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THE MINIMUM OPTIMAL STEEL PLANT AND
THE SURVIVOR TECHNIQUE OF COST ESTIMATION

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The Minimum Optimal steel Plant and the Survivor
Technique of Cost Estimation

by

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The survivor technique is used to examine economies of scale
in the steel industry, and the results are compared to an earlier engineering approach study by Tarr. Specifically the paper focuses on the conventional integrated steel mill of over 1 million tons a year. The results are consistent with Tarr's estimate of a steel mill Minimum Optimal Scale of 6 million tons a year.

I. Introduction

Economists have long been interested in ways to determine
the relationship between plant or firm size and efficiency as reflected by average cost. In many industries economies of scale are so large relative to market demand that there is room for only a few firms of efficient size. Consequently, in

cost and output. However, there are problems with measuring
various components of cost such as normal profits and the cost of
capital (see Fisher and McGowan (1983), Saving (1964), and
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employment. 1 Besides stigler, Saving (1961) and Weiss (1964)
have used the survivor technique.

All three techniques have some advantages and some disadvantages. While the engineering technique indicates why a given plant is efficient, its estimate of the size of that plant is only hypothetical. In contrast, the survivor technique indicates which plant sizes hold their own in the market but not why. Therefore the survivor technique is a natural complement to the engineering technique, and it would be useful to examine the consistency of the two approaches.

III. Background on the Steel Industry and the Data

Steel is produced by three different types of plants: the predominant type in total production share being the conventional steel mill. This mill is a combination of three major components: the blast furnace which smelts the iron ore into iron or pig iron, the steel furnace which refines the iron into steel, and the rolling mill which rolls the steel into the shapes useful to the mill customers. The second most prevalent type of steel mill in production share is the Electric Furnace (EF) minimill which uses scrap steel. In many circumstances where scrap and electrical power are cheap and readily available, this is the lowest cost way of making steel. The third type of plant combines the Electric Furnace with the Direct Reduction of ore into iron without a blast furnace. Except in a few areas with very low gas ghis

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(formerly part of the Ford Motor Company), and the Great Lakes mill of National Intergroup.

Furthermore, there has been great technological change.
Direct casting has changed the nature of the rolling mill process in both the conventional plant and the minimill. The minimills in general have expanded not only their total market share but also their product line. In 1990, one minimill company, Nucor, started to make sheet steel, which was heretofore a product only of the conventional mills. All these changes have led to sUbstantial improvements in the productivity of the steel industry. Thus it is an interesting question as to whether Tarr's estimates of MOS would hold up during this period.

This paper focuses only on the conventional steel mill of
over one million ton (1 MT). First sufficient data are not available to apply this technique to the minimill. Many of the minimill companies are privately held and do not make their capacity data public. Second, minimills cater to a wide variety of geographic and product markets, and an effici~nt size mill in one situation might not be

IV. The Application of the Survivor Technique to the Integrated Steel Plant

Tarr's paper was the latest of a number of studies on economies of scale in the mid-twentieth century steel industry. (See Scherer (1975), Leckie and Morris (1968), and Pratten and Dean (1971).) Tarr focused on two types of steel mills: the conventional integrated mill and the electric furnace minimill. The Tarr estimates provide an ideal setting for comparing engineering estimates with those provided by the survivor technique. In particular, the most recent data on steel mills can be used to compare the actual sizes of present-day steel mills with Tarr's MOS estimates based on engineering approach in the mid-1970s.

with his engineering approach, Tarr concludes that the
Minimum Optimal Scale (MOS) capacity for a conventional steel mill is 6 million tons (6 MT) of steel a year. Tarr's reason for this estimate is that the MOS for the modern blast furnace is roughly 3 MT a year, and a mill needs two such furnaces to maintain a continuous flow of product. Repair and maintenance requires that one furnace be out of production for considerable periods of time.

To conduct our survivorship test, capacity data were
collected on conventional steel plants of over one million tons

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capacity (1 MT) for 1976. For 1987,

For each furnace type, there is, however, a considerable range in these ratios. Thus, we compute the three different estimates of yearly capacity for each furnace in the plants without available yearly capacity. The first, the Medium estimate, is based on the average of the available heat size-yearly capacity ratios for the given type of furnace; the second, the Low Estimate, is computed from the average ratio minus one standard deviation for the sample; and the third, the High Estimate, is computed from the average ratio plus one sample standard deviation. From these estimates for the furnaces, we aggregate ~o arrive at three yearly capacity estimates for each plant.

Based on these plants estimates, we obtain three 1987 plant
size distributions; the Low Distribution assumes that each furnace without capacity data has a capacity equal to our Low Estimate. The Medium Distribution assumes that each furnace without capacity data has a capacity equal to our Medium Estimate, and High Distribution assumes that each furnace without capacity data has a capacity equal to our High Estimate. For the Low Distribution, the total capacity (of mills of over 1 MT) is 72.4 MT; for the Medium Distribution, it is

1976 capacity share for this category is 1.46 for the Medium estimate, 1.37 for the Low estimate, and 2.21 for the High estimate. It is admittedly an increase in the share of a declining total since the total capacity in the united states of these over 1 MT plants dropped from 144.8 MT to 72.4, to 8j.1 or to 92.1 MT depending on which 1987 distribution we accept. The decline in total industry capacity lends an even more compelling significance to the increase in the market share by Tarr's MOS size category. In a market with falling demand, the pressure for technical efficiency is even greater than in markets with rising or stable sales.

Alternatively, the change in the shares of plants over the
size classes may be due to random fluctuations with the
underlying distribution of plants remaining unchanged. Thus,
Chi-Square statistics were used to test for the hypothesis that
the change in the shares was due to random variation. For all
three distributions, the Chi Square test indicates that it is
extremely unlikely that the change in plant distribution was due
to chance, the 11.8 476.01 567.6 Tm (ovefficiency)50 0 11.8 402..814.01e2m (oveffic

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Table I

Distribution of U. S. Steel Mills of Over 1 MT* by Capacity, 1976 and 1987
I. Medium Estimate

Plant Size Category

Over 7.5 MT
4.5 to 7.49 MT
1.5 to 4.49 MT
1. 0 to 1. 49 MT

Total Capacity

II. Low Estimate

Percentage
of Total
Capacity

1976**

16.4
19.3
61.4
2.9

(3)
(5)
(32)
(4)

144.8 MT (44)

Percentage
of Total
capacity

Plant Size Category 1976**

Over 7.5 MT
4.5 to 7.49 MT
1.5 to 4.49

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