PROBLEMS IN THE MEASUREMENT OF REAL INVESTMENT IN THE U. S. PRIVATE ECONOMY

by

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ABSTRACT

The thesis is part of a larger research project on the sources of variation in the capital-output ratio in the U. S. Private Economy since World War I. This installment of the project is a critical evaluation of previous methods used in the estimation of real investment, the basic ingredient in measures of capital input. Chapter I reviews conceptual issues in the field of capital measurement and recommends the gross capital stock expressed in constant base-year prices as the most appropriate concept for use in the study of productivity change.

In Chapter II alternative investment estimates are compared, discrepancies between them are examined, and a set of revisions is proposed. Chapter III reveals a large stock of assets, structures and equipment financed by the Federal government for operation by private firms, which have hitherto been ignored in the measurement of private capital input. A detailed analysis of government documents results in an estimate of annual investment expenditures on these neglected assets.

After two chapters concerned with investment data measured in current dollars, Chapter IV turns to the controversial subject of price deflators for capital goods. A major effort is devoted to the review of evidence on construction deflators, and a new index is proposed. The conclusion of the thesis, Chapter V, demonstrates the combined effect of the revisions on measures of the capital-output ratio in the U. S. Private Economy for the period 1910-1965.

Thesis Supervisor: Robert M. Solow

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CHAPTER I

INTRODUCTION

Since World War II economists have devoted considerable energy to the construction of growth models, the aim of which is the analysis of steady states in which the equilibrium growth rates of all relevant variables remain constant. Theorists examine these models to determine whether a steady-state growth path exists, whether the system tends to converge to or diverge from this path when one or more variables are displaced from their equilibrium values, and how these steady-state values are affected by changes in the parameters of the system.[1] Considerably more attention has been paid in this literature to refinements of theoretical points than to serious attempts to verify the main conclusions of the models. Most empiricism has been rather casual, often taking the form of an examination of certain "great ratios" between important variables for evidence that they exhibit the tendencies predicted by theory.[2] The capital-output ratio is one of the most important of these, and its historical behavior in the American and other economies has been examined to determine

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[1]The best summary of the growth literature is Hahn and Matthews [1964].

[2]The phrase "great ratios" appears to have originated in an article by Klein and Kosobud [1961]. Several great ratios are also exhibited in Samuelson [1967], p. 717.

whether the stability expected in steady-state growth has been occurring.[3]

I. THE USES OF CAPITAL DATA AND ITS LIMITATIONS

Several studies have presented evidence on the capital-output ratio, and Kendrick's [1961a] result for the U. S. private domestic economy is shown by the solid line in Figure 1.[4] The fluctuations in the ratio represent cyclical variations which are not representative of long-run trends. To isolate the latter a dashed line has been drawn to connect troughs in

---

[3] In the Harrod-Domar model a fixed marginal capital coefficient (v) is assumed. Harrod admits that the desired capital coefficient "depends on the state of technology and the nature of the goods constituting the increment of output. It may be expected to vary as income grows and in different phases of the trade cycle; it may be somewhat dependent on the rate of interest." Harrod [1939]. But variations in the capital coefficient do not play any role in the behavior of the model. The neoclassical models of Solow [1956a], Swan [1956], and others replace Harrod's fixed coefficients with a concave differentiable production function and allow v to vary until the warranted growth rate s/v is equated with the natural rate n (where s is the constant proportion of income saved and n is the rate of population growth). In the steady state v is constant, for labor, capital, and output all grow at the same rate. The introduction of technical progress in models where s is constant does not alter the necessity in steady growth of a constant v, but brings with it the restriction that technical change must be purely labor-augmenting. In the following paragraphs we will be referring to the <u>average</u> capital-output ratio, the stability of which assures the stability of the marginal ratio.

[4] Other similar evidence has been presented by Kuznets [1961] and Domar [1961b]. Both Domar and Kendrick base their capital data on Goldsmith's pioneering <u>A Study of Saving in the United States</u> [1955].

the ratio (excluding the abnormal World War II years), and the resulting secular trend shows a pronounced decline of almost 50 per cent between the 1890's and the 1950's. Most of the drop appears to have taken place between 1916 and 1952, although there was some decline in the earlier years.

The explanation of secular decline in the ratio presents a challenge to growth theorists, who must ponder the possibility that the American economy was not experiencing steady-state growth, at least during most of the last 70 years.[5] In addition the decline is relevant to several other economic topics.

1. In most estimates of production function parameters capital has been assigned a relatively small role in the explanation of the growth of output because of the relatively slow growth of capital relative to output. A natural inference is that incentives to investment will not yield important increases in the future growth rate of output.[6]

2. Trends in the capital-output ratio cast light not only on changes in production relations but also on savings behavior. For instance, the simultaneous decrease in the capital-output ratio and increase in the ratio of national debt to income

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[5]For one possible interpretation, see Kendrick and Sato [1963].

[6]There have been innumerable attempts to fit production functions. Several early efforts include Solow [1957] and Denison [1962]. For comments on the methodology of this approach, see Abramovitz [1962] and Domar [1961a].

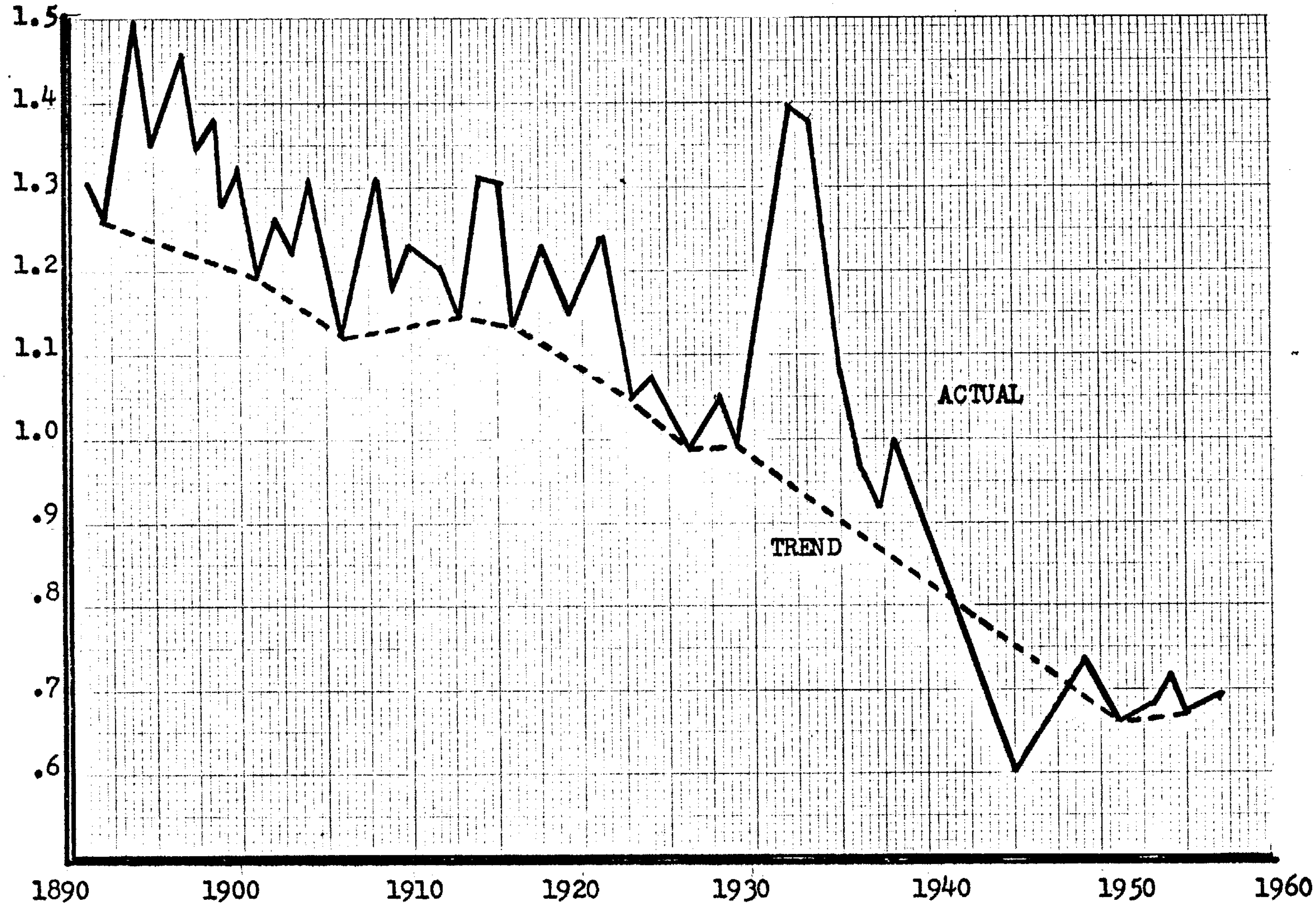

Figure 1

KENDRICK'S CAPITAL-OUTPUT RATIO, PRIVATE DOMESTIC ECONOMY, 1890-1957, IN CONSTANT 1929 DOLLARS.

<u>Source</u>: Reciprocal of Kendrick [1961a], Table A-XIX, p. 328, column 9.

between 1929 and 1948 has enabled Modigliani to conclude that an increase in the national debt of x per cent generates a burden by causing a reduction of about .65 x in the stock of private tangible capital.[7]

3. The capital-output ratio enters into most discussions of the distribution of national income.[8] The period of rising national debt, for instance, was also a time of increased Corporation Income Tax rates, and the simultaneous decline in the capital-output ratio may reflect the depressing influence of the tax on investment, causing firms to eliminate projects with relatively low rates of return and high marginal capital-output ratios.[9] With an elasticity of substitution smaller than one, this increase in pre-tax profit rates would also have been reflected in a rise in the income share of capital, reflecting the success of firms in shifting the burden of the Corporation Income Tax in the long-run.[10]

4. An understanding of the causes of the decline in the capital-output ratio is important in long-term forecasts of investment, for any long-run factors operating to diminish the

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[7]See Modigliani [1966], pp. 205-6; also Modigliani [1961] [1964].

[8]See the recent survey by Scitovsky [1964].

[9]As shown in Figure 1, other causal factors must have been responsible for the decline of the ratio during the earlier years when the Corporation Income Tax was not an important factor.

[10]For a discussion of the relation between the capital-output ratio and <u>short-run</u> tax shifting, see R. J. Gordon [1967].

ratio of desired capital to output imply a decline in real purchases of investment goods for a given level of real output and a consequent weakness of demand in the private investment sector of the economy.

5. The decline in the capital-output ratio is of interest in the study of innovations as possible evidence that technical progress has been relatively capital-saving (in the sense of Harrod).[11]

6. Cyclical variations in the capital-output ratio for the private economy and its sub-sectors provide hints about the utilization of capacity during the pre-World War II years for which other utilization estimates are not available. The interruptions of the decline in the dashed line in Figure 1 between 1926 and 1929, for instance, may indicate that 1929 was not a year of peak utilization and that the pressure of demand in the economy was less intense than in the mid-1920's.

Critiques of Capital Data

Until very recently discussions of the stability of the capital-output ratio, the sources of long-run growth, and other related issues accepted without question the capital stock data

[11]For Harrod's original definition, see Harrod [1948], pp. 24-26, and an admirable summary of different definitions of innovational bias in Salter [1960], Chapter 3. On the relation of capital-saving innovation and private asset preferences, see Thorn [1962].

developed by Goldsmith, Kuznets, and others at the National Bureau of Economic Research and by Robert C. Wasson at the Department of Commerce.[12] But in the last five years an increasing volley of criticism has been directed at the NBER/Commerce capital data as inappropriate for studies of long-run growth and the sources of productivity change. Five main points have been made:

1. The investment flows on which the capital estimates are based are <u>overdeflated</u> with price indexes which exaggerate the increase of structures prices by ignoring productivity improvements and overstate the rise in producers' durable equipment prices by failing to take account of quality change.[13]

2. In the cumulation of investment flows into capital stocks, structures and equipment are <u>overdepreciated</u>. The NBER studies calculate <u>net</u> stocks using the straight-line method of depreciation which writes down the portion of an investment good remaining in the capital stock more rapidly than the decline in

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[12]The initial economy-wide study was by Goldsmith [1955], whose figures are used by Kendrick [1961a]. Separate NBER volumes on sub-sectors of the economy have been written by Ulmer [1960], Grebler, Blank, and Winnick [1956], Tostlebe [1957], and Creamer, Dobrovolsky, and Borenstein [1960]. These sectoral studies are summarized by Creamer [1961] and were followed by an overall survey by Kuznets [1961], who developed long-period capital estimates based on a different scheme of national income accounting than Goldsmith's and whose figures are used by Domar [1961b]. More recently Goldsmith has updated his estimates to 1958 [1962] [1963]. The Commerce estimates use most of the same methods and appear in an initial (Jaszi, Wasson, and Grose [1962]) and a final version (Grose, Rottenburg, and Wasson [1966]).

