, 12).

Integrated steelmakers cut over 12 million tons of raw steel capacity between 1977 and 1981, but their finished product capacity remained almost the same. This seeming paradox is explained by the fact that almost all cuts were of aged, standby mills or excess capacity not needed with more efficient continuous casters (Mueller,
With the 1983 recession, however, steel management cut deeper. As blast furnaces and coke ovens came up for periodic maintenance, they frequently were abandoned.

This is particularly clear in coke production. While U.S. steelmakers' finished steel capacity dropped by ten percent between 1973 and 1983, their coke oven capacity fell by one-half as firms chose not to invest in repairs (McManus, 1984f:59). At other mills, steel corporations are abandoning the "hot end" of steel production entirely, such as at U.S. Steel's South Works and Bethlehem's Lackawanna plant, where the blast furnaces and basic oxygen furnaces have been shut down. Severe rationalization also has taken place in the finishing end of steel production wherever minimills have become dominant. Integrated mills largely have abandoned the production of, for instance, light structural and rebar.

A more positive aspect of rationalization is the increased ties between plants. As operations are phased out, steelmakers have abandoned the goal that each plant be completely integrated. An example is the emerging tie between Armco's Middletown and Ashland plants, separated by 130 miles. To produce a coil of cold-rolled steel, Armco plans to ship coke from Middletown to Ashland, where the steel will be made and cast on a slab caster, then to ship the slabs to Middletown to be rolled on the hot-strip mill before sending them back to Ashland for cold-reduction (Hogan, 1984:49). A more severe plan is U.S. Steel's rationalization of four Pittsburgh area plans into the Mon Valley Works. Each mill, which was fully or partially integrated, is being reduced to a few functions: Edgar Thomson-Duquesne will make steel and roll slabs; Clairton, coke;
Homestead, plate and structural slabs and blooms; and National, seamless pipe. This new configuration involves an immense capacity reduction of 1.57 million tons per year (State of the Industry, 1984:E-2).

Extensive rationalization often accompanies mergers. The LTV/Republic merger of 1984 has enabled the new company to combine and close facilities drastically. In Cleveland, for example, where the company now has two mills across the river from each other, inefficient operations (such as the J & L hot-strip mill) are being shut down (Hogan, 1984:71). The merger will allow LTV to avoid making any major investments in coke and to shut down blast furnace and basic oxygen furnace production at its Aliquippa plant, as it relies instead on Republic's facilities (Hogan, 1984:72).

The most extreme form of rationalization is the increased reliance on foreign sources of semifinished steel. One of the steel industry's major goals in this period of restructuring is never again to be as plagued with the low rates of capacity utilization that occurred during the dark days of 1982. To this end, it is restructuring capacity so that it will run to full capacity during years of average steel demand, particularly in blast furnaces and BOP shops. National, for instance, intentionally has preserved more hot-strip and cold-reduction mill capacity than steel-making capacity at its Great Lakes plant, planning to turn to foreign sources of semifinished steel for the shortfall when needed (Hogan, 1984:54). U.S. Steel proposed to make foreign steel the sole source of steel for its Fairless plant, thereby allowing it to realize the same benefits
as a massive capital improvement campaign with much less expense. But the proposal floundered amidst howls of protest (Tumazos, 1985:A-9).

**Limited Investment**

The traditional investment strategy of U.S. steelmakers has been labeled "massive modernization" by Barnett and Schorsch. Its fundamental tenet -- that improved performance is predicated on sizable investments for large, capital-intensive equipment -- underlay spending decisions through the 1970s (Barnett and Schorsch, 1983:170-71). But with higher interest rates, the debt loads created by this strategy dictated a change in tactics. Steel firms in the 1980s are targeting their spending on technologies that will immediately cut costs and labor, boost quality and provide a high value-added product for which there is strong demand (Mueller, 1984:110-17).

Firms vary, however, in their commitment towards strategic investments. At the low end is U.S. Steel. It repeatedly has dropped out of steel lines when facing minimill competition, such as rod-producing Raritan River and Georgetown Steel (Hogan, 1984:27). It also retreated when other steelmakers were willing to make major financial investments. In 1983, U.S. Steel cancelled its plans for a South Works rail mill, while Wheeling-Pittsburgh and Bethlehem built new lines. U.S. Steel has announced that it no longer will be a "one-stop supermarket." The shelves are becoming bare as product lines fail "return on investment" tests and are dropped (Chandler, 1983:26). But U.S. Steel is likely to be one of the few profitable steel companies in 1985.
Bethlehem Steel represents an intermediate case. It chose to shut rather than modernize an obsolete plant (Lackawanna), and has not replaced the battery of open-hearth furnaces at Sparrows Point (Hogan, 1984:38-39). But without making extraordinarily heavy investments, it has created state-of-the-art plants at Burns Harbor and Sparrows Point as well as fine facilities in smaller plants. It has proved flexible and adaptable -- for instance, boosting the scrap use at the Sparrows Point open-hearth complex to minimize costs -- and has not shrunk from pursuing reinforcing bars (at its Bethlehem plant) despite considerable pressure from minimills ("Steel/Integrated", 1984:73462).

The recent history of Wheeling-Pittsburgh demonstrates the potential and risks of fully committing a steel company to modernization. Among the major investments completed within the past four years were two continuous casters and a rail mill (Hogan, 1984:79). Though well conceived and certainly needed, the awesome debt the company incurred in building them -- and the initially slow demand due to depressed conditions when the equipment went on line -- led Wheeling-Pittsburgh to declare bankruptcy earlier this year (Cuff, 1985c:41). In this case, technological investments were a two-edged sword.

Geographical Centralization

One result of the recent rationalization and limited investment strategies has been a new centralization of steel production in the Midwest, especially in the Chicago area, northern Ohio and Detroit\(^1\) (See Chapter 3). Outside of the East North Central region, minimills are becoming the primary local producers. Some outlying plants were

\(\text{---186---} \)
sold directly to the minimills, such as Armco's sale of its small facility in Sand Springs, Oklahoma (Hogan, 1984:47). This transfer also is taking place indirectly: when Bethlehem shut down its Los Angeles plant in 1982 -- representing 25% of steel-making capacity on the West Coast -- minimills swarmed in to capitalize on the opportunity (Haflich, 1982:10).

A number of compelling reasons are leading steelmakers to make new investments in the Midwest. To begin with, steel-using industries are still concentrated here, and industrial linkages documented in Chapter 3 continue to work. These ties are particularly strong between steel manufacturers and the automotive and appliance industries. Meanwhile, other regions have not fared as well. The major steel companies have largely abandoned the West Coast to imports and minimills. Though manufacturing in the Southeast and West has boomed, most of the products made there use little steel, such as consumer non-durables and aerospace. Finally, the newest and best major American steel mills are located in the Midwest: Bethlehem's Burns Harbor plant, the Inland complex at Indiana Harbor, and U.S. Steel's Gary Works. Steel companies have consistently invested in their better plants, while balking at putting more money into their obsolete mills (Crandall, 1981:145).

6.2 Investment Strategies: Minimills

Minimills today also are in volatile situation, perhaps even more so than the major firms. As Chapter 5 documents, after a decade of spectacular growth, minimills find themselves facing some of the same problems that integrated firms do: over-capacity, major losses and cutthroat competition. The analysts at World Steel Dynamics attribute
much of these problems to overconfident minimills forgetting their original mission -- to remain small, produce a few products of moderate quality, and let the major mills set the tone (Kirsis, 1985:2). Despite arguably having the best technology in the U.S. steel industry, minimills recently have faced rising scrap prices, an inability to cut production costs further, and the approaching saturation of traditional minimill products (Cantor, 1984a:16). Thus, leading minimills have feverishly been exploring new strategies to lift themselves from their current doldrums.

**New Products**

Many analysts believe the only minimills that will escape the cyclic depressions are those which emphasize developing new products. Those minimills that have resisted changing their product mix -- as local Northwestern Steel and Wire until recently -- have lost market share steadily ("Steel/Specialty", 1984:75782). The three most promising such product lines are alloy bar, plate and, more distantly, continuously cast sheet (See Chapter 5).

Minimills dominate rebar and merchant bar production, and they are actively investing in capacity to produce alloy bar. Leading the way is Quandex, which has just opened a new alloy and special-quality bar mill (Weimer, 1985a:50B1). Chaparral Steel is an innovator here as well, having just installed a horizontal continuous caster to make billets for high-quality bars. Other minimills are likely to emulate them if these efforts prove successful.

