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PRODUCTIVE CAPACITY, INDUSTRIAL PRODUCTION, AND STEEL REQUIREMENTS

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A. INTRODUCTION

THIS paper will attempt to analyze the factors controlling the demand for steel and to suggest a method of estimating steel requirements based on separating total industrial production into a capacity-determined, or long-term, and an output-determined, or short-term, component.

This approach should be especially useful for making long-term projections. The method is applied to data for the years 1919-40. The usefulness of the relationships is tested by extrapolating them into the postwar period to project the demand for steel in 1950 and neighboring years.

Analyses of steel demand have been attempted both to develop economic theory and to answer questions of economic policy. Early analysts of the general supply and demand relationship used the price of a commodity as the sole determinant of its demand. This emphasis on the "level of the price" was modified a quarter of a century ago by G. C. Evans, who introduced the "change in price" as another factor.[1]

The fact that the level of the price, the change in price, and even the relative prices of other commodities do not sufficiently explain demand was stressed by C. F. Roos in 1929.[2] In 1936, R. W. Whitman applied this general demand theory to the steel industry in particular.[3]

Note: This paper was prepared with the assistance of Todd May, Jr. and Charlotte Boschan. The analysis presented has profited greatly from the spirited advice given by Franco Modigliani and the constructive suggestions of George G. Garvy and others. Comments by various industry analysts have provided a better insight into the problems discussed.

[1] G. C. Evans, "The Dynamics of Monopoly," *American Mathematical Monthly*, Vol. 31, No. 2, February 1924.

[2] ". . . in some cases it [demand] may even depend upon the rate of production, the acceleration of the rate of production, and upon the cumulation of these effects. . . ." C. F. Roos, "Dynamical Theory of Economics," *Journal of Political Economy*, Vol. 35, 1929.

[3] R. W. Whitman, "The Statistical Law of Demand for a Producer's Good as Illustrated by Demand for Steel," *Econometrica*, Vol. 4, No. 2, pp. 138-52.

This movement away from the classical concept of a demand function was not without controversy. The question of the influence of price on steel demand developed into political argument. Several studies were submitted for both sides in the *Hearings before the Temporary National Economic Committee* in 1940.[4] One of the most useful of these was a study of over-all steel consumption by various major industry groups.

A continuation of the trend away from using price as a determinant of steel demand and toward introducing production, or some measure of general business activity, is shown in L. J. Paradiso's study for the National Resources Planning Board.[5] The price factor was also ignored in a study by L. H. Bean.[6]

The starting point for this analysis is the comparison of steel production for ingots and castings with total industrial production as measured by the Federal Reserve Index of Industrial Production. Chart 1 clearly reveals that in the period from 1919 to 1940, fluctuations in the demand for the production of steel can be accounted for largely by fluctuations in the level of industrial activity. Correlating steel output with total industrial production for the years 1919-40 leads to a correlation coefficient of 0.897 and the following regression equation:

Formula I

$$S_T = -17.49 + 0.697\, P_T = 0.697(P_T - 25.1)$$
$$[6.25] \quad [6.90] \quad [0.077]$$

S_T: Annual production of steel for ingots and castings, in millions of net tons.

P_T: Total industrial production (Federal Reserve Index, 1935-39 = 100).

In brackets: Standard error of estimate and standard error of regression coefficients.

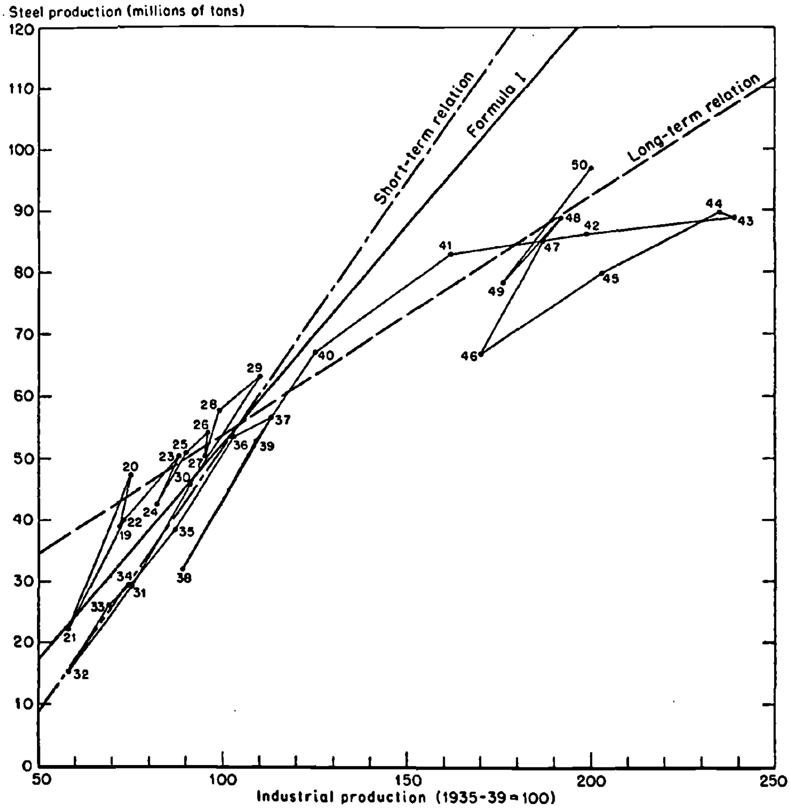
[4] H. G. Lewis under the direction of T. O. Yntema, *United States Steel Corporation, A Statistical Analysis of the Demand for Steel, 1919-1938*, TNEC papers, Pamphlet No. 5.

[5] L. J. Paradiso, *Capital Requirements, A Study in Methods as Applied to the Iron and Steel Industry* (Government Printing Office, 1940). On page 25, Dr. Paradiso presents an estimate of steel demand for 1941 based on an extrapolation of a trend line through the peaks of steel production during the period 1899-1929. Actual steel production in 1941 exceeded his estimated level by less than 1 percent.

[6] *The Dependence of Industrial-Agricultural Prosperity on Steel Requirements for Full Employment*, statement by Louis H. Bean, Office of the Secretary, Department of Agriculture, before the Steel Subcommittee of the Senate Committee to Study Problems of American Small Business, June 19, 1947 (mimeographed).

CHART 1

Relation of Steel Output (Ingots and Castings) to Industrial Production



The regression line corresponding to Formula I is indicated by the solid black line on Chart 1 and in Table B-3, column 1 (see Appendix B). Although the line provides a well-fitting general description of the conditions during the period of observation, its use for projecting the demand for steel in the postwar period, when industrial production was far beyond prewar bench marks, would have resulted in substantial overestimates of steel demand. For the five postwar years 1947-51 in particular, when the index of total industrial production averaged 195, or 122 percent above the average for 1919-40, Formula I yields an estimate of the demand for steel of 118.4 million net tons, 31 percent above the actual production of 90.7 million tons. Obviously Formula I does not provide a suitable basis for long-run projections.

B. THE BASIC APPROACH OF THIS ANALYSIS

Close inspection of Chart 1 provides an explanation for the shortcomings of Formula I and suggests an alternative method of estimation, more adequate for long-term projections. If the observations for those years which established an unprecedented peak in total production (1920, 1923, 1925, 1926, 1928, 1929, 1940) are emphasized, it becomes apparent that the straight line approximating the relation between steel demand and industrial production for those years is considerably flatter than the overall regression line of Formula I. On the other hand, whenever the Federal Reserve Index fluctuates below a previous peak, the relation between steel and industrial production is represented by much steeper lines, like those marked by the years 1920-22, 1929-36, or 1937-39. Two distinct relationships between steel output and industrial production are thus revealed by Chart 1: a short-term or cyclical one, illustrated by the steep dashed-dotted line, and a long-term one, illustrated by the shallow dashed line. The apparent prewar relation expressed in Formula I—and shown by the solid line falling between the two others—is a hybrid of both. It is for this reason that this formula is unusable for long-term projections. The apparent relationship between steel output and industrial production must be resolved into a short-term and a long-term component, and only the latter used for long-term projections.

This difference in long-term and short-term relationships has also been observed in other economic series. Several authors have discussed its nature and significance, especially in connection with the problem of estimating an aggregate consumption function for purposes of long-run forecasting.[7] We shall attempt to apply to the steel problem a variant of a general method suggested by Modigliani for separating cyclical and secular components in the relation between two variables.

Modigliani was concerned with the relation between income and consumption. He suggested that, for a number of reasons, aggregate consumption depends not only on the current level of

[7] Franco Modigliani, "Fluctuations in the Savings-Income Ratio: A Problem in Economic Forecasting," *Studies in Income and Wealth, Volume Eleven* (NBER, 1949), pp. 371-443. James S. Duesenberry, *Income, Saving, and the Theory of Consumer Behavior*, Harvard Economic Studies, No. 87 (Harvard University Press, 1949).

income, but also on the "cyclical position of income." He measured the cyclical position of income by relating current income to the highest previous peak of disposable income. The previous income peak serves as a moving bench mark, and we can consider it an "associated secular function" of current income. In Modigliani's approach, therefore, consumption was ultimately expressed as a function of both current disposable income and the highest previous peak of disposable income.

Modigliani himself has suggested various modifications of this kind of function, according to the requirements of the problem at hand. Following his general method, we shall express the demand for steel as a function of the current level of industrial production and of the "cyclical position" of industrial production. We propose to measure the "cyclical position" of a given level of production by relating it to the highest previous peak or, more generally, to an "associated secular function."

Before applying this technique, let us consider the theoretical justification for its use in this case.

Nearly all major steel-consuming industries are represented by the components of the production index. Cyclical sensitivity as well as consumption of steel per unit of product vary from industry to industry. A simple demonstration suggests that these conditions lead to cyclical sensitivity of steel consumption.

Suppose two industries, $i = 1$ and 2, make up total industrial production. The production index is, therefore, the sum of the absolute contribution P_i to total output P_T:

$$P_1 + P_2 = P_T \qquad (1)$$

The absolute contribution P_i to production index P_T is the level of activity in that particular industry, in terms of its base period activity, multiplied by the weight of the industry in the base period. Multiplication by the base period weight is a scale transformation which permits us to express the level of activity in each industry in terms of a common denominator, that is, in units of total industrial production. Suppose aggregate steel requirements of industry i, at a level of activity P_i, are S_i; then the average rate of steel requirements per unit of production for industry i is

$$s_i = S_i/P_i \qquad (2)$$

Total steel requirements, at a level of total production of $P_T = P_1 + P_2$, will therefore amount to $S_T = s_1 \cdot P_1 + s_2 \cdot P_2$.

The average rate of steel consumption, s_T, can then be expressed in terms which will reflect the relative composition of total production:

$$s_T = S_T/P_T = s_1 \cdot (P_1/P_T) + s_2 \cdot (P_2/P_T)$$
$$= s_2 + (s_1 - s_2)\,(P_1/P_T) \qquad (3)$$

If the cycle sensitivity is not the same for both industries 1 and 2, then it follows from the identity

$$(P_1/P_T) + (P_2/P_T) \equiv 1 \qquad (4)$$

that the relative contribution of industry 2 will vary inversely to that of industry 1 at any time during the business cycle. Suppose now that industry 1 is not only the heavier steel consumer per unit of production, or $s_1 - s_2 > 0$, but that it is cyclically more sensitive than total production. Given two positions in the course of the cycle, marked by superscripts $'$ and $''$, it follows, in the case of a decline,

$$1 > P''_T/P'_T > P''_1/P'_1 \qquad (5)$$

that as the relative importance of industry 1 declines, that of industry 2 increases, or

$$P'_1/P'_T > P''_1/P''_T \quad \text{and} \quad P'_2/P'_T < P''_2/P''_T \qquad (6)$$

From (6) it follows that average consumption of steel will be lower for the second position:

$$s'_T = s_2 + (s_1 - s_2)\,(P'_1/P'_T) >$$
$$s''_T = s_2 + (s_1 - s_2)\,(P''_1/P''_T) \qquad (7)$$

since s_2 is inherently positive and $(s_1 - s_2)$ is positive by assumption.

The rate of average steel consumption $s_T = s_T(t)$ is thus cyclically sensitive, that is, it depends upon the cyclical position of P_1/P_T. An obvious example for an industry which is not only a heavy consumer of steel per unit of production, but also cyclically more sensitive than total production, is the behavior of the metal-fabricating industries: machinery and transportation equipment manufactures. Their behavior in the short run and in the long run is shown in the following table with the average rate of steel consumption:

Year or Period	*Relative Importance of Metal Fabricating in Total Industrial Production, in Percent*	*Rate of Steel Consumption per Point of the Index of Total Industrial Production, S_T, in Thousands of Tons*
1929	20	575
1932	12	264
1937	18.5	501
1938	14.7	357
1923-25	17.3	552
1935-39	16.7	466

If we now explicitly introduce a bench mark for measuring the cyclical position, such as the highest previous peak of total industrial production (more generally, the "associated secular function"), P^0_T, then the rate P^0_T/P_T can be used as a measure of the cyclical position of total industrial production. The simplest form for stating the cyclical sensitivity of the industry i is the linear relationship of the two rates:

$$P_i/P_T = c_i - d_i\,(P^0_T/P_T) \quad (d > 0; i = 1, 2) \qquad (8)$$

All the measures entering (8) must be considered as functions of time t, that is, $P_i = P_i(t)$, $P_T = P_T(t)$, and $P^0_T = P^0_T(t)$. Because of the identity (4), which holds for any time t, the parameters c_i and d_i are subject to the condition that the c_i's add up to unity, the d_i's to zero.

The presentation of average steel requirements as a function of the relative importance of the component industries, (3), can now be transformed with the help of (8) into a presentation of average steel requirements as a function of the cycle position of total industrial production:

$$\begin{aligned} s_T = S_T/P_T &= s_1\,[c_1 - d_1\,(P^0_T/P_T)] + s_2[c_2 - d_2\,(P^0_T/P_T)] \\ &= 1/P_T\,[(s_1c_1 + s_2c_2)P_T - (s_1d_1 + s_2d_2)P^0_T] \\ &= 1/P_T\,[\qquad p \cdot P_T - \qquad q \cdot P^0_T] \qquad (9) \end{aligned}$$

Aggregate steel requirements will, therefore, be of the general form

$$S_T = s_T \cdot P_T = p \cdot P_T - q \cdot P^0_T = -p(P^0_T - P_T) + (p - q)\,P^0_T \quad \text{(G)}$$

From the fact that all the s_i's, c_i's, and d_i's are positive, it follows that p and q are also positive. For a given level of industrial production, P_T, steel requirements will tend to be lower the higher the bench mark value P_T^0 is, and they will, in general, also tend to be lower the lower P_T is relative to the bench mark P_T^0. The derivation of Formula G holds, not only for the case $n = 2$, but, in general, for any number of industries.

In addition to the "product-mix" effect in the case where cyclical sensitivity is correlated with unit requirements of steel, another factor contributes to the cyclical sensitivity of steel consumption: working-inventory requirements. Working inventories are built up or depleted according to whether a given level of production is reached on the upswing or on the downturn. This is true for every component industry and *ipso facto* for total industrial production itself. When, in the gradual long-run expansion of production, a level of 90 on the Federal Reserve Index was reached from below—as in 1925—working-inventory requirements expanded, as reflected by a rate of 564,000 tons of steel per point on the Index. But when total industrial production, after having reached a high of 110, fell off to a level of 91 on the Index—as in 1930—inventories previously geared to higher production levels became excessive as working inventories and thus depressed the demand for new steel below the level indicated by the long-run expansion of production. Steel requirements in 1930 amounted to 501,000 tons per point on the Index.

Thus the working-inventory factor alone would be able to cause both a moderate rate of increase in steel consumption in a gradual long-run expansion of industrial activity and a much sharper backsliding of steel demand during a recession of production. This is shown by the pattern of successive cycle swings in Chart 1. Since two factors are operative, one might ask whether their effects can be separated. The results of a test introducing the annual rate of change in production as an additional factor in the analysis are reported in Section F-3.

First, however, the general hypothesis embodied in Formula G will be tested.

C. THE ASSOCIATED SECULAR FUNCTION OF INDUSTRIAL PRODUCTION

In order to test Formula G, it is necessary to develop a suitable measure for the "associated secular function" of the index of industrial production corresponding to the variable P_T^0 of this formula. This series must, in some sense, represent a measure of "normal" production, so that the relation of actual industrial production to it will provide a reasonable measure of cyclical slack or strain.

Such a series could be derived in various ways. One could, for instance, apply directly the specific technique used by Modigliani and define the associated series in the year t, $P^0_T(t)$, as the highest level of total industrial production preceding the year t. Another simple method has been used by A. G. Hart.[8] According to this method, the associated function would consist of a time series of annual points including the successive peaks of industrial production and points interpolated annually between them leading in geometric progression from one peak to the next.

While any of these methods would probably yield a reasonable approximation, a somewhat different approach will be used here, which, at least conceptually, appears more suitable for the purpose on hand. The associated function in any given year will be expressed as an estimate of productive capacity for that year, measured—like production itself—in points of the Index; in other words, as a series measuring the highest level that total industrial production could reach on the basis of productive capacity in existence in that year.

The relation of production to productive capacity is a reasonable over-all measure of cyclical position. Indeed, the difference between actual production and productive capacity seems to be a very good operational measure of the notion of cyclical slack or strain. In addition, such a relation may be expected to indicate the effect of cyclical strain on the activity of producers' equipment industries. These industries are heavy users of steel, the main raw material for producers' equipment. Such a relationship for manufacturing and mining equipment is illustrated in Chart A-1 and Table B-2 (see Appendix B).

The task of developing a measure for over-all productive capacity obviously presents some serious problems, both conceptually and statistically. Some of these problems are mentioned in Appendix A, in which an estimate of productive capacity for every year from 1919 to date is developed. This estimate was constructed on the basis of yearly data on the flow of equipment installed and on yearly estimates of retirements of existing ca-

[8] A. G. Hart, *Money, Debt, and Economic Activity* (Prentice-Hall, 1948), pp. 260ff.

pacity.[9] The estimate represents no more than a rather crude, though useful, over-all approximation of the theoretically relevant concepts. There has been considerable interest in the general problem of developing, both conceptually and statistically, suitable measures of productive capacity. Such measures have a number of important potential applications, of which the present is but one. It is to be hoped that the work now in progress will yield more refined methods of estimation and improved estimates for the past.

D. STATISTICAL TESTS OF THE HYPOTHESIS

In order to test the hypothesis and to estimate the coefficients of the general formula G, total steel production S_T is correlated with total industrial production P_T (Federal Reserve Index) and with the measure of productive capacity P_{CAP}. The conditions of the period 1919-40 are then summarized as follows:

Formula II

$$\begin{aligned} S_T &= k + p \cdot P_T - q \cdot P_{CAP} \\ &= \underset{[5.48]}{15.40} + \underset{[0.044]}{0.857} P_T - \underset{[0.052]}{0.403} P_{CAP} \qquad R = 0.969 \end{aligned}$$

The resulting parameters are obviously quite favorable to the hypothesis. The coefficient of P_{CAP} is negative, as expected, and is highly significant by standard statistical tests, being 7.75 times as large as its standard error. The multiple correlation coefficient rises to 0.969, as against a simple correlation of 0.897 for Formula I.

In order to see fully the implications of Formula II, it will be useful to perform certain algebraic transformations. In the first place, it must be remembered that the variable P_{CAP} denotes the maximum level consistent with existing capacity. In general, however, a level of production equal to capacity, that is, a 100 percent rate of use, can hardly be considered normal. Ideally

[9] It is likely that installation of equipment is highly sensitive cyclically. Thus, when the surviving annual equipment installations of preceding years (or their capacity equivalents) are cumulated, it must be expected that the series of productive capacity will show an echo effect, that is, ripples of the damped and lagged effect of the business cycle. As far as these ripples are still present, productive capacity is only an approximation of the "associated secular function." The series on productive capacity was originally developed for the Econometric Institute, Inc. It is described in Appendix A. It forms part of the copyrighted service of the Institute, and is presented here by permission of its president, C. F. Roos.

the "normal" rate of use might be defined as that rate at which firms, in the aggregate, do not wish either to expand or to contract their capacity. In general, such a rate of use will be significantly less than 100 percent of P_{CAP}, especially since the measure of capacity is a ceiling for the production during any month of the year and enough slack capacity must be allowed to take care of seasonal fluctuations in production. We assume that 85 percent of capacity represents a normal rate of use. In fact, this assumption is implicit in the method of estimating the capacity series.

On the basis of this assumption, the "normal level of production" for the year t, or $P_{\mathrm{N}}(t)$ would not equal 100 percent of $P_{\mathrm{CAP}}(t)$, but only 0.85 $P_{\mathrm{CAP}}(t)$ or

$$P_{\mathrm{N}} = P_{\mathrm{N}}(t) = 0.85 P_{\mathrm{CAP}}(t) \qquad (10)$$

In the following reformulation of Formula II, P_{N}, the "normal" level, will be used as the "associated secular function." The qualifications which apply to P_{CAP} (see footnote 9) apply also to P_{N}. Production, P_{T}, will not only fall short of capacity, P_{CAP}, but more often than not, of the normal rate of production, $P_{\mathrm{N}} = 0.85 \cdot P_{\mathrm{CAP}}$. This was the case in 15 out of 22 prewar observations. Only in 5 cases did P_{T} exceed P_{N}. Thus it appeared advisable to introduce the cyclical position of production not as a cyclical strain, ~~P_{T}~~ $-$ P_{N}, but as a cyclical slack, $P_{\mathrm{N}} - P_{\mathrm{T}}$. It should be noted that the substitution of P_{N} for P_{CAP}, while logically desirable, does not affect the results substantively.

Substituting (10) into the general formula G and into the formula with numerical parameters (II) leads to

$$\begin{aligned} S_{\mathrm{T}} &= k + p \cdot P_{\mathrm{T}} - (q/0.85) \cdot (0.85 P_{\mathrm{CAP}}) & \\ &= k + p \cdot P_{\mathrm{T}} - q' \cdot P_{\mathrm{N}} & \text{(G-a)} \\ &= 15.40 + 0.857 P_{\mathrm{T}} - 0.474 \cdot P_{\mathrm{N}} & \text{(II-a)} \end{aligned}$$

These formulae may be rewritten in the following forms, which will be used in the following discussion:

$$\begin{aligned} S_{\mathrm{T}} &= k + (p - q') \cdot P_{\mathrm{T}} - q' (P_{\mathrm{N}} - P_{\mathrm{T}}) & \text{(G-b)} \\ &= 15.40 + 0.383\, P_{\mathrm{T}} - 0.474 (P_{\mathrm{N}} - P_{\mathrm{T}}) & \text{(II-b)} \end{aligned}$$

or also:

$$\begin{aligned} S_{\mathrm{T}} &= k - p \cdot (P_{\mathrm{N}} - P_{\mathrm{T}}) + (p - q') \cdot P_{\mathrm{N}} & \text{(G-c)} \\ &= 15.40 - 0.857 (P_{\mathrm{N}} - P_{\mathrm{T}}) + 0.383 \cdot P_{\mathrm{N}} & \text{(II-c)} \end{aligned}$$

From the expression on the right-hand side of Formula II-a, it is apparent that as long as P_N remains constant, S_T will tend to change by 857,000 tons per point of the Federal Reserve Index. In the short run, P_N will be relatively stable compared with P_T. Indeed, especially if P_T fluctuates below P_N (this has been called a "cyclical fluctuation" in production), P_N is likely to change very little, if at all. Hence, given a stable value $\overline{P}_N$, the relation between steel output and industrial production during any given cycle may be approximately described by

$$S_T = (k - q' \cdot \overline{P}_N) + p \cdot P_T \qquad \text{(G-d)}$$
$$= (15.40 - 0.474\overline{P}_N) + 0.857\, P_T \qquad \text{(II-d)}$$

This is a line with considerably steeper slope than the slope of 0.697 million tons per point on the Federal Reserve Index indicated by the "hybrid" Formula I. It is indicated by the dashed-dotted line on Chart 1. As P_N changes—that is, increases from one cycle to the next—this line will shift to the right as indicated by the configurations on Chart 1 for the years 1919-22, 1929-36, and 1937-39.

Alternative statements of Formula G—(G-b) and (G-c)—are designed to bring out the long-run aspects of the demand for steel more clearly.

A long-run change in the demand for steel may now be operationally defined as a change in demand S, associated with a change in the over-all level of production P, when enough time has been allowed for the level of capacity to adjust itself to the new level of production. Clearly this definition of "long run" is basically consistent with the traditional Marshallian notion. By means of Formula II-b, the long-run change in the demand for steel which is associated with a change in production can be computed. Suppose the starting point is the year 0 with a level of production $P_T(0)$. Suppose now the level of capacity is fully adjusted; then

$$P_T(0) - P_N(0) = 0$$

and therefore

$$S_T(0) = 15.40 + 0.383\, P_T(0)$$

Suppose that production rises to a new level

$$P_T(1) = P_T(0) + \Delta P_T(0)$$

If, as has been assumed, capacity is fully adjusted to this new level, or

$$P_T(1) - P_N(1) = 0$$

and hence

$$S_T(1) = 15.40 + 0.383\,P_T(1)$$

then the change in demand will be given by

$$\Delta S_T = 0.383\,\Delta P_T$$

Thus Formula II implies that, in the long run, the demand for steel would tend to change only 0.383 million tons per point of the production index, as contrasted with a rate of 0.857 million tons per point of the production index in the short run and a rate of 0.697 million tons on the production index in the hybrid Formula I. The equation obtained for the vanishing cyclical slack $(P_N - P_T) = 0$ is

$$\begin{aligned} S_T &= k + (p - q')P_T = k + (p - q')P_N = k + n \cdot P_N \\ &= 15.40 + 0.383\,P_N \end{aligned} \qquad \text{(G-e)}$$

This equation may thus be considered an estimate of the long-run relation between the demand for steel and industrial production. The coefficient $n = p - q'$ is an estimate of the long-run marginal steel requirements per unit of change in the production index. The long-run relation is indicated by the slope of the dashed line in Chart 1 and by column 1 of Table B-4 (see Appendix B).

E. EXTRAPOLATION TESTS

The introduction of the variable P_N in addition to P_T resulted in a substantial reduction in the variance which was not explained by Formula I. A more significant test of Formulae I and II, because the parameters are based on prewar observations only, is to use these equations for an estimate of the demand for steel for the postwar period, say, around 1950, when production was at much higher levels. Since the change in production between 1940 and 1950 can be regarded largely as a long-run change, Formula II should be expected to yield somewhat more accurate results than Formula I. At the same time a margin of error considerably larger than in the period of observation must be expected, since the stretch of years between 1940 and 1950 is substantial, and some changes in the basic relation between production and steel requirements might have occurred.

If Formula II is used to estimate the demand for steel at the 1950 level of production (200), it is also necessary to specify the assumption about the associated secular function, or its approximation P_N. An assumption of no cyclical slack, that is, complete adjustment of capacity to this production level, yields the estimate $S_T(1950) = 15.40 + 0.383(200) = 92$ million net tons of steel. The actual level of production in 1950 was 96.8 million net tons, so that this long-run projection represents an underestimate of about 5 percent. For the year 1951, the underestimate is of the same order of magnitude, with an estimated level of 99.6 million tons and an actual level of steel output of 105.1 million tons. This represents a striking improvement over Formula I, the use of which leads to overestimates in the order of 25 and 30 percent, respectively, for these two years. (See Table B-3, column 2, in Appendix B.) With a value for $P_T(1948)$ of 192, the long-run projection of steel demand is 88.9 million net tons; with a value for $P_T(1949)$ of 176, it turns out to be 82.8 million net tons. These estimates compare with actual levels of steel output of $S_T(1948) = 88.6$ million net tons and $S_T(1949) = 78$ million net tons. In every case the error is in the order of 5 percent or less. These results can also be obtained from Chart 1, by reading the projected long-run steel demand at each level of total industrial production from the dashed line showing this long-term projection. The vertical excess of actual steel output from each of these levels gives the extent of the deviation in millions of net tons.

Actually it is possible to develop some supplementary, though tentative, information on P_N for the postwar period. It is shown in Table B-2, column 4. Substituting these values in Formula II leads to a more accurate extrapolation, shown in column 3 of Table B-3 and in column 1 of Table B-4. For the five-year period 1947-51, actual steel production averaged 90.7 million net tons, estimated steel production derived by Formula II amounted to 92.5 million net tons. The absolute average error is 7.4 million net tons.

At this point it may suffice to point out that Formula II performs far better than Formula I and that its use for long-run projections is reasonably satisfactory. Before further extrapolation tests are undertaken, some refinements of the hypothesis must be introduced.

F. SOME REFINEMENTS OF THE HYPOTHESIS

1. *Changes in rates of consumption of steel within the period of observation, 1919-40*

The period 1919-40 is a long one, in the course of which some changes in the underlying relation between steel output and total industrial production might have occurred. To test this hypothesis, two sets of coefficients, p and n, one for the period 1919-29, the other for the period 1930-40, were simultaneously reestimated. We call the analysis of total production of steel for ingots and castings with different levels of p and n Formula III. To distinguish the reestimated coefficients and the constant from those derived for the period as a whole in Formulae G-a—e, the number of the formula is introduced as a subscript of the parameter, e.g., p_{II}, p_{III}, etc. refer to the coefficients of total industrial production in the general formula G-a or to that of the cyclical slack $(P_N - P_T)$ in Formula G-c, while n_{II}, n_{III} refer to the coefficient of P_T in (G-b). Finally k_{II}, k_{III} refer to the constant term, which covers the entire period 1919-40 in each of these formulae.

A comparison of the coefficient p_{III} for the two separate periods (see Table 1) reveals a substantial decline from the twenties to the thirties in the short-term rate of steel consumption and a less pronounced decline in the long-term rate n_{III}. There are good reasons for these declines in steel requirements per unit of production. It is probable, in the short term, that improvements in the control of flow and the stocking up of raw materials for operating inventories took place. The cooperation of some steel producers with automobile manufacturers in an effort to tighten up steel delivery schedules is one of several examples. In the long run, use of better-grade steel and more elaborate end-use specifications reduced the requirement per unit of output. How closely Formula III fits the data can be seen from Chart 2. In this chart, actual steel production is shown as a heavy solid line, while steel production as estimated from Formula III is represented by a thin line. (For all other lines see Section H.)

2. *Demand for steel for the domestic market*

Not all finished steel produced from the output of steel ingots

TABLE 1

COMPARISON OF THREE ALTERNATIVE ESTIMATES OF COEFFICIENTS FOR THE GENERAL FORMULA $S = k + n \cdot p_N - p \cdot (P_N - P_T)$

Parameter	Period 1919-40	1919-28	1929	1930	1931-40
	Constant				
k_{II}	15.40(5.48)	—	—	—	—
k_{III}	5.575(10.7669)	—	—	—	—
k_{IV}	0.744(10.4623)	—	—	—	—
	Coefficient for the normal rate of production				
n_{II}	0.383(0.076)	—	—	—	—
n_{III}	—	0.5073(0.2372)	0.4922	0.4719	0.4568(0.1227)
n_{IV}	—	0.5225(0.2216)	0.4986	0.4668	0.4429(0.1191)
	Coefficient for the cyclical strain, $P_N - P_T$				
p_{II}	0.857(0.044)	—	—	—	—
p_{III}	—	0.9916(0.1491)	0.9323	0.8532	0.7939(0.0486)
p_{IV}	—	1.0705(0.1448)	0.9413	0.7690	0.6398(0.0471)

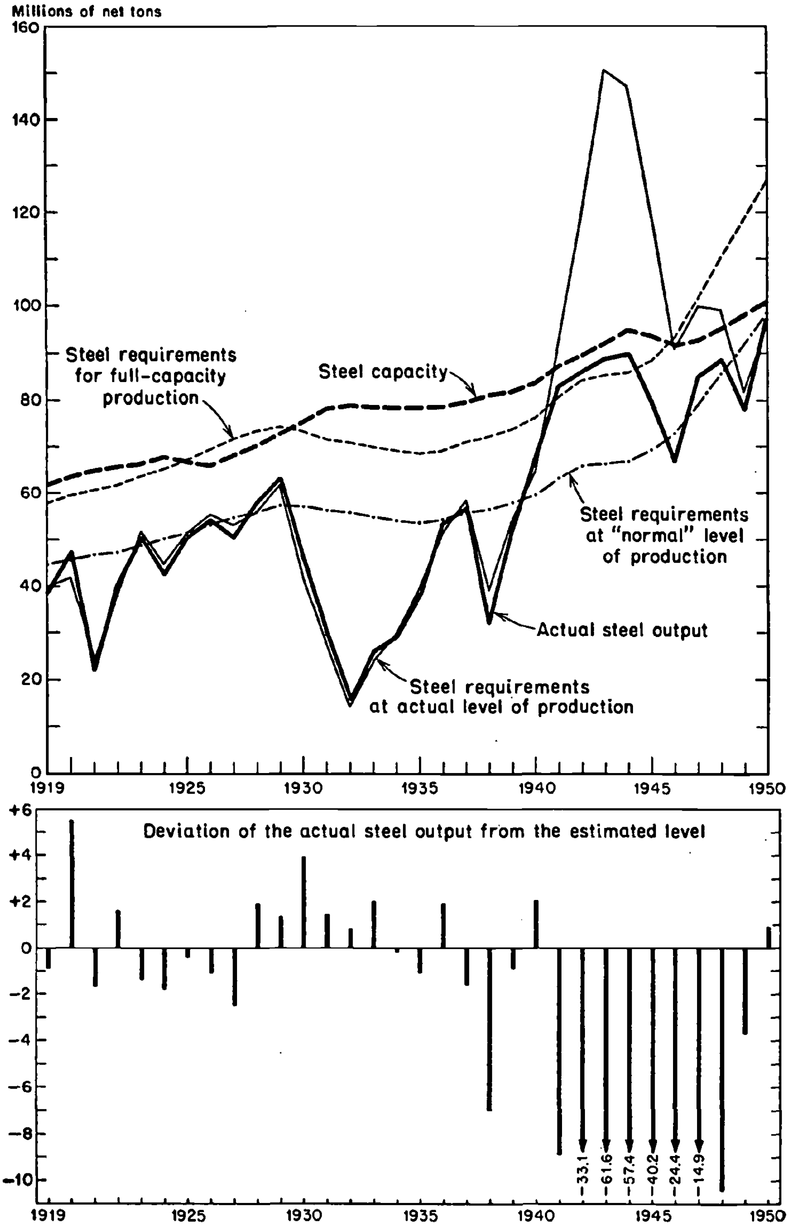
Note: Standard errors of regression coefficients are given in parentheses. The transition between the twenties and the thirties has been derived heuristically. Various types of splicing were tested and the one with the least error of estimate selected. This particular form of splicing does not jump immediately from the higher level of the parameters in the twenties to the lower level of the parameters for the thirties, but provides for two intermediate stages in the transition: the year 1928 is the last year of the higher level, the year 1931 the first year of the lower level for the parameters. In descending from the higher level, the year 1929 is placed 0.3 of the total jump below the higher level; 1930 is placed 0.3 of the total jump above the lower level for the parameters.

and castings is consumed in the domestic market.[10] While United States business cycles may affect the rest of the world, factors other than industrial production in the United States also have been determinants of foreign demand for American steel. For instance, the shortage of steel in other countries after each of the two world wars caused exports of steel to rise more sharply than domestic consumption. The proportion of United States domestic raw steel production ultimately shipped abroad as finished steel has varied from 3 percent to 18 percent during the last thirty years. For this reason the coefficients of Formula III were re-estimated and only the domestic supply of steel was used as a dependent variable.

[10] In order to estimate this portion, it was necessary to translate the exports of rolled steel (*Metal Statistics, 1951* [American Metal Market, 1951], p. 260) into the equivalent steel for ingots and castings. The conversion factors were derived by comparing total rolled steel for sale with total ingot production, assuming a one-month lag of rolled steel shipments after the production of ingots.

CHART 2

Steel Output and Capacity and Estimated Demand for Steel at Various Levels of Industrial Production



The estimates thus obtained are denoted, k_{IV}, n_{IV}, and p_{IV}. They are compared in Table 1 with the various estimates discussed previously.

An interesting result of the successive refinements of the analysis is the progressive fall in the constant term from 15.40 million net tons for Formula II to less than 1 million net tons for Formula IV.

It should be noted that the original hypothesis, as expressed in Formula G, lacked a constant term. There is no reason to expect that this condition would be exactly satisfied by a regression equation fitted to the data. The measure of total production is not only directly representative of manufacturing and mining industries consuming steel, but it acts also as an indirect measure of the variations in the demand of nonmanufacturing steel consumers, such as railroads or public utilities. Nonetheless the constant term of 15.40 million net tons was uncomfortably large. It had to absorb the effect of averaging over the entire period 1919-40 in the determination of the value of n_{II}. Inspection of n_{III} indicates that while the rate for the thirties was 10 percent below that of the twenties, it was still 16 percent above the "average" rate of n_{II} for the entire period. The latter is, therefore, not a pure average of the two rates 0.5073 and 0.4568, which ought to be around 0.48, but contains also the slurring effect of moving from the higher long-run relation to the lower long-run relation for the later years. The difference in the amount of variation, explained by an average of the long-run parameters of Formula III and by that of Formula II, appears as a difference of about 10 million net tons between the constants of the two formulae.

Formula IV not only confirms the decline in the rate of steel requirements, but suggests that the difference in this respect between the thirties and the twenties is even greater than that indicated by Formula III: for p, the drop amounts to 20 percent in the case of Formula III and 40 percent in the case of Formula IV; for n to 10 percent and 15 percent. An analysis of these shifts from the viewpoint of technology would be desirable. The Formula III estimates of 95.9 million net tons for 1950 and 104.6 million net tons for 1951 come closer to the actual performance of 96.8 and 105.1 million net tons than the Formula IV estimates of 92.8 and 102.4 million net tons.

The mean square deviation for the period 1947-51 amounts to

7.6 million net tons in the case of Formula IV, 8.3 million net tons in the case of Formula III, 8.5 million net tons in the case of Formula II, and to 27.8 million net tons in the case of Formula I.

As stated earlier, it should be noted that there are other segments of steel consumption in addition to exports which are not measured by the Federal Reserve Index of Industrial Production. A certain portion of steel is shipped directly to railroads, utilities, waterworks, farmers, government, etc., and thus does not pass through any manufacturing stage outside the steel industry. To this extent the parameter of Formula IV contains an indirect weight for such steel consumers.

3. *The rate of change of industrial production as a factor in the demand for steel*

In the theoretical discussion of the basic approach to the general Formula G, the product-mix change was given as one reason why the cyclical position of industrial production ought to be considered as well as the rate of production. The working-inventory requirements for steel were given as another factor. Working-inventory changes resulting from changes in the level of production are not necessarily cyclical in nature. It may, therefore, be asked whether we can substitute the change in the *level* of production for the cyclical slack of production and reach an equally satisfactory explanation of steel requirements. Will the introduction of the change in the level of production as a third supplementary variable contribute to a sharpening of the analysis and to a separation of the "product-mix" from the "working-inventory" effect?

In order to obviate, at least partially, the inadequacy of annual data on production changes as indicators of inventory movements, two different forms of the annual change in production have been tested, both by use of Formula II.

a. The change from the last year—which amounts roughly to the change during the preceding fiscal year—has shown a positive effect. At maximum it amounted in 1938 to 4.8 million tons, if used as a substitute for the cyclical slack in production, and to 1.8 million tons, if used as a supplementary third variable. In general, a change of one point on the production index is accompanied by a change in steel output of nearly 200,000 tons and 75,000 tons, respectively. The reduction in unexplained variation resulting from the introduction of the change during the fiscal year is, however, insignificant.

b. The change during the calendar year—which points further into the future—has a negative effect of 46,000 tons per point on the production index, if used as a substitute, and of 39,000 tons if used as a supplementary variable. Its introduction scarcely reduces the unexplained variation.

If an analysis of inventory changes based only on annual data can be considered fair evidence, the effect of these annual changes is minor, or insignificant, and an *ex post* adjustment, rather than an immediate adjustment or anticipation.

G. EXTRAPOLATIVE VALUE

1. *Wartime conditions*

The formulae cannot be applied to steel requirements under wartime conditions: P_{CAP} is a measure of peacetime civilian capacity. Total military and civilian production exceeded peacetime capacity in the two main war years 1943 and 1944 by about 80 points. The measure of production expanded by 137 points over 1935-39, while peacetime civilian capacity, which excludes the capacity of ordnance and similar plants, advanced only 28 points. Peacetime capacity also does not allow for multiple-shift use of a plant if normally it is used only in single-shift operations. It also excludes the obsolete or obsolescent stand-by equipment returned temporarily to operation under emergency conditions.[11] The development of a properly calibrated measure of wartime additions to capacity, which would take all the distortions into account and allow for the shifts in the composition of production, has not been undertaken. A proper test of the formulae by extrapolation is, therefore, confined to the postwar period.

[11] The war period was characterized by a rapid expansion of the machinery and transportation equipment industries. This can be explained, in part, by the greater amount of fabrication and inspection actually required for the output of combat material, and, in part, statistically, by the use of labor input as a measure of output. During the prewar period, 1919-40, the metal-fabricating segment of the production index amounted to 1.1 times its basic metal segment plus 1 point on the index. The equivalent for the postwar period was about 11 points higher than the prewar relation. During the height of the war, 1943 and 1944, the metal-fabricating segment actually rose 90 points above the prewar relation. In 1951, it rose 4 points above the postwar relation.

2. *The postwar period*

Formulae II, III, and IV overestimate steel requirements in the first few years of the postwar period. This result emphasizes the temporary effect of wartime demand and suggests that steel requirements per unit of production may have declined. On the other hand, these overestimates decline from year to year until they change into underestimates either in 1949 or in 1950. Such a pattern would point to the existence of real steel shortages, especially in the strike years 1946 and 1949. On the whole, it seems not unlikely that the truth is somewhere between the two extremes: part of the overestimate from 1946 to 1949 may reflect a true shortage of steel, while part of it may reflect a genuine overestimate. Formula IV would result in a gross overestimate of about 40.7 million net tons for the three years 1946 to 1948. If—by way of an illustration—this gross overestimate is formally segregated into a "genuine" steel shortage of 25 million net tons and a "genuine" overestimate of about 15 million net tons, the effect on the parameters of Formula III or IV can be expressed as a drop of 8 percent in the short-term parameter, as compared with a drop of 40 percent in the same parameter between the twenties and the thirties; and a drop of 3 percent in the long-run parameter n_{IV} as compared with a drop of 15 percent between the twenties and the thirties. Thus the formal assumption of a steel shortage of about 25 million net tons during 1946-48 would suggest that a further drop of unit requirements for steel has occurred, amounting to about one-fifth of that which characterized the transition from the twenties to the thirties. Further evidence will be needed before a definite statement can be made.

H. STEEL CAPACITY AND STEEL REQUIREMENTS FOR FULL-CAPACITY PRODUCTION

One interesting application of Formula G is its use in estimating "steel requirements at capacity operations," that is, steel requirements for a level of industrial production equal to capacity. This represents an estimate of the maximum steel requirements in any given year.

The original formula

$$S(P_{\mathrm{T}}, P_{\mathrm{CAP}}) = k + p \cdot P_{\mathrm{T}} - q \cdot P_{\mathrm{CAP}}$$

is a convenient starting point for estimating "steel requirements at capacity operations." Substitution of $P_T = P_{CAP}$ leads to

$$\begin{aligned} S(P_{CAP}) &= S(P_{CAP}, P_{CAP}) = k + (p - q)P_{CAP} \\ &= k + (n + q' - q)\,P_{CAP} = k + (n + q' - 0.85q')P_{CAP} \\ &= k + [n + 0.15(p - n)]P_{CAP} \qquad (11) \end{aligned}$$

Using the values $n_{III} = 0.5073$ to 0.4568 and $p_{III} = 0.9916$ to 0.7939, the coefficients of P_{CAP} assume the following values: for 1919-28, 0.580; for 1929, 0.558; for 1930, 0.529; and for 1931-40, 0.507.

These estimates of "steel requirements at capacity operations" are shown as a time series in Chart 2 and compared with steel capacity, actual and estimated steel production, and steel requirements at the "normal" level of production (that is, 85 percent of capacity). "Steel requirements" according to Formulae II, III, and IV are shown for the "normal" level of production in columns 1, 2, and 3 and for capacity industrial operations in columns 4 and 5 of Table B-4 (see Appendix B).

An inspection of Chart 2 reveals the relative closeness of actual steel capacity and "steel requirements at capacity operations" as estimated from Formula III. During the thirties—as a result of the decline and the slow recovery of industrial capacity—"steel requirements at capacity operations" fell below actual steel capacity, which remained relatively constant. If the rate of short-term, or output-determined, and the rate of long-term, or capacity-determined, steel requirements are applied to the postwar period without any further reduction, it appears that industrial capacity has expanded much faster than steel capacity. During 1946, when existing steel capacity dropped nearly 5 percent as a result of writing off obsolete facilities, "steel requirements at capacity operations" started to exceed actual steel capacity. In fact, steel capacity fell so far behind that it was only 2 million tons above the steel requirements for the normal level of activity (85 percent of capacity) for the year 1950, thus leaving little leeway for the expansion of activity beyond this level. Since steel capacity was so much lower in 1950 than the steel requirements indicated by estimates of peacetime production capacity, one might expect it to have had a limiting effect on the expansion of industrial production in recent years.

I. STEEL CAPACITY AS A LIMIT TO THE TOTAL LEVEL OF INDUSTRIAL PRODUCTION

An estimate of the ceiling imposed on the possible level of total industrial production by the available capacity for producing steel can be derived by inverting Formula G and solving it for total industrial production P_T. From

$$S_T = k + p \cdot P_T - q \cdot P_{CAP} \qquad (12)$$

it follows that

$$P_T = (q/p)P_{CAP} - (1/p)(S - k) \qquad (13)$$

Substituting first $q = 0.85 \cdot q'$ and then $q' = p - n$ into the formula leads to

Formula V

$$P_T = 0.85(1 - n/p)P_{CAP} + (1/p)(S - k)$$

Formula V is to be regarded as measuring the amount of industrial production that can be supported by a given supply of steel, S. Introduction of estimates of the parameters n, p, and k and of the level of steel capacity S_{CAP} in Formula V yields an estimate of the maximum level of industrial production consistent with the available capacity to produce steel. If the values assumed by the coefficients for the period after 1930 ($n_{III} = 0.4568$, $p_{III} = 0.7939$, and $k_{III} = 5.575$) are used, and if the values prevailing in 1952 are approximated by P_{CAP} (1952) $= 286$ and S_{CAP} (1952) $= 111.5$ million net tons, the production potential can be estimated at

$$0.4246 \cdot 243 + 1.2596(111.5 - 0.0 - 5.6) = 237 \text{ points} \qquad (14)$$

The ceiling for total industrial production is determined by the steel supply for the domestic market, or 111.5 — 3.8 million net tons, rather than the total steel supply. Using the comparable parameters of Formula IV for the period after 1930 results in

$$0.3078 \cdot 243 + 1.5630(111.5 - 3.8 - 0.7) = 239 \qquad (15)$$

Introducing the tentative reduction of steel requirements developed in Section G-2 would increase the industrial production potential to about 245 points, or 6 points above the results based on 1930-40 parameters.

J. SUMMARY

Earlier investigations have demonstrated that price alone is not a major determinant of changes in steel demand. More and more emphasis has been placed upon the shift of the demand function itself. Steel constitutes a unique raw material for many durable goods. The area where substitutions are technologically or economically feasible comprises only a minor fraction of aggregate steel demand. This being the case, how will the steel consumer who wants to stay in business react to an increase in steel prices? He will ask whether it is possible to shift the whole cost increase to his customers without impairing the size of the market for his product and he will consider whether his profits permit him to absorb the price increase. Only in a few cases will he find it possible to use a substitute or to reduce his unit demand for steel on short notice. In the long run, one must expect steel savings to result more from the continual striving for efficiency and general cost reduction rather than in response to isolated shocks of increases in the price of steel. Thus, using the language of the classical demand and supply analysis, it is necessary to explain the shifts in the demand function itself. The extent of the shifts of the demand function will make shifts along the demand curve due to price changes appear unimportant.

An attempt at explaining shifts in the demand function might be expected to consider industrial production as such or the activity of an individual steel-consuming industry. But this approach can be refined. Our method refines it by taking into account not only the over-all level of production, but also its cyclical position. The cyclical variation in the "product-mix" of industrial output and variation in the "working-inventory requirements" will be reflected in the short-term component. This refinement of the approach leads to Formula II, which provides not only an improved explanation of the demand for steel during the period of observation, 1919-40, but also leads to radically different and far more accurate results when used for long-run extrapolation. A further attempt at estimating the effect of technological progress in steel consumption within the 22 years under consideration resulted in Formula III.

There was an indication that the output destined for the foreign market was often distorted substantially by exogenous factors not related to the level of domestic industrial activity. Since foreign demand accounted for a fluctuating share of the total steel output, varying from 3 percent to 18 percent, the output for the domestic market was investigated separately. This relation is described by Formula IV.

Finally, it seemed useful to explore the relation of steel capacity to over-all industrial capacity, both to gauge the adequacy of steel capacity during the period of observation as well as thereafter and to gain a better understanding of the concept and statistical construction of industrial capacity. Formula V expresses industrial peacetime capacity in terms of steel requirements. An inversion of the process could be used to determine the cyclical expansion permitted by the level of rated steel capacity, but this is subject to the qualification that the estimate of steel requirements per unit of output is based on peacetime goods. If industrial production comprises a large portion of combat material other than ships, unit steel requirements are lowered and allow a considerable extension of the area of cyclical expansion. This happened during World War II when more intensive use of facilities also caused industrial activity to exceed the peacetime level of industrial capacity.

The successive steps of this analysis are: (1) distinguishing between the long-term and short-term components of demand, (2) distinguishing between conditions of steel demand in the twenties and the thirties, and (3) distinguishing between export and domestic demand. Some of the procedures as well as some tools of the analysis are of a tentative character and subject to further improvements, but it is hoped that the general outline of the procedure will be useful for a similar analysis of raw materials or finished products.

APPENDIX A

Peacetime Civilian Capacity for Industrial Production

The series on peacetime civilian capacity for industrial production used in the analysis of steel requirements is a revision of an earlier series, developed by C. F. Roos, V. V. Szeliski, and F. L. Alt before World War II.[12] A more detailed account of the conceptual problems, construction, and limitations of this series will be found in a forthcoming paper. The description presented here is confined to the essential elements.

[12] The series forms an integral part of the copyrighted service of the Econometric Institute, Inc. The data and the series are presented here by permission of C. F. Roos, president of the Institute.

The basic principles of the capacity series were used by Roos in somewhat cruder form in 1937 in order to point out that in spite of an army of nearly 8 million unemployed, the mechanical facilities were becoming scarce and that, therefore, demand for investment goods would take a sharp upturn.

The series is constructed on the basis of annual data on installation of equipment in manufacturing and mining given in 1935-39 prices (column 1, Table A-1). It is essentially a portion of the producers' equipment data of the gross national product account of the Department of Commerce[13] deflated by H. Shavell's price indexes for capital equipment.[14] The series has been carried back with the help of data developed by S. Kuznets and W. H. Shaw.[15] Data after 1945 have been derived from subsidiary information and are only tentative.

The efficiency factor shown in column 2 of Table A-1 converts the dollar volume of equipment installed (column 1) into terms of gross addition to capacity (column 3). A gradual linear increase in initial efficiency has been assumed. This increase is implicitly given once the bench marks for capacity are set, and the pattern and length of retirement assumed. The retirement pattern applied to gross addition to capacity assumes a full life of 16 years before 1939 and 14 years for the later period. It is a compromise between a straight-line retirement for 16 years and an 8-year step function dropping from 100 to 0 percent survival. A one-parametric sequence of such retirement has been developed by B. F. Kimball.[16] The first eight years of the symmetric retirement pattern for 16 years indicate the following survival values: 1.000, 1.000, 0.994, 0.977, 0.933, 0.841, 0.692, 0.500. Column 4 of Table A-1 represents the portion of capacity retired during calendar year *t*. If column 4 is subtracted from the gross addition for the same year (column 3), the net addition to capacity (column 5) is derived. Going forward and backward from the bench mark level of 126 for the end of 1929, the annual capacity series is computed (column 6). Interpolating the midyear capacity, together with total industrial production for the calendar year (column 8), determines the rate of capacity use (column 9).

[13] "National Income Supplements" to the *Survey of Current Business*, July 1947, table 32, p. 45; and July 1950, p. 26.

[14] Henry Shavell, "Price Deflators for Consumer Commodities and Capital Equipment, 1929-1942," *Survey of Current Business*, May 1943, pp. 13ff. The deflation of producers' equipment by segments was undertaken before the appearance of "Estimates of Gross National Product in Constant Dollars, 1929-1949," *Survey of Current Business*, January 1951, p. 9.

[15] Simon Kuznets, *Commodity Flow and Capital Formation*, Vol. I (NBER, 1938); William H. Shaw, *Value of Commodity Output since 1869* (NBER, 1947).

[16] Bradford F. Kimball, "A System of Life Tables for Physical Property," *Econometrica*, September 1947.

The capacity series presented here is an over-all series. It is not an aggregation of capacities in individual industries, which, by necessity, must be higher than the over-all series so long as imbalances between consuming and supplying industries exist. Its bench marks have been developed for years of peak production. Assuming that "normal" production is characterized by 15 percent unused, stand-by capacity to take care of seasonal and other peaks during the year or to meet emergencies, the "peak" rate of operations was set halfway between the 85 percent "normal" rate of operations and the 100 percent capacity rate of operations.

Paralleling the analysis of steel demand is an estimate of the relative importance of equipment for manufacturing and mining in total industrial production, based on the rate of operations during the preceding fiscal year. Introducing P_{EMM} for producers' equipment for manufacturing and mining in points of the total production index, and

$$r_{\overline{t-\frac{1}{2}}} = [P_{\text{T}}(t-\tfrac{1}{2})]/[P_{\text{CAP}}(t-1)]$$

the rate of operations in percent of capacity, we have

Formula VI

$$P_{\text{EMM}}/R_{\text{T}} = P_{\text{EMM}}(t)/P_{\text{T}}(t) = 1.794 + 0.479 \cdot r_{\overline{t-\frac{1}{2}}}$$

The volume of equipment for manufacturing and mining is translated from constant 1935-39 dollars into terms of the production index by a conversion factor of $315.8 million (1935-39 dollars) per point on the index developed for the output of capital goods as a whole. Table A-2 contains the necessary annual data and indicates the computations. Except for 1937, the war years 1944-45, when investment anticipated reconversion, and 1950, the year in which defense investment was accentuated by fears of material shortages, the actual observations differ from the calculated relative importance of producers' equipment by not more than 0.7 percent of the production index. These limits are shown in Chart A-1, which compares the output of equipment for manufacturing and mining industries (in percent of total industrial production) with the rate of operations during the preceding fiscal year (in percent of capacity).

This is rather remarkable, since the dollar volume of new equipment installed is stated in nondescript constant dollars: it does not say whether $100 worth of equipment is for a steel mill or a candy factory. It cannot be expected that the output po-

TABLE A-1

CAPACITY IN MANUFACTURING AND MINING, 1918-1950

Year	Equipment Installed (in Millions of Dollars, 1935-39 Prices) (1)	Efficiency, (t − 1900) × 0.170787 (2)	Gross Capacity: Added (3)	Gross Capacity: Retired (4)	Net Capacity Added (5)	Capacity at End of Year (6)	Capacity as of July 1 (7)	FRB Index of Production (1935-39 = 100) (8)	Rate of Operation, (8) ÷ (7) (in Percent) (9)
			(IN POINTS OF THE FRB INDEX, 1935-39 = 100)						
1918	1,597	3.074	4.91	1.49	3.42	88.34			
1919	1,398	3.245	4.53	1.68	2.86	91.20	89.77	72	80.2
1920	1,541	3.416	5.26	1.88	3.38	94.58	92.89	75	80.7
1921	889	3.587	3.19	2.11	1.08	95.66	95.12	58	61.0
1922	1,259	3.757	4.73	2.41	2.32	97.98	96.82	73	75.4
1923	1,675	3.928	6.58	2.80	3.78	101.76	99.87	88	88.1
1924	1,468	4.099	6.02	3.28	2.74	104.50	103.13	82	79.5
1925	1,697	4.270	7.25	3.77	3.48	107.98	106.24	90	84.7
1926	1,827	4.440	8.11	4.18	3.93	111.91	109.95	96	87.3
1927	1,672	4.611	7.71	4.45	3.26	115.17	113.54	95	83.7
1928	1,892	4.782	9.05	4.61	4.44	119.61	117.39	99	84.3
1929	2,256	4.953	11.17	4.78	6.39	126.00	122.80	110	89.6
1930	1,647	5.124	8.44	5.08	3.36	129.36	127.68	91	71.3
1931	1,181	5.294	6.25	5.55	0.70	130.06	129.71	75	57.8
1932	772	5.465	4.22	6.14	−1.92	128.14	129.10	58	44.9
1933	755	5.636	4.26	6.77	−2.51	125.63	126.88	69	54.4
1934	967	5.807	5.61	7.39	−1.77	123.86	124.75	75	60.1
1935	1,307	5.978	7.81	7.94	−0.13	123.73	123.79	87	70.3
1936	1,906	6.148	11.72	8.32	3.40	127.13	125.43	103	82.1
1937	1,918	6.319	12.12	8.36	3.76	130.89	129.01	113	87.6
1938	1,407	6.490	9.13	7.99	1.14	132.03	131.46	89	67.7
1939	1,635	6.661	10.89	7.31	3.58	135.61	133.82	109	81.5

TABLE A-1 (concluded)

Year	*Equipment Installed (in Millions of Dollars, 1935-39 Prices)* (1)	*Efficiency, (t − 1900) × 0.170787* (2)	*Gross Capacity* *Added* (3)	*Gross Capacity* *Retired* (4)	*Net Capacity Added* (5)	*Capacity at End of Year* (6)	*Capacity as of July 1* (7)	*FRB Index of Production (1935-39 = 100)* (8)	*Rate of Operation, (8) ÷ (7) (in Percent)* (9)
			(IN POINTS OF THE FRB INDEX, 1935-39 = 100)						
1940	2,146	6.831	14.66	7.48	7.18	142.79	139.20	125	89.8
1941	2,560	7.002	17.93	7.48	10.45	153.25	148.02	162	109.5
1942	1,586	7.173	11.38	7.98	3.40	156.65	154.95	199	128.4
1943	1,278	7.343	9.38	9.35	0.03	156.68	156.67	239	152.5
1944	1,794	7.515	13.48	10.99	2.49	159.17	157.93	235	148.8
1945	2,436	7.685	18.72	11.77	6.95	166.12	162.65	203	124.8
1946	3,400	7.856	26.71	12.68	14.03	180.15	173.14	170	98.2
1947	3,800	8.027	30.50	13.11	17.39	197.54	188.85	187	99.0
1948	3,700	8.198	30.33	13.45	16.88	214.42	205.98	192	93.2
1949	3,500	8.369	29.29	13.62	15.67	230.09	222.26	176	79.2
1950	4,150	8.539	35.43	16.08	19.35	249.45	238.6	200	83.8

TABLE A-2

THE RECURSION FOR THE RENEWAL AND GROWTH OF PRODUCTION CAPACITY, 1919-1950

Year	Peacetime Civilian Capacity (Beginning of Calendar Year), $P_{CAP}(t-1)$ (1)	Total Civilian Industrial Production (Fiscal Year) $P_T(t-\frac{1}{2})$ (2)	Rate of Operations (Fiscal Year, Percent), $r_{\overline{t-\frac{1}{2}}}$ (3)	Share of Equipment for Manufacturing and Mining in Civilian Industrial Production (Percent): Calculated, $s_t(r_{\overline{t-\frac{1}{2}}}) = 1.794 + 0.0479\, r_{\overline{t-\frac{1}{2}}}$ (4)	Share (Percent): Actual, s_t (8) ÷ (6) (5)	Civilian Industrial Production (Calendar Year) $P_T(t)$ (6)	Output of Equipment for Manufacturing and Mining in Points of the Index of Total Industrial Production: Calculated, (4) × (6) (7)	Output: Actual, $P_{EMM}(t)$ (8)	Output: Deviation, (8) − (7) (9)
1919	—	71	80.4	5.65	6.15	72	4.07	4.43	+0.36
1920	91.2	77	84.4	5.84	6.51	75	4.38	4.88	+0.50
1921	94.6	64	67.7	5.04	4.85	58	2.92	2.81	−0.11
1922	95.7	64	66.9	5.00	5.47	73	3.65	3.99	+0.34
1923	98.0	84	85.7	5.90	6.02	88	5.19	5.30	+0.11
1924	101.8	85	83.5	5.79	5.67	82	4.75	4.65	−0.10
1925	104.5	85	81.3	5.69	5.96	90	5.12	5.36	+0.24
1926	108.0	93	86.1	5.92	6.03	96	5.68	5.79	+0.11
1927	111.9	97	86.7	5.95	5.56	95	5.65	5.29	−0.36
1928	115.2	95	82.5	5.75	6.09	99	5.69	5.99	+0.30
1929	119.6	107	89.5	6.08	6.49	110	6.69	7.14	+0.45
1930	126.0	103	81.7	5.71	5.73	91	5.20	5.22	+0.02
1931	129.4	82	63.4	4.83	4.98	75	3.62	3.74	+0.12
1932	130.1	65	50.0	4.19	4.21	58	2.43	2.44	+0.01
1933	128.1	60	46.8	4.04	3.46	69	2.79	2.39	−0.40
1934	125.6	76	60.5	4.69	4.08	75	3.52	3.06	−0.46
1935	123.9	78	63.0	4.81	4.75	87	4.18	4.14	−0.04
1936	123.7	94	76.0	5.43	5.85	103	5.59	6.03	+0.44
1937	127.1	114	89.7	6.09	5.36	113	6.88	6.07	−0.81
1938	130.9	95	72.6	5.27	5.02	89	4.69	4.46	−0.23
1939[a]	132.0	98	74.2	5.35	4.80	108	5.78	5.18	−0.60

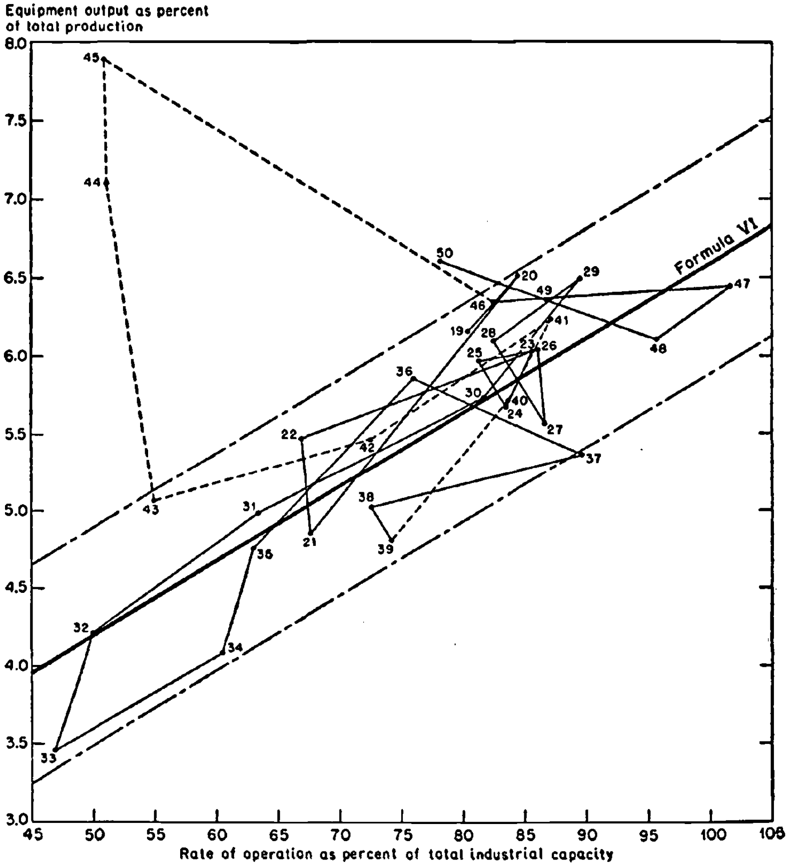
TABLE A-2. (concluded)

Year	Peacetime Civilian Capacity (Beginning of Calendar Year), $P_{CAP}(t-1)$ (1)	Total Civilian Industrial Production (Fiscal Year) $P_T(t-\frac{1}{2})$ (2)	Rate of Operations (Fiscal Year, Percent), $r_{\overline{t-\frac{1}{2}}}$ (3)	Share of Equipment for Manufacturing and Mining in Civilian Industrial Production (Percent): Calculated, $s_t(r_{\overline{t-\frac{1}{2}}}) = 1.794 + 0.0479\, r_{\overline{t-\frac{1}{2}}}$ (4)	Share (Percent): Actual, s_t (8) ÷ (6) (5)	Civilian Industrial Production (Calendar Year) $P_T(t)$ (6)	Output of Equipment for Manufacturing and Mining in Points of the Index of Total Industrial Production: Calculated, (4) × (6) (7)	Output: Actual, $P_{EMM}(t)$ (8)	Output: Deviation, (8) − (7) (9)
1940[a]	135.6	113.5	83.7	5.80	5.71	119	6.90	6.79	−0.11
1941[a]	142.8	124.5	87.2	5.97	6.23	130	7.76	8.10	+0.34
1942[a]	153.2	111	72.5	5.27	5.46	92	4.85	5.03	+0.18
1943[a]	156.7	86	54.9	4.42	5.06	80	3.54	4.05	+0.51
1944[a]	156.7	80	51.1	4.24	7.10	80	3.39	5.68	+2.29
1945[a]	159.2	81	50.9	4.23	7.89	90	3.81	7.71	+3.90
1946	166.1	137	82.5	5.75	6.34	170	9.78	10.76	+0.98
1947	180.2	183	101.6	6.66	6.44	187	12.45	12.04	−0.41
1948	197.5	189	95.7	6.38	6.10	192	12.25	11.71	−0.54
1949	214.4	186	86.8	5.95	6.35	175	10.41	11.09	+0.68
1950	230.1	180	78.2	5.54	6.60	200	11.08	13.20	+2.12

[a] Civilian production as indicated in table on page 852 of the *Federal Reserve Bulletin*, September 1945, for the calendar years 1939 through 1945.

CHART A-1

Output of Manufacturing and Mining Equipment Compared with Rate of Operation of Total Industrial Capacity



Output of equipment for manufacturing and mining is measured as a share of total industrial production during the calendar year.

Rate of operation is measured as the portion of peacetime civilian capacity used by total industrial production during the preceding fiscal year.

Estimates for the years 1939-45 cover only nonwar industrial production and are indicated by the dashed line (figures from the Federal Reserve Bulletin, September 1945).

The Formula VI estimate of manufacturing and mining equipment output compared with rate of operation is indicated by the heavy line. Note that in most years the range of variation of actual data from this estimate is not more than ±0.7 of 1 percent (indicated by the dot-dashed lines).

tential will be the same in each case. The same holds for capacity itself. The set of conditions accompanying the capacity levels in bench mark years is not necessarily duplicated in the unknown composition of annual gross addition to capacity. Thus, developing capacity levels only on the basis of a nondescript constant-dollar volume of installed new equipment may lead at times to an unattainable level of capacity. This was demonstrated by the constraint imposed by steel capacity shown in Formula V, in Section H. However, it must be assumed that such deviations are more or less short-term in character. Thus, given a long-term projection of industrial production, Formula VI permits a recursive development of a long-term projection of capacity. This provides, in turn, a partial test of the long-term projection of industrial production itself, since the changes in the internal structure of industrial production during the business cycle are of a fairly definite character. They will permit a check of the estimates of producers' equipment for consistency.

APPENDIX B

TABLE B-1

STEEL PRODUCTION, CAPACITY, AND REQUIREMENT RATES IN THE UNITED STATES, 1919-1951

YEAR	Production of ingots and steel for castings destined for various markets (millions of net tons): Total, S_T (1)	Domestic, S_D (2)	Foreign, S_E (3)	Production capacity for ingots and steel for castings, midyear (millions of net tons) S_{CAP} (4)	Apparent rate of steel requirements[a]: Total, S_T/P_T (5)	Domestic, S_D/P_T (6)
1919	38.8	31.7	7.1	61.7	539	440
1920	47.2	39.7	7.5	63.3	629	529
1921	22.2	19.0	3.2	64.9	383	328
1922	39.9	36.8	3.1	65.6	547	504
1923	50.3	47.1	3.2	66.2	572	535
1924	42.5	39.8	2.7	67.6	518	485
1925	50.8	48.0	2.8	66.7	564	533
1926	54.1	50.7	3.4	66.0	564	528
1927	50.3	47.1	3.2	68.0	529	496
1928	57.7	53.9	3.8	70.1	583	544
1929	63.2	59.2	4.0	72.7	575	538
1930	45.6	43.0	2.6	75.2	501	473
1931	29.1	27.7	1.4	78.1	388	369
1932	15.3	14.7	.6	78.7	264	253
1933	26.0	25.1	.9	78.4	377	364
1934	29.2	27.6	1.6	78.3	389	368
1935	38.2	36.6	1.6	78.3	439	421
1936	53.5	51.1	2.4	78.4	519	496
1937	56.6	50.8	5.8	79.4	501	450
1938	31.8	28.4	3.4	81.0	357	319
1939	52.8	48.1	4.7	81.7	484	441

TABLE B-1 (concluded)

YEAR	PRODUCTION OF INGOTS AND STEEL FOR CASTINGS DESTINED FOR VARIOUS MARKETS (MILLIONS OF NET TONS) Total, S_T (1)	Domestic, S_D (2)	Foreign, S_E (3)	PRODUCTION CAPACITY FOR INGOTS AND STEEL FOR CASTINGS, MIDYEAR (MILLIONS OF NET TONS) S_{CAP} (4)	APPARENT RATE OF STEEL REQUIREMENTS[a] Total, S_T/P_T (5)	Domestic, S_D/P_T (6)
1940	67.0	54.8	12.2	83.4	536	438
1941	82.8	73.4	9.4	87.0	511	453
1942	86.0	75.7	10.3	89.4	432	380
1943	88.8	78.3	10.5	91.9	372	328
1944	89.6	81.3	8.3	94.7	381	346
1945	79.7	72.4	7.3	93.7	393	357
1946	66.6	59.7	6.9	91.6	392	351
1947	84.9	75.9	9.0	92.7	454	406
1948	88.6	82.2	6.4	95.2	461	428
1949	78.0	70.6	7.4	97.8	443	401
1950	96.8	92.7	4.1	100.6	484	463
1951	105.1	100.5	4.6		478	457

[a] In thousands of net tons annually per point on the Federal Reserve Index of Industrial Production.

Column		*Average, 1919-40*
1	Source: American Iron and Steel Institute, *Metal Statistics, 1950*, p. 119.	43.7
2	($S_T - S_E$)	40.0
3	This is an estimate based on the percentage which "Iron and Steel Exports Other than Scrap" (Department of Commerce, *Metal Statistics, 1950*, p. 260) is of "Rolled Steel Products for Sale" (American Iron and Steel Institute, *op.cit.*, p. 135) applied to column 1. Both series are stated for the 12-month period ending January 31. The comparison of rolled steel for sale with production of ingots and steel for castings implicit in this procedure accounts (a) for the rate of scrap and (b) for the share of rolled steel not for sale (but for reconversion). Both rates vary over time.	3.7
4	Reported or estimated for midyear as an approximation for the annual average. Source: Same as column 1.	72.9
5	Column 1 ÷ column 1 of Table A-2.	
6	Column 2 ÷ column 1 of Table A-2.	

TABLE B-2

TOTAL INDUSTRIAL AND SELECTED METAL PRODUCTION, 1919-1951 (1935-39 = 100)

	Production			Industrial Production		
Year	Total Industrial, P_T (1)	Metal and Metal Products, P_{MET} (2)	Iron and Steel Products, $P_{I\&S}$ (3)	Normal Level, 0.85(P_{CAP}) or P_N (4)	Cyclical Slack, P_{CY} (5)	Peacetime Civilian Capacity (Midyear), P_{CAP} (6)
1919	72	24.2	9.2	77	5	90
1920	75	27.3	11.2	79	4	93
1921	58	13.6	5.3	81	23	95
1922	73	22.9	9.4	82	9	97
1923	88	30.2	12.0	85	—3	100
1924	82	27.2	9.9	88	6	103
1925	90	31.1	11.9	90	0	106
1926	96	33.6	12.7	94	—2	110
1927	95	31.1	11.9	97	2	114
1928	99	34.9	13.3	99	0	117
1929	110	40.4	14.6	105	—5	123
1930	91	29.7	10.7	109	18	128
1931	75	19.8	6.7	111	36	130
1932	58	11.8	3.5	110	52	129
1933	69	16.1	5.9	108	39	127
1934	75	19.9	6.7	106	31	125

TABLE B-2 (concluded)

Year	Production: Total Industrial, P_T (1)	Production: Metal and Metal Products, P_{MET} (2)	Production: Iron and Steel Products, $P_{I\&S}$ (3)	Industrial Production: Normal Level, $0.85(P_{CAP})$ or P_N (4)	Industrial Production: Cyclical Slack, P_{CY} (5)	Industrial Production: Peacetime Civilian Capacity (Midyear), P_{CAP} (6)
1935	87	25.4	8.9	105	18	124
1936	103	33.3	12.6	106	3	125
1937	113	37.9	13.5	110	−3	129
1938	89	22.9	7.5	111	22	131
1939	109	33.1	12.5	114	5	134
1940	125	43.8	16.2	118	−7	139
1941	162	65.5	20.5	126	−36	148
1942	199	94.8	21.9	132	−67	155
1943	239	125.6	22.9	133	−106	157
1944	235	123.5	22.7	134	−101	158
1945	203	94.2	20.1	139	−64	163
1946	170	61.4	16.6	147	−23	173
1947	187	70.9	21.5	161	−26	189
1948	192	72.8	22.9	175	−17	206
1949	176	64.9	20.6	189	13	222
1950	200	77.0	24.8	203	3	238.6
1951	220	88.8	28.5	222	2	261.7

Column		Average 1919-40
1	Source: Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin*, October 1943.	87.8
2	Source: Same as column 1.	27.7
3	Source: Same as column 1.	10.3
4	Source: See Appendix A.	99.3
5	Because of the prevalence of slack rather than strain ($-P_{CY} = P_T - P_N$) during the period 1919-40, cyclical slack has been used as the short-term variable.	11.5
6	Source: See Appendix A.	116.8

TABLE B-3

ESTIMATES OF TOTAL STEEL PRODUCTION AND OF PRODUCTION OF STEEL FOR THE DOMESTIC MARKET BASED ON INDUSTRIAL PRODUCTION AND ITS NORMAL RATE, 1919-1939 (IN MILLIONS OF TONS)

Year	*Formula I*		*Formula II*		*Formula III*		*Formula IV*		
	$S_T(P_T)$ (1)	*Residuals,* $S_T - (1)$ (2)	$S_T(P_T,P_N)$ (3)	*Residuals,* $S_T - (3)$ (4)	$S_T(P_T,P_N)$ (5)	*Residuals,* $S_T - (5)$ (6)	$S_D(P_T,P_N)$ (7)	$S_E + S_D(P_T,P_N)$ (8)	*Residuals,* $S_T - (8)$ (9)
1919	32.7	+6.1	40.6	−1.8	39.7	−0.9	35.6	42.7	−3.9
1920	34.8	+12.4	42.3	+4.9	41.7	+5.5	37.7	45.2	+2.0
1921	22.9	−0.7	26.7	−4.5	23.9	−1.7	18.5	21.7	+0.5
1922	33.4	+6.5	39.1	+0.8	38.3	+1.6	34.0	37.1	+2.8
1923	43.8	+6.5	50.6	−0.3	51.7	−1.4	48.4	51.6	−0.7
1924	40.0	+2.5	44.0	−1.5	44.3	−1.8	40.3	43.0	−0.5
1925	45.2	+5.6	49.9	+0.9	51.2	−0.4	47.8	50.6	+0.2
1926	49.4	+4.7	53.1	+1.0	55.2	−1.1	52.0	55.4	−1.3
1927	48.7	+1.6	50.9	−0.6	52.8	−2.5	49.3	52.5	−2.2
1928	51.5	+6.2	53.3	+4.4	55.8	+1.9	52.5	56.3	+1.4
1929	59.2	+4.0	59.9	+3.3	61.9	+1.3	57.8	61.8	+1.4
1930	45.9	−0.3	41.7	+3.9	41.7	+3.9	37.8	40.4	+5.2
1931	34.8	−5.7	27.0	+2.1	27.7	+1.4	26.9	28.3	+0.8
1932	22.9	−7.6	12.9	+2.4	14.5	+0.8	16.2	16.8	−1.5
1933	30.6	−4.6	23.4	+2.6	24.0	+2.0	23.6	24.5	+1.5
1934	34.8	−5.6	29.4	−0.2	29.4	−0.2	27.9	29.5	−0.3
1935	43.1	−4.9	40.2	−2.0	39.3	−1.1	35.7	37.3	+0.9
1936	54.3	−0.8	53.4	+0.1	51.6	+1.9	45.8	48.2	+5.3
1937	61.3	−4.7	60.1	−3.5	58.2	−1.6	51.4	57.2	−0.6
1938	44.5	−12.7	39.0	−7.2	38.8	−7.0	35.8	39.2	−7.4
1939	58.5	−5.7	54.8	−2.0	53.7	−0.9	48.0	52.7	+0.1

TABLE B-3 (concluded)

	Formula I		Formula II		Formula III		Formula IV		
Year	$S_T(P_T)$ (1)	Residuals, $S_T - (1)$ (2)	$S_T(P_T,P_N)$ (3)	Residuals, $S_T - (3)$ (4)	$S_T(P_T,P_N)$ (5)	Residuals, $S_T - (5)$ (6)	$S_D(P_T,P_N)$ (7)	$S_E + S_D(P_T,P_N)$ (8)	Residuals, $S_T - (8)$ (9)
1940	69.6	−2.6	66.6	+0.4	65.0	+2.0	57.5	69.7	−2.7
1941	93.4	−12.6	94.6	−11.8	91.7	−8.9	79.5	88.9	−6.1
1942	121.2	−35.2	123.4	−37.4	119.1	−33.1	102.1	112.4	−26.4
1943	149.1	−60.3	157.1	−68.3	150.5	−61.6	127.4	137.9	−49.0
1944	146.3	−56.7	153.3	−63.7	147.0	−57.4	124.7	133.0	−43.4
1945	124.0	−44.3	123.4	−43.7	119.9	−40.2	103.2	110.5	−30.8
1946	101.0	−34.4	91.4	−24.8	91.0	−24.4	80.6	87.5	−20.9
1947	112.8	−27.9	99.4	−14.5	99.8	−14.9	88.7	97.7	−12.8
1948	116.3	−27.7	97.0	−8.4	99.0	−10.4	89.2	95.6	−7.0
1949	105.2	−27.2	76.7	+1.3	81.6	−3.7	76.2	83.6	−5.7
1950	121.9	−25.2	90.6	+6.2	95.9	+0.9	88.7	92.8	+4.0
1951	135.9	−30.8	98.7	+6.4	104.6	+0.5	97.8	102.4	+2.7

TABLE B-4

ESTIMATES OF STEEL REQUIREMENTS AT NORMAL LONG-RUN AND CAPACITY RATES OF TOTAL INDUSTRIAL PRODUCTION BASED ON VARIOUS FORMULAE, 1919-1951 (IN MILLIONS OF TONS)

	NORMAL LONG-RUN RATES BASED ON FORMULA			CAPACITY RATES BASED ON FORMULA	
	II	*III*	*IV*	*II*	*III*
	$S_T(P_N)$	$S_T(P_N)$	$S_D(P_N)$	$S_T(P_{CAP})$	$S_T(P_{CAP})$
YEAR	(1)	(2)	(3)	(4)	(5)
1919	44.9	44.6	41.0	56.3	57.8
1920	45.7	45.7	42.0	57.6	59.5
1921	46.4	46.7	43.1	58.5	60.7
1922	46.8	47.2	43.6	59.4	61.8
1923	48.0	48.7	45.2	60.8	63.6
1924	49.1	50.2	46.7	62.2	65.3
1925	49.9	51.2	47.8	63.5	67.0
1926	51.4	53.3	49.9	65.3	69.3
1927	52.6	54.8	51.4	67.2	71.7
1928	53.3	55.8	52.5	68.5	73.4
1929	55.6	57.3	53.1	71.2	74.2
1930	57.1	57.0	51.6	73.5	73.3
1931	57.9	56.3	49.9	74.4	71.5
1932	57.5	55.8	49.5	74.0	71.0
1933	56.8	54.9	48.6	73.1	70.0
1934	56.0	54.0	47.7	72.2	69.0
1935	55.6	53.5	47.2	71.7	68.5
1936	56.0	54.0	47.7	72.2	69.0
1937	57.5	55.8	49.5	74.0	71.0
1938	57.9	56.3	49.9	74.9	72.0
1939	59.1	57.7	51.2	76.2	73.6
1940	60.6	59.5	53.0	78.5	76.1
1941	63.7	63.1	56.5	82.6	80.7
1942	66.0	65.9	59.2	85.8	84.2
1943	66.3	66.3	59.6	86.7	85.2
1944	66.7	66.8	60.1	87.1	85.7
1945	68.6	69.1	62.3	89.4	88.3
1946	71.7	72.7	65.9	93.9	93.4
1947	77.1	79.1	72.1	101.2	101.5
1948	82.4	85.5	78.3	108.9	110.1
1949	87.8	91.9	84.5	116.2	118.2
1950	93.1	98.3	90.7	123.7	126.6
1951	100.4	106.9	99.1	134.5	138.5