Working Paper 8606

THE BIRTH OF THE COMPETITIVE MARKET IN THE STEEL INDUSTRY

by Philip Israilevich

The author would like to thank Gary Garofalo and Michael Fogarty for providing data on capital stock and Kim Kowalewski for valuable comments. Special thanks to Amy Durrell for excellent research assistance.

July 1986

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I. Introduction

In the last two decades, economists have been trying to unravel the mystery of the slowdown in productivity growth of the U.S. economy. Most of the studies have been directed toward the entire manufacturing or disaggregated manufacturing sectors of the whole country. Hulten and Schwab (1984) (H-S) were the first to study the decline in productivity growth from a regional perspective. They have found that decline of productivity growth in the Snowbelt is not more apparent than in the Sunbelt. The H-S finding rejects arguments of some economists that the efficiency of the Snowbelt economy is declining more rapidly than its southern counterpart. Therefore, change in efficiency (measured as the index of total factor productivity) does not explain a regional shift of the industrial sector. The H-S study was based on the entire manufacturing sector. The analysis of the disaggregated industrial sector may reveal more fully the sources of a regional shift.

This paper presents a regional analysis of the steel industry. The major change in the geographical distribution of steel-producing facilities is due to the development of the so-called minimill. Three aspects of the economic performance of minimills and integrated mills are considered in this paper: technology, price mechanism, and efficiency.

Development of electric-arc furnace technology allowed small mills to compete with integrated mills and gave birth to a new organizational entity--the minimill, which operates on a different price mechanism. To clarify theoretical differences in price mechanisms in the steel industry, minimills are treated as small Marshallian firms, and integrated mills are treated as oligopolistic firms. However, because empirical data on minimill prices are scarce, support for the theoretical arguments on price differences is drawn from the steel industry and from other industries as well.

The efficiency difference between minimills and integrated mills is based on the observation of regions where either minimills or integrated mills predominate. Direct observations of individual firms were not available. The results of this study indicate that states with growing numbers of minimills did not gain efficiency relative to states where integrated mills predominated. These findings are consistent with those of H-S study for total manufacturing, in which it is argued that efficiency indicators are not sufficient to describe regional differences. As opposed to aggregated manufacturing, several features of the steel industry clearly describe regional differences. These features are technological and organizational and are reflected by the growth of minimills in one set of regions and the decline of integrated mills in another set of regions.

Section II gives a brief history of the regional development of the steel industry. This is followed, in section III, by a description of recent changes in the industry--namely, the opening of minimills. Section IV describes the differences in price mechanisms of integrated mills and minimills. A comparative inter-regional efficiency analysis, based on total factor productivity (TFP) analysis, of states with integrated mills and states with minimills is presented in section V. Findings are summarized in the conclusion; data sources are presented in appendix I.

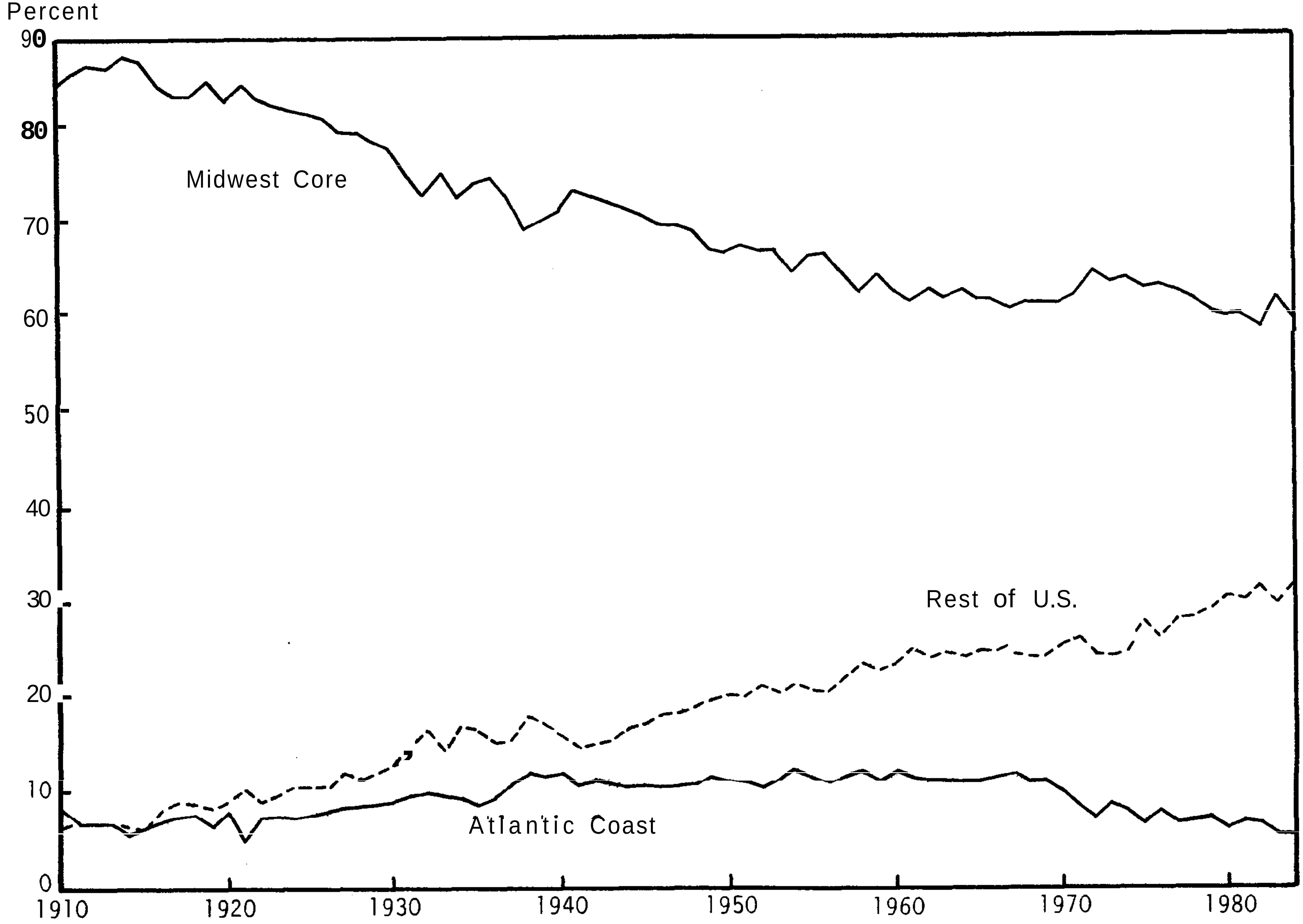
II. Regional Development History of the Steel Industry.

During most of this century, steel producers have been concentrated in just four states: Illinois, Indiana, Ohio, and Pennsylvania. This four-state region is referred to here as the Midwest Core (MWC). At no time since 1910 has MWC's share of raw steel production fallen below 60 percent of total U.S.

output (see chart 1). MWC's share in the production of steel has gradually declined, while new regions have emerged in the steel production arena. In the last two decades, the South's share of steel production has steadily increased from 10 percent in 1960 to 17 percent in 1985--the fastest growing share among steel-producing regions. The share of the Atlantic Coast states during the same period declined from 12 percent to 6 percent. The regional structural change in the last two decades is more dramatic with respect to mill openings in states that were not involved in raw steel production previously. Ten new states were added to the list of steel-producing states compiled by the American Iron and Steel Institute (AISI) since 1954, while in the previous 40 years, only nine states were added (see table 1). These developments are typical of the Snowbelt/Sunbelt manufacturing shift, but this study focuses on a particular industrial sector. In this setting, in addition to analyzing productivity trends, we can address the industrial organization issues of the industry. Industrial organization analysis devoted to differences between minimills and integrated mills explains the regional shift.

Minimills, which first appeared in the late 1950s and have become established in the last two decades, process scrap steel with an electric-arc furnace. Minimills are small-scale producers, with 100,000 tons of average annual capacity. Before the advent of minimills, most steel producers were fully integrated, large corporations and had blast furnaces with an average annual capacity of 2 million tons. Because integrated mills have not expanded their facilities in the last two decades, the major factor in regional changes in the steel industry is distribution of minimills and reduced capacity of integrated mills. A map of the minimills reveals a fairly even distribution of facilities over the country (see figure 1).

Chart 1 Raw Steel Production
(production as a share of U.S. total)



SOURCE: American Iron and Steel Institute, <u>Annual Statistical Report,</u> 1910 to 1984, Washington, DC.

TABLE 1: Attrition and Addition of States to AISI List of Steel Production

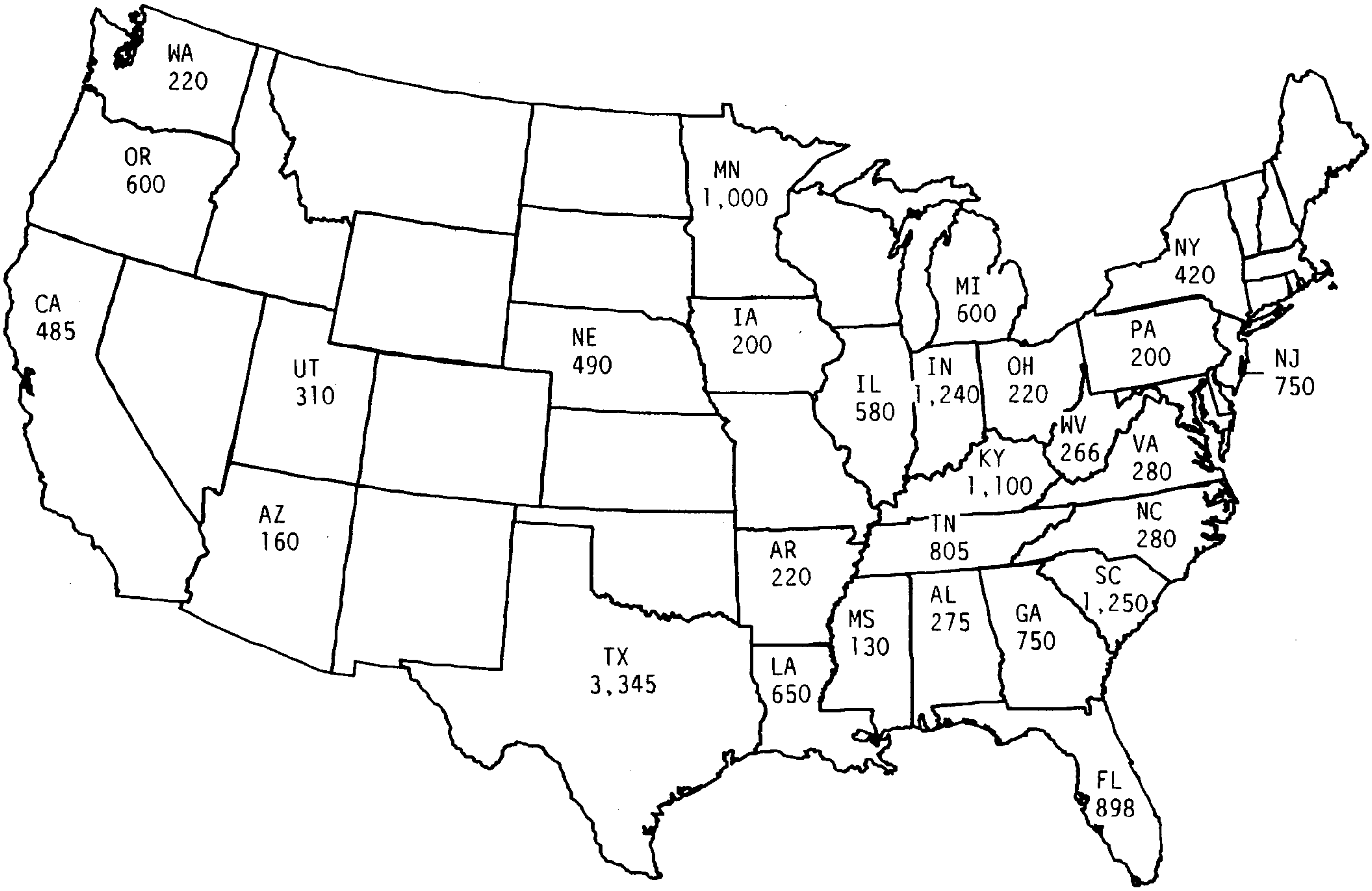
States	1914	1919	1924	1928	1933	1936	1943	1954	1958	1960	1966	1975
Alaska						-						
Arkansas												
Arizona												
Washington, DC												
Florida									+			
Hawaii										+		
Kansas	-											
Louisianna												
Iowa												
Massachusetts									-			
Mississippi									+			
Nebraska	+				-							
Nevada				+	-							
North Carolina	+	-										
Oregon							+					
South Carolina		+	-									
Utah					-		+					
Wisconsin					-							

	1914-1943	1943-1975
Total Addition	9	10
Total Attrition	15	1

KEY : + State added to list
- State deleted from list

Source: Annual Statistical Report, American Iron and Steel Institute 1914-1975, Washinyton, DC

Figure 1 Raw Steel Capacity by Minimills
(in thousands of tons)



SOURCE: Table 2

As much as 24.4 percent of the minimills' capacity is currently in the North Central region, and 7.7 percent of capacity is in the Northeast region. The greatest share of total minimill capacity (57.8 percent) is in the South, and 10 percent is in the West. (These figures are calculated from table 2, which reflects the distribution of steel-producing capacities in 1983.) Integrated mills have historically been concentrated in the MWC, while minimills have spread all over the country.[1] As a result, an analysis of output distribution, or new openings, creates the impression that the steel industry is moving to the South. It is clear that searching for particular features that make the South attractive to the steel industry (such as rising productivity or relatively falling factors costs) is not useful.

III. Technological Differences Between Minimills and Integrated Mills

Prior to the 119-day steelworkers' strike in 1959, the share of minimills in the steel industry was very small but, in the last 20 years, they have become a strong competitor of the integrated steel producers. Small-scale steel operations are not new; several such steel mills have been in operation for 50 years or more (see Kotch [1971]). In the past, these mills were built either to support an existing plant or were intended to develop into a large corporation. By contrast, the purpose of the minimill is: a) to build small-capacity facilities that remain relatively small, b) to compete with large integrated mills by adopting lower capital cost technologies, and c) to specialize in producing a special type of steel that large mills produce less efficiently.

More than 40 minimills were built in the 1960s, and 20 were built in the 1970s (see table 2). The average capacity of individul minimills has increased since their start. In the 1960s, individual minimills did not exceed 40,000 tons of annual steel production.

Table 2 Comparison of Minimills and Integrated Plants in 1983

	Capacity[a]		Number of plants					
			Start-up dates of minimills				Total plants	
State	Minimills	Integrated	pre-60s	60s	70s	80s	Minimills	Integrated
OH	220	24,700				2	2	6
IL	580	21,500	2			1	3	6
IN	1,240	13,500	2				2	2
PA	200	28,100	2				2	6
NJ	750				1	1	2	
NY	420	4,000	1		1		2	1
VA	280		1	1			2	
MD		7,500						1
MI	600	10,600				1	1	3
MN	1,000			1	1		2	
KY	1,100	2,000		1		2	3	1
TN	805		1	1		1	3	
SC	1,250			2	1		3	
TX	3,345	3,000	3	2	3		8	2
FL	898		1		2		3	
LA	650					1	1	
MI	130		1				1	
MO		1,100						1
NC	280			1			1	
WV	266	4,000			1		1	1
AL	275	5,000	1				1	2
AK	220				1		1	
GA	750		1				1	
OR	600			2			2	
CA	485		2	1	1		4	
HA	60		1				1	
CO		1,700						1
IA	200				1		1	
NE	490				1		1	
UT	310	2,800				1	1	1
WA	220		1				1	
AR	160			1			1	
Total	17,784	129,500	20	13	14	10	57	34
Total number of companies							45	16

a. Capacity is expressed in 100 tons per year.

NOTE: Data for 13 minimills that did not appear in The Minimill Handbook were supplemented by phone interviews.

Sources: Minimill Data: 33 Metal Producing (1983); Marketing Economics Institute; and Serjeantson et al. (1983). Integrated mill data: Acs (1984).

In the 1970s, the capacity of some minimills exceeded 900,000 tons a year, compared to 2 million tons per year for the average blast furnace operation (see McManus [1970]). Total minimill capacity tripled in the 1970s, reaching 17,000,000 tons a year, and capturing about 20 percent of the steel marketplace (see 33 Metal Producing [1983]).

The product range of minimills has remained relatively narrow. Minimills produce mostly rounds, angles, channels, flats, rods, and curves used in construction and light manufacturing (see McManus [1980]). The integrated mills are geared toward large construction projects--dams, railroads, bridges, and automobiles. Although in the 1960s minimills were associated with low-grade products that did not require sophisticated equipment, this is gradually becoming less true. Today, minimills are moving into the mainstream of steelmaking, as they have exhausted market potential in low-grade products and are exploring new technologies (see Iverson [1984]).

Minimills use scrap metal, which is processed in an electric-arc furnace, a technology that enables producers to bypass coke ovens and blast furnaces, which are parts of the integrated process. This technology cuts the sunk cost of minimill construction, lowers energy consumption per ton of steel, and reduces pollution-abatement costs. In 1978, integrated producers used 35.2 million Btus to produce a ton of shipped steel, while the non-integrated producers used 9.9 million Btus to make the same amount. While the integrated sector uses about 10 man-hours to produce one ton of finished steel, minimills use about three man-hours per ton. A scrap-based electric furnace mill (minimill) can be built for less than $300 to $400 per ton of annual capacity, while an integrated mill requires $2,000 per ton of annual capacity (see Iverson [1984]; and American Iron and Steel Institute [1985, p. 241).

Construction of a minimill takes one to two years, while construction of an integrated mill takes five to seven years.

Minimill producers adapt faster to technological breakthroughs than integrated producers do. Minimills were quick to make use of the electric furnace and to implement furnace improvements and continuous casting. For example, by 1978 only 11 percent of steel produced by integrated mills was continuously cast, while 51 percent of minimills' steel was continuously cast (see Congress of the United States, Office of Technology Assessment [1980, p. 290, table 1181). The first on-line continuous casting machinery was employed by a minimill (see Kobrin, [1967, p.72]).

Approximately 25 percent of total minimill capacity is located in the North Central census region, 7 percent in the East North Central area, over 50 percent of the total capacity is concentrated in the South, and 10 percent is distributed in the West. (These figures are calculated from table 2.) The interstate comparison suggests that minimills are able to compete in areas where traditional integrated facilities are established, such as the MWC region. In addition, minimills are located in areas that are sparsely populated by corporate facilities, thereby developing new local markets, such as the West and the South.

The minimills rely on speed and flexibility in serving local markets. They are able to fill small steel orders at competitive prices and to offer shorter delivery times than many larger steel service centers. Closeness to the consumer cuts costs of maintaining large inventories and reduces transportation costs. Immediate reaction to new orders minimizes lead time and levels of product inventory.

IV. Corporate and Competitive Sectors' Price Mechanism

The engineering survey in section III suggests that minimill technology allows more efficient production of steel than the technology of the integrated mill. In section IV, the superior efficiency of small-firm operation is addressed.

In this century, small family-controlled firms have gradually changed into large corporations with administrative pyramids.

> The Marshallian capitalist ruled his factory from an office on the second floor. At the turn of the century, the president of a large national corporation was lodged in the higher building, perhaps on the seventh floor, with greater perspective and power. In today's giant corporation, managers rule from the top of skyscrapers; on a clear day, they can almost see the world. Steven Hymer (1972, pp.113-140).

During the last two decades, the steel industry has experienced the reverse of this process. In the nineteenth century, steel production was concentrated in the hands of a few corporations, but in the last two decades, these corporations started to lose business to smaller producers and to imported goods. The steel industry, therefore, provides a natural experiment that can help economists analyze the performance of large corporations relative to that of small firms in the same market.

To explain the differences between the minimill producers and the integrated producers, it is useful to think of the differences between Marshallian and corporate firms. Minimills are referred to in the economic literature as <u>competitive sector</u>. Some analysts consider imported steel as a competitive sector, too, because prices of minimills and imported steel are sensitive to demand conditions. Vertically integrated mills are referred to in the economic literature as the <u>corporate steel sector</u>. Prices of corporate mill products are less sensitive to demand conditions and are mostly determined by the price of labor and materials. In this section, a theoretical explanation of corporate and competitive price mechanisms and an empirical verification are presented.

A Marshallian (competitive) firm is a price-taker. If demand increases, it is the customer, not the producer, who dictates price change through the wholesaler (who would offer higher prices to obtain the good). If demand falls, the wholesaler must accept lower prices and impose the new price on the producer. An increase in demand would not be allowed to remain unsatisfied. The fear of financial loss and business failure is the incentive for a firm to respond to price changes. In the competitive market, supply and demand are equated by the price change.

In the corporate market, the manufacturer influences the price. In the corporation, prices are set by administrative action; this price mechanism is much less flexible than the competitive market's. An inefficiently managed branch of the company does not necessarily face extinction, as it would in a Marshallian firm. Such a branch can be subsidized by other branches.

The <u>competitive market</u> was coined by Gardiner Means as the competitive flexprice market operation, where supply and demand are brought into equilibrium by a flexible price. In a corporate fixprice market, supply and demand are equated at an inflexible price through the principle of effective demand (see Gardiner Means [1939]).

To verify whether corporate prices are insensitive to variations in demand, as the above discussion suggests, and that they are determined by the factor costs, economists have analyzed the formation of prices in large bureaucratic firms.' In addition, they have analyzed price variations in markets with a dominant share of corporate firms.[3] By studying the behavior of big corporations, the author found that there is a desire to stabilize prices and to target market share. The oligopolistic firm does not use marginal principles in setting prices.

The price mechanism, rather, can be explained by the normal price hypothesis. Eichner (1976) and Wood (1974) argue that the firm chooses a markup that will yield the required level of retained earnings, given its dividend-payout ratio and debt-to-equity ratio. The pricing behavior of a firm in the corporate market, therefore, is determined by the need of funds for internal investment rather than by the change in the demand for product. This argument, based on the analysis of the firm structure, is supported by econometric studies that found cost factors to be much more important than demand factors."

The fixprice behavior of large firms is deeply rooted in the steel industry. Yamawaki (1985) has analyzed the investment behavior of the dominant and competitive fringe firms in the steel industry from 1907 to 1930. The U.S. Steel Corporation represented such a dominant firm. Its share in total U.S. ingot capacity was 50.1 percent in 1908, while Jones and Laughlin, then the second-largest producer, had only 4.2 percent of total capacity. In the observed period, Yamawaki found that the price variable had a statistically significant effect on investment decisions among competitive firms, but price was not significant in influencing investment decisions in the dominant firm. The industry demand variable did not have a statistically significant relationship with the investment decision of the dominant firm, while it had a significant effect on the capital level in the competitive firm.

An econometric study of the price mechanism in the U.S. corporate steel industry was done by Acs (1984) for 1956 to 1975. The author's conclusion is similar to that of earlier study of corporate firm behavior, in which the price-setting mechanism was inflexible. During the observed period, the steel industry was dominated by corporate firms. Acs (1984, p. 54) describes the difference between two types of firms: "Once production has taken place, prices have no relationship to costs in competitive markets. In corporate markets, it is precisely the opposite. Once production takes place, demand has no impact on price."

Acs found that in the 1974-75 recession, steel 'mill prices did not rise during the boom and fell only slightly during the decline, while prices of minimills and imported steel rose in the expansion and fell significantly in the decline. The same findings were confirmed by the Council on Wage and Price Stability (1977).

According to Acs, by maintaining a constant dividend-to-payout ratio, steel corporations have provided a fertile climate for wage increases during most of this century. In the last two decades, the emergence of a competitive sector in the steel industry has forced corporations either to lower their prices or to exit from the competitive end of steel products. Because of concessions to organized labor, corporations are not abie to lower wages when the competitive market requires it. The organizational structure of the corporate sector, which developed in the atmosphere of an oligopolistic market, has a natural resistance to reorganization. Lower entry barriers, through lower sunk cost, determines minimills' entrance into the limited number of carbon-steel producers. In this range of products, superior technological efficiency and a flexible price adjustment mechanism enable minimills to force integrated producers out of the market.[5]

V. A Measure of Interregional and Intertemporal Efficiency Differences

A comparison of the productivity of integrated mills and minimills would require time-series data on the firm level, but, unfortunately, none are available. In lieu of the firm-level data, state census data are used here.

States were aggregated into two sets, one representing integrated mills, and the other, minimills.

The MWC region represents a set of states where big corporations dominate steel production. Although minimills exist in this area, their percentage in total capacity of MWC by 1982 was less than 3 percent (calculated from table 2). States where minimills were in the majority among steel producers by 1982 are selected as representative of minimills (these states are selected from table 2). Some of these states were excluded from the analysis, because data are not reported (for disclosure reasons) by the Census of Manufactures. The remaining states are aggregated and termed as competitive states." There were integrated mills in some of the competitive states during the observed 1963-82 period, but their share was declining, while the share of minimills was increasing. Under this condition, the change in the state figures reflects differences between minimills and integrated mills.

The analysis of the efficiency of MWC steel producers relative to the competitive states' producers is performed by utilizing the total factor productivity (TFP) framework. Labor productivity, a term used frequently in the media, does not reflect efficiency of labor. Similarly, the ratio of output per any single factor, which forms the "partial" productivity index, cannot adequately measure factor efficiency. Output per worker may rise, for example, even in the absence of any change in workers' efficiency if labor is equipped with more means of production. The question of labor efficiency is of major importance, especially if different organizations, such as corporate and competitive firms, are being analyzed. The rise in output per worker-hour productivity is the composite effect of changing labor, capital, and other materials' efficiency, as well as capital-labor substitution. If the efficiency of each factor remains unchanged, and if capital is substituted for labor, a decline would necessarily occur in output per unit of capital, along with a rise of output per unit of labor. Each factor's partial productivity can be weighted by its relative importance, as indicated by factor shares in total output. This weighted average is TFP, which would show changes in efficiency, free of changes in factor proportions. For a more detailed definition of TFP, see appendix II.

Economists are interested in measuring the change in efficiency of an industry from one year to another or, more recently, from one region to another. The TFP measure of efficiency is the difference between observed output, and output that would be produced by the technology of the previous year (or another region). By assigning an arbitrary level to TFP at the reference year (region), TFP for each year can be computed from the series of TFP changes. The relative TFP change is denoted as A°. For more details on the A° derivation, see appendix II.

Let us denote output as V. Then the partial productivity index of labor is V/L, and the partial productivity index of capital is V/K, where L and K are physical amounts of labor and capital. The proportional change in time of these partial productivities, correspondingly, are $\overset{o}{(V/L)} = V^{\circ} - L^{\circ}$ and $\overset{o}{(V/K)} = V^{\circ} - K^{\circ}$, where $(.^{\circ})$ denotes proportional change in time.[7]

Weighted sums of the changes in partial productivities amount to a proportional change of TFP :

$$(1) \quad A^{\circ} = s_K(V^{\circ} - K^{\circ}) + s_L(V^{\circ} - L^{\circ}),$$

where s is a factor proportion in output.

The industry's output is measured as the deflated value added. This approach is used by many economists who measure regional TFP, due to the lack of data on energy and materials. Data for the TFP indicators were derived from the Census of Manufactures. The discrete analog of continuous time derivatives is the logarithmic differences between two periods (regions), according to the Tornquist approximation.— — hares of factor inputs are the arithmetic average of shares between two periods. In this setting, A° is calculated as:

$$(2)\quad A^\circ = (\ln V_t - \ln V_{t-1}) - s_L(\ln L_t - \ln L_{t-1}) - s_K(\ln K_t - K_{t-1})$$

Equation (2) indicates how much extra output is produced in period, t, relative to $(t-1)$, accounting for differences in factor inputs. If one substitutes region i, instead of t, and region j, instead of $t-1$, then A° measures the differences in efficiency of production in region i relative to region j:

$$(3)\quad A^\circ = (\ln V_i - \ln V_j) - s_L(\ln L_i - \ln L_j) - s_K(\ln K_i - \ln K_j).$$

VI. Productivity Analysis

The efficiency measures of MWC and competitive states are presented below, based on the methodology described in section V. Data analysis of this section is based on the Census data and on the estimation of capital for the steel producers in each region, which is described in appendix I. Capital data were available from 1958. As a result, TFP for the MWC region is measured for the period 1958-82, for each "Census" year. For competitive states, census data are available after 1967, because for earlier years, the amount of steel produced by this region was too small to report.

Table 3. Decline of Steel Productivity in MWC

MWC Steel Producers Rates of Change (Percentage Change)"

Period	1=2+3 TFP change	2 Capital contribution in TFP change	3 Labor contribution in TFP change
1958-1963	18.7	9	9.6
1963-1967	1.2	-2.5	3.8
1967-1972	-5.7	-5.6	0
1972-1977	-14	-11.8	-2.2
1977-1982	-33	-13.6	-19

a. In this and following tables, the sum of components might not be equal to the total, due to rounding.

In MWC, efficiency of production has been declining since 1967. (See table 3, column 1). This decline was mostly due to the decline in capital productivity up to the fourth period, 1972 to 1977. In the fourth period, the labor productivity decline contributed 2.2 percent to the TFP decline. In the last period, 1977 to 1982, the nature of the TFP decline was markedly different from previous periods because more than half of the decline was due to the drop in labor productivity. During this period, steel producers experienced profound changes. Their output (in value-added terms) declined by 75 percent, while labor decreased by only 43 percent. Thus, labor productivity during this period decreased by a staggering 31 percent (see table 4). It is interesting to note that labor productivity was only slightly affected by the change in the capital-to-labor ratio. Change in capital intensity raised labor productivity in all periods, which is reflected by the positive numbers in column 2 of table 4.

Table 4 Sources of Labor Productivity Change Among Steel Producers in the MWC Region

Period	1 Change in output	2=3+4 Change in labor productivity	3 Change in capital intensity	4 TFP change
1954-1958	7.9	13.6	NA	NA
1958-1963	20.1	18.6	0	18.7
1963-1967	18.5	7.6	6.4	1.2
1967-1972	-9.3	-0.1	5.5	- 5.7
1972-1977	-12.0	-4.2	9.8	-14
1977-1982	-74.7	31.5	2.0	-33

Based on table 4, one can observe two long-term trends in labor productivity. From 1954 to 1967, labor productivity grew when output rose. From 1967 to 1982, labor productivity declined, along with output, at the points of observation. This suggests that in the face of declining demand, corporations do not respond rapidly enough with reduction of labor force to prevent a drop in labor productivity. This is especially evident in the 1977-82 period, when output declined by 74 percent, and labor productivity fell by 32 percent.

Productivity measures for steel producers in competitive states are presented for 1967-72, 1972-77, and 1977-82. (The presence of minimills earlier in those states was negligible, and data, in most cases, were not reported by the <u>Census of Manufactures.</u>) In each competitive state, the number of minimills increased during these three periods and, therefore, the observed rates of change reflect the efficiency of minimills.

Labor productivity fell in competitive states by 4 percent during the

1967-72 period and by 9 percent in the 1972-77 period (see table 5). Labor productivity decline in competitive states was faster than labor productivity decline in MWC states for these two periods.

Table 5 Sources of Labor Productivity Change in Competitive States

Period	1 Change in VA	2=3+4 Change in labor productivity	3 Change in capital intensity	4 TFP change
1967-1972	-11.0	-4.1	7.5	-11.7
1972-1977	-6.5	-9.1	9.8	-13.9
1977-1982	-3.6	11.0	56.1	-45.1

Labor productivity of competitive states, similar to that of MWC states, was positively affected by the change in capital intensity (see table 5, column 3).[9]

Differences in labor productivity and TFP between competitive and MWC states are summarized in table 6. In 1967-72 and in 1972-77, average labor productivity and TFP in competitive states are lower than in MWC.

Table 6 Competitive State Productivity Differences Relative to MWC[a]

Period	1=2+3 Labor productivity	2 Capital intensity	3 TFP change	4 Output change differences
1967-1972	-10.1	-3.3	-6.9	-1.7
1972-1977	-15.1	-8.2	-6.9	5.5
1977-1982	29.0	36.7	-7.7	71.7

a. A negative sign indicates that productivity (intensity, output) in competitive states is lower than in MWC states. A positive sign indicates the opposite.

