Empirical studies of returns to scale are rather limited. Ideally, cross section samples of plants might be used, but we propose that valid conclusions can be drawn from time-series data. Jorgenson (1972) cites the work of Bain (1956) and Kamerschen (1968), and proposes a model where changes in industry concentration ratios are used as a "crude test" for stability of the size distribution of firms within an industry, the latter indicating the nature of returns to scale. In this paper, we examine detailed Census data for 37 selected manufacturing industries for 1947, 1954, 1958, and 1963 for comparison with the Jorgenson analysis. Unlike Jorgenson we use measures of the size distribution of employment (mean and variance) among establishments within each industry, for comparison with the concentration ratios, and find that there are very few cases where the indicators of scale effect are consistent.

I. Introduction
The form of the production function, and the nature of returns to scale, have important implications for the theory of investment behavior and for market structure, or the concentration of industries. Fittingly, a vast literature emerged from the seminal article which introduced the CES class of production functions [Arrow, et al. (1961)], and much of it was an attempt to reconcile conflicting empirical evidence from both cross-section and time-series studies. Jorgenson (1972) presented an interesting eclectic case for the special Cobb-Douglas form and, based on separate evidence, for constant returns to scale. In this paper we critically examine the Jorgenson model and data, on the scale parameter, and present an alternative method for 37 selected manufacturing industries for the same sample period.

II. The Jorgenson Model
In the theory of production, the concept of optimal scale or "capacity" corresponds to the minimum point on the long-run average cost curve. Technology in a particular industry might dictate economies of scale, or decreasing unit cost, up to some size; constant returns or decreasing returns to scale might be the norms in other individual industries. Allowing that all three conditions might exist in the same industry (a U-shaped long-run average cost curve), it seems useful to look for a general characterization of scale in each industry over the observed ranges of experience.

A model suggested by Jorgenson is both plausible and operational. The model is that...

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*The sample of 37 industries was selected in connection with the author's research on industry production functions estimated from time-series data [Draganette, (1974)], as a prior study where extensive input and output data (including price deflators) are available. The analysis of returns to scale could be extended to virtually every SIC four-digit manufacturing industry, as well as to more recent Census years.
plant economies imply that the average growth rate of firms is associated with firm size. Conversely, constant returns to scale implies that firm size and growth rate are independent, which suggests that the size distribution of firms should be relatively stable over time. Jorgenson proposes what he calls a "crude test" for stability of size distribution, viz., stability of the industry concentration ratio over time. Reporting on Bain (1956) and Karmersch (1968), Jorgenson concludes that constant returns to scale is the rule within U.S. manufacturing. Economies of scale characterize only the very small firms as they expand from miniscule to more normal size, we are told.7

One feature of Jorgenson's analysis seems peculiar: he averages the concentration ratios for all SIC four-digit industries and concludes that they have been very stable. Is such averaging at all meaningful in this context? Quoting Jorgenson:

"...: concentration ratios averaged over four-digit manufacturing industries are very stable over the period 1947-1963. Over the whole period, concentration ratios increased for 30 percent of the industry groups, remained the same for 22 percent, and decreased for 48 percent. Our overall conclusion is that evidence on the rate of growth of firms by size and evidence on size distribution of firms is consistent with the hypothesis of constant returns to scale. Direct evidence on returns to scale from Bain's analysis of engineering estimates is consistent with constant returns to scale beyond a firm size equal to the minimum efficient size of the plant."

A conclusion which seems more logical is:

"...: concentration ratios averaged over four-digit manufacturing industries are very stable over the period 1947-1963. Over the whole period, concentration ratios increased for 30 percent of the industry groups, remained the same for 22 percent, and decreased for 48 percent. Our overall conclusion is that evidence on the rate of growth of firms by size and evidence on size distribution of firms is consistent with the hypothesis of constant returns to scale. Direct evidence on returns to scale from Bain's analysis of engineering estimates is consistent with constant returns to scale beyond a firm size equal to the minimum efficient size of the plant."

That constant returns are indicated for about twenty percent of the four-digit industries, if we look strictly at concentration ratios. In order to apply the Jorgenson test to our sample industries, we have examined in detail the Census data on concentration ratios, or percentage of value of shipments accounted for by the largest four, eight, twenty, and fifty companies in each industry. These data are published separately in each of the Census of Manufactures volumes for 1947, 1954, 1958, 1963, and 1967. (In a few cases data for only the later years are available.) A summary of the results is the following: concentration ratios increased for fifteen of the industries (SIC 212, 227, 241, 286, 312, 316, 319, 324, 325, 326, 328, 375, 386 and 393), suggesting economies of scale in those cases; concentration ratios were about constant for twelve industries (SIC 211, 231, 283, 285, 301, 303, 306, 307, 334, 341, 351 and 359); ten industries showed a drop in the concentration ratio or a suggestion of decreasing returns to scale (SIC 253, 302, 311, 313, 348, 379, 381, 382, 383 and 385).

We believe that changes in the concentration ratios, which are based on the number of companies, can be a misleading indicator of the scale effect. Concentration can be simply a reflection of increasing barriers to entry and/or horizontal integration. In cigarette manufacturing (SIC 211), for example, the concentration ratio based on the four largest firms declines over the sample period, suggesting the possibility of decreasing returns at the upper end of the size distribution, while the 8 and 20-firm ratios are stable which might suggest constant returns. But the size distribution data (Table 1 below) shows a clear consolidation toward larger establishments in that industry, suggesting some plant economies of scale. In the following section, we shall pursue this kind of analysis for the whole list of sample industries.
III. An Alternative Model

Fortunately, there are rather complete Census data on the distribution of employment among establishments within each industry, which seems to be a better indicator of scale than concentration ratios. For example, a significant rise in the average size of establishment would suggest economies of scale. Consolidation toward larger (or smaller) establishments might also result in a decrease in the variance of employment among establishments. On the other hand, a stable size distribution (mean and variance) should be a reflection of constant returns to scale.

An inspection of the raw Census data (not shown here) reveals several cases of industry growth which appear to be uncorrelated with size of establishments, i.e. pretty evenly spread across sizes, except for some drop in numbers of establishments at the upper end of the size distribution. However, there are many cases where total employment declines or is stable, but there is a significant increase in the number of small establishments. In a few cases, consolidation toward larger establishments occurs.

Means and variances of employment among establishments within each industry are calculated for several Census years and shown in Table 1. On the basis of Table 1,

"An establishment is defined as..." (footnote)

...an economic unit, generally at a single physical location where business is conducted or where services or industrial operations are performed. (For example: A factory, mill, ...)." (source: Executive Office of the President, Office of Management and Budget, Standard Industrial Classification Manual (Washington, 1972).

...The Census data for each industry are the number of establishments with an average of 1 to 4 employees, 5 to 9, 10 to 19, 20 to 49, 50 to 99, 100 to 249, 250 to 499, 500 to 999, 1000 to 2499, 2500 and over employees.

"Using standard statistical methods, we estimate the means and variances by calculating the midpoints of the class intervals. In those industries with some establishments employing 2500 or more persons, we have assumed a midpoint for that class interval of 2575 employees, for the estimation of means and variances.

Economies of scale are indicated for only about eight industries (SIC 211, 212, 283, 303, 312, 315, 316 and 325). Of these eight, the concentration ratio increased in five cases. On the other hand, the concentration ratio increased for ten other industries where the employment data show either stability or a decrease in average size and variance. Approximately constant returns appear to characterize about five of the industries (SIC 241, 307, 319, possibly 328, 341, 379, 382, 383 and 393) but only two of these appear constant in terms of the concentration ratios. There are now twenty cases where the average size of establishment decreases and generally the variance also decreases (SIC 213, 227, 253, 285, 286, 301, 302, 306, 311, 313, 324, 326, 334, 346, 348, 351, 359, 375, 385, and 386). It is obvious that there are very few cases where the concentration ratios and the average size of establishment give a consistent indicator of the scale effect. From Table 1, on the other hand, there is a clear drop in the variance of employment in most of the industries where the mean employment either increases or decreases, reflecting a consolidation over time toward the optimal size of establishment. When the mean employment suggests constant returns to scale, the variance also tends to be stable. We conclude that concentration ratios, which are based on the market share of companies, are a misleading indicator of the scale parameter, and that data on the size distribution of employment among establishments are much more revealing.

IV. Conclusion

In reaction to Jorgenson’s (1972) results, and more generally to the whole empirical literature, we propose that extensive time-series data are available for individual manufacturing industries which are likely to show an interesting diversity of technologies. In this preliminary analysis, it seems that concentra-