Several minimills also have branched out into plate production recently, though they have been publicized little. The new Tuscaloosa Steel plant will have a 112"-wide coiled plate mill. Another $165
million plate mill is planned in Cleveland, to be run by management

group with little steel experience (McManus, 1985e:37).

In sheet, on the other hand, the major obstacle is technological:
how to cast steel slabs thin enough so that they do not need to be
re-rolled in an expensive rolling mill. Nucor is leading the effort,
aiming to continuously cast slabs 1-1/2" thick or less within the next
three to five years. These slabs then would be re-rolled into low-
quality sheet products such as pails, drums and siding. After several
years of production, the company may consider tackling the production
of high-quality automotive sheet (McManus, 1985e:30, 35).

New Plant Additions

Very few minimills are trying to survive the anticipated minimill
shakeout by expanding. Investing in new plants in the Southeast,
Southwest and on the Pacific Coast -- once the most popular approach
-- now has gone into eclipse. The troubles that Nucor has had in
penetrating the West Coast market with its state-of-the-art Plymouth,
Utah plant have not been lost on minimill operators (Lautenschlager,
1985b). Many minimill operators are encountering difficulties
obtaining financing for expansions (Acs, 1984:8). Though some old
mills still are being bought and rehabilitated, gaining entry through
new plants into additional markets is not likely to be viable strategy
because the markets are saturated.

6.3 Analysis of Recent U.S. Steel-making Investments

Having delineated the major investment strategies of the current
period, we turn now to examine spending in 12 distinct stages of
steel-making. This analysis illustrates in greater detail the
patterns just sketched and suggests critical areas for future steel
investment. We reviewed every major project of the integrated firms from 1980 to 1985, of three innovative and/or local minimills (Nucor, Northwestern Steel and Wire, and Continental Steel), and of selected small steel companies when it is ground-breaking work (See Appendix for complete listing).  

Total Capital Expenditures, 1967-82

Steel investment has fallen dramatically since 1968. By 1982 it amounted to a mere 38.5% of 1968 investment in real terms (Table 6.1). The Census also provides a state-by-state investment breakdown every five years. The important shifts in where new steel investments are being made, however, are obscured by the inclusion of pollution and maintenance expenses (Table 6.2).

Coke Ovens

The early 1980s saw few efforts to rebuild coke ovens across the nation. Firms have eschewed spending the $200 million that a new battery costs. Instead, they buy coke from foreign steelmakers or U.S. merchant coke distributors (McManus, 1984:65). Many of the coke batteries still operating -- including some built within the past decade -- need urgent repairs but are likely to be shut instead. The Environmental Protection Agency’s recent crackdown on coke emissions is likely to ensure that little future investment will take place (Thompson, 1985:19-3).

Blast Furnaces

There has been some relining and rebuilding of blast furnaces at most major U.S. mills. As a typical four-blast furnace steel mill comes up for repair, steel companies typically have tended to reline two of them, close one, and reduce another to a standby facility. These shutdowns are explained by the high cost of blast furnace...
Table 6.1 Investments in Blast Furnaces and Steel Mills, SIC 3312, 1967-82

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</tr>
<tr>
<td>1977</td>
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<td>930.1</td>
</tr>
<tr>
<td>1976</td>
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<tr>
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<td>1972</td>
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<td>748.6</td>
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<td>1971</td>
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<tr>
<td>1968</td>
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<td>1967</td>
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</tr>
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Table 6.2 Investment in Blast Furnaces and Steel Mills by State, 1967-1982

<table>
<thead>
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<td>(D)</td>
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<td>1661.0</td>
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relines, as well as by the declining demand for domestic steel. Inland built the only new blast furnace in recent years, and despite its state-of-the-art technology, it reportedly is not very profitable. Plans by Armco and U.S. Steel to build major new furnaces were cancelled. This moderate level of investment is likely to continue.

**Basic Oxygen Process**

There have been no new investments in basic oxygen furnaces since 1980. This lack of spending reflects steelmakers' general reluctance to invest in the "hot end" of steel-making -- coke ovens, blast furnaces and basic oxygen furnaces -- and the substantial overcapacity here. There are still many obsolete basic oxygen furnaces needing rebuilding and open-hearth furnaces needing conversion, but these units are being retained in their present condition, shut down or converted into electric furnace complexes.

**Electric Arc Furnaces**

There has been a great deal of interest in new electric furnace technology by both integrated and small steelmakers. The integrated steelmakers have recently reconfigured a few major mills as minimills. These new plants, such as Bethlehem's Johnstown bar, rod and wire division, are comparable to minimills in technology, pricing and pay scale (Cuff, 1985a). Several integrated firms also are observing the minimills' new investments with considerable interest. Probably the most significant new furnace is the Energy Optimizing Furnace at Connecticut Steel, which produces steel from only scrap, coal and oxygen (Roth, 1985).

**Continuous Casting**

Continuous casters have absorbed most of the funds devoted to new steel-making equipment across the nation over the last five years. As
might be expected, it is also the steel-making technology with the highest return on investment (Long, 1981:49). The percentage of steel continuously cast at U.S. mills still lags behind foreign producers considerably (in 1983: U.S. - 35.1%; E.C. - 65.0%; Japan - 87.4%) (Steel Panel, 1985:29). Minimills continue to excel in continuous casting, with many small mills now totally continuous cast. Several minimills are doing innovative work with casters, especially Chaparral's investigation into horizontal casting.

Sheet and Strip

Very little investment has taken place in the integrated steel industry's hot- and cold-strip mills. This does not reflect an abandonment of flat-rolled products -- on the contrary, they are the brightest spots in the U.S. steel industry today -- but merely the recent vintage and condition of most of these mills. However, Inland's proposed continuous cold-rolling strip mill would represent a great leap forward for the industry (McManus, 1985a:35). This line would use Nippon Steel technology to combine pickling, tandem and temper mill rolling, annealing and automatic inspection into one process, cutting production time from twelve days to one (Labee and Samways, 1985:D-18-19; Strahler, 1985:61).

Billets, Bars, Rod and Wire

Today this cluster of products is dominated by the minimills. The integrated firms have closed most of their merchant bar, rod, wire and billet mills within the past few years. Quality bar remains the only area within this category that they dominate, and even here little has been invested. On the other hand, the minimills have been sinking large sums into upgrading the quality and production of their
bar and rod mills. One of the best is Quandex's special quality and alloy bar mill in Fort Smith, Arkansas (Weimer, 1985a).

**Rail, Structural and Plate**

The "heavy" steel goods remain dominated by a few integrated steel companies. The majority of integrated steel companies have concentrated on flat-rolled products and have shown no hesitancy about paring away inefficient structural and plate facilities. U.S. Steel and Bethlehem, traditionally the two biggest producers of these goods, have taken different tacks here. U.S. Steel mercilessly has trimmed at plate and light structural production, eliminated rail-making, and only shown enthusiasm about acquiring capacity in tubular and flat-rolled products. On the other hand, Bethlehem has invested heavily in rail, structurals, and plate, particularly in its East Coast plants.

**Tubular Products**

The boom in oil exploration during the 1970s (and the hysterical buying of seamless tube at inflated prices that accompanied it) led many steel makers to boost their production of seamless tube. In 1982, by which time most of these mills were well on the way to completion, the oil glut led to a collapse of seamless demand. Particularly hurt were Armco, which took an immense write-off, and LTV, whose Campbell plant (Youngstown), though state-of-the-art, is running today at a very low rate.

**Heat Treating and Annealing**

As we have seen, very little has been spent on upgrading hot-or cold-strip rolling mills. However, new techniques of finishing strip, especially for the automobile industry, have attracted considerable attention. Continuous annealing lines, which two Chicago-area mills
have installed, are one manifestation of this interest. The limited
demand for annealed steel (about equal to current capacity) and high
cost of these lines forestalled any general move by steelmakers to
install such capacity. Nonetheless, it is worth noting that in Japan
during the mid-1970s, demand from many manufacturers for high-strength
steel skyrocketed after two manufacturers installed continuous
annealing lines to serve the auto industry (McManus, 1983a).

**Galvanizing and Other Coatings**

Galvanizing, particularly electrolytic, has been the other way to
improve finishing of sheet for the auto industry. While a fair amount
was spent on hot-dip systems (incorporating various innovations)
through 1983, 1984 saw a giant boom in electrogalvanizing. Pressed by
automakers to become major suppliers by 1986, steelmakers responded
with massive investments to build huge lines (McManus, 1984b:57).
These lines all were located near the Detroit area. Even Inland
forsook investing in its Indiana Harbor plant for a joint venture with
Bethlehem near Toledo. Three of these lines -- at LTV, National and
Wheeling-Pittsburgh -- are being built with Japanese technical and
financial assistance.

**Research and Development**

The steel industry has been extremely unaggressive in researching
new technologies (Table 6.3). Data for 1983-84 demonstrate the extent
to which steel lags behind other industries, even mature ones. Out
of the 32 sectors examined, only tobacco spends less for R & D as a
percentage of sales, and only tobacco and textiles/apparel are lower
in R & D spending per employee. Many industries -- including
automobile, farm/construction equipment and machine tools/industrial
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Table 6.3  Research and Development Spending by Major Steel Corporations (continued)

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<td>175.5</td>
<td>0.6</td>
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<td>1982-83</td>
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<td>1981-82</td>
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<tr>
<td>1980-81</td>
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<tr>
<td>1979-80</td>
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<td>1978-79</td>
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<td>1977-78</td>
<td>137.4</td>
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<tr>
<td>1976-77</td>
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<tr>
<td>1975-76</td>
<td>105.9</td>
<td>0.6</td>
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machinery -- spend five times as much on R & D, when measured as a share of sales; and unlike many other sectors, only in the last few years have steel companies begun to do cooperative research.

6.4 Future Scenarios for a Steel Industry Investment

We have now seen the major strategies afoot today in the steel industry and gauged their impact on investments in particular technologies. Our next objective is to anticipate investments over the next decade in the steel industry and to attempt to identify the key technologies where investments and research by Chicago-area mills should be encouraged.

First, we will present several alternative scenarios for iron and steel investment in the next decade, for technological considerations must fit into the overall market strategy. The recently completed National Academy of Engineering study of steel industry competitiveness (Steel Panel, 1985:121-22) determined that three factors would be crucial in shaping the industry over the next decade:

- the rate of economic growth
- the relative strength of the dollar
- the degree of protection from exports in the U.S. economy

We would add four factors to this list:

- the future of environmental regulations
- the role the U.S. chooses to play in international trade and development
- the federal budget mix between military and non-military items
- the availability of capital

We have identified three alternative patterns into which steel investment, shaped by these factors, could conform. These scenarios are not intended to be exhaustive but to provoke thought. To a considerable extent, the future of steel will depend on federal
government actions in the budgetary, tax, research, regulatory and international arenas, issues that are addressed in Chapter 8.

Centralized, Large Scale Steel

The first model suggests that steel production will continue to be rationalized and steadily become more geographically concentrated. A recent survey of steel-related firms by Metal Progress found a consensus of companies believes that very large, modern, "Japanese-type" steel plants will become the rule. Such production doubtless would be concentrated in the Midwest, maximizing employment here. Most metal producers and suppliers felt that, in all likelihood, mergers will reduce the ranks of integrated firms to three or four companies with a handful of massive "four million ton/year plus" plants. Minimills, limited by technological and market forces, will provide basically only the same product lines as today through the 1990s. Scrap shortages, limited access to capital, and technical difficulties in casting steel sheet all will combine to keep steel minimills small (Chandler, 1984:31, 48).

Decentralized, Smaller Scale Steel

A second vision that is emerging from recent trade magazines is of a dramatically changed steel industry. Instead of being comprised of massive, inflexible plants producing four million tons or more, with a scattering of minimills on the periphery, the U.S. steel industry will be driven by technology to decentralize. Minimills and integrated producers will grow closer together (Szekely, 1983:51).

These speculations suggest that far more flexible, yet very efficient, mills will spring up, producing between .5 and 2 million tons per year. Two separate forces will be at work here. To begin
with, minimills (and plants spun off by major producers to ESOPs) will expand their product lines to include special quality bars, plate and even sheet. As a result, these firms will become larger, with a more diversified product line (Hogan, 1984:112-13).

On the other hand, according to this model, integrated mills will become smaller and more flexible. Crucial to this transformation will be a move away from traditional steel-making (McManus, 1985c:90). Coke ovens, blast furnaces and basic oxygen furnaces all will be rendered increasingly unnecessary as new direct reduction technologies emerge. Several steel industry observers believe that such a revolution is imminent and that most efficient production will soon take place below 2 million tons per year (McManus, 1985h). Certainly integrated steelmakers would welcome a new technology to replace their costly and demanding coke ovens and blast furnaces.

If such a new technology were to become prominent, there likely would be considerable flux in the location of steel mills. The current trend towards concentration of steel production in the region likely would be reversed, as smaller facilities requiring less investment spread out, to be close to markets or to the sources of coal or ore.

Declining Steel

A third vision of the steel industry's future is discussed less often in the trade magazines, but is nonetheless an all-too-real possibility. This envisions the steel industry declining rapidly, faster than steel demand (McManus, 1983d:MP-10, 12). Manufacturers will confine themselves to the most profitable lines, rolling sheet from imported semi-finished steel slabs in highly automated plants.
If steel firms decide to liquidate all but the most profitable mills and devote most of their investments to outside the industry, it is unlikely that minimills will be able to take up the slack. Periodic steel shortages will occur and a broad-based dependency on imports will be the rule. Employment in steelmaking would dwindle drastically.

6.5 Future Technologies: A Summary

The Office of Technology Assessment reviewed emerging steel technologies in the late 1970s (U.S. OTA, 1980:Chapter 6). Several efforts have been made to update this work and identify crucial technologies for steel-making during the next decade (Chandler, 1984; Long, 1981; State of the Industry, 1984; Steel Panel, 1985; Szekely, 1983). Analysts generally agree on which technologies steelmakers must invest in immediately, if they have not done so already. New basic oxygen furnaces, continuous casters, ladle metallurgical stations, computer controls for blast furnaces and other steel-making operations are thought to be essential for all integrated mills. Any mill that does not invest in these technologies is condemned to be uneconomical.

Centralizing Technologies

As for the technologies that will emerge in the next decade, they can be divided into those that tend to lead to geographic centralization of the steel industry, those that will advance the geographic decentralization of steel-making, and those that appear to be neutral. Both new coke-making technologies and electrogalvanizing should advance centralization.
Over the past decades, several new ways have been developed to make and utilize coke more efficiently that will increase yield and limit pollution. Preheating coke is the only such method being used at all in the U.S. Promising formcoke technologies are attracting little interest today because of the steel companies' capital crunch and reduced federal energy research (McManus, 1985c:90).

Electrogalvanizing technologies had been experimented with by steelmakers for many years, but they scaled up their latest designs in a hurry when urged to begin production by the automakers. Bethlehem and Inland pooled their knowledge and capital to build a joint line, as did Rouge and U.S. Steel. The only progressing research venture in electrogalvanizing is National's experimental line at Portage, but it is proceeding with the production of a major line anyway at its Great Lakes plant (McManus and Berry, 1985:83).

Decentralizing Technologies

Technologies that will change the nature of steel-making radically are attracting more interest today. These technologies tend to combine a number of intermediate operations into a single step and replace batch operations with continuous ones. Among the most significant research frontiers today are direct reduction and the continuous casting of sheet.

Direct reduction technologies render furnaces superfluous by combining ore, coal and oxygen in a single vessel and producing steel in one step, reducing capital costs for steelmakers by up to 50%. Three very significant research projects that could have a major impact in this area are under way today: the "Keyworth Initiative" (a joint research effort by the Argonne and Oak Ridge National
Laboratories, the National Bureau of Standards, and the American Iron and Steel Institute); a pilot test in West Germany of the KR direct reduction process developed by Korf Engineering (AISI-sponsored); and Korf's small energy-optimizing furnace (a new technology developed by the Group in Brazil using only scrap, oxygen and coal), now in use at Wallingford, Connecticut (Argonne, 1984:2; McManus, 1985; Roth, 1985; Yafie, 1984).

Four major research efforts to cast thin slabs or sheet are under way: a $30 million Department of Energy (DOE) funded joint venture by U.S. Steel and Bethlehem Steel to continuously cast 1"-thick slab by 1989; another DOE-sponsored project by Armco and Westinghouse ($2.6 million) to directly cast 0.125" sheet; Nucor's $20 million attempt to cast 1.5" slabs; and an investigation of advanced casting technologies in the Keyworth Initiative research (Argonne, 1984:2; McManus, 1985e:30, 35; "Westinghouse", 1985).

Neutral Technologies

There are also a number of new technologies that should benefit integrated and minimills equally and which should be valuable whatever new shape the steel industry takes. Industry analysts have identified the most important of these as being automatic inspection, rapid in-process analysis, computer control, ladle metallurgy, horizontal continuous casting, and new steels.

The automatic 100% inspection of steel products is a major desire of all steel companies as they seek to boost quality. Two major investigations of optical and electronic scanning are under way today. The AISI has initiated — as well as six steel and three aluminum companies and Westinghouse — an investigation into how to detect and
control surface defects in strip during cold-rolling. Seven steel firms, as well as controlmakers Magnasonics and Magnaflux, are involved in a related project, sponsored by the National Bureau of Standards, to detect porosity automatically in pipe, billets, blooms and slabs (State of the Industry, 1984:Sect. 0, pp. 6-7).

The rapid analysis of liquid metals is a similar attempt to give steelmakers greater control over production. The Department of Energy is sponsoring such an investigation at Los Alamos, which includes 13 steel companies and 2 aluminum producers (State of the Industry, 1984:Sect. 0, p.6).

Computer control of blast furnaces, rolling mills, continuous casters and many other operations is an important technology of interest to every steel company. With encouragement from the Association of Iron and Steel Engineers, integrated firms have pressed forward with applying these technologies (McManus, 1983c:MF-10). Automation and instrumentation will be the focus of a small joint research effort as part of the Keyworth Initiative (Dwight Diercks, personal communication).

Ladle metallurgical techniques that treat steel just before it is cast have been around for a long time. They only recently have been seen as an integrated package rather than an aggregate of many different techniques. U.S. steel companies have been peculiarly reluctant to enter into joint research ventures with domestic manufacturers of ladle metallurgical equipment, preferring to license or purchase complete ladle metallurgical systems from foreign steelmakers (McManus, 1984d:38). Some research is being completed by U.S. suppliers, but several important new ladle metallurgical
technologies have not yet widely diffused among U.S. steelmakers (Chandler, 1984:33, 41).

Horizontal continuous casting is a new technology whose ultimate impact is still unclear. It involves casting steel in a plane rather than employing the arc mold traditionally used in continuous casters. In this way, higher quality, stress-free steel is produced, but it is unclear whether it will be economical to produce carbon steel (as opposed to higher valued specialty steels) through this method. Early investigations were pioneered by General Motors, but today Armco, Chaparral Steel and a few smaller firms are leading the way in applying these casters (McManus, 1985b).

The application of new steels and composites to a variety of industrial uses is another promising frontier, for only by winning back niches from plastics and ceramics will the gradual decline in steel intensity be affected. However, the new steels developed recently all have been proprietary products. Competition between firms to develop innovative steels seems to be intensifying. It seems a joint research effort in this area only would lead to competition and discord.

6.6 Implications for the Chicago Area

We sketched above three alternative futures for the U.S. steel industry: one characterized by a Midwestern concentration of a few massive plants, one a decentralized pattern of smaller, more flexible mills, and one of generalized decline. We also have seen how promising technologies can be divided up according to whether they will tend to lead to a centralized or decentralized steel industry or are neutral.
We now must turn to the concrete questions. Which technologies should the City of Chicago encourage local steelmakers to purchase and research? Should the City encourage centralizing or decentralizing technologies? If a few dominant, large-scale mills emerge, they would centralize steel-making employment in the region and stabilize the local community of metalworking industries. But if the revolutionary decentralized -- or "leap-frog" -- technologies now being developed prove economically feasible, the steel industry's shape may change very rapidly. Steel mills would grow more mobile as smaller plants without coke ovens, blast furnaces and basic oxygen furnaces are adopted. Where these new plants would locate is still unclear, but it is suggestive that the first U.S. commercial-scale test of the KR process is planned for U.S. Steel's Mintac, Minnesota ore plant (Lautenschlager, 1985a). In all probability, later "leapfrog" mills would gravitate around wherever the first pilot plants are established. Thus, encouraging research in decentralized technologies may help preserve Chicago's steel industry even if the underlying technology changes rapidly, for adopting these "leap-frog" technologies may be the only course that allows the U.S. steel industry to remain competitive without cutting wages.

**Needed Investments for Chicago Mills**

While considering which equipment to encourage steelmakers to buy in the near future, all thoughts of "leap-frog" technologies must be banished. The City's short-term goal must be to preserve the viability of Chicago-area plants and the jobs of those who work there. No energy-optimizing furnaces or pilot direct reduction facilities will do this -- only updated versions of proven technologies. The
steel companies must be encouraged to invest in equipment that will be economically sound and quality improving.

First, investments should be encouraged to prevent shutdown of raw steel-making capability. Wherever possible, the wholesale closure of coke ovens, blast furnaces and basic oxygen units should be avoided. Mills in Chicago itself are in good shape in this regard, but LTV's Indiana Harbor plant poses a problem. LTV has shut down entirely its two coke plants, and some industry observers suggest LTV plans to shut down the plant's blast furnaces and basic oxygen steel-making facilities (DuBois, 1985a). Interlake also may resist making major investments in relining blast furnaces and soon turn to the purchasing of semi-finished slabs (Tumazos, 1985:A-4).

Installation of continuous casters should also be encouraged. The critical plant in this regard is LTV's South Chicago plant, which can produce bars, seamless pipe and rods, yet does not have a billet caster. As we have seen above, the major new seamless pipe mills built by U.S. Steel at Fairfield and LTV at Campbell are fed by casters, as are Inland's world-class 12" bar mill at Indiana Harbor and most minimills' bar and rod mills (AISI, 1984). Not to purchase a caster would be tantamount to closing the plant.

Wherever possible, continued investments in cold-rolling and finishing of flat-rolled products should be encouraged. Sheet and strip traditionally has been the Chicago region's most competitive steel, and it certainly is the healthiest product today. While there appears to be a sufficiency of hot-strip mill capacity today to supply the automotive and appliance industries, there has been a wide variety of innovations in the cold-rolling and finishing of flat-rolled
products (McManus, 1985a:35). More specifically, several real opportunities exist: (a) National should be encouraged to continue to operate its experimental electrogalvanizing line at its Midwest Steel Division; (b) National should also be encouraged to consider installing a continuous annealing line at its Midwest Steel Division; and (c) Inland should be urged to build its proposed continuous cold-rolling mill at Indiana Harbor or elsewhere in the Chicago area (Goozner, 1985).

Producers of "heavy" steel goods perhaps should be urged to make strategic investments in carefully selected product lines. The two Chicago plants producing primarily "heavy" steel products -- U.S. Steel's South Works and LTV's South Chicago plant -- are deeply troubled. Major modernizations of these facilities should not be encouraged until a market study of capacity and demand for "heavy" steel goods is competed (Hogan, 1984:132-34). It may be very difficult to discover a niche in seamless tube, rod or bar for the LTV plant, even after major investments. However, this is not to say that there is no hope for these plants; for instance, the proposed South Works rail mill may be deserving of full support.

Suggested Research for City Sponsorship

When we turn to considering where the City should cultivate research, we again are faced with the question of centralized versus decentralized technology. The City should continue to support the Keyworth Initiative and push for the creation of a pilot plant in the region. At the same time, research should be encouraged into other promising steel-making technologies. We propose that the following criteria should guide the selection of other areas to be researched:
(1) The finished product should be supplied to an important Chicago-area industry.

(2) It should be economically feasible to test each innovation on a bench-lab scale suitable for a research center.

(3) There should not be under way any major government-sponsored or joint research project investigating the same technology.

(4) As there seems to be a dearth of research under way on centralized technologies, topics to be sponsored by the City should either promote centralized steel-making or else be neutral.

(5) Preference should be given to projects that promise to expand employment opportunities as well as output.

It must be emphasized that this effort will require the cooperation of both the steel industry and academic laboratories and the knowledge of both those within engineering departments and those experienced with the workings on the plant floor.

Ladle Metallurgy

A technology meeting these criteria very well is ladle metallurgy. There is a bewildering variety of processes in ladle metallurgy, but they can be divided into three distinct stages: (a) primary conditioning, in which the molten steel is emptied from the furnace into an (often preheated) ladle and various alloys are mixed in; (b) secondary conditioning, when such techniques as vacuum arc degassing, vacuum oxygen decarbonization and argon stirring are used to purify the molten metal of impurities such as sulfur, oxygen, phosphorus, oxygen and hydrogen; and (c) casting operations, where the steel is transferred to a continuous caster, frequently under near-vacuum conditions (Guthrie, 1982:43-44).
The primary advantage of ladle metallurgy is that it produces far cleaner and stronger steel. For instance, in steel forgings it can prevent catastrophic failures due to impurity embrittlement. While at first used only for high-quality steels, the technologies now are starting to be employed in making many other steels as well. For example, Inland first employed argon stirring in its #4 BOP shop in the early 1970s, then a few years ago expanded its use to the #1 electric furnace shop. Now it is installing two more advanced ladle metallurgy stations in its #2 BOP shop, incorporating such state-of-the-art technologies as arc heating, argon stirring and macro- and microalloying (McManus, 1984d:31, 33; Labee, 1985:D-3). Less sophisticated units have been installed as well at Bethlehem's Burns Harbor facility, the J & L Indiana Harbor plant, and U.S. Steel's Gary Works. Minimills also have been coupling ladle metallurgical units to their continuous casters.

Ladle metallurgy presents an ideal opportunity for the City of Chicago to sponsor a research project. The relative merits of alternative ladle metallurgy technologies have not been compared adequately, nor have many relatively straightforward improvements been made, especially in the primary conditioning of molten steel (Guthrie, 1982:44). Another compelling reason for such a research project is that one of the world's leading designers of ladle metallurgy systems, A. Finkl and Sons, is located in Chicago, though it has had a hard time selling them to U.S. firms (McManus, 1984d:38). Thirdly, ladle metallurgy shops are quite cheap (frequently under $10 million), and a successful research project could be done for relatively little (McManus, 1984d:31).
Finally, the Japanese are pushing the bounds of ladle metallurgy far beyond the conceptions of American steelmakers. They envision that basic oxygen furnaces only will produce one kind of steel, which then will be modified in the ladle (McManus, 1982:MP-11). This concept is particularly relevant to the Chicago steelmakers. If the predictions of the centralized model are correct, American steelmakers soon will be building, and perhaps sharing, massive blast furnaces to make uniform batches of steel (McManus, 1985f:84). Sophisticated ladle metallurgy then would be used to tailor the molten steel to each product line's particular needs.

Electrogalvanizing

Much of the steel sheet produced in the U.S. during the past few decades has been strengthened by being hot-dip galvanized. The steel is lowered into a hot zinc bath, and the zinc atoms link with the iron, creating a thick surface coating. However, this coating generally is marred by rough spangles that resist a smooth coat of paint. As a result, very little galvanized steel traditionally has been used by two of the biggest consumers of steel sheet and strip: auto and appliance manufacturers (Hoetzl, 1985:31). But in the 1970s, Japanese automakers began employing electrogalvanized steel, in which the zinc coating is placed on the steel electrolytically. Not only does the new method produce a smooth, thin coat that can be painted easily, but the coated steel has not been heated and thus retained all of its ductility ("Galvanized Steel", 1983:74) This is a technology, to be sure, geared for use at centralized major mills.

As American automakers strove to attain technological parity with the Japanese, they pushed U.S. steelmakers to create
electrogalvanizing lines themselves. The current rush to add capacity began at a December 1983 meeting that General Motors called for its steel suppliers, where the company revealed that it intended to begin using electrogalvanized steel widely in its 1987 model cars (McManus, 1984b:57). As a result, five major projects were announced within a matter of months.

Though these ventures will produce close to four million tons of electrogalvanized steel a year, a capacity shortage still may exist after they come on line. Demand for this steel is growing exponentially: in 1983, all galvanized steel used in the average American car totaled 180 lbs., while in 1988 there will be more than 300 lbs. of electrogalvanized steel alone (Wrigley, 1984; Meyer, 1984:10). As a result, automakers are buying more of this steel from abroad, such as Ford's recent purchases from Nippon Steel, Nippon Kokan, Kawasaki and Sumitomo (McManus and Berry, 1985:30).

The Chicago region has been neglected in this rush to build electrogalvanizing capacity. Mindful of the Big Three's adoption of just-in-time production, steelmakers have put their electrogalvanizing lines at existing or new plants close to Detroit. The only such facilities in the Chicago area are Bethlehem's new Burns Harbor line, significantly smaller than the other major lines (Labee and Samways, 1985:D-20). The status of National's prototype testing facility at Midwest Steel at Portage is uncertain due to the firm's decision to install a major line at its Great Lakes Division (McManus, 1984b:57); and the 54" strip line installed in 1982 by a local metal processor, Chicago Finished Metals, is to serve only the local appliance and hardware markets (Scott Seaburt, personal communication). As
Northwestern Indiana traditionally has been a major strip supplier to the auto and appliance industries, the paucity of electrogalvanizing construction here is most disturbing.

The appropriate strategic response must capitalize on this very lack of electrogalvanizing investment in Chicago. While steelmakers are pouring billions into these lines, the technology of electrogalvanizing continues to change rapidly. For instance, a joint venture by Nippon Steel and Toyota recently has developed the revolutionary approach of placing several very thin coats on a steel plate, some pure zinc and other zinc-iron mixtures. ("Galvanized Steel", 1983:74). In addition, Nissan will begin coating steel strip electrolytically with a zinc-nickel layer, then apply a zinc-rich paint (McManus and Berry, 1985:32). Furthermore, according to some analysts, the cost of electrogalvanized steel on the lines currently under construction will exceed Detroit's target price considerably (McManus, 1984a:56).

In view of these considerations, a better approach for U.S. steelmakers might be to build a low-cost flexible line today, waiting until the technology stabilizes to make a major investment. In fact this was Republic's plan, but when LTV took over, it chose to purchase a major line from a Japanese manufacturer (Markusen, 1985c). If a group of local metal finishers and galvanizers, and perhaps the few local steel producers that have not invested in lines elsewhere, were to join together to research new technologies in this field, they could enjoy significant competitive advantages a few years hence. An experimental line of about 100,000-ton annual capacity to test these
techniques could be built for about $25 million (Labee and Samways, 1985:20-24).

A related research project that might generate significant results would test recent breakthroughs in traditional hot-dip galvanizing. The most promising such new technology is mini-spangling, which first passes the steel coated with hot liquid zinc through a nitrogen atmosphere and then through a steam mist (Hoetzl, 1985:31-33). In this way, the surface remains uncontaminated by oxides, and many small spangles form a smooth surface easy to paint. A few lines in the U.S. use this technique, but there is considerable room for refinement. This is hardly the first instance where a mature technology, when challenged by a new process that would replace it, experiences a sudden flurry of innovations itself.

**Computer Control**

Enhanced computer control of iron and steel-making is another attractive technology for a research project. It is true that computers have been used for some time in the production of steel. Their impact has been most dramatic on blast furnaces. For instance, blast furnace #13 at Gary Works ran so poorly that in 1979 U.S. Steel had to rebuild it, with a Japanese-designed computer system, after only five years of operation. To prevent future failures, computers monitor and control such crucial variables as burden surface and vertical pressure distribution (McManus et al, 1984:34). The best recent furnaces, such as Mannesmann's Huckingen Furnace B and Bethlehem's Sparrows Point L Furnace, also have incorporated extensive controls (Samways and Poole, 1983:33; McManus, 1981b:MP-8).
Computers today are being used at many other points in the steel-making process. Among the most innovative applications are as follows:

- Bethlehem and Canada's Dofasco have led in utilizing the computer to monitor and adjust the making of steel in basic oxygen furnaces (McManus, 1981a).

- The Canadian Algoma Steel and Bethlehem, among others, have aggressively incorporated computer monitoring and data analysis into their continuous casters (Bennett and Weimer, 1984:57; Dupuis, 1982).

- Inland has computerized its #4 slab rolling mill at Indiana Harbor with most satisfactory results (McManus, 1983:MP-14).

- A consortium of steel companies is investigating computer inspection of several finished products (State of the Industry, 1984:Sect. 0, pp.6-7).

The most promising frontier for computer control is the establishment of linkages between different steel-making operations. Computer networks are an extremely topical issue, recently discussed by a panel at a meeting of the International Iron and Steel Institute (McManus, 1984e:57). The leader here is unquestionably Nippon Kokan, whose Keihin Works has a truly staggering hierarchical network to coordinate steel-making operations, gather information, and facilitate management planning (McManus, 1984e:58, 60). Domestic leaders in these technologies include Armco, which has created a tight network in its Middletown plant, and U.S. Steel, which has developed such control at its Texas Works and its Fairfield pipe mill (Besselievre et al, 1982; McManus, 1983c:MP-14; McManus, 1984e:60).

Computer networks are certainly worthy of a City of Chicago-sponsored research program. To begin with, the technology is extremely relevant. These linkages facilitate management planning, particularly important in an era of "just-in-time" production. It
represents a substantive response to customer demands for better quality, and these networks are a way to increase productivity without making massive expenditures. An equally important factor is the ease with which such a research program could be arranged. Unlike many other steel-making technologies, it is possible to research electronic networks meaningfully under bench-lab conditions. Finally, a facility that already has investigated computer control of steel-making and might be a useful partner -- the Purdue Laboratory for Applied Industrial Control -- is in the Chicago area (McManus, 1983c:MP-9-10).

**Horizontal Continuous Casting**

Another technology -- not yet widely diffused but potentially important -- is horizontal continuous casting. Its principle is simple: while most continuous casters rely on gravity's pull to get the molten steel in the mold, then gradually bend the hot metal until it straightens, here the steel simply is forced into a horizontal mold. Efforts to put such a caster into practice failed from the mid-nineteenth century until about 1965, though similar horizontal continuous casting systems for pig iron and non-ferrous alloys succeeded. One of the biggest problems was how to withdraw the steel smoothly from the mold, for which the ultimate solution was having the steel strand oscillate in a start-stop manner (Haissig, 1984:65).

The first industrial use of horizontal continuous casting was at General Motors' Lansing, Michigan Oldsmobile factory to cast billets in 1971. While production here was subsequently halted, GM solved many of the technical difficulties outlined above and licensed them to Technica-Guss, Mannesmann Demag, and several other firms. But diffusion of this technology in the U.S. lagged behind its adoption in
other steel-making nations. Only a handful of very small horizontal casters were installed, and these were for the production of specialized batches of superalloys (McManus, 1985b:30, 32).

The first horizontal continuous caster in regular production at a U.S. steel plant was not installed until 1984, at Armco's Baltimore Works. It will cast 50,000 tons of stainless steel a year once fully operational and has proved successful to date (Zalner and Taylor, 1985:44). Since then, Chaparral Steel also has installed a horizontal caster, a single-strand machine to make small billets out of carbon steel. Chaparral is discovering that horizontal machines produce higher quality billets than conventional continuous casters, for it is very hard to keep a conventional billet caster free from impurities (McManus, 1985b:30).

While foreign companies dominate the manufacturing of these casters, Chicago's steel industry should begin to explore the use of these casters in large-scale production. The cracks and bulging due to bending and straightening high-quality steel in a conventional caster can be a serious liability, and these are almost completely avoided in horizontal casters, especially in small sections (Schrewe, 1981:90). Such small, high-quality sections are the basis of many products that are most important to the Chicago economy, including machine tools, steel forgings and fabricated metal products. To allow the Germans, Soviets and Japanese to outstrip us in the use of horizontal continuous casters will give their machine tool and metal fabricating industries a great competitive advantage. Yet aside from some work by Armco, Chaparral and Steel Casting Engineering (a California-based firm), very little research is being done here into
applying this new technology. These casters are not cheap (while the price of the Armco caster was not published, it is likely to have been about $10 million (see the price range for casters in McManus, 1983b)), but the purchase of such a device for a joint experimental venture is a strategic necessity.

Coke Production

The last suggested area for a City of Chicago-sponsored joint research project is a review of alternative coke-producing technologies. The production of coke by U.S. steelmakers today is dwindling, as manufacturers choose to close obsolete coke ovens instead of renovating them and to purchase coke from abroad. As observed above, while net U.S. steel capacity was cut by 10% between 1973 and 1983, coke-making capacity fell by one-half (McManus, 1984f:59).

There are two reasons for the reluctance of steelmakers to build new coke ovens. To begin with, a new coke battery is extremely expensive. For instance, a one million ton/year facility is likely to cost $200 million, which most steel firms would rather spend elsewhere. Secondly, environmental legislation may have made it almost impossible to produce coke economically in the U.S.

Steelmakers' traditional short ovens had an average life of 37 years. When the steel companies responded to environmental regulations by shifting to tall ovens in the early 1970s, the results were disappointing. The early tall ovens had a life span of only a decade and frequently produced coke at a rate 200,000 or 300,000 tons below projections (McManus, 1984f:65).
Steelmakers' most recent tall ovens have not been plagued by some of these problems but do remain subpar. Projected life spans of the newest coke ovens are now around 18 years (McManus, 1984f:65). Many incremental innovations have been added to the newest coke ovens, particularly automated handling devices (DiCola and McCollum, 1983). But steelmakers generally have shied away from any more innovative breakthroughs, such as coke preheating (Williams, Smith, and Busciani, 1983:45). With ever-tightening environmental restrictions, U.S. steelmakers' willingness to experiment with new technologies is unlikely to increase.

However, there are a number of new coke-making technologies that are potentially revolutionary. Many of these ideas have been discussed for decades but have attracted little research interest (Kiessling, 1981:1847-48). But the most interesting group of new technologies -- the formcoke processes -- have garnered considerable corporate and governmental investment, and several pilot projects have proved promising.

Three major formcoke processes have emerged in recent years. They differ from conventional coke-making in several important respects: they utilize cheaper, non-metallurgical coals in whole or part; production is in a closed, environmentally sound system; and the coke produced is of uniform size, which boosts blast furnace productivity (Sheridan, 1976:20). In all three processes, non-coking coal is carbonized, crushed, mixed with a bituminous binder, formed into shapes and reheated.

Three major pilot formcoke efforts have been undertaken by U.S. steel companies:
U.S. Steel's Clean Coke Process, funded in large part by the Office of Coal Research, was developed in the mid-1970s. This cold-pelletizing process was unique in recovering many coal byproducts. While this complex recovery system raised the cost of the very small pilot facility considerably, it also would have boosted the potential profitability of any commercial plant using this process (Schowalter and Boodman, 1974).

A cold-briquetting process was developed by the Food Machinery Corporation (FMC) during the 1960s, with the help of U.S. Steel. Though U.S. Steel subsequently withdrew to develop its own process, FMC went on to complete several tests of its formcok in various blast furnaces. Though the test at Inland Steel in the mid-1970s showed considerable promise, the proposed 500,000 ton/year formcok plant at Indiana Harbor never was built ("Aim of Coking", 1972; "Handicapping", 1975:36-37).

Formcok Associates was a consortium of Bethlehem, National and Republic steel companies, as well as Consolidated Oil, which grew out of Consolidated's research in the 1960s. The group operated a pilot plant at Bethlehem's Sparrows Point plant in the late 1970s. This 454-ton/day facility, utilizing the hot-pelletizing process, operated for several years before federal funding was terminated ("Handicapping", 1975:36-38).

As these brief histories make clear, formcok has not lived up to its promise. A decade ago, many analysts believed that formcok would be a major steel-making technology by now. For instance, the Bureau of Mines projected that between 15 and 20 million tons of formcok would be produced in 1985 (Mutschler, 1975). Instead, the steel industry's capital crunch and the Reagan administration's cut of the Department of Energy research budget combined to bring the pilot formcok projects to a halt (Kiessling, 1981:1249).

It well may be that formcok production remains uneconomical, but a City-sponsored review of what has been written about this technology is nonetheless a very attractive proposition. Buried in many National...
Technical Information Service reports lies a great deal of information that could be drawn together at very little cost. If formcoke appears to be feasible, than the City certainly should seek to sponsor a research project in this technology. The potential dividends in the area would be great, inasmuch as coke production involves a large share of steel-making jobs, and the development of formcoke processes probably would stem the flow of these jobs to foreign countries. In addition, if this technology is feasible, it well may allow the conversion of Illinois high-sulfur coal into coke ("Handicapping", 1975:38; 1975; Schowalter and Boodman, 1974:82). As a first step, then, the City should encourage a review of the already completed investigations of formcoke.

Conclusions

To sum up the final recommendations that have emerged from our analyses of present and future investment in new technologies, the expenditures the City should encourage immediately are:

- investments to shore up raw steel-making capacity;
- investments in continuous casters;
- investments in cold-rolling and finishing flat-rolled products;
- possible strategic investments to upgrade the quality in selected "heavy" steel lines;

In terms of research, steel firms should be encouraged to participate in a number of City of Chicago-sponsored efforts, including examinations of:

- various ladle metallurgical systems;
- the potential of horizontal continuous casters;
- new, experimental electrolytic galvanizing units;
- computer control of steel-making, especially networks linking different operations;
- ways to enhance coke production.
Major Investments in Steel-making, 1980-85

Following are the major investments in new steel-making facilities, as well as major renovations and upgrades.

Coke Ovens

Bethlehem: (1) Announced in 1979 intention to build 80 6-meter ovens at Sparrows Point (Maryland), with a total of 850,000 tons per year (tpy) capacity, using the most advanced, pollution-free technology. Signed a $150 million contract in late 1980, and the $165 million coke battery A was fully operational by 1982. (2) Announced in 1982 plan to do a $61 million renovation of the 82 6.12-meter ovens of the #1 coke battery at Burns Harbor (Indiana). Completed in 1983, the renovated facility has a 128,000 tpy capacity.

Inland: Opened new coke battery at Indiana Harbor in 1980.

LTV: (1) Installed a $150 million emission control system at the five coke batteries at Pittsburgh in 1980. (2) Installed in 1982 a coke gas desulfurizing process at Aliquippa (Pennsylvania).


Rouge: Started modernization and rebuilding of coke battery C at Rouge (Michigan) in 1983, still in progress.

U.S. Steel: (1) Announced in 1979 it would install two 6-meter and four 4-meter coke batteries at Clairton (Pennsylvania). After some debate with the U.S. Environmental Protection Agency, installed 75 6-meter
ovens with 800,000 tpy capacity, completed in 1982.
(2) Installed in 1982 coke battery emission control facilities at Fairless (Pennsylvania).

Blast Furnaces

Armco: Rebuilt blast furnace #3 at Middletown (Ohio) in 1984. Previously had intended to build major new blast furnace there.

Bethlehem: Relined blast furnace L at Sparrows Point in 1984.

Inland: (1) Started up in 1980 blast furnace #7, a 7,000-ton per day, 45-foot diameter furnace at Indiana Harbor. It made broad use of advanced computer control and material-handling technologies. (2) Relined blast furnace A at Indiana Harbor -- the plant's second largest -- in 1982. (3) Started reline of blast furnace #5 at Indiana Harbor in 1983, completed in 1984.

Interlake: Relined and rehabilitated for $9.4 million the 874,000-tpy blast furnace A at Chicago in 1984.


Republic: (1) Began reline of blast furnace at Warren in 1980, with expansion from 2,900 to 3,400 tons per day. Completed in 1981. (2) Began reline of blast furnace #5 at Cleveland in 1982. Project expanded by LTV in 1984 to include $35 million in productivity-boosting improvements. Still in progress.


Electric Arc Furnaces


Bethlehem: Began constructing a 1.2 million tpy complex in 1980 at Johnstown (Pennsylvania), including two 180-ton per heat EAFs, a computer system and a scrap yard (to replace a coke battery, blast furnace and open-hearth furnace). Completed $100 million facility in 1981.

Connecticut Steel: Installed an Energy Optimizing Furnace that can operate on 100% scrap with only coal and oxygen as fuels, with 260,000 tpy capacity, at Wallingford, Connecticut, in 1984. This was part of a $50 million rebuild of old Yale Steel (including a continuous caster) by the Korf Group, which developed the furnace in Brazil.

Northwestern Steel and Wire: Expanded its three EAFs at Sterling (Illinois) from 250 to 400 tons per heat each in 1980.

Nucor: (1) Installed three new EAFs (each 45 tons per year) at Jewett (Texas) in 1980. (2) Installed two EAFs (75 tons per year) at Plymouth (Utah) in 1981. (3) Will install in 1985 one of world's first single-electrode DC furnaces (35 tons per heat) at Darlington (South Carolina).

Oregon Steel and Raritan River Steel: Installed first eccentric bottom tapping furnaces (all 150 tons per heat) in U.S. during 1984. The European-developed technology reduces tapping time, temperature loss, melting time and refractory consumption.

U.S. Steel: Installed first taphole valve system on a tilting EAF at Baytown, Texas, in 1982. This eliminates slag and facilitates ladle metallurgy.

Continuous Casting

Armco: (1) Announced in 1981 plans for $104 million, six-strand seamless bloom caster at Ashland (Kentucky) to cast 720,000 tpy of 8" to 13.5" square blooms, to be completed by 1983. In 1982, the project was put on hold due to the drop in price of oil. In 1983, the caster project was reactivated and completed. In 1984,
Armco announced plans to convert two out of six lines of the caster to slab casting for flat-rolled products. Added second slab caster to Butler (Pennsylvania) to cast 368,000 tpy of stainless and electrical steel in 1982, at a total cost of $55 million. (3) Announced construction of horizontal continuous caster for 4" to 8" square billets at Baltimore in 1982. In 1984, production (rated at 43,000 tpy) of stainless steel billets for wire, rod and bar began.

Bethlehem: (1) In 1980 announced $85 million, three-strand, 1.2 million tpy bloom caster for Steelton (Pennsylvania) for Steelton rail mill and some structural steel. Completed caster (which makes 14.6" x 23.6" blooms) in 1983. (2) In 1983 announced $260 million, 2.2 million tpy slab caster for Sparrows Point to be completed in 1986. Still in progress. (3) In 1983 announced a $280 million slab caster for Burns Harbor with a total capacity of 2.9 million tpy to be completed in 1986. The caster (which will be able to cast slabs from 24" to 86" wide, as well as blooms) is still in progress.

Chaparral Steel: Installed single-strand horizontal billet caster (which can cast from 5" x 5" to 5" x 7") in 1985 at Midlothian (Texas).

Continental Steel: In 1983 announced 650,000 tpy, eight-strand billet caster, costing $21 million, for Kokomo (Indiana) rod mill with 1985 start-up. Still in progress.

Inland: (1) Did preliminary engineering work on slab/bloom caster in 1982. In 1983 announced for Indiana Harbor a two-strand, 1.1 million tpy slab/bloom caster that can cast blooms 15" x 20" or 15" x 24", to be completed in 1985. (2) In 1982 announced 1.4 million tpy, single-strand slab caster for Indiana Harbor, which can cast 9-1/4" thick slabs from 35" to 76" wide for sheet and plate, to be completed in 1985. (These two casters will cost $200 million.)

LTV: (1) In 1981 announced at Indiana Harbor two slab casters (one of which will cast from 40" to 76" wide, the other from 8" to 10" thick and 28" to 42" or 80" wide) with a combined capacity of 3.1 million tpy. Completed in 1983 at a total cost of $165 million. (2) Converted Aliquippa six-strand billet/bloom caster to a billet/round caster in 1982.

National: In 1981 started up 1.2 million tpy slab caster (8.75" thick x 49" - 84" wide) at Granite City.
Northwestern: In 1980 ordered two six-strand, 1.2 million tpy bloom casters (able to cast billets from 8" x 5-1/2" to 13" x 8", with one strand for 28" x 16" billets) for Sterling (Illinois). Order changed to one such 1.2 million tpy caster and one eight-strand, 5-1/4"-square billet caster, with 1.0 million tpy capacity. These two casters installed in 1983 at total cost of $41.6 million.

Nucor: (1) In 1980 installed two-strand billet caster with 250,000 tpy capacity at Jewett (Texas) for bar casting. (2) In 1981 installed three-strand, 400,000 tpy billet caster at Plymouth (Utah).

Republic: In 1981 announced for Cleveland two-strand, 1.4 million tpy slab caster for hot- and cold-rolled strip and some plate. In 1983 installed an upgraded 1.8 million tpy caster at approximate cost of $100 million, with the ability to cast 9"-thick strip between 31" and 71" wide.

Rouge: In 1982 announced two-strand, 1.8 million tpy slab caster (8" thick x between 38" and 75"), to be completed in 1986. Still in progress.

U.S. Steel: (1) In 1980 announced 1.3 million tpy slab caster (7"-8" thick x 49"-80" wide) for sheet and tin mill at Edgar Thomson (Pennsylvania), with completion in 1983. Caster suspended in 1982, never restored. (2) In 1980 announced six-strand, $145 million, 500,000 tpy round caster (6" and 7"diameters) for oil country products and bars at Lorain (Ohio), to be completed in 1983. Caster delayed in 1982; restored and completed in 1983 as 550,000 tpy caster forming 6.5"-, 7"- and 9.25"-diameter rounds for seamless pipe. In 1984 announced plan to convert into billet caster. Still in progress. (3) In 1980 announced 30% capacity boost (to 1.8 million tons) and expansion of width range (up to 9.3" x 46"-76") of slab caster at Gary. Completed in 1982. (4) In 1983 announced two-strand, 3.3 million tpy slab caster for Gary, to be completed in 1986. Still in progress. (5) In 1981 announced four-strand, 600,000 tpy bloom caster (10-1/2" square) for Fairfield (Alabama). Caster started up in 1984, to produce blooms for oil country goods and bars. (6) In 1984 announced 2.2 million tpy slab caster for Fairfield. Still in progress. (7) In 1981 announced six-strand, 1.2 million tpy bloom caster (from 10" square to 10" x 16") for South Works bar mill and proposed rail mill. Caster cancelled.


Sheet and Strip


Inland: (1) In 1984 awarded $11 million contract to modernize four-strand tandem cold-reducing mill at Indiana Harbor with new control system and terminal facilities. Still in progress. (2) In 1984 began preliminary engineering work on quarter billion dollar (or more) 1 million tpy cold-rolling mill for Indiana Harbor or elsewhere in the region to be completed in 1988. Decision if and where to build the mill not yet made.


Rouge: In 1982 added #7 finishing stand to hot-strip mill.

Billets, Bars, Rod and Wire

Armco: In 1983 installed monitoring devices and central computer control at Kansas City rod mill.


Continental: In 1983 announced $18.5 million modernization of two-strand, 25-stand rod mill at Kokomo, boosting the line's capacity from 300,000 to 400,000 tpy. Started up expanded rod mill in 1984.

Inland: In 1983 installed process control system and speed regulators at Indiana Harbor 12" bar mill.

Northwestern: In 1982 announced $33 million modernization of 500,00 tpy 12" merchant bar mill, including

Nucor: (1) In 1980 installed 11-strand bar-rolling mill at Jewett. (2) In 1981 installed 13-stand, 400,000 tpy bar-rolling mill at Plymouth (Utah) for angles, flats, channels and rounds. (3) In 1983 announced $13 million modernization of 250,000 tpy #1 bar mill at Darlington (South Carolina), to include additions of two finishing strands, cooling equipment and handling equipment, to be completed in 1985. Still in progress. (4) In 1984 announced upgrade of electrics and drive control system at #1 and #2 bar mills at Norfolk (Nebraska). Still in progress.

Quandex: In 1981 announced 280,000 tpy special quality and alloy bar plant at Macsteel Division in Fort Smith, Arkansas. Construction of the $91 million facility -- the largest rotary continuous casting plant in the United States -- was suspended in 1983, resumed in 1984, and completed in 1985.

Rail, Structural and Plate

Bethlehem: (1) In 1980 completed improvement program at Steelton (Pennsylvania) rail mill. (2) In 1980 announced construction of six soaking pits at Bethlehem (Pennsylvania) to heat ingots for 48" structural mill. Pits completed in 1981, at a cost of $9 million. (3) In 1984 announced $18 million modernization of Steelton rail mill including a 50% capacity boost and increasing the maximum rail length produced from 60' to 80', to be completed by 1986. Still in progress. (4) In 1984 announced $50 million modernization of 48" structural mill at Bethlehem, to be completed by 1986. Among improvements are conversion of main steam-driven engine to an electric-drive motor. Still in progress. (5) In 1984 began installation of plate identification system at 160" mill at Sparrows Point, using a computer to identify and trace the plates, to be completed in 1986. Still in progress.

U.S. Steel: (1) In 1981 announced conversion of 34" structural mill at South Works to a rail mill capable of producing 700,000 tpy of rails up to 118' long. With an EAF and continuous caster, rail mill would cost $225 million. Delayed in 1983; reactivated in 1983; cancelled in 1984. (2) In 1984 upgraded production at 52" structural mill at South Works.

Tubular Products


LTV: In 1982 announced $65 million modernization of Campbell (Ohio) seamless mill #1 to boost production of 6"-14" pipe by 50% to 685,000 tpy by installing a rotary hearth furnace and other equipment. Completed in 1983.


U.S. Steel: (1) In 1981 started up new quench and temper line at Duquesne, increasing the heat-treating capacity at the plant from 360,000 to 540,000 tpy. (2) In 1981 announced $650 million, 600,000 tpy computer-controlled seamless mill at Fairfield (Alabama), including a walking-beam furnace, a laser telemetric gaging system, and four automated, non-destructive testing facilities, to produce 3-1/2" - 8-5/8" tubing for oil country goods, to be completed in 1984. In 1983 started as 545,000 tpy facility. (3) In 1981 announced quench and temper line and 24-stand stretch-reducing mill for Gary. Apparently cancelled in 1982. (4) In 1983 installed nondestructive testing facilities on #3 seamless line at Lorain.

Heat Treating and Annealing

Armco: In 1982 installed 27' continuous coil annealing line for stainless rod and wire at Baltimore.

Bethlehem: In 1981 announced $60 million, 600,000 tpy continuous annealing line for Burns Harbor, using Nippon Kokan technology to treat high-strength, low-alloy (HSLA) steel strip (from .025" to .065" thick, up to 60" wide) for the auto industry. Completed in 1983.

Inland: In 1981 announced $80 million, 400,000 tpy continuous annealing line #3 at Indiana Harbor, using Nippon Kokan technology to produce HSLA steel strip (from .019" to .085" thick, and between 24" and 60" wide) for the auto industry. Completed in 1983.

Galvanizing and Other Coatings

Armco: (1) In 1980 announced rebuilding of #3 zinc grip, hot-dip galvanizing line at Middletown (Ohio) to work faster while using less energy. Completed in 1982, with $9 million cost. (2) In 1984 completed modification of terne coating line at Middletown (.017"-.082"- thick strip) for automotive uses, especially gas tanks. (3) In 1984 announced $50 million, 210,000 to 396,000 tpy electro-galvanizing line at Middletown with ability to coat 72" strip between .015" and .063" thick, to be completed by 1986. Still in progress.

Bethlehem: (1) In 1981 installed first wire-coating line using its Galvalume process at Sparrows Point, with up to 600-foot/minute rate. (2) In 1981 announced $10 million expansion of Lackawanna (New York) hot-dip galvanizing line by 15%, with installation of a quality-improving zinc dust minispangling system at a cost of $10 million. Apparently completed in 1982. (3) In 1984 announced $15 million expansion of Galvalume line at Sparrows Point. Still in progress. (4) In 1984 announced conversion of 48" halogen tinning line at Burns Harbor into 100,000 tpy electrogalvanizing line, coating one- or two-sided 48" strip, to be completed in 1985. Still in progress.

Bethlehem, Inland and Pre-Finish Metals: In 1984 announced $80 million expansion of existing Pre-Finish Metals line at Walbridge, Ohio, to 400,000 tpy electro-galvanizing line, coating one- or two-sided strip .135" thick and 72" wide. Still in progress.

Continental: In 1984 completed $3 million relocation and modernization of #5 and #6 (36,000 tpy total) wire galvanizing lines at Kokomo.


ITV: In 1984 announced $130 million, 400,000 tpy electrogalvanizing line for 72" strip at Cleveland, to be built by 1986 in conjunction with Sumitomo Metals, which has a 40% interest in the line. Still in progress.

National: In 1981 installed at Midwest Steel (Portage, Indiana) a 120,000 tpy Galvalume hot-dip galvanizing...
system for 48" strip with an electrolytic cleaner. (2) In 1982 announced $6 million in improvements for experimental electrogalvanizing line at Midwest Steel to coat 72" coils, on one or two sides, with a variety of zinc-based protective layers. Completed in 1984. (3) In 1984 announced $70 million, 400,000 tpy electrogalvanizing line for Great Lakes (Michigan) using the technology of its partner, Nippon Kokan, to be completed in 1986. Still in progress.

Rouge and U.S. Steel: In 1984 announced joint $150 million, 560,000 to 700,000 tpy electrogalvanizing line at Rouge, to be completed by 1986. Still in progress.

U.S. Steel: In 1982 installed Galvalume hot-dip galvanizing line at Irvin (Pennsylvania).

Wheeling-Pittsburgh: In 1984 announced proposed hot-dip galvanizing line with Nisshin Steel at Follansbee, West Virginia. Currently on hold pending resolution of bankruptcy case.