An increase in the labor productivity gap in the 1967-77 period (column 1 of table 6) is due primarily to more intense use of capital per worker in MWC states (see column 2 of table 6). A tremendous labor productivity gain in competitive versus MWC states from 1977 to 1982, coincides with a reduction in output of MWC producers. Output in MWC states has declined 71.7 percent faster than output in competitive states during this period. The reduction in output was not sufficiently matched with reduction in labor among MWC producers. It is important to note that in spite of labor productivity differences, TFP between two sets of states was very stable for all three periods. This difference ranges between 6.9 percent and 7.7 percent. This result indicates that if the level of input factors were the same in both regions, then output in MWC would be around 7 percent higher than output among competitive states, under the assumptions of Hicks-neutrality. It is interesting to note that our results are similar to those of H-S, who found no significant change in TFP differences between the Snowbelt and the Sunbelt, and to those of Denny, Fuss, and May (1981), who found no significant change in TFP differences among six Canadian regions.

Engineering surveys suggest that the production process used in minimills is more efficient than the production process of analogous goods in the integrated mills. Integrated mill shutdowns and minimill openings in the same area (such as Ohio), again, suggest the superior efficiency of minimills. However, our findings, that efficiency of and labor productivity of competitive firms are not greater than or increasing faster than efficiency and labor productivity of corporate firms in either 1967-72 or 1972-77, contradict that argument.

This controversy might be caused by the problem of aggregation. Minimills produce lower-grade products, and production of these products by integrated mills has been declining (see table 7). In our analysis, because of lack of data, output of both minimills and integrated mills were aggregated into one product (blast furnaces, steelworks, and rolling and finishing mills (Standard Industrial Classification Code--SIC--331).

The difference in efficiency between the MWC states and competitive states can be explained in the following way. Integrated mills are changing their product mix by decreasing the share of low-grade products (see table 7). For the low-grade products, minimills can be more efficient than integrated mills, but this superior efficiency cannot be observed because of the aggregation problem. During the 1967-77 period, MWC states gained greater efficiency by changing their product mix than competitive states gained by adopting minimills, which suggests that the production of low-grade products is less efficient than the total production process in MWC. From 1977 to 1982, due to a sharp decline in demand for the integrated mills' product, competitive states became more efficient than MWC states.

To summarize: during the observed period, 1967 to 1982, the difference in efficiency between MWC and competitive states is fairly stable (table 6, third column). Competitive states, relative to corporate producers, expanded their output (table 6, last column) as well as product mix (table 7), which is especially evident from 1977 to 1982.

This analysis of steel producers indicates that, contrary to the H-S assertion, equal rates of change of TFP among the Snowbelt and Sunbelt producers do not necessarily rule out the possibility of a competitive disadvantage of one region relative to another.[10] H-S data were aggregated to the entire manufacturing sector, which makes one even more hesitant about H-S conclusions. A region that is at a competitive disadvantage, while losing its production share, may repeatedly change its product mix to sustain TFP stability, relative to states with newer and more efficient producers

Table 7 USA Minimill Share of Total USA Production
(Percent of Total Tonnage)

	1970s	1980s	1990s
Wire rod	20%	70%	90%
Rebar	50	80	100
Light shapes	50	80	100
H.R. bar-merchant	10	50	75
H.R. bar-special	5	15	50
Medium structurals	5	70	85

SOURCE: Marcus and Kirsis (1985).

VII. Conclusion

From a historical point of view, the steel industry has gone through a major reform since the late 1950s. This reform, the birth of a competitive sector, was instigated by the development of the electric-arc furnace and easy access to scrap metals. Technological changes led to a new form of administrative organization in the steel industry and to a new regional distribution of steel producers. The distribution of minimills is fairly even in the country, while corporate producers are concentrated in MAC region. In the future, the share of minimills is expected to increase, creating even further decentralization of steel producers.

A very significant change among MAC producers took place in the 1977 to 1982 period. The value added in this region fell by 75 percent during this period. The decline in demand for corporate producers was not matched with a decline in labor, and labor productivity fell by 31 percent. In the future, corporate producers will have to either shrink their facilities and labor force further, or lower their prices and regain the lost share of the market. The first option seems to be more appealing.

The emerging competitive firms have been more efficient than corporate firms. Nevertheless, states where competitive firms affect steel-producing performance did not exhibit superior performance relative to **MWC** producers. Therefore, similar rates of change or levels of TFP do not necessarily mean that there is no more deterioration in one region than another. In other words, competitive disadvantage of the region cannot be determined only by the aggregated measure of productivity, as H-S implied. In the **MWC**, steel producers are losing their market to other states, most likely as a result of being less efficient in the low-grade products. As a result, the changing product mix of **MWC** producers is keeping their TFP on a level higher than that of competitive states.

Appendix I

Description of Data

Output. Output is represented by value added in constant dollars. Regional time series for value added were derived from Census of Manufactures for the Census years for 1957 to 1982. Regional output deflators for the steel products were not available; therefore, a national deflator for Total Steel Mill Products (SIC=331, reported by Bureau of Labor Statistics) was used.

Labor. The Census of Manufactures reports data on salaries for nonproductive workers and wages on productive workers, and productive workers' hours and nonproductive employees (but no nonproductive hours). For the analysis, the nonproductive workers' contributions were expressed in hours. For that purpose, the number of nonproductive employees was multiplied by 2,080, the hours worked during the year, assuming a 40-hour workweek.

The change in labor contribution was presented by the Divisia index of productive and nonproductive workers:

$$\ln L(t) - \ln L(t-1) = \sum_i \underline{v}_i [\ln L_i(t) - \ln L_i(t-1)]$$

where

$\underline{v}_i = .5[v_i(t) + v_i(t-1)]$, and
$v_i = (w_L^i L^i)/\Sigma w_i L^i$

i = type of employee (productive, nonproductive), and

w_L = wages or salaries.

Capital. Capital is estimated with a well-established, value-added approach. According to this approach, cost of capital (C_k) is derived as a difference between value added and payroll (both variables are reported by the Census of Manufactures). Such a cost of capital includes much more than the cost of reproducible capital. It includes cost of land, value of services, cost of working capital, etc. The estimate of cost of reproducible capital is more desirable, but necessary data on the quantity of physical data are not available.

Capital is calculated as a ratio of capital cost to rental price of capital (P_k):

$$K = C_k/P_k\ .$$

Values for P_k for each state were computed according to the Jorgenson approach. Calculation and data sources for this approach are described in Garofalo and Malhotra (1985). Since rental price of capital varies from state to state, capital for aggregated regions (such as MWC) is calculated as sum of quantities of capital in each state:

$K^I = \sum_s (C^k_s/P^k_s)$, where region I consists of states, s.

Price of capital, P^k, reflects variation in tax rates over states, but **it** does not reflect dynamics of the rate of return specific to the industry. On the other hand, the American Productivity Center has computed capital stock for the industry. Based on this stock value, rental price of capital (P^k_*) was computed for the nation. The ratio of P_k and P^k_* is used to adjust rental prices of capital. Capital stock for each region was computed as:

$$K^I = (P_k/P^k_*) \sum_s (C^k_s/P^k_s).$$

Appendix II

We assume the Hicks-neutral production function--that is, output attainable from each input, rise, or decline is stipulated by the unchanged marginal rates of substitution. In the Hicks-neutral production function, factors are assumed to be paid the value of their marginal product. The major purpose is to identify the shift of the production function, which means increase (decrease) of production of output having input levels fixed. In reality, though, the shift of production function and change in input quantities take place at the same time. The share-weighted sum of input growth rates describes the shift along the production function. The residual output change represents the shift of production function that is called TFP.

Due to the data availability constraint, value added is used as a measure of output. This imposes a weak separability assumption between value added and intermediate goods and energy. Our production function is:

(1) $Vt = F\ (At,\ Kt,\ L_t)$.

Logarithmic differentiation of this function provides

(2) $V^\circ{}_t = S^t_k\ K^\circ{}_t + S^t_u\ L^\circ{}_t + A^\circ{}_t$,

where

$S_k + S_u = 1$,

assuming that the marginal product of each input is equal to its price. In the following, time subscript will be omitted for convenience.'' A° is calculated as a residual in (2). Thus, besides technological change, it includes measurement errors and errors that emanated from the restrictiveness of the assumptions, such as constant returns to scale, weak separability, or neutrality.

Based on (2), one can view change in labor productivity ($V^\circ - L^\circ$) as a function of the TFP and the capital labor ratio change:

$$(3)\quad V^\circ - L^\circ = S_k K^\circ + (S_u - 1) + A^\circ = S_K (K^\circ - L^\circ) + A^\circ,$$

where

$K^\circ - L^\circ$ is a change of capital-to-labor ratio or capital intensity.

A° can be expressed, based on (2), as a weighted sum of capital and labor productivity changes.

$$A^\circ = (S_k + S_l) V^\circ - S_k K^\circ - S_l L^\circ = S_k (V^\circ - K^\circ) + S_l (V^\circ - L^\circ),$$

where

$V^\circ - K^\circ$ is capital changes, and $V^\circ - L^\circ$ is labor productivity changes.

Data Sources

Minimill Data

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The Changing Structure of the U.S. Economy: Lessons from the Steel Industry. New York, NY: Praeger, 1984.

NOTE: Data for 13 minimills that did not appear in The Minimill Handbook, were supplemented by phone interviews.

Notes

1. In spite of the high concentration of the integrated facilities in MWC, this area attracted as much as 15 percent of the total minimill capacity.

2. Dirlam et al. (1955) examined price formation in large bureaucratic firms, such as Exxon, U.S. Steel, and General Motors.

3. For a comprehensive discussion of the subject, see Federal Reserve System and the Social Science Research Council (1972).

4. Eckstein and Fromin (1959), based on the U.S. data, found that standard unit labor costs and material prices were important on the cost side; on the demand side, capacity utilization and the ratio of unfilled orders to sales, which represents demand, were insignificant. Godley and Nordhaus (1973) found, based on the United Kingdom data, that the normal price hypothesis is sound, and prices do not respond to short-run changes in demand. Coutts, et al. (1978) found, " The normal price hypothesis is that the markup of price over normal cost is independent of the conditions of demand of both product and factor markets."

5. The discussion of this phenomenon is presented in section VI.

6. These states are New Jersey, Minnesota, Tennessee, Mississippi, Georgia, California, Washington, Arkansas, Texas, Oklahoma, and Louisiana.

7. Proportional change in labor, for example, is its time derivative divided by its value: $\frac{dL}{dt} \cdot \frac{1}{L} = \frac{d\ln L}{dt}$,

therefore:

$$\overset{\circ}{(V/L)} = \frac{d\ln(V/L)}{dt} = \frac{d\ln V}{dt} - \frac{d\ln L}{dt} = \overset{\circ}{V} - \overset{\circ}{L}$$

8. For a good discussion of this topic, see Cowing et al. (1981)

9. A note on the capital measure is due. The rate of return on capital was adopted from the national data, which are the major components in the calculation of rental prices of capital services. From 1977 to 1982, major corporations in MWC had a significant reduction in rates of return. These rates basically determine national figures. Thus, the estimated amount of capital for competitive states was, most likely, grossly overestimated. Therefore, TFP change is probably underestimated for competitive states for the 1977 to 1982 period.

10. That is, large MWC steel corporations are losing their business to small competitive steel producers, but that does not affect a TFP change.

11. For a critical evaluation of this approach, see Norsworthy and Malmquist (1984).

12. For detailed derivation, see Gollop and Roberts (1982), or Israilevich (1985).

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