[13]Griliches [1964]; Anderson [1961].

its ability to produce.[14]

3. The service lifetime over which an investment good remains in the capital stock is assumed constant over the entire period of the NBER/Commerce calculations, and the possibility of important secular or cyclical changes in service lifetimes is ignored.[15]

4. It is not the value of the capital stock which directly produces output, but hours of capital services. The use of the NBER/Commerce capital stock data in production functions obscures historical changes in the hours of utilization of the stock.[16]

5. The input of different types of capital services should be aggregated into an overall measure of capital input using service prices as weights, not the asset prices implicitly used in the NBER studies.[17]

These criticisms of the NBER measurement techniques have been ignored or dismissed in the most recent discussions of trends

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[14]Griliches [1963]; [1961a], p. 448; Ruggles and Ruggles [1961], p. 395.

[15]The only investigation of changes in service lives is by Huntley [1960]. Unfortunately his results are of little use since his data do not separate structures and equipment, do not adjust for the postwar decline in average service lives due to the increasing proportion of equipment in the capital stock, and, most importantly, are based on tax lives rather than actual service lives.

[16]Griliches and Jorgenson [1966], p. 60; Jorgenson and Griliches [1967], pp. 39-41; Foss [1963].

[17]Griliches and Jorgenson [1966], p. 58; Jorgenson and Griliches [1967], pp. 42-46.

in the relative growth of capital and output.[18] Yet the issues of measurement are crucially important in any study of long-run growth and deserve to be considered more seriously. A detailed study is needed to evaluate the conceptual and statistical validity of recent criticisms and to recommend such changes in the NBER-Commerce capital stock data as careful evaluation of the methods used may suggest. The thesis is the first installment of a larger research project devoted to this general subject; the thesis revises both the Commerce current-dollar investment estimates and the deflators used to convert these to constant prices. In future stages of the project the author will study problems involved in converting these new investment data into a capital input series. At that stage new measures of capital-output ratios can be calculated and an attempt made to explain their secular behavior.

The thesis is thus unusual in its preoccupation with problems of measurement to the exclusion of any investigation of "actual" economic phenomena. Most economists, although often aware of weaknesses in data, are anxious for final conclusions and are unwilling to devote more than cursory attention to the data on which those conclusions rest. In the field of productivity analysis, unfortunately, the proliferation of econometric studies based on flawed measures of capital, unbalanced by any equivalent

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[18] Among these are Kendrick and Sato [1963]; Abramovitz and David [1965], Chapter V; Mayor [1965], Chapter II; and LaTourette [1965].

effort to minimize these flaws, may represent a serious misallocation of intellectual resources, for final results may be more sensitive to data revisions than to the actual econometric models or methods used. What effort has been devoted to issues in capital measurement has largely been confined to repetitive articles which have listed defects in present data but have not attempted to produce any new numbers to replace them. It is hoped that the new data supplied in the thesis and in the next stages of the author's research project will improve the accuracy of empirical studies and lessen the chance that future data revisions might invalidate their results.

II. BOUNDARY FENCEPOSTS FOR THE STUDY

The principal purpose of the overall research project, of which this thesis is the first part, is the study of the sources of long-run economic growth, and so the discussion concentrates on capital in its role as a factor of production. Thus the thesis is concerned only with private fixed nonresidential tangible producers' capital, the structures and equipment used to produce output in the private U. S. economy. Residential structures and consumer durables are excluded since these investment goods are demanded primarily for consumption rather than production purposes. Inventories are ignored to limit the size and scope of the project.

In the analysis of capital-output ratios care must be taken to exclude from output any goods or services not produced with capital as circumscribed by this definition. Of the components of gross national product, the compensation of government employees should obviously be omitted since no account is taken of the government-financed capital with which they work. Similarly, the exclusion of residential capital requires the subtraction from output of the imputed rent on owner-occupied dwellings and the rent paid by tenants in residential buildings owned by others.

Should gross national product, net national product, or national income be the base from which these deductions are made? Gross output data are more appropriate, since capital goods intended for replacement purposes are produced by private capital input in the same way as any other capital or consumer goods. Gross private domestic product, however, is not a suitable base, for our desired real output concept should be measured by deflated factor costs rather than deflated market prices. Indirect taxes, which constitute a wedge between market prices and factor costs, must be excluded from output to avoid a spurious difference between the capital-output ratios of two periods or nations in which production relations are identical but the relative importance of indirect taxes is different.[19] Normally the use of either

[19]This is not a crucial matter if price indexes used to deflate output take account of the impact of indirect taxes on market prices.

demand price or supply price is legitimate in the calculation of output, for both lead to the same result; when a tax drives the two prices apart, however, supply price is a better indicator in studies of production relationships.[20]

Finally, as we shall see in Chapter III, a part of private output is produced by capital which is owned by the government and is thus excluded from the private capital stock. Data are not available to eliminate this portion of private output, and instead in Chapter III an attempt is made to add to private capital the portion of government-financed capital which produces private output. This is an important adjustment for our purposes, for this inconsistency in the U. S. national accounts is a factor which became important during the 1929-48 period when a large part of the decline in the capital-output ratio occurred and helps to explain some of that decline.

The thesis aims at achieving an estimate of capital input for the period from 1910 to the present. There are no reliable annual equipment estimates before 1889, and an average service lifetime of about 20 years sets 1910 as the earliest year in which a full 20 years' history of equipment estimates are available.[21] Equipment data are the operating constraint, for

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[20]These adjustments--the subtraction of actual and imputed residential rents and indirect business taxes from gross private product--will not be attempted in the thesis but will be accomplished in future stages of the project after final capital estimates have been completed.

[21]1889 is the initial date of the annual series in Shaw [1947].

construction figures are relatively crude before 1915 and the acceptance of this limitation would obviate any capital estimates during the lifetime of pre-1915 buildings, i.e., up through the present! Primary emphasis has been placed on the improvement of estimates of construction expenditures and deflators for the period since 1915, and revisions performed on existing pre-1915 estimates are accomplished by crude extrapolations rather than a detailed historical investigation. The 1910 starting-point is sufficiently early to include the period of the decline in the capital-output ratio between World War I and the end of World War II and to allow comparisons among three prosperous peacetime periods--1910-14, the 1920's, and the post-World War II years.

III. CONCEPTS OF CAPITAL INPUT

What does Capital Mean?

Let us consider an economy operating during a base period b in which n different types of investment goods I_j are produced (of which r are types of equipment and n-r are types of structures) by a set of m factors X:

$$(1) \qquad I_j(b) = g_j \left(X_{ij}(b),\ldots,X_{mj}(b);b\right) \qquad (j = 1,\ldots,r,s,\ldots,n)$$

(The date b enters into the production function for investment goods to suggest that the function may shift over time). These machines, tractors, trucks, and buildings must be converted into money values before they can be added up. Their base-period price $p_j(b)$ is equal to average factor cost

$$(2) \qquad p_j(b) = \sum_{i=1}^{m} q_i(b)\, x_{ij}(b)$$

where $q_i(b)$ is the price per unit of factor i during the base period and $x_{ij}(b)$ is its base-period unit input requirement, defined as

$$(3) \qquad x_{ij}(b) = \frac{X_{ij}(b)}{I_j(b)}$$

In any given year v the total value of each type of investment good produced is $p_j(v)\ I_j(v)$. To compare the quantity of production of each type during periods with different prices, a set of price deflators $D_j(v)$ must be used to express the values of each year in base-period prices:

$$(4) \qquad p_j(b)\ I_j(v) = \frac{p_j(v)\ I_j(v)}{D_j(v)}$$

where

$$(5) \qquad D_j(v) = \frac{p_j(v)}{p_j(b)} = \frac{\sum_{i=1}^{m} q_i(v)\ x_{ij}(v)}{\sum_{i=1}^{m} q_i(b)\ x_{ij}(b)}$$

The process of deflation takes account both of changes between periods b and v in factor prices and in unit input requirements. A given machine might be cheaper in 1967 than in 1927 despite the intervening increase in wages if substitution and technical progress had sufficiently reduced the input requirement of labor.

The investment goods built during period v are not capable of production forever and are eventually retired. $\pi_j(v,t)$ represents the proportion of investment goods of type j and vintage v which have not been retired by t ($t \geq v$). The gross stock of these goods at t, valued at base period prices, is then:

$$(6) \qquad K_j(v,t) = \pi_j(v,t)\, p_j(b)\, I_j(v)$$

$K_j(v,t)$ is expressed in units commensurable with saving and consumption and represents the economy's sacrifice of consumption goods at v, adjusted for price changes and retirements. But it is not $K_j(v,t)$ which directly produces final output, but rather hours of capital services $S_j(v,t)$ measured in constant efficiency units. In practice efficiency units may vary for different types of capital--those of a lathe or drill press may be measured in revolutions per minute, those of a truck in ton-miles of capacity per hour, and those of a factory in cubic feet. The capital-service-hours obtainable from a given amount of $K_j(v,t)$ depends on hours of utilization, improvements in operating practices, the rate of decline in efficiency due to deterioration, and differences in the efficiency of the designs of different vintages.

Specifically,

$$(7) \qquad S_j(v,t) = S_j(\, K_j(v,t), H_j(v,t), U_j(v,t), \Psi_j(v,t), \phi_j(v,t)\,)$$

where $H_j(v,t)$ is the annual number of hours of "normal" operation, $U_j(t)$ is the percentage of "normal" hours during which the capital is actually utilized during period t, $\Psi_j(v,t)$ is the efficiency of an hour of capital services relative to efficiency at some base-period ("vintage 0") in the absence of wear and tear, and $\phi_j(v,t)$ is the deterioration function representing the decline in services due to wear and tear. Both the date of construction v and the calendar date t enter as arguments in the H and Ψ functions since both normal hours and efficiency per hour can be increased either by embodied design improvements at the time of construction or by disembodied changes in operating practice as experience accumulates with the passing of calendar time.[22]

Once $S_j(v,t)$ is defined, the production function for output produced at time t with capital of type j and vintage v can be written:

$$(8) \qquad Q_j(v,t) = F_j(S_j(v,t), L_j(v,t), t)$$

where L is homogeneous labor, the allocation of which among machines is free to vary with both v and t, and the argument t represents disembodied technical change (in addition to the capital-augmenting

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[22]The ϕ function might be more realistic if cumulative hours of use were included as an argument. See, for instance, U. S. Interstate Commerce Commission [1963], p. 156, which reports that 45 per cent of railroad boxcar deterioration is attributable to use and 55 per cent to time.

disembodied technical change which has already entered into the definition of $S_j(v,t)$ above in (7)).[23] Output for all the vintages of capital of type j can be characterized by a "type-aggregate" production function:

$$(9) \qquad Q_j(t) = \sum_{v=t-\mu_j}^{t} F_j(\, S_j(v,t),\, L_j(v,t),\, t)$$

$$= G_j(\, J_j(t),\, L_j(t),\, t)$$

where μ_j is the age of the oldest unit of capital of type j and where the aggregate of capital of different vintages is $J_j(t)$, which has been variously called "surrogate capital" and "jelly" in the literature, and which exists if and only if (7) can be factored into:

$$(10) \qquad S_j(v,t) = K_j(v,t)\, H_j(v,t)\, U_j(t)\, \Psi_j(v,t)\, \emptyset_j(v,t)$$

i.e., if and only if all capital-embodied technical change is capital-augmenting.[24]

The further step of adding up the type-aggregates of (9) into economy-aggregates is possible only for types which are perfect substitutes. Whatever the similarities of individual

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[23] In order to write (8) and (11) below, we must assume that only one kind of output is produced by each variety of capital--otherwise we would need a different F_j function for each type of output (each would require different combinations of labor and capital).

