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the U.S. Steel Industry

Ming-Je Tang
Zenon S. Zannetos

College of Commerce and Business Administration
Bureau of Economic and Business Research
University of Illinois, Urbana-Champaign

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Ming-Je Tang, Assistant Professor
Department of Business Administration

Zenon S. Zannetos
Massachusetts Institute of Technology

ENTRIES INTO AND EXITS FROM THE U.S. STEEL INDUSTRY

ABSTRACT

This paper explores the entries and exits in the U.S. steel industry. First, reasons for and the performance of entries are examined and then characteristics of exits are studied. It is found that entry-with-new-technology strategy results in different performance, and ineffectiveness and inefficiency contribute equally to the exits from the steel industry.

Introduction

How to compete is the central issue of the business level strategy. The behaviors of incumbent firms, entrants, and exits have significant impact on competition. Analyzing entry and exit conditions is one step toward studying competitive strategies and is particularly useful from two perspectives. From an incumbent firm's perspective, understanding entry conditions helps the firm to identify an important source of competition and to formulate an appropriate strategy to cope with it. Additionally, an understanding of exit behaviors helps the incumbent firm avoid losing competitiveness and being forced out of the market. From a potential entrant's perspective, understanding entry conditions provides guidelines toward entry strategy. This study focuses on a particular entry strategy, the entry-with-new-technology strategy, and the resulting exits, all within the context of the U.S. steel industry.

During last two decades, the most significant structural changes in the U.S. steel industry have been the penetration of foreign steel, notably Japanese steel, and the emergence of minimills. With a scale of less than one million net ton annual capacity, minimills, by employing Electric Arc Furnace and continuous casting as their primary steelmaking technologies, have successfully made inroads into the markets that were originally dominated by integrated steel mills. Japanese steelmakers have also acquired a significant share of the U.S. market. As the demand for steel has remained stagnant, these entries have forced some integrated steel firms to close their plants with sizeable losses. Before explaining the specific entry and exit phenomena in the

U.S. steel industry, we first review relevant entry and exit literature and provide an introduction to steelmaking technologies.

LITERATURE REVIEW

The decision of whether to enter an industry depends on the perceived profits after entry as compared to the costs involved in overcoming entry barriers. Entry studies either focus on the entry barriers inherent to a particular industry, such as economies of scale [Bain 1956], or on incumbent firms' strategies which deter entry by post-entry profits reduction, such as limiting pricing [Gaskin 1971], excess capacity [Spence 1977], and spatial competition [Hay 1976, Schmalensee 1978]. As noted by Bernheim [1984], studies on entry deterrence strategies either ignore the sequential aspect of entry deterrence or are extremely asymmetric, focusing on a dominant incumbent firm. Ignoring the sequential aspect of entry is not consistent with the strategic viewpoint because a firm's strategy should consider not only one entrant, but all potential entrants. Extremely asymmetric treatment narrows the applicability of the models to managerial decision making. Other problems with entry studies are that, with few exceptions [Gaskin 1971, Harrigan 1981], most of these studies lack empirical evidence. Furthermore, entry deterrence studies assume identical production function for potential entrants and incumbent firms. However, under continuous technological change, this assumption does not hold and thus entry behavior needs to be analyzed from a different angle.

The notion of critical fixities, proposed by Tang and Zannetos [1986], could explain entry behavior under continuous technological change. As Tang and Zannetos [1986] show, unless the marginal cost of the existing equipment plus the gains from waiting for advanced equipment exceed the average cost of the new equipment plus switching costs, a firm will not adopt a process innovation. The combined effects of the marginal cost and switching cost on restraining innovation adoption represent the critical fixities of a firm. A corollary of this proposition is that entries and exits will occur. If an innovation is not advanced enough to bring down the average cost, critical fixities will cause existing firms to not adopt a process innovation even though this will put themselves in a cost disadvantageous position relative to the entrants with the new technologies. As a result, entrants will easily outperform existing firms and sometimes make an extra profit. In other words, the critical fixities of the incumbent firms create "certain unimitability", as opposed to "uncertain imitability" [Lippman and Rumelt 1982] which acts as an "entry facilitator", as opposed to an entry barrier, to invite entry. In a stagnant industry such as the steel industry, entries create exits. Therefore, critical fixities may explain the coexistence of entries and exits which result from technological innovations.

This paper studies entries into and exits from the steel industry in order to answer the questions: (i) what are the characteristics of the entries? (ii) how well do the entrants perform relative to existing firms? and (iii) what are the characteristics of exits? An understanding of steelmaking technologies is necessary to understand the characteristics of new-technology entries and exits.

STEELMAKING TECHNOLOGIES

The major reasons that steel is a widely used material are its high strength, reasonable stiffness, and ductility. These properties are largely determined by the chemical composition of steel. The purpose of steelmaking is to obtain the desired chemical composition by eliminating unwanted elements found in the iron ore or scrap, from which steel is made.

The basic process of steelmaking from iron ore is to first obtain liquid iron by burning iron ore with coal, and then refine the liquid iron into liquid steel. The refinement is done in one of two kinds of furnaces: the Open Hearth (OH) or the Basic Oxygen Furnace (BOF). Then, the liquid steel is rolled or cast, and formed into the desired shapes. Steel plants that produce steel products through these processes are called "integrated" steel mills. Another method of making steel is to refine scrap in an Electrical Arc Furnace (EF) and then roll, or cast the liquid steel into the desired shapes.

The steel industry has experienced significant changes in each of the steelmaking stages. First, massive cheap iron ore reserves were discovered in Brazil and Australia in the 60's. Second, gigantic blast furnaces were developed in the 60's, which increased by six times the daily output rate. Third, the BOF was commercialized in 1954 and soon replaced the OH as the dominant steelmaking technology. The BOF, however, requires more hot metal (liquid iron) than the OH. Converting an OH shop to a BOF shop, depending upon existing hot metal supply, requires additional hot metal production facilities such as blast furnaces and sinter plants. Fourth, continuous casting, developed in the late 60's and early 70's, replaced ingot casting as the main casting technology. Continuous casting can reduce labor requirements by two-thirds and also reduces the economies of scale in casting to roughly an annual capacity of half a million tons (Battelle Memorial Institute, 1964). Finally, in the 60's, the capacity of the EF was enlarged significantly. As the scale of the EF increased, and as the economies of scale in casting decreased, it became economical to produce low carbon steel through the EF at an annual capacity less than 1 million tons.

Combining the EF and continuous casting created the so called "minimills": steel mills with less than a 1 million ton annual capacity. Continuous casting plus relatively cheap scrap provide minimills significant cost advantages over integrated mills. However, because scrap contains a significant amount of "tramp elements"--unwanted elements that cannot be removed by the EF, the BOF nor the OH--the steel made from minimills cannot be rolled into steel sheets and strips because tramp elements are detrimental to their quality. Thus, those integrated mills which produce steel sheets and strips are immune from competition with minimills.

ENTRANTS AND THEIR PERFORMANCE

An EF shop uses 100% scrap and thus does not need blast furnaces and iron ore processing equipment to supply hot metal. Therefore, converting an OH shop to an EF shop will make hot metal producing facilities useless. Because of this, the marginal cost of the OH was lower than the average cost of EF [Tang 1985]. Therefore, using the notion of critical fixities, the OH shops of the early 60's should not have been replaced by the EF, even though the average cost of the OH was higher than that of the EF.[1] As integrated mills were not willing to switch to the EF, minimills equipped with the EF and continuous casting easily surpassed the integrated mills. If prices are set by the cost of the dominant technology, in this case, the OH, the minimills can earn an extra profit. Motivated by this profit, some existing firms, which have knowledge of the EF may exploit their expertise by expanding their facilities. Additionally, new firms may be formed to take advantage of the new technology and some steel product distributors may vertically integrate backward. All of these changes have occurred in the steel industry in the last two decades.

A list of entrants with new technologies is given in Table 1. One of these entrants used the BOF to enter the integrated steelmaking business, McLouth Steel. This is because substantial economies of scale in both hot metal production and steelmaking stages created high entry barriers to those intending to use the BOF. However, over twenty minimills entered the low carbon steel market by using the EF. These minimills essentially produce low-end steel products such as steel bars and wire rod. Over 90 percent of these minimills also employed another major innovation: continuous casting. At the same time, integrated steelmakers were slow in switching to the EF; only four OH shops have been replaced by EF shops in the last two decades. Additionally, it wasn't until after the early 60's that the BOF was widely used. These facts clearly show that the reluctance of existing firms to adopt new technologies prompted entry of new firms to the industry.

Insert Table 1 about here

Since those entrants were motivated by the extra profit that could be realized through the use of new technologies, the performance of those entrants is hypothesized to be better than that of the existing firms. The following section compares the profitability of one company, McLouth Steel and several minimills to that of large integrated steel firms.

PERFORMANCE OF ENTRANTS: TWO CASES

The BOF Case: McLouth Steel

In the early 50's, before entering the integrated steel sector, McLouth was engaged in the stainless steel business, using the EF as its primary steelmaking technology. In 1954, McLouth opened the first BOF shop in the U.S. To supply hot metal to its BOFs, McLouth also built a new blast furnace that was one of the largest blast furnaces in the country. Four years later, McLouth added two larger BOFs, and an even larger blast furnace: based on its height and diameter, this blast furnace was the largest in the U.S. at the time. Through this combination of modern blast furnaces and BOFs, McLouth had one of the most advanced steelmaking facilities in the U.S.

Because the marginal cost of the OH was less than the average cost of the BOF in the early 60's, most steel companies were not willing to adopt modern steelmaking technologies. Since McLouth's competitors were not willing to imitate its strategy, one would expect that McLouth's profitability was higher than other integrated steel companies.

Table 2 compares the return on investment (ROI) and the return on sales (ROS) of McLouth Steel and the eight largest steel companies for the periods 1956-59 and 1960-66. As this table shows, after McLouth finished its BOF shop in 1960, its profits rose while the other companies' profits fell. During 1956-1959, McLouth's profitability was below the average of the eight largest steel companies. However, in the following period, 1960-1966, McLouth's average profitability was 30 percent higher than these companies. These results conform to the prediction that entrants will earn an extra profit by using the new technologies that existing firms are not willing to adopt.

Insert Table 2 about here

However, the superior performance of McLouth did not last long. In 1980, McLouth went bankrupt. One reason is that McLouth's advantages turned to disadvantages. McLouth was the first U.S. steel firm to adopt the BOF. At the time, 1954, the BOF technology was rather premature; furnace size was as small as 35 tons. 1958, McLouth added two 110 ton BOF's. However, in the 60's, the size of the BOF improved significantly and was capable of refining 300 tons of liquid steel within 40 minutes. As McLouth's competitors adopted larger and more efficient BOF's, McLouth's advantages began to disappear. Despite the advance in BOF technology, in 1968 McLouth added two 110 ton BOFs, not the new 300 ton ones, to replace its 35 ton BOFs. As a result, McLouth had five 110 ton BOFs, not two 300 ton BOFs. Perhaps the reason McLouth adopted the less efficient BOFs was that it had to maintain compatibility of cranes and transportation equipment between new furnaces and its existing 110 ton furnaces. This need for compatibility would have increased switching costs if McLouth had added 300 ton furnaces.

The McLouth case illustrates that, although early adopters of a new technology gain a temporary cost advantage, other firms can come in later with a better technology. As these other firms enter the market, the critical fixities prevent the original early adopters from using the better technology. The McLouth case also illustrates the leap-frog type competition which can result from continuous technological change. The same situation seems to be repeating itself in the case of Japanese steelmakers. After two decades of dominance in the world steel market, Japanese integrated steelmakers now are threatened by Korean and Taiwanese steelmakers, who are using better technologies.

The Minimills Case

In the previous section, Table 1 gave a list of companies that entered the low carbon steel market by using the EF and continuous casting. Among those firms, only a few went public and among these, only four are engaged primarily in the carbon steelmaking business, competing directly with large, integrated steel mills.

In Table 3, the performance of these four minimills is compared with that of integrated steel firms. Due to data availability, only ROS is used as the performance indicator.[2] For the period from 1970 to 1982, on the average, the four minimills earned 11.24 percent return on sales while integrated firms earned only a fraction of that, 3.65 percent. Given that minimills are less capital-intensive than integrated mills, the ROI of minimills must be even higher than that of integrated mills. Some of the integrated mills barely broke even and would rather have suffered an accounting loss than replace their out-of-date facilities. For example, Kaiser Steel was in the red 7 out of 11 years and yet did not replace its OHs until 1978, twenty years after its first BOF installation.

The t-statistic of the ROS between the minimills and the integrated mills is 5.71, with significance beyond the .01 level. Thus, the null hypothesis that there is no performance difference between minimills and integrated steel companies is rejected. Table 3 clearly indicates how entrants took the opportunities created by technological advancement and by the critical fixities of existing firms to earn an above-average profit.

Insert Table 3 about here

In a stagnant industry such as the steel industry, these entrants forced some plants to close. According to AISI's Directory, there were 53 integrated steel works which produced carbon steel by employing the blast furnace and the OH in 1960. By 1983, sixteen of them were permanently shutdown, four were replaced by the EF, and only thirty-three integrated steel works were still in operation. Although all plants faced the same threats from minimills and imports, one might wonder why only some plants were closed, thereby causing significant financial losses for their firms. The characteristics of these exits are investigated below and a simple model is derived which seeks to explain the exit decision of an integrated mill.

THE MODEL OF EXITS

Assuming a firm maximizes its market value, the major reason for it to shut down a steel plant is that the cash flow of exit is higher than the cash flows of other alternatives. For an aged integrated steel plant using the old technology, the OH, the other alternatives are to maintain current operations, or to replace OH shops with new technologies, such as the BOF. If the firm chooses to maintain current operations, the plant's net cash flow would be $P\text{-}MC_{old}$, where P is the price and MC_{old} is the marginal cost of the existing product. If the plant is to be replaced by new technologies, the net cash flow is

$$P\text{-}AC_{new} - SC \qquad (2)$$

where AC_{new} is the average cost per unit using the new equipment and SC is the unit switching cost. To close the plant, the unit net cash flow of exit, C_{EXIT}, must be greater than the cash flow of the other two alternatives. Thus, if

$$C_{EXIT} > \mathrm{Max}[P\text{-}MC_{old},\ P\text{-}AC_{new}\text{-}SC] \qquad (3)$$

the firm will close the integrated plant.

Equation 3 indicates that, given the same cash flow of exit per unit, the lower the price of the product, and the higher the MC_{old}, the AC_{new}, and the SC, the more likely it is that the integrated plant will be closed. Several factors that affect the price, MC_{old}, AC_{new}, and SC need to be discussed and tested. Then these factors will be used to explain the exits from the steel industry.

Hypotheses

First, due to the substantial economies of scale of the BOF, the annual production capacity of a plant affects the AC_{new}. Small plants are likely to have higher AC_{new} if they had been converted to the BOF. To reduce the AC_{new}, the plant has to be expanded. This includes the expansion of all facilities such as blast furnaces, sinter plants, and rolling capacities. In a stagnant market, these expansions are hardly justifiable. Therefore, it is expected that the smaller the annual production capacity of an integrated steel plant, the more likely it is that it will be closed.

Second, a typical integrated steel plant has several blast furnaces. The average annual capacity of blast furnaces is an indicator of their efficiency. Integrated plants with smaller blast furnaces are more likely to have higher marginal costs and thus will either be shut down or be replaced by the BOF. Replacement, however, is unlikely to be the choice because the inefficient blast furnaces will increase the average cost of the BOF, which requires more hot metal. Additionally, switching costs will increase if those blast furnaces are to be enlarged or rebuilt. Therefore, plants of small blast furnaces are more likely to be closed.

Third, since switching to the BOF requires more hot metal, low hot metal availability increase switching costs. (Hot metal availability is measured as the ratio of annual pig iron capacity to annual steel capacity.)

Fourth, as minimills enter the market, the prices of products made by the EF could be lower because the EF has a lower average cost. But due to tramp elements in the scrap, those integrated plants producing sheet and strip do not compete with minimills. Therefore, it is expected that a higher percentage of sheet and strip capacities would increase the possibility of the survival of an integrated steel plant.[3]

In summary, it's hypothesized that those plants characterized by small size, small average size of blast furnace, low hot metal availability, and low steel sheet production capacity are likely to be closed. Since the dependent variable is dichotomous, discriminant analysis is used to test these hypotheses.

Empirical Analysis

For purposes of this analysis, two types of exits are used. The first type is the exit from the integrated steelmaking business, including four OH shops that shut down their integrated steelmaking facilities and replaced them with the EF. The second type is the exit from the steel industry, comprised of only those steel plants that were permanently shut down before 1983. The results of the discriminant analysis are summarized in Table 4.

Insert Table 4 about here

The two discriminant functions using the two different exits show significant discriminant power with the chi-square of the two equations significant beyond the .001 level. Also, over eighty percent of the cases are correctly classified. These results indicate that the overall explanatory power of these two discriminant functions, consisting of the four prediction variables mentioned above, is adequate.

Standardized canonical coefficients indicate that the size of the steel plant, the annual capacity of blast furnaces, and the percentage of steel sheet capacity contribute more or less equally to the discriminant function. As is shown, their signs are consistent with expectations. However, hot metal availability appears to contribute only marginally.

Comparison of the discriminant functions of the two types of exit shows that the contribution of the product mix variable to the discriminant function increases as the four EF replacements are included in the analysis. The standardized canonical coefficient of SHTH, a measure of hot rolled steel sheet and strip capacity, increases from 0.424 to 0.650. In addition, for those exits from the integrated steel business, the product mix variable contributes the most to the discriminant function. These results reflect the technological limitation of the EF. Because steel sheet and strip cannot be made from the steel from the EF, having strip and sheet production capacity would reduce the possibility of converting an integrated OH shop to an EF shop. Therefore, the product mix variable becomes more significant for the sample that includes the four OH shops which are replaced by the EF.

Interestingly, the discriminant function can provide some predictions regarding future closings of integrated steelmaking facilities. Using both equations, the five plants which have the highest negative discriminant scores but which have not been shut down before 1983 are: CF&I's Pueblo plant, United States Steel's Duquesne plant, Republic Steel's Buffalo plant, Republic Steel's Gadsen plant, and Wheeling-Pittsburgh Steel's Monessen plant. According to the discriminant function, these plants are misclassified; they should have been shut down before 1983 but they were not. Therefore, it is predicted that they will be closed before other integrated plants that had not been closed before 1983. This prediction is largely in line with what actually occurred. In 1983, the first three plants were closed and discussion was underway about selling the fourth. The fifth went bankrupt in 1985. Thus, here is an indication of the predictive power of the discriminant functions.

These exits can be viewed as victims of technological innovations. The impact of the EF and continuous casting can be seen from the fact that integrated plants producing products similar to minimills are likely to be forced to close because of the high switching costs of converting non-competitive steel products to steel sheet and strip. This reflects the ineffectiveness (undesirable output) of an integrated steel plant relative to its minimill rivals. The impact of the BOF is revealed by the fact that the small size of an integrated plant created high switching costs and thus significantly reduced its chances of survival. Also, not surprisingly, efficiency plays an important role in plant closings.

CONCLUSION AND STRATEGIC IMPLICATIONS

This paper exemplifies a techno-economic-strategic analysis in which key characteristics of technologies are first analyzed, and economic consequences are then derived, followed by strategic implications. Additionally, it demonstrates how technological innovations coupled with critical fixities of a firm can partially explain the entry, exit, and performance of firms in the U.S. steel industry.

This paper also illustrates that, because of the reluctance of existing firms to switch to new technologies, entrants using these new technologies entered the low carbon steel market and earned an extra profit. The existing integrated firms would rather have suffered accounting losses than replace their obsolete equipment as long as the cash flow remained positive. However, entrants into the integrated steel industry having new technologies, such as McLouth and the Japanese steelmakers, enjoyed only short-term cost advantages. Critical fixities associated with new technologies inhibited them from adopting more advanced technologies. Yet leap-frog type competition has not been observed for minimills. This difference may be because (i) minimills are less capital intensive than integrated mills, and therefore critical fixities are not as serious as for integrated mills and (ii) the minimill sector is still expanding, creating many opportunities to adopt new technologies. Therefore, the entry-with-new-technology strategy should be evaluated in light of future technological changes and expansion possibilities.

Finally, it was shown that as the demand for steel leveled off, those entrants forced some existing firms to close their plants and even forced some integrated firms to go bankrupt. These exits are characterized by high switching costs resulting from small size, and low competitiveness resulting from improper product mix. It is shown that inefficiency (caused by small furnaces) and ineffectiveness (caused by improper product mix) contribute equally to the exits.

FOOTNOTES

[1]See Battelle Memorial Institute [1964], and United Nation's [1962] studies.

[2]Integrated steel companies began their diversification in the 1970s. As a result, their performance cannot represent the performance of their steelmaking business. To correct this, we use the information of their steelmaking business as presented in the business segment section of their annual reports. If business segment data are not available, we use corporate data. It should be kept in mind that each company has its own definition of "steelmaking" and each company has its own policies on allocating corporate expenses and transfer pricing. The use of business segment information also leads us to choose ROS as the performance indicator because information on "identifiable assets" and depreciation for a particular business segment are not always available.

[3]Only hot-rolled strip and sheet capacity is counted because cold-rolled strip and sheet capacity can be utilized by purchasing hot-rolled strip and sheet from other companies.

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TABLE 1

A PARTIAL LIST OF ENTRANTS INTO THE LOW CARBON STEEL MARKET AFTER 1954

Year	Company	Steelmaking Furnace	Casting Machine	Annual Capacity as of 1982 (in net tons)
1954	McLouth	BOF	Ingot	1,000,000
1961-66	Border Steel	EF	Continuous	200,000
1963-70	Intercoastal Steel	EF	?	80,000
1964-78	Roblin Steel	EF	Continuous	200,000
1965-81	Florida Steel*	EF	Continuous	1,578,000
1966	Tennessee Forging	EF	Continuous	160,000
1967-79	North Star Steel*	EF	Continuous	1,140,000
1967	Keystone Group	EF	Continuous	800,000
1967	Witteman Steel	EF	Ingot	60,000
1968	Nucor Corporation*	EF	Continuous	2,000,000
1968-75	Northwestern Steel & Wire*	EF	Continuous	2,400,000
1968-82	Marathon Steel	EF	Continuous	175,000
1968-75	Marion Steel	EF	Continuous	250,000
1968	Owen Electric Steel	EF	Continuous	100,000
1969	Korf Industries	EF	Continuous	700,000
1970	Cascade Steel Rolling Mills	EF	Continuous	275,000
1971	Razorback Steel	EF	Continuous	120,000
1971-79	Connors Steel	EF	Continuous	200,000
1972	New Jersey Steel	EF	Continuous	200,000

TABLE 1 (continued)

1974	Mississippi Steel Division	EF	Continuous	180,000
1974-83	Quanex Corporation	EF	Continuous	460,000
1975	Auburn Steel	EF	Continuous	250,000
1975	Chaparrel Steel	EF	Continuous	950,000
1976	Charter Electric Melting	EF	Continuous	120,000
1977	Tamco	EF	Continuous	300,000
1979	Raritan River Steel	EF	Continuous	600,000

? Means information on casting method is not available.

Definition of Entrants: New firms entering the market with new technologies or existing firms expanding their steelmaking capacities over three times its original capacity in 1960.

* Indicates firms that expanded their capacities aggressively by using new technologies.

Source: Iron and Steel Society, AIME Complete Listing: Electric Arc Steelmaking Furnaces in United States, Warrendal, PA.: Iron and Steel Society, AIME, 1982. Richard Diley and William Pietrucha, Steel Industry in Brief: Data Book, U.S.A., Green Brook, NJ.: Institute of Iron and Steel Studies, 1983. American Iron and Steel Institute, Directory of Iron and Steel Works of U.S. and Canada, Washington, D.C.: American Iron and Steel Institute, various years. Association of Engineers, Directory, Iron and Steel Plants, Pittsburgh, PA: Association of Iron and Steel Engineers, 1984.

TABLE 2

PERFORMANCE COMPARISON BETWEEN MCLOUTH AND THE EIGHT LARGEST STEEL COMPANIES

	1956-1959		1960-1966	
Company	ROI	ROS	ROI	ROS
McLouth	9.33	9.94	14.83	14.63
Armco	14.50	13.43	9.93	10.44
Bethlehem	13.61	13.26	9.41	9.95
Inland	15.14	13.99	12.40	12.95
Jones & Laughlin	8.95	9.21	8.51	8.75
Kaiser	6.75	13.11	5.04	8.30
National	12.70	14.09	10.96	12.32
Republic	15.45	12.74	7.99	8.33
United States	15.17	16.12	8.23	10.95
Largest 8 Average	12.78	13.24	9.06	10.25

Source: Moody's Investors Service Inc., Moody's Industrial Manual, New York: Moody's Investors Service Inc., 1956-1966.

TABLE 3

RETURN ON SALES (ROS) FOR MINIMILLS AND STEELMAKING SEGMENT IN INTEGRATED STEEL FIRMS (IN PERCENTAGE)

Minimills			Steelmaking Segment		
Company	Period	ROS	Company	Period	ROS
Nucor	1970-82	11.72	USS	1970-82	1.39
Northwestern Steel and Wire	1970-82	13.06	Bethlehem	1970-82	2.32
Quanex Steel	1974-82	10.74	Inland	1970-81	8.70
Florida Steel	1970-82	9.44	Republic	1970-82	2.11
			Kaiser	1970-82	0.62
			National	1970-82	3.41
			Armco	1970-81	4.50
			LTV	1970-81	4.88
			Wheeling-Pittsburgh	1970-82	1.30
			Interlake	1970-81	4.39
			Lone Star	1970-82	6.57
Average ROS: $\overline{X}$=11.24					$\overline{X}$=3.65
T-statistic=5.71					

Source: Annual Reports, various years

TABLE 4

DISCRIMINANT ANALYSIS RESULTS OF EXITS

	Eq. No.	Standardized Canonical Coefficients SIZE	BFCAP	HMA	SHTH	No.* Obs.	Chi-square	Canonical Corr.	Eigen-value	Percentage of cases correctly classified
Exits from steel industry	1	0.486	0.569	0.114	0.424	46	18.92**	0.602	0.569	80.4
Exits from integrated business	2	0.554	0.377	0.192	0.650	50	20.7**	0.602	0.570	82

* Kaiser Steel, McLouth Steel, and Jones and Laughlin's Aliquippa plant are excluded due to their BOF capacity.

** Indicates significance level beyond the 0.001 level.

Definitions of Prediction Variables:

SIZE: annual steelmaking capacity (in million tons) as of 1960
BFCAP: average annual capacity of blast furnaces as of 1960
SHTH: hot-rolled steel sheet and strip capacity as a percentage of total hot-rolled products capacity as of 1960
HMA: hot metal availability, measured as pig iron capacity over steelmaking capacity.

Source: American Iron and Steel Institute (AISI), Directory of Iron and Steel Works in U.S. and Canada, (Washington, D.C., AISI), various years.