[24] For a proof of this statement and further references on the subject of capital aggregation, see Fisher [1965]. Other recent discussions of the problem are Diamond [1965], Whitaker [1966], and Hall [1966]. See also the earlier article by Solow [1956b].

types of machines or buildings, equipment is not a perfect substitute for structures, and no economy-wide jelly which includes both structures and equipment can be defined. This consideration suggests that (8) is inaccurate. It is impossible to separate a plant's output into segments attributable to the structure and individual pieces of equipment (what would be the output of a conveyor belt in an auto factory if there were no other pieces of equipment to produce something to be conveyed?) It is more sensible to write a separate production function for each type of structure, in which one of the arguments is the aggregate of all types and vintages v* of equipment housed in those structures:

$$(11) \qquad Q_k(v,t) = F_k\left(S_k(v,t), \sum_{m=1}^{r} \sum_{v^*=t-\mu_m}^{t} S_{mkv}(v^*,t), L_k(v,t), t\right)$$

$$(m = 1,\ldots,r;\; k = s,\ldots,n)$$

or

$$Q_k(v,t) = F_k\left(S_k(v,t), J^E_{kv}(t), L_k(v,t), t\right)$$

where J^E is an equipment aggregate which exists if all types of equipment are perfect substitutes for each other and if capital-embodied technical change in equipment is characterized by condition (10). Then, aggregating over all types and vintages of structures, we obtain an economy-wide production function, in which output is a function of structures and equipment measured separately in homogeneous efficiency units, labor, and time:

$$(12) \qquad Q(t) \doteq \sum_{k=s}^{n} \sum_{v=t-\mu_k}^{t} F_k(S_k(v,t), J^E_{kv}(t), L_k(v,t), t) = G(J^S(t), J^E(t), L(t), t)$$

The set of equations (1)-(6) and (10)-(12) clarifies several important points in capital measurement:

1. As an input into the production process, capital is measured by <u>services</u>, while the resources consumed during the past in the construction of capital are measured by the capital stock stated in base-period prices.

2. The capital services obtainable from a given capital stock are not invariant, but can change with varying utilization, improvements in quality, and deterioration over time.

3. Technical progress takes place not just in shifts in the aggregate production function relating output to capital services, but also in shifts of the function (7) or (10) relating capital services to the capital stock.

4. Since they are not perfect substitutes, the services of structures and equipment should enter the production function separately.

Armed with our set of definitions and concepts, we may now determine which concept of capital is most appropriate in our long-term study of the capital-output ratio.

Stocks or Services?

In their recent article on capital measurement, Griliches and Jorgenson [1966] criticize the use of unadjusted Commerce/NBER capital stocks in the analysis of productivity growth.[25] They make several "corrections" to convert official measurements of the aggregate capital stock $K(t)$ into data on the input of aggregate capital-service-hours $J(t)$, including an adjustment for changes in normal hours $H(v,t)$, a reweighting of different types of capital services by their service prices rather than asset prices, and an adjustment for changes in the efficiency ratio $\Psi(v,t)$ by the use of new price deflators for investment expenditures which are claimed to represent more accurately changes in productivity $(1/x_{ij}(v))$ in the making of capital goods and quality changes in their ability to produce output. Using the method popularized by Solow[1957] the contribution of the growth of capital and labor input is calculated by weighting each by its share in total factor compensation, and the resulting weighted growth rate of input is subtracted from output growth to identify the "residual" or "costless technical change," that part of output growth which is not due to

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[25]For an elaborated version of the 1966 paper, see Jorgenson and Griliches [1967].

growth in capital or labor input.[26]

The final Griliches-Jorgenson measure of $J(t)$ grows much faster than the NBER/Commerce $K(t)$, and the resulting speed-up in the growth of input contribution almost eliminates the residual. But the Griliches-Jorgenson technique, however appropriate for calculating the rate of growth of $J(t)$, cannot be used to identify the presence or absence of the residual. For costless technical progress appears in more than one way, represented not just by the disembodied "t", the last argument in (12) above, but also appearing in (10) in the $H_j(v,t)$ and $\Psi_j(v,t)$ functions. Griliches and Jorgenson only identify the first, forcing the other two to vanish by definition by counting all changes in the ratio of capital services S to stocks K as cost-increasing boosts in capital input and forgetting that changes in S/K may be partly or largely due to "costless" shifts in $H_j(v,t)$ and $\Psi_j(v,t)$.[27] Put another

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[26] Nordhaus [1967], p. 3, remarks that "The notion of 'costless increases in productivity' is a pleasant fiction." It is probably true that every improvement in technique has a minimum cost representing the time taken by someone to think up the new idea and to implement it. In our discussion, however, we assume that increases in productivity take place in two distinct ways, (1) by increments in capital, which is included as an argument in the production function, and (2) by increased inputs of other factors, e.g., research and development expenditures, which are not arguments. It is assumed that the marginal product of (2) is significantly higher than the marginal product of capital, so that technical improvements achieved by boosts in non-included factors are "relatively costless."

[27] Costless shifts could also occur in the $\phi_j(v,t)$ function, if the rate of deterioration were reduced, for instance, by the discovery of improved maintenance methods.

way, the object of the exercise is to distinguish cost-increasing movements along the production function from "costless" shifts in the production function. Griliches and Jorgenson haved failed to notice that there are two production functions which can shift costlessly--not just the one relating Q to S and L, but also the one relating S to K. If all costless technical progress were to take the form of improvements in machine quality and of the discovery of methods for utilizing machines more hours per year, the Griliches-Jorgenson method would fail to identify any technical progress at all. Thus the two intrepid investigators were premature to announce that "Perhaps the day is not far off when economists can remove the intellectual scaffolding of technical change altogether."[28]

In a well-known paper, Denison [1957] suggested three possible methods for the measurement of capital. The first is a measureiin terms of base-period cost. The second concept of capital is total capacity, and the third is capital's contribution to production. In our terminology these correspond respectively to $K(t)$, $Q^*(t)$ (defined by (12) with the constraint that in equation (10) $U(t) = 1.00$), and $J(t)$ times its factor share. The second is an uninteresting concept of capital since it includes the contribution of other factors and defines the average productivity of capital as unity. The third allows the productivity of capital to change

[28] Griliches and Jorgenson [1966], p. 61.

via substitution between capital and labor services and disembodied improvements in technology, but identifies other capital-embodied elements of technical progress as increases in capital input rather than in the productivity of capital. Dension strongly recommends Method 1, the measurement of capital as K(t), and this approach seems most sensible for this study, the principal emphasis of which is on changes in the average productivity of capital. Changes in H(v,t) and Ψ(v,t) should not be ignored, but they should be treated as elements which may explain changes in the productivity of capital rather than as changes in capital itself and should be investigated <u>after</u> K(t) has been measured. A virtue of Method 1, as we have seen above, is that K(t) is measured in the same units as saving and investment and is the appropriate concept to use in answering questions like "If we start investing more, how much extra output will we get?"[29]

A final advantage of Method 1, of course, is that there is no need to worry about aggregation conditions, since capital is measured by base-period dollar costs rather than in efficiency units. Griliches and Jorgenson's use of Method 3 to calculate aggregate capital services J(t) is only valid if all capital-

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[29]The measurement of capital by its cost rather than its ability to produce is endorsed by Hicks [1961], who refers to the two methods respectively as the "backward-looking" and "forward-looking" concepts of capital.

embodied technical change is capital-augmenting and only if all types of capital are perfect substitutes. This is a problem in addition to the basic statistical objection that there is little direct information available for the estimation of the ratio of capital services to stock. Even if disaggregated data are available on $H(v,t)$, there is no way in which experiments with aggregate data can separate $\Psi(v,t)$ and $\phi(v,t)$.[30]

The Calculation of Price Indexes

As defined above in (5), the value of each investment good in current prices $p_j(v)\ I_j(v)$ is converted into base-year prices with a deflator $D_j(v)$ which expresses the price a base-year contractor using base-year technology would have bid on the current-year bundle of goods.[31] The difference between current and base-year bids reflects all cost-changing factors, including differences in input prices q_i and in input requirements x_{ij}. Costless advances in design in the current year, however, do not reduce the base-period cost of production or raise the quantity of real investment. Two otherwise similar machines have the same base-period cost of production even if it has been (costlessly)

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[30]Hall [1966], pp. 7-10.

[31]Other surveys of the issues discussed in the next two sections are Ruggles and Ruggles [1961]; Kendrick [1961b]; Kendrick, Hyams, and Popkin [1964], pp. 67-84; and Jaszi [1962].

discovered how to make the second operate twice as fast as the first. Costless quality change must be distinguished from quality improvements, e.g., larger components and added accessories, which increase base-period cost. Cost-increasing quality change can be represented as an increase in $p_j(b)\ I_j(v)$ and in $K_j(v,t)$, whereas costless quality change increases $\Psi_j(v,t)$ and therefore $S_j(v,t)$.

The representation of costless quality change in capital goods as an increase in the average productivity of capital rather than as an increase in capital input differs from the treatment of consumers' goods, the price of which measures not the cost of production but the cost for a person of maintaining a constant level of utility.[32] Costless welfare-increasing quality changes reduce the cost of a constant-welfare market basket and should reduce the consumption goods deflator.[33] While quality improvement in capital goods, then, leaves the real capital stock unchanged and instead raises its productivity, quality improvements in consumers' goods raise the volume of real consumption since the "productivity of consumption goods in producing welfare" by

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[32]This distinction is not understood by Anderson [1961], who makes the comment that "Valuing capital assets on a different basis than output violates the concept that a capital good's value is derived from the value of the output it produces." This is irrelevant for production analysis, since the current market value of an asset measures its stream of future income, not its ability to produce current output.

[33]The "constant-utility market basket"is an idealization which ignores the problems of defining a constant level of utility, especially those of taking account of elements of satisfaction which cannot be measured.

definition never changes.[34]

Therefore our statistical goal should be an ideal capital goods deflator which accurately reflects all facts which change the total cost of production, including changing factor prices, productivity, and profit margins, but which does not further adjust for costless improvements in quality. The criticism that the NBER/Commerce capital stocks are overdeflated is valid to the extent that the official price deflators do not adequately take account of all cost-changing factors but is in error when it suggests that adjustments should be made for all quality improvements as well.

Net or Gross?

Should capital be measured gross or net of depreciation, which is a deduction for the decline with advancing age in the value of a capital good? In productivity analysis we should not deduct for depreciation, for a machine's value is not proportional to its current ability to produce services but to the discounted

[34]The distinction between the deflation of capital and consumer goods is not mentionned by Griliches in his article on price and quality change [1964]. He has shown [1961b] the disparity between the automobile quotations in the Consumers' Price Index and a quality-corrected "hedonic" deflator, but he has not performed similar calculations for producers' durable equipment. The latter would be relevant in computing estimates not of the capital stock $K(t)$ but of $\Upsilon(v,t)$.

value of future services and would decline rapidly with passing time even if the machine's ability to produce physical service-hours did not change at all with age. Nor in calculating the capital stock should we deduct for deterioration, which is the decline in the capital services obtainable from a machine over its lifetime as lower speeds are required when parts become worn, as fewer service-hours per year are possible because of increased maintenance, and as equipment is shunted aside to standby duty, only to be required during periods of peak demand. Compared to the rapid decline in a machine's value over its lifetime and the less precipitous fall in its annual services, the base-year cost of a given machine $p_j(b)\ I_j(v)$ does not decline at all during its lifetime. Thus any single investment good should be counted in full as part of the capital stock between its construction date and the time of its retirement without any deduction for the decline in its services nor for the decline in its value (this is the approach of the "one-horse-shay," a mythical item which works at full efficiency until the day of its death, when it instantaneously vanishes into a pile of dust). A deduction for wear and tear should be performed only when a calculation of service-hours is desired, but for productivity studies capital input should be measured not in service-hours, but in base-period cost. As Griliches has said, "For productivity analysis the one-horse-shay assumption may not be all that bad."[35]

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[35] Griliches [1961a], p. 448. Smith [1964] is in agreement

(Footnote continued on next page)

The NBER capital stocks published by Goldsmith and others are calculated net of straight-line depreciation. While this may have been an appropriate procedure in the construction of national wealth estimates, the net values clearly should not have been used by Kendrick as a measure of capital input for the purpose of measuring productivity growth. Kendrick has defended the use of capital net of depreciation in his study of productivity:

> Real stocks net of accumulated depreciation allowances are taken as a better measure of a basic capacity to contribute to production and revenue than gross stocks (i.e. the number of items in use, each weighted by base period price regardless of age). Studies have shown that the gross output capacity of various types of machinery tends to fall with age, and the repair and maintenance charges rise so that the contribution to net revenue falls even more. More significantly, the marginal revenue products of older types of equipment are less than those of new, improved types because of technological advance and resulting obsolescence. [1961a], p. 35.

But this argument is faulty, due to Kendrick's failure to distinguish between capital stocks and capital services. The decline in "gross output capacity" of capital represents a decline in the ratio of services to stock S/K, not in the stock K, whose base-period cost has not changed. Obsolescence, further, is irrelevant, causing a decline in the value of <u>future</u> services but not in base-period cost.[36]

(continued from preceding page) on the use of gross stocks in productivity analysis. Griliches [1963] suggests that the net concept is useful in investment functions as an indicator of replacement needs, but this is a separate issue from the one considered here.

[36] The relation between depreciation and replacement in a simple dynamic model is explored by Domar [1953].

If the application of straight-line depreciation to the initial cost of an investment good is to be abandoned, what method should be used to calculate the gross capital stock? Each investment good is to be counted in full throughout its lifetime, but we do not have data on the lifetime of every single machine and building. Since data on lifetimes refer to fairly broad classes of capital, the initial base-period investment in each class should be written out of the capital stock to reflect the distribution of retirements among the members of the class. In practice recent calculations have made use of the "S-3" curve" developed during the 1930's by Robley Winfrey, which is close to a normal distribution of retirements around the class mean lifetime.[37]

Although irrelevant to the calculation of the capital stock, the decline in annual hours and in services per unit of capital stock may be causes of changes in the productivity of the stock. If the rate of decline in the ratio of service-hours to stock over a machine's lifetime does not change, the effect of the decline on productivity varies with the rate of growth of

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[37]The Winfrey "S-3" and other distributions are discussed by Winfrey and Kurtz [1931]. The "S-3" is used in Grose, Rottenberg, and Wasson [1966] and in Terborgh [1960]. Wasson [1964] comments on his and Terborgh's use of the distribution. The decline of Barna's [1961], p. 89, survival curve is similar to that of a straight line, but it is obtained from a sample survey for all types of assets, from tools lasting three years to buildings lasting 100 years, and thus sheds no light on the retirement distributions for given asset types.

the capital stock, which affects the average age and thus the efficiency of machines in the stock. It is hard to gauge the importance or magnitude of the decline of services with advancing age. Periodic maintenance and repair probably retain a machine's initial output level of services per hour, but annual machine utilization may decline with advancing age as the machine becomes less reliable and more difficult to maintain.[38]

The clear conceptual distinction between gross and net capital stocks becomes somewhat fuzzier with the consideration of changes in the operators of capital over the service lifetime. While relatively unimportant for industrial and public utility buildings and the equipment inside, which is mostly bolted down, changes in tenants are frequent in the categories of store and office buildings. The "output" of commercial buildings as measured in the national accounts is the rent received, and this undoubtedly declines over the lifetime of a building as it becomes less attractive to prime tenants and is leased to firms which produce less value added per square foot and pay lower rents. Similarly, office equipment tends to be more mobile than industrial machines and in the late years of its lifetime probably tends to be sold to firms in which office workers are paid less than those employed by the original

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[38]See Terborgh [1954], whose evidence applies only to tractors, locomotives, and other types of movable equipment which are easily shunted aside for newer models. The utilization of pieces of equipment which are bolted to the floor is probably fixed by the utilization of other nearby machines in its production process and thus may be independent of the machine's age.

owner and consequently contribute less to national income and output.

To summarize, we can now evaluate the five frequent criticisms of the NBER/Commerce capital stocks in the light of the preceding conceptual discussion:

1. There may have been overdeflation due to the failure to take account of changing productivity in construction, but not to the further extent of ignoring quality change in structures and equipment.

2. The deduction of straight-line depreciation from the initial value of investment goods <u>does</u> understate their ability to contribute to output.

3. Changes in service lifetimes should be taken into account in the cumulation of investment series into capital stock estimates.

4. It is incorrect, however, in the calculation of productivity change to correct capital stocks for changes in normal hours of utilization of capital, for (relatively) costless technical improvements may have been the factors which made the increase in utilization possible.

5. Since the relevant concept for studies of the sources of productivity growth is the capital stock $K(t)$ rather than capital services $S(t)$, it is permissible to follow the present practice of using asset prices rather than service prices as weights in the aggregation of $K(t)$.

IV. THE PLAN OF THE THESIS

The basic raw materials in capital stock estimation are the undeflated data on purchases of investment goods $P_j(v)\ I_j(v)$. These are described and subjected to a close analysis in Chapter II. It is discovered that a major omission for the purposes of productivity analysis has been structures and equipment financed by the government for use in the production of private output. Chapter III describes the difficult task required to estimate the timing and value of these government purchases of investment goods. Before the revised current-dollar investment flows can be deflated, however, the official price indexes for structures and equipment $D_j(v)$ are evaluated in Chapter IV. The investigation reveals weaknesses in official construction deflators and results in the estimation of a new price deflator for structures, which is used to deflate the revised current-dollar investment flows. In Chapter V the deflated real investment series $p_j(b)\ I_j(v)$ are cumulated into capital stocks $K^E(t)$ and $K^S(t)$ and the effect of the revisions of each chapter on previous estimates is calculated. Finally the new figures are used to compute revised capital-output ratios for the U. S. The new capital stock data are presented as interim figures pending the completion of a future study of changes in useful lifetimes and will be recalculated in the light of those results.

CHAPTER II

THE ESTIMATION OF PRIVATE INVESTMENT EXPENDITURES

> The government are very keen on amassing statistics. They collect them, add them, raise them to the N^{th} power, take the cube root, and prepare wonderful diagrams from them. But you must never forget that every last one of those figures comes in the first instance from the village watchman who just puts down what he damn pleases. -- Anon.

I. INTRODUCTION

The Role of Investment Data in Capital Estimates

If the value of fixed capital were determined by an annual census of wealth, historical data on investment flows would not be needed for the measurement of capital input. In a land where the cost of producing capital never changed, a marching army of census-takers could calculate both the gross and net value of capital by asking respondents simply for the original cost of plant and equipment on hand and for accrued depreciation. Most of the problems discussed in this thesis would be avoided; a special blessing would be the abandonment of the present perilous task of guessing service lifetimes to be used when investment flows are cumulated into capital stocks.[1]

A regular census of wealth could replace investment flow

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[1]This assumes that respondents have accurate information on lifetimes when they compute depreciation.

data for capital estimation even if the cost of producing capital did change, although in this case the census questionnaire would necessarily have to be more complicated. Respondents would be asked to report the installation date of each type of asset and of all additions and alterations to plant, and the Census Bureau would program its computer to calculate the value of capital in constant prices by applying appropriate price deflators to the capital goods surviving from each year. There would still be difficult and familiar problems, of course, for a price index could not be estimated for obsolete models of equipment no longer available on the market, and changes in the cost of construction could not be properly measured unless firms asked for detailed bids on structures having constant specifications. But a properly conducted census of wealth would significantly improve existing methods of estimating capital input.

Unfortunately most of this generation of economists will not live long enough to enjoy the use of a time series of census of wealth results. If completed on schedule, the forthcoming 1970 census of wealth will be the first in almost fifty years.[2] And it will be the first really useful census of wealth ever, for the previous ones, taken in 1880, 1890, 1900, 1912, and 1922, are inadequate because of informal procedures of valuation and a

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[2]For plans and proposals concerning the proposed census of wealth and details on earlier surveys, see Conference on Research in Income and Wealth [1964b].

failure to obtain any information about service life distributions. Another unsatisfactory set of data on the value of fixed capital in place, available for corporations since the end of World War I, is the U. S. Internal Revenue Service Statistics of Income [1919-63] series. In addition to the obvious omission of noncorporate capital, the figures are not deflated, and the problems of deflation are especially difficult because the IRS, unlike the old 1880-1922 censuses, does not distinguish between structures and equipment. Other defects are the impossibility of distinguishing gross from net capital before 1934, the inclusion of intangible assets in fixed capital from 1940 to 1953, the failure to separate land from fixed reproducable capital before 1939, the deconsolidation of returns in 1934 (before then enterprises with subsidiaries in different industries were allowed to file consolidated returns, resulting in a discontinuity in industry definitions between 1933 and 1934), the prevalence of downward capital revaluations in the 1930's which did not represent the evaporation of durable capital inputs, and the fact that service lifetimes used on tax returns have been constant over long periods and in many cases do not reflect underlying changes in actual service lives. Despite these limitations, the IRS data provide detail by industry unavailable from any other source extending back to the early 1920's, and these data may be used in later stages of the overall research project to provide a check on other figures.

Because of the absence of census of wealth reports and the inadequacy of IRS data on fixed assets, the gross capital stock must be estimated by roundabout methods. Flows of expenditures on investment goods in past years must first be estimated, then deflated by appropriate indexes of investment goods prices, and finally cumulated into a capital stock after the subtraction of retirements. The basic raw materials in this thesis are the most recent estimates of investment, bearing the official sanction of the U. S. Department of Commerce and constructed by Robert C. Wasson of the Office of Business Economics.

Wasson is like a merchant who keeps his everyday goods constantly on display in the front showroom, while fancier models intended only for special customers are out of sight in a back workroom. Wasson's front-room goods are the investment components of the national income and product accounts (henceforth called the "NIP data"), available for every year since 1929 and quarter since 1946, and updated regularly in the Survey of Current Business and other government publications.[3] The hidden back-room merchandise is a set of investment expenditure estimates which agree precisely with the NIP aggregate series after 1929 but extend back from 1929 to the last century and, in addition, decompose aggregate expenditures on each type of investment good by the sector of the purchaser

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[3]For the full detail back to 1929 see U. S. Department of Commerce, Office of Business Economics [1966a], Tables 5.2-5.5, pp. 80-85.

(manufacturing, farm, and nonfarm nonmanufacturing).[4] The back-room investment data are the basis of new capital stock estimates recently presented in considerable detail in the Survey of Current Business which, since the underlying investment data are unpublished, will doubtless be accepted by most economists as Gospel Truth.[5] Some more curious researchers may manage to obtain the back-room investment data but will probably accept them without question, for there is no written explanation, published or unpublished, of the methods used in their estimation.[6]

This chapter is meant to provide the missing description of Wasson's methods and, after reporting what he has done, to evaluate his estimates and suggest improvements. The Wasson data are compared with the work of previous investigators to reveal areas of disagreement. Since the results of productivity studies depend more on the rates of growth of inputs than on their levels, special emphasis is placed on elements on incomparability between the estimates for different years. An effort is also made to identify the figures which rely on such inadequate data that they

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[4] U. S. Department of Commerce, Office of Business Economics [1966b].

[5] Grose, Rottenberg, and Wasson [1966].

[6] The only satisfactory discussion is in the ancient National Income, 1954 Edition, which explains only the principles underlying the aggregate NIP post-1929 series, not the extensions, extrapolations, and refinements introduced in the back room. See U. S. Department of Commerce, Office of Business Economics [1954], pp. 122-135.

cannot be considered reliable no matter how subtle the estimating technique. After a close look at some of these methods, particularly for the earlier years, many economists will be less confident about the regression results which they obtain from them.

Methods of Estimation

The techniques used to estimate investment expenditures vary for different types of investment goods and for different years, and it is important for users of the data to understand the various methods and to know the series to which each method has been applied. The most solidly based figures are actual reports on investment expenditures, mainly those relating to construction in public utilities since World War I. Only slightly less reliable are actual reports of investment goods produced, mainly the reports of the *Census of Manufactures* on the production of producers' durable goods during scattered years in the past.[7] In its introduction to each *Census*, the Bureau describes how intensively it works to ensure full coverage of all manufacturing establishments (including those owned by nonmanufacturing firms), and there is little reason to question the completeness of the *Census*.[8] The

[7]Every ten years 1809 to 1899, every five years 1899 to 1914, biennially 1919-1939, and since then in 1947, 1954, 1958, and 1963.

[8]The only omitted establishments are those producing less than $5,000 of product annually--before 1919 the cut-off point was $500.

only scope for error is in the conversion of Census production reports into investment expenditure data. Investigators, currently the National Income Division of the Office of Business Economics, begin by selecting out those manufactured goods which are considered producers' durables, must then add on mark-ups for goods sold through wholesale and retail dealers (e.g., farm tractors), and must add imports to Census production figures and subtract exports. These adjustments may seem trivial, but there are considerable differences between the end results in the present NIP accounts and in earlier work by Kuznets and Goldsmith covering the same years and based on the same production reports.

Slightly less reliable than complete censuseesare sample surveys , most notably the Annual Survey of Manufactures, based on a probability sample which in 1962 included 20 per cent of all manufacturing establishments.[9] A sample is used in the Annual Survey to reduce costs and naturally introduces a source of error through sampling variability. Standard errors of estimate are included in most tables and are relatively small. The likelihood of significant errors is minimized by a complete canvass of all companies having establishments employing 100 workers or more.[10]

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[9] Available at the time of writing for non-Census years between 1949 and 1963.

[10] For a recent discussion of the sampling procedure, see U. S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures [1962], pp. 1-11.

Another type of sample data, used particularly for earlier periods, are data from a sample of states used for interpolating national totals between Census years. Usually the states were chosen for the availability of detailed production figures and are not a representative sample. Any errors of interpolation are unimportant for our purposes, however, since they have little effect on the long-run rate of growth of the capital stock.[11]

Many of the estimates, especially for earlier years, are not based on surveys or samples but instead are much cruder. Expenitures on structures before 1915, for instance are based on Census of Manufacturing data on production of construction materials. In converting from materials to actual expenditures on structures, a constant raising ratio is used and the technique thus ignores changes in markups, transportation and distribution costs, the relative importance of labor and material costs, wage rates, and productivity.[12] Similarly, Goldsmith's method for determining industrial construction before 1915 is simply to set industrial construction in every year equal to exactly 20 per cent of total nonfarm nonresidential private construction, ignoring the increase in the importance of manufacturing relative to public utilities

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[11]For details on the use of state data for interpolation, see Shaw [1947], pp. 92-100.

[12]The derivation of construction expenditures from 1869 to 1919 is explained in Kuznets [1946], notes to Table II 5, p. 99.

over this period.[13] The discussion in this chapter points out those series which have been estimated by crude methods and warns against extensive use of them.

Ideally a study of the determinants of investment behavior would have access to disaggregated estimates for different industries and sectors of the economy. Unfortunately it is possible to perform a disaggregated study only for a limited period of time on a very few sectors and types of capital. The basic problem is that Census of Manufacturing data on equipment production are compiled by type of equipment, not by industry of use, and many kinds of equipment (e.g., trucks, cars, engines, etc.) are used in more than one industry or sector. The situation is slightly more favorable for structures, at least for the public utilities sector since World War I, since estimates have been based on direct reports. But data on construction expenditures for even as large a sector as manufacturing are unreliable before 1939, which was the first year in which the Census of Manufactures asked respondents about the value of their capital expenditures on structures and equipment. Because of the difficulty of making sectoral estimates, primary emphasis in this chapter will be on aggregate data for equipment and structures, and these are treated separately in the two main sections which follow.

[13]Goldsmith [1955], Vol. I, note to Table R-13, col. 1, p. 598.

II. EQUIPMENT

The Definition of Equipment

Producers' durable equipment consists of commodities which are used in the production process for three or more years with the exception of durable goods permanently attached to structures.[14] Investment in equipment excludes purchases of replacement parts, which are quite naturally considered as part of the cost of maintaining old capital and not as increasing the stock of new capital. National income accounting conventions, then, result in a gross capital stock in which each machine is costlessly rejuvenated through expenditures on replacement parts which are not counted as part of investment. This exclusion is fortunate for our purposes, for we have assumed that the gross stock of capital approximately measures capital's ability to produce output even without a deduction for deterioration, and that a piece of equipment should only be removed from our measure of the capital stock when it is retired.

Purchases of used equipment are excluded from expenditure

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[14] Specific items included in structures rather than equipment are "service facilities, including plumbing, heating, central airconditioning, lighting equipment, elevators and escalators, processing equipment when largely fabricated on site including towers, vats, and related piping at chemical plants, blast furnaces at steel plants..." (U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 75.)

series to avoid double-counting; the capital stock is increased only when a new good is purchased, not when an old good is transferred from one owner to another. If the good is transferred through a middleman, however, the mark-up must be included in equipment expenditures to represent the value of the services of the middleman which are now embodied in the traded good. A measure of equipment input to be used in production function estimation should include only equipment actually in operation. Official estimates, however, include machinery purchased for establishments not yet in operation, and in a period of rapid changes in investment may inaccurately represent the equipment capable of production.

Methods of Estimation of Total Equipment Expenditures in NIP Accounts

Total expenditures on equipment are fairly reliable, particularly when compared to breakdowns of expenditures on different sub-types of equipment and on the division of purchases between the manufacturing, farm, and nonfarm nonmanufacturing (hereafter NFNM) sectors. For years since 1929 the main source of data are the NIP accounts, calculated by the "commodity flow" method. This procedure is used because it is easier to obtain data from the few sellers of a commodity than from its thousands of buyers. Since investment data must express the amounts paid by buyers, however, an involved series of calculations must be performed to make the production data useable.

The first step in the NIP conversion of Census production figures into private investment expenditures is the separation of finished producer goods from unfinished goods and finished consumer products. This is not very difficult for most types of equipment, for few households, for example, buy hydraulic presses and lathes. The most difficult tasks are the allocation of automobiles between consumer and producer use and the exclusion of tools and machine parts. Then inventory changes are subtracted from production, and the resulting shipments figures are adjusted for net exports and sales to government.[15] Next, census surveys of distribution are used to allocate goods among direct sales to final users, sales to wholesalers, and sales to retailers. Appropriate margins for the cost of transportation and wholesale and/or retail mark-up are applied where relevant.[16]

The 1965 revision of the NIP accounts added further refinements to the estimation of equipment expenditures. Purchases of small

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[15] The adjustment for changes in manufacturers' inventories was made in the 1930's, but beginning in 1947 the Census began reporting sales rather than production and thus the inventory adjustment was no longer necessary. Imports for most equipment items are negligible. Export sales, obtained from balance of payments statistics, must be "marked down" to a production-cost basis before they can be subtracted from manufacturers' shipments. Government purchases are estimated from a great variety of federal, state, and local publications and reports.

[16] An exception to this procedure is the automobile category, which is divided between producer and consumer purchases after the conversion to market prices.

tools were no longer counted in gross capital formation. The logic of this exclusion is not obvious, since a hand drill is closely substitutable with a large floor-mounted power drill. Dealer mark-up margins on purchases of metalworking machinery and office equipment were allowed for in addition to the long-standing adjustment for vehicle mark-ups. Another innovation was the subtraction of exports of used machinery and an addition for sales to private firms of equipment formerly owned by the government and thus not included in private capital formation at the time of its original installation. This last adjustment explains the unusual excess of the OBE estimates over Census figures for 1946-49 and 1955. As we shall see below in Chapter III, Wasson's procedure, in which the transferred capital is valued at a bargain-basement sales price, is inappropriate for our purposes since our measure of capital should reflect its base-year cost.

Varying techniques have been used to estimate equipment expenditures in intercensal years:

1. Since 1949 the Annual Survey has been the basic source and the steps taken to derive expenditures are similar to those outlined above for Census years. There is little reason to doubt the accuracy of the Annual Survey figures, since the standard error of estimate for machinery production is below one per cent.[17]

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[17]For four-digit components of machinery the standard error in 1962 ranged from one to 13 per cent.

2. For the intercensal years between 1929 and the first Annual Survey in 1949, the NIP interpolators were sales figures for comparable four-digit industries from the Source Book of the Internal Revenue Service Statistics of Income.[18] Although the IRS data cover only corporations, they should be a reliable basis for interpolation because about 95 per cent of the income of the machinery industry is earned by corporations.[19]

3. Production data for the war years 1942-45 were mainly taken from unpublished data, particularly Form WPB-732 reports submitted by metal-fabricating plants to the War Production Board. Estimates of wholesale and retail mark-ups were not directly available for the war years and were obtained by interpolating between 1939 and 1947 values. Deductions for government purchases of producers' durables were based on WPB summaries of government-financed facilities expansion (reports which will prove very useful in Chapter III below).[20]

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[18] The years interpolated with IRS data were 1930, 1932, 1934, 1936, 1938, 1940, 1946, and 1948. For 1941-45 see the following paragraph.

[19] The corporate income shares in non-electrical machinery for 1929, 1939, and 1949, respectively, were 94.1, 93.6, and 93.1. The equivalent figures for electrical machinery were 98.5, 98.4, and 98.5. See U. S. Department of Commerce, Office of Business Economics [1954], Exhibit 2, p. 77, and Table 18, pp. 184-5.

[20] Further more detailed information on the NIP post-1929 commodity flow estimates is available in U. S. Department of Commerce, Office of Business Economics [1954], pp. 126-135. See also Ruggles and Ruggles [1956], pp. 105-110.

Wasson's Pre-1929 Total Equipment Data and A Comparison with Earlier Estimates

Wasson's detailed NIP commodity flow estimates extend back only to 1929, but information on equipment expenditures for a much longer period is necessary for a perpetual inventory capital stock beginning in the mid-1920s. Wasson's back-room data for years before 1929 are not original estimates based on primary sources but are extrapolated back from the front-room NIP 1929 values for each equipment group by Shaw's [1947] estimate for that equipment group. The Wasson total for equipment expenditures, then, is the sum of all the extrapolated groups.

Shaw estimated producer durable production and net exports for 1869, 1879, and every year between 1889 and 1919. His post-1919 figures are not his own but are based on Kuznets' original work in Commodity Flow and Capital Formation [1938], slightly adjusted for better comparability with Shaw's pre-1919 data.[21] The Shaw series refer only to production less net exports ("production destined for domestic consumption") and are not expenditure estimates since no adjustments are made for transportation costs or distributive mark-ups.

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[21] Table I-1 in Shaw [1947], pp. 30-61, displays his original estimates for 1869-1919. Table I-2, pp. 62-69, gives his revisions of Kuznets for the years after 1919, which originally appear in Table II-5, pp. 146-48 in Kuznets [1938].

Both Kuznets and Shaw estimated production by allocating Census of Manufactures products among unfinished, finished consumer, and finished producers' goods. They employed varying methods for interpolating in intercensal years. Kuznets' estimates for 1926 and 1928, like the NIP estimates for later intercensal years, were interpolations based on sales data from the Statistics of Income. For 1920, 1922, and 1924 the basic sources were state production reports for Massachusetts and Pennsylvania and special tabulations of IRS data.[22]

Shaw's task for the years before 1919 was more difficult since Census years were further apart and the IRS Statistics of Income were not available. His main sources were state production reports and assorted trade association and government agency publications. The use of the state data posed some of Shaw's thorniest problems, since the available sample of states changed in almost every year.[23]

In Figure 2 the Wasson estimate of total equipment expenditures (the solid line) is compared with the commodity production data of Shaw (dashed line) which were the basis for Wasson's pre-1929 extrapolations. The series appear to be in very close agreement, and there are several obvious explanations for the visible differences between the two.

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[22]Kuznets [1938], p. 122.

[23]Shaw [1947] describes his interpolation procedures on pp. 92-100 and pp. 202-246.

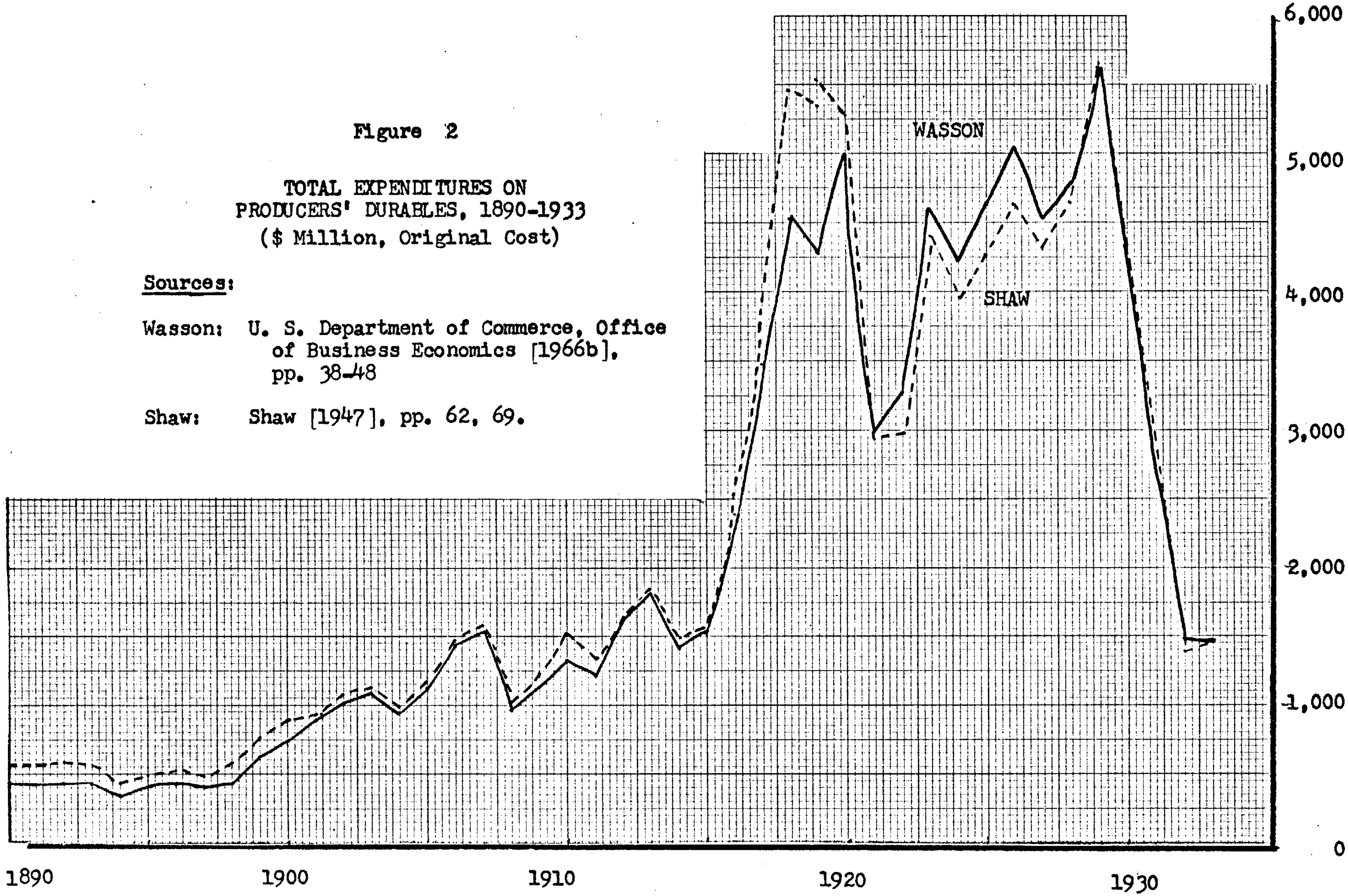

Figure 2

TOTAL EXPENDITURES ON
PRODUCERS' DURABLES, 1890-1933
($ Million, Original Cost)

Sources:

Wasson: U. S. Department of Commerce, Office of Business Economics [1966b], pp. 38-48

Shaw: Shaw [1947], pp. 62, 69.

1. The Wasson total only includes equipment groups necessary for perpetual inventory capital stock estimates which begin in 1925, and items are omitted prior to the date 1925 - L (where L is the longest lifetime assumed for each type of equipment in the OBE Capital Goods Study). Thus before 1912 the Wasson estimates are below Shaw, the basic source, because of the omission of short-lived articles like trucks and tractors.

2. During the World War I years the Shaw series, which includes government purchases of producers' durables, is naturally higher than the Wasson series. After 1920 many of these government-financed goods were resold to private owners and were added to the Wasson private expenditure series at the resale price, raising the Wasson series somewhat above Shaw.

Thus, with these minor exceptions, Wasson's data before 1929 are a straightforward extrapolation of Shaw. But since the latter did not take account of distributive margins, Wasson's acceptance of his data involves the implicit assumption that there was no change in relative mark-up margins in the fifty years before 1929. This is probably an invalid assumption. One might expect, for instance, that firms, whose average size was increasing during this period, would have relied less on wholesale and retail sellers of equipment and instead would have tended to make more purchases direct from equipment manufacturers.[24]

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[24] I have not had time to do a detailed investigation on this

(Footnote continued on next page)

By now an inconsistency in Figure 2 should be apparent. Why, if Wasson includes but Shaw excludes the distributive margin, are the levels of the two series so close together in 1929? An investigation into this paradox reveals that the closeness is merely a coincidence. Differences in definition and statistical technique contribute both positive and negative discrepancies which almost exactly offset each other. Figure 2, in fact, really compares the incomparable--Shaw's production series with Wasson's expenditure series.

A more enlightening comparison is in Figure 3, where the Wasson expenditure series, again represented by a solid line, is copied from the previous Figure and is compared with Kuznets' expenditure series, which is shown by the cross-hatched line. Another estimate of expenditures on equipment, made by Goldsmith in A Study of Saving [1955], is represented in Figure 3 by the dotted line. A comparison of these alternative estimates teaches a useful lesson on the improvements in estimating procedures made since the late 1930's when Kuznets did his original work on the interwar period.

First, exactly why does the Kuznets series in Figure 3 exceed Shaw's in Figure 2? Kuznets' total of shipments less net exports, e.g. $5.6 billion in 1929, agrees closely with Shaw's,

(footnote continued from preceding page) point. At least one writer thinks that mark-ups increased during the period, but he does not give a reason nor present any evidence. See the comment by Oswald W. Knauth in the preface to Kuznets [1946].

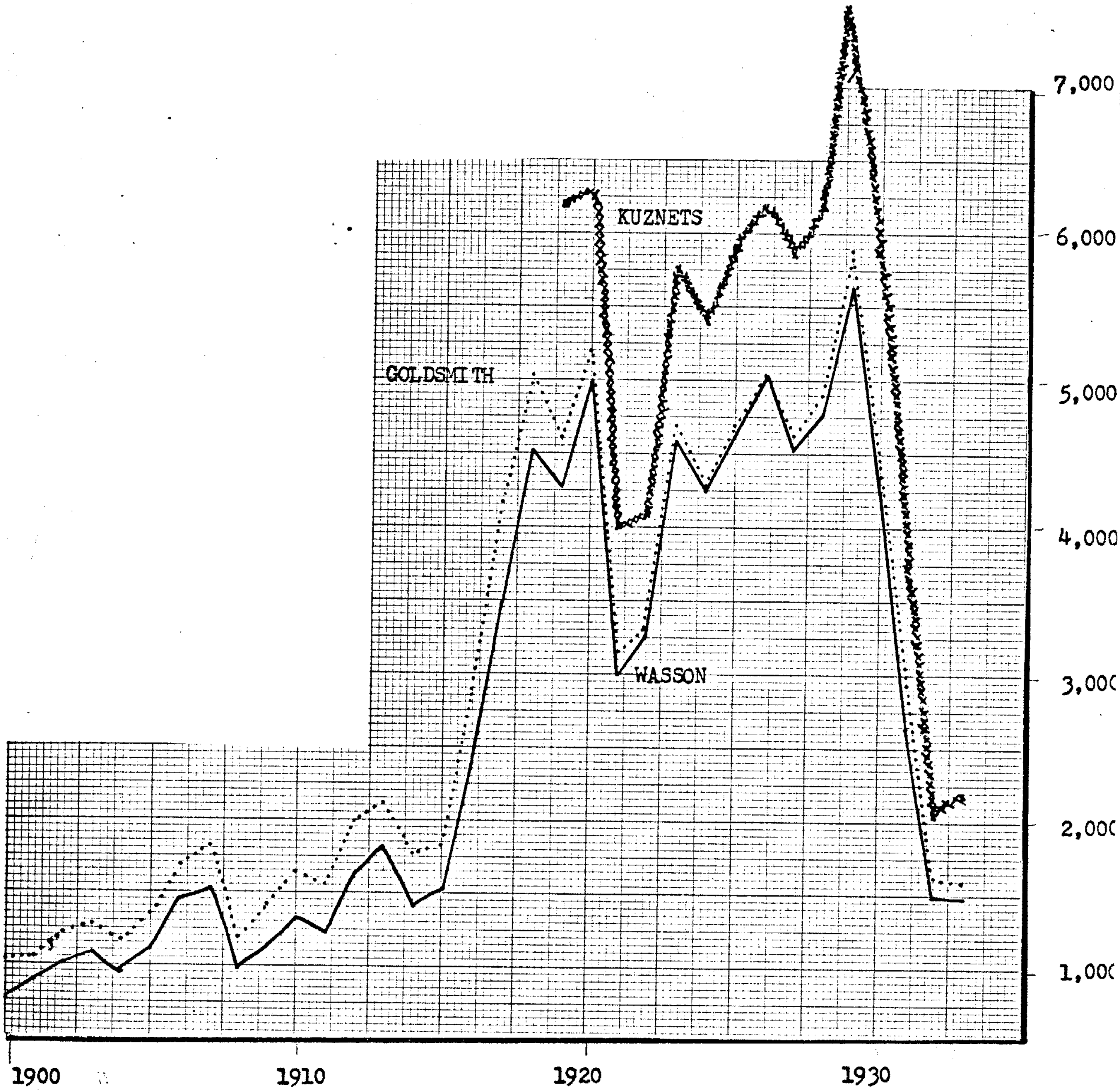

Figure 3

TOTAL EXPENDITURES ON
PRODUCERS' DURABLES, 1900-1933
($ Million, Original Cost)

Sources:

Kuznets: Kuznets [1946], Table I-6, p. 36.

Goldsmith: Sum of the following from Goldsmith [1955]. Column 1 from Table P-5, p. 877; Table A-16, p. 773; Table A-18, p. 777; Table A-19, p. 778; Table P-13, p. 893; Table P-14, p. 895; Table P-16, p. 899; plus Wasson's unpublished series on farm automobiles.

Wasson: U. S. Department of Commerce, Office of Business Economics [1966b], pp. 38-48.

but he goes beyond Shaw to consider the costs of transportation and distribution. Kuznets, by means of a careful examination of the interwar Census publication Distribution of Sales of Manufacturing Plants, allocates domestic shipments into three groups: direct sales, sales through wholesalers, and sales through retailers. He laboriously develops detailed information on mark-ups from the 1929 Census of Distribution and arrives at 16.2 per cent as an estimate of the average total mark-up. Thus, adding on the 16.2 per cent mark-up margin, his figure for total sales of producers durables in 1929 is about $6.6 billion.[25]

In addition, in their earlier work Kuznets and Shaw neglected to note that business firms actually do own and use passenger cars. Kuznets eventually recognized this omission and revised his earlier estimates upwards by adding on about $1.0 billion for business purchases of passenger cars.[26] This raises his estimate for total expenditures on producers' durables in 1929 from about $6.5 to about $7.5 billion.

As recently as 1961 in Capital in the American Economy Kuznets continued to adhere to the $7.5 billion figure, even though

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[25] The mark-ups range from nothing for signs, locomotives, and ships, to 50 per cent for carpenters and mechanics' tools. See Kuznets [1938], Table III-5, pp. 212-13.

[26] The earlier estimates in Commodity Flow and Capital Formation [1938] omit passenger cars. The revisions are in Tables I-1 and I-6 of National Product Since 1869 [1946].

it is one-third larger than the official NIP-Wasson estimate of $5.6 billion.[27] Kuznets attributes his 33 per cent excess "partly to statistical discrepancies, partly to the inclusion here of nonmilitary producers' durables purchased by governments." Even in his most recent work [1961], he has not accepted the long-standing convention of separating out government expenditures as a separage category of final spending on GNP.[28] Government pruchases of producer durables are thus included in the Kuznets totals of spending on equipment.[29]

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[27] See Kuznets [1961], Table A-2, p. 476, where his producers' durables figure is $7.5 billion and the "Commerce" figure is shown as $5.8 billion. In the 1965 NIP revisions the official Commerce figure was reduced from $5.8 billion to $5.6 billion. See U. S. Department of Commerce, Office of Business Economics [1965], p. 13.

[28] Kuznets approximates other government expenditures by personal tax payments on the assumption that the government, in its all-knowing sophistication, fixes personal tax payments at an amount just equal to the value which the public places on the services of government.

[29] The rather large discrepancy between his estimates and those of Commerce seems to disturb Kuznets: "It would be comforting to be able to assert that this residual difference [e.g., between $7.5 billion and $5.6 billion for 1929] represents a fair approximation to the annual flow of nonmilitary producers' durables to governments. But this cannot be claimed even for 1929-33, for which years we have independent estimates of total producers' durables by the National Bureau and of private producers' durables by the Department of Commerce. All that can be said is that the average level seems reasonable." --Kuznets [1961], p. 475.

But actual government expenditures on equipment in 1929 were only about $140 million, leaving most of Kuznets' excess to be explained by "statistical discrepancies."[30] This residual difference between Kuznets and Commerce represents improvements in estimating techniques since the mid-1930's when the original Kuznets-Shaw estimates were made. The basic reason for the smaller NIP estimate of expenditures on producers' durables was the postwar discovery that many goods had erroneously been classified as finished producers' durables when in fact they should have been classified as intermediate products.[31] It was primarily the continual improvement in the commodity detail of the Census of Manufactures which allowed these new estimates to be made. The previous Kuznets-Shaw data included expenditures on replacement parts, which are omitted by definition from capital formation in the National Income Accounts. In Kuznets' detailed estimates for 1929, for instance, $248 million of commodities specifically listed

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[30] I was not able to find an estimate of government purchases of producers' durables in 1929. The figure for 1939 was $265 million (U. S. Department of Commerce, Office of Business Economics [1954], Exhibit 3, p.129), equal to 8.6 per cent of government "other purchases" from private business (U. S. Department of Commerce, Office of Business Economics [1966a], Table 3.1, p. 52). Applying this same percentage to 1929 "other purchases of $1,657 million yields government purchases of producers' durables of $143 million.

[31] "On the basis of the greater product detail in the 1947 Census of Manufactures and additional research into product uses, many...items formerly regarded as producers' durable equipment were reclassified wholly or in part as intermediate products." -- U. S. Department of Commerce, Office of Business Economics [1954], p. 128.

as replacement parts are included.[32] In addition many other expenditures on producers' durables counted by business firms as current expense are excluded from the NIP figures on gross capital formation, and a further $200 million in tools was excluded in the 1965 revisions of the NIP accounts.[33]

The Goldsmith series, shown by the dotted line in Figure 3, agrees very closely with the Wasson data. But this is not coincidental. Unlike Kuznets, Goldsmith did not make his own original estimates from primary sources but copied down and adjusted the original estimates made by others. All of his post 1929 figures are those of the official NIP accounts and differ only to the extent that the NIP data have been revised in the fifteen years since Goldsmith copied down his figures in A Study of Saving [1955]. For almost every equipment group Goldsmith's pre-1929 data are very close to Wasson's, because Goldsmith, like Wasson, extrapolated backwards on the basis of Shaw linked to the NIP 1929 benchmark. The Goldsmith series is somewhat higher than Wasson's before 1921 because of differences in three categories:

1. Goldsmith's industrial machinery group is consistently higher than Wasson's since it was linked in 1929 to obsolete NIP

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[32] Kuznets [1938], Table I-4, pp. 89-95.

[33] U.S. Department of Commerce, Office of Business Economics [1965], p. 13.

figures which have since been revised downward.[34]

2. In 1920 and earlier years the Goldsmith series on agricultural machinery is almost double Wasson's. Goldsmith's figures were copied from Department of Agriculture data which have been drastically revised since the time of Goldsmith's work. The new series seems reasonable, since it appears to be an extrapolation of Shaw for the pre-1929 period. The old unrevised series used by Goldsmith is about equal to Shaw in the 1920's but for some reason is much higher previously.

The Shaw series, of course, excludes the distributive mark-up margin, which for farm machinery in 1929 was about 25 per

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[34]The current NIP accounts distinguish eight types of general industrial machinery, whereas Shaw published estimates for only one. Goldsmith followed Shaw in presenting only one combined group for industrial machinery and linked Shaw's 1929 estimate to the sum of the following NIP groups: special industrial machinery, mining machinery, construction machinery, metal working machinery, pumps, general and miscellaneous machinery, engines and turbines, and durable containers (see Goldsmith [1955], Notes to Table P-5, p. 876, columns 2 to 7). Wasson's unpublished back-room data sheets present pre-1929 figures for each of the sub-groups, but this was achieved simply by assuming that for every year before 1929 each Wasson industrial machinery sub-group was a constant fraction of the Shaw industrial machinery series. Thus Wasson's pre-1929 estimates for equipment types in this category should <u>not</u> be used for econometric work; their publication on the same pages with equipment groups for which Shaw presents fairly solid information is a misleading practice. The equipment types to which this stricture applies have been slightly renamed since the time of Goldsmith's work--the categories "pumps" and "durable containers" have been abandoned while "fabricated metal products" and "service-industry machinery" have been added.

cent.[35] The Wasson-NIP 1929 figure of $335 million is much lower than the Shaw-plus-25-percent total of $484 billion because of postwar statistical revisions based on a more detailed classification of commodities.[36]

3. Goldsmith's estimates in the automobile category after 1918 are considerably below Wasson's, and this almost exactly offsets the Goldsmith excess in industrial equipment for those years. Before 1918 this offsetting factor vanishes since Wasson's pre-1918 total does not include automobiles (with a seven-year life only automobiles built in 1918 and after were in the capital stock in 1925). The discrepancy between Wasson and Goldsmith on business expenditures on passenger cars is due to a conceptual disagreement. For some unexplained reason Goldsmith does not feel that farmers, professionals, and traveling salesmen use their cars for business purposes. He thus reduces the proportion

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35 Kuznets [1938], p. 213.

36 The NIP revision, for instance, excludes from Shaw's total all replacement parts for farm machinery. In addition Shaw assumed that farmers were the only users of wire fencing, pumps, and other equipment, and the NIP total is reduced to adjust for nonfarm use of these articles. See Shaw [1947], Table II-1, p. 128.

of cars purchased by business from Wasson's 30 per cent to 10 per cent.[37] But income earned by each of these excluded groups is included in private business product, and so the automobiles which they use to produce their incomes should be included in private business capital.

Since there is little direct evidence available on business outlays on automobiles, Wasson's 30 per cent allocation of passenger car sales to business purchasers for the interwar years is one of the weakest links in his capital estimates. The only basis for this percentage was a 1936-37 survey which reported that the proportion of automobile mileage travelled for business purposes was 35 per cent.[38] This figure is arbitrarily reduced to 30 per cent because the survey's definition of business use was very broad and its result could have included some driving to and from work and school and other nonbusiness trips. Another road-use survey made in 1951-54, with a stricter definition of business use, resulted in a reduced business proportion of 17 per cent. The proportion used in the national accounts is thus 30 per cent before 1948, 17 per cent after 1953, and a linearly

[37]"The proportion of passenger cars allocated to business was derived on the assumption that, if business use of passenger cars by farmers, professionals, and traveling salesmen--which under the definition used here is regarded as individual and not as business expenditure--was eliminated from Department of Commerce allocation of 30 per cent of total expenditures, resultant percentage would be about 10 per cent." Goldsmith [1955], notes to Table P-13, p. 892, col. 1.

[38]The Commerce methodology is reported in Grose and Bassett [1962], pp. 17, 24.

declining fraction between those dates.

An elaborate survey program was carried out in 1957-58 to discover the proportion of purchases actually made by business, not just the fraction of trips driven by business. The result, about 15 per cent, was fairly close to the 17 per cent figure which had been used by Commerce. But there is some reason to suspect that the NIP estimates for earlier years may be too high. In the first place, percentages of business travel obtained from the use of mileage surveys to approximate relative business purchases requires the assumption that cars driven in business use travel the same number of miles as personal cars. But business firms and their traveling salesmen surely drive their cars further each year than ordinary consumers. This suspicion cannot with existing evidence be proved, unfortunately, since mileage and purchase surveys have never been taken at the same time.[39] But there is a strong presumption that the NIP interwar estimates may be too high.

A second reason for doubting the NIP interwar percentage is the broad definition of business in the 1936-37 mileage survey as compared to the much tighter definition in the 1951-54 surveys. The OBE, by using 30 per cent as its prewar fraction, assumes that only a small part of the decline from 35 per cent to 17 per cent

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[39]The 1957 purchase survey may have been incomparable with the 1951-54 mileage surveys, for instance, since the former was a year of high business investment.

between the prewar and postwar surveys was due to the difference in definition and that most of it represented an actual decline in the importance of business purchases. The opposite assumption may be just as valid, suggesting the possibility that a lower prewar fraction could just as well be used.

Finally, the business proportion of road use may have been abnormally high during the Depression years because fewer consumers could afford to take long vacation trips, while the doctors, lawyers, and traveling salesmen may have had travel patterns which more closely approximated those of the prosperous years of the 1920's and after World War II. Whatever the proper figure chosen for business purchases in the 1930's, the 1920's fraction should probably be lower.

This reasoning suggests that the business fraction of automobile purchases in most interwar years should be reduced below Wasson's 30 per cent. My solution for years before 1941 is to set the fraction equal to 20 in 1929 and to 35 in 1933 and to let the fraction vary between these limits in proportion to the unemployment rate in other years. The basic assumption is that in years of recession and depression consumers have a less urgent need for automobiles and are better able to postpone their next purchase than persons who use their cars for business purposes. For the immediate postwar years of shortage, 1946-48, my business fraction is 25 per cent, declines to 17 per cent for 1949-53, and equals the present OBE range of 15-17 per cent for 1954 and later years. The result of this adjustment can be seen in the column labelled "Autos" in columns 3, 6, and 10 of Table 6, p. 96a.

Manufacturing, Farm, and Nonfarm
Nonmanufacturing Sectoral Estimates

For the years after 1929 Wasson's estimates of total equipment expenditures are exactly the same as the official NIP data on private purchases of producers durables. Wasson goes further in the Capital Goods Study, however, and creates separate sectoral estimates for manufacturing, farm and NFNM which are not included in the official NIP accounts. The techniques used to estimate the breakdown of equipment expenditures among the three sectors are much rougher than those underlying the totals, and economists should consequently be more skeptical of results obtained with the sectoral data.

Since the only solid information available is the periodic Census of Manufactures report on plant and equipment expenditures in manufacturing, Wasson's approach is to develop data for the manufacturing and farm sectors and obtain the NFNM value as a residual. Most of this discussion, therefore, is devoted to problems estimating manufacturing and farm equipment purchases.

1. Manufacturing.

Since 1939 the Census of Manufactures and the postwar Annual Survey have asked respondents about their expenditures on new plant and equipment. As in all Census inquiries firms are included in the manufacturing sector on an establishment basis, and nonmanufacturing establishments owned and operated by manufacturing firms are excluded. This is a reasonable definition and is accepted by Wasson, although it impairs the comparability of his data with the results of the OBE-SEC plant and equipment survey, which is on a company rather than an establishment basis.

Wasson's series on manufacturers' equipment purchases is compared with the reported Census figures in Figure 4. Wasson's data are higher because of an adjustment for private purchases of producers' durables from the government, an addition which was important only in the immediate postwar years, 1946-50. Manufacturing expenditures on particular types of equipment are based on a matrix developed by the Bureau of Labor Statistics as part of the 1958 input-output survey.[40] The manufacturing share of total expenditures on a given equipment group is assumed to be constant in years other than 1958 and on this basis a preliminary estimate for other Census years is developed. Then the total of the preliminary group estimates is divided by the reported Census total, and each preliminary group estimate is adjusted by this ratio to bring the group total into agreement with the Census. For the intercensal years 1940-46 and 1948 the same technique is used with Internal Revenuse Service sales data used to interpolate

[40]Details on estimating techniques were obtained from Wasson in an interview in Washington, February 8, 1967.

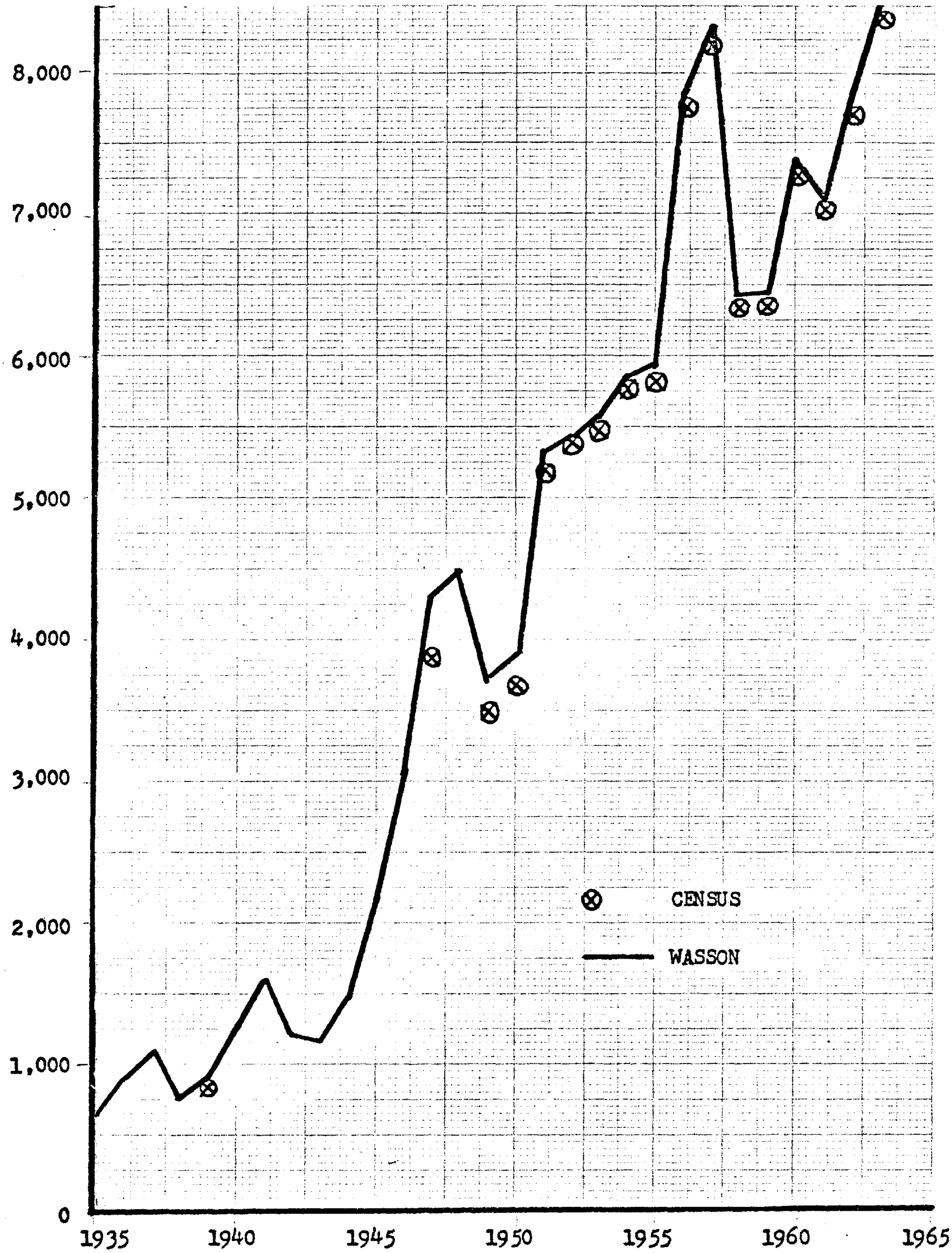

Figure 4

EXPENDITURES ON EQUIPMENT IN MANUFACTURING, 1935-1963
($ Million, Original Cost)

Sources: Wasson: U. S. Department of Commerce, O. B. E. [1966b], pp. 46-52.

Census: Census of Manufactures and Annual Survey of Manufactures, various issues.

the Census totals.[41]

There was no Census inquiry to guide Wasson before 1939, and his approach for these early years was extremely arbitrary. He simply assumed that before 1939 the manufacturing share of total expenditures on a given equipment type remained constant, ignoring both cyclical and secular trends in the importance of manufacturing output. Table 1 suggests that manufacturing output was a larger fraction of GNP in 1939 than in years before 1929. Thus we should expect that manufacturers probably purchased a smaller fraction of each equipment type in the early years of the century than in 1939. Wasson's estimates of manufacturing purchases, therefore, probably are too high for the early years and grow too slowly.

Since some assumption about manufacturing investment has to be made, it is preferable to take account of the growing importance of manufacturing in national output. Wasson's

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[41] Before 1951 the Census reports did not include expenditures on structures and equipment for establishments not yet in operation, and Wasson made an upward adjustment to the 1939 and 1947-50 Census totals of about 11 per cent allow for this.

TABLE 1

MANUFACTURING OUTPUT AND REAL GROSS PRODUCT, KEY YEARS, 1889-1957
(1929 = 100)

Year	Manufacturing Output	Real Gross Product	Manufacturing Ratio (1)/(2)
	(1)	(2)	(3)
1889	18.3	22.3	.820
1894	18.8	25.5	.737
1899	27.5	34.6	.793
1904	34.2	41.2	.830
1909	43.4	52.1	.832
1914	51.1	54.8	.933
1919	61.0	69.7	.876
1924	73.4	83.6	.877
1929	100.0	100.0	1.000
1934	69.1	76.9	.902
1939	102.5	104.1	.983
1944	232.5	162.8	1.429
1948	184.2	163.8	1.128
1953	243.4	202.9	1.199
1957	264.6	225.2	1.177

Source by column:

(1) Kendrick [1961a], Table D-II, pp. 465-466.

(2) Kendrick [1961a], Table A-XXII, pp. 333-5.

assumption can be written:

$$(1) \qquad I_i^M(t) = a_i(39)\ I_i(t)$$

where $I_i(t)$ is the total expenditure on equipment of type i at time t, $I_i^M(t)$ is the expenditure by manufacturers on that type at time t, and $a_i(39)$ is the fraction of that type purchased by manufacturers in 1939. An improvement would be to assume

$$(2) \qquad I_i^M(t) = a_i(39)\ I_i(t)\ \frac{Q^M(t)}{Q(t)}$$

The increasing share of output in manufacturing would thus be reflected in increasing manufacturers' purchases of the i^{th} type of equipment. Implicit is the assumption that the capital-output ratio for the i^{th} type of equipment in manufacturing behaves as the i^{th} capital-output ratio in the whole economy.

The resulting adjustments are shown in columns 4 and 8 in Table 6 on p. 96a. (the columns titled "Growth of Output.") Since estimates of total expenditures on equipment are not affected by this revision, the smaller values for the manufacturing sector for the early years are offset by higher values for the residual NFNM sector.

Wasson's estimates of expenditures on manufacturing equipment are compared in Table 2 with those made by Lowell Chawner [1941]. Why is the Chawner series consistently higher than Wasson's? The mistake seems to have been an overestimate by Chawner rather than an underestimate by Wasson. The Census provides a

TABLE 2

A COMPARISON OF ESTIMATES
BY CHAWNER AND WASSON OF
EXPENDITURES ON MANUFACTURING EQUIPMENT
($ Million, Original Cost)

Year	Chawner (1)	Wasson (2)
1915	428	334
1916	703	552
1917	1231	833
1918	1547	1023
1919	1409	936
1920	1916	1095
1921	971	645
1922	1009	699
1923	1437	978
1924	1260	868
1925	1384	1010
1926	1535	1079
1927	1406	995
1928	1455	1065
1929	1777	1209
1930	1292	873
1931	781	595
1932	456	338
1933	593	344
1934	713	476
1935	930	639
1936	1172	880
1937	1534	1095
1938	1102	769
1939	1230	902
1940	1619	1275

Sources by Column:

(1) Chawner [1941], p. 10.

(2) U. S. Department of Commerce, Office of Business Economics, [1966b], pp. 42-48.

benchmark figure for 1939 of $840 million, increased by Wasson to $902 million to take account of equipment expenditures for plants not yet in operation. Chawner's figure, however, is $1,230 million, about 36 per cent greater than Wasson's. The difference is of about the same proportion as the excess of Kuznets over NIP-Wasson for total producers' durables in 1929 (see above, p. 54), and it is probably a safe assumption that Chawner's excess was caused by the same factors as Kuznets'. Many expenditures on parts and other equipment were probably included in investment when they should have been classified by present national income accounting conventions as intermediate products. In addition Chawner's method of determining the manufacturing share of equipment purchases may have been partly responsible for his overestimate. 60 per cent of his manufacturing total was made up of "special-purpose" machinery (textile, shoe, rubber-working, etc.) which he allocated completely to manufacturing. Some of this machinery (perhaps, say, shoe-repair machinery) actually was purchased in the nonmnufacturing sector. His estimates for general-purpose machinery (engines, pumps, trucks) were proportions "based on data obtained from trade associations and technical specialists in the various machinery industries."[42]

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[42] Chawner [1941], p. 15

These sources of information may have used informal methods which tended to overestimate the importance of manufacturing purchases. The phrasing in Chawner's methodological appendix is ambiguous, but it seems to suggest that the manufacturing percentages applied to general-purpose machinery were the same in each year (the same as the Wasson method for years before 1939). Thus Chawner's series cannot be used to assess the importance of the bias in Wasson's technique discussed above.

For most years the ratio of Chawner's series to Wasson's is between the limits of 1.3 and 1.5. Chawner's excess is especially high in the years 1917-19 because he fails to exclude government purchases of producers' durables. "Manufacturing facilities for public ownership by the War Department, the Navy Department, the Emergency Fleet Corporation, and other Federal agencies were constructed during the fiscal years 1917, 1918, and 1919 at a cost of approximately $500 million."[43]

Thus Wasson's estimates of manufacturing expenditures, while fairly well based for years after 1939, are on much shakier ground for earlier years. Our modification discussed above can remove only a little of the suspicion with which we must view these figures. But, even so, the estimates for manufacturing equipment are a paragon of reliability when compared to several other categories to be discussed later.

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[43]Chawner [1941], p. 10. In the next chapter Wasson's expenditure series are adjusted for government-financed plant and machinery used by private contractors.

Farm Estimates

As we have seen, manufacturers' purchases of a particular equipment type were estimated as a constant fraction of total expenditures on that type. The sum of expenditures on all types was then compared with the Census report on aggregate equipment purchases, and the preliminary equipment group estimates were then adjusted upwards or downwards to correspond to the Census total. In the farm sector preliminary estimates for different types of equipment were obtained in the same way and were added up, but there was no benchmark total provided by a census or survey. Thus farm equipment expenditure estimates are only as reliable as the estimates for the individual equipment types--in other words, not very reliable.

Farmers buy four main types of equipment--tractors, farm machinery, trucs, and cars. Estimates of farmers' purchases of the first two should be satisfactory for the simple reason that farmers buy most of the tractors and all of the farm machinery. In fact Wasson's figures for these groups are considerably smaller than those of the Department of Agriculture (DoA).[44] The primary reason for the differences seems to be that the DoA estimates antedate Wasson's most recent revisions, which make use of commodity flow

[44] The most recent DoA estimates are published in U. S. Department of Agriculture [1966], Table 18H.

data from the 1958 input-output study.[45] However there still seems to be some disagreement about the reliability of Wasson's farm expenditure series. The one solid source of information is a 1955 survey of farmers' purchases of durable goods, but Wasson's 1955 estimate of tractor purchases is 11 per cent below the survey result. Until Wasson and DoA come to an agreement on the levels of farm machinery and farm tractor purchases, not much trust should be placed in the Wasson estimates. There is not sufficient information available, unfortunately, for me to make a firm decision in favor of either series. My solution is to compromise and take the DoA tractor series (the one which agrees with the 1955 survey result) and Wasson's farm machinery estimates. The shift from the Wasson to the DoA tractor series is shown in columns 7 and 11 of Table 6 on p. 96a (the columns labelled "tractors"). Since estimates of <u>total</u> tractor purchases are not affected, an offsetting change is made in the NFNM tractor expenditures.

Truck purchases by farmers are obtained by a perpetual-inventory-in-reverse. The <u>Census of Agriculture</u> reports every five years on the numbers of trucks on farms. Total investment in vehicles over a five-year span is simply the intercensal change in the stock plus replacement investment. Annual replacement is assumed

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[45] Telephone conversation with William Paddock of the Department of Agriculture, March 1, 1967.

to be 16 per cent of the stock throughout the 45-year span of the DoA estimates.[46] The resulting figures on the number of trucks purchased by farmers over the five-year intercensal period are then interpolated annually and converted to current prices. I was unable to discover the method of interpolation. Economists should be wary of attempts to explain reported annual farm purchases of trucks or any other series where the source of interpolation is not known. A regression designed to explain purchases might include as an <u>independent</u> variable the very series, e.g. farm income, which had been used to create the <u>dependent</u> variable!

The prices used to convert the number of trucks into a value figure are not entirely appropriate for our purposes. Only new purchases of trucks or purchases from the nonfarm sector should be included in farm gross capital formation, and the trucks should be valued at their original cost. But the prices used by the DoA to value truck purchases are an average of current prices of new and used trucks weighted by the proportion of each purchased by farmers.[47] The average price is therefore too low,

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[46]The <u>Bulletin "F"</u> life of medium trucks is sex years. See U.S. Internal Revenue Service, <u>Bulletin "F"</u> [1942], p. 42.

[47]Current truck prices are from the Agriculture Statistical Reporting Service and proportions of new and used trucks are from the 1955 survey of farmers' purchases of durable goods.

since the proportion of used purchases is heavily weighted with transactions among farmers of trucks which when resold do not increase the farm capital stock. Also, of course, purchases of cars previously used by other sectors are too low since they are valued at the used price and not at original cost. The downward bias in the estimates of expenditures may be considerable, since the weight given to the price of used trucks is 69 per cent.

An offsetting bias is Wasson's failure to adjust for the use of farm trucks for nonbusiness purposes. For years since 1955 the DoA truck estimates are only 78 per cent of Wasson's, reflecting the DoA's estimate of the relative use of farm trucks for business purposes.[48] But the DoA figures are inconsistent since the 22 per cent reduction is not made before 1950 and thus the growth rate of farm truck expenditures since World War II is biassed downwards. At least the trend of Wasson's series is not biassed, whatever the merit of its level. My procedure is to accept the Wasson series without change and to assume that the underestimate of the average price paid offsets the overestimate due to the failure to exclude nonbusiness use of farm trucks.

DoA and Wasson are in agreement on only one series--purchases of automobiles by farmers. For recent years the information

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[48] William Paddock of the Depart of Agriculture was unable to recall the specific source of the 78 per cent figure. Telephone conversation, March 1, 1967.

is based on an inquiry by the Michigan Survey of Consumer Finances on the percentage of farm spending units buying new and used cars in the preceding year. These percentages are multiplied by the number of farms to obtain the number of cars purchased by farmers annually. The resulting totals are compared with Census of Agriculture stock figures every five years and are adjusted where necessary. The valuation of cars is inappropriate, but it is difficult to determine the direction or magnitude of the bias. Gross capital formation by farmers should include only purchases for new cars and vehicles purchased from outside the farm sector, and these should be valued at original cost. Transfers of used cars from one farmer to another should not be included (except for the sales commission). An offset to the overinclusion of used purchases in the Michigan survey reports is the undervaluation of new purchases. New cars are valued at their net price (i.e., after the value of the trade-in has been subtracted) rather than at their full retail price as is the case for all other types of producers' durables.

I have been unable to find out the basis of the automobile estimates for years before the Michigan survey reports became available, or even the date of changeover to the Michigan reports. (This is one of many examples in which a rapid turnover in the bureaucratic ranks leaves many data-gatherers without any knowledge of their own statistical products.) There is no point in exploring this topic at length since the Census stock estimates are available at five-year intervals for estimates of the capital stock, and it is unnecessary to rely completely on a cumulation of a stream of past investment expenditures.

Nonfarm Nonmnufacturing Equipment Estimates

The NFNM equipment estimates are simply the residuals which remain after the subtraction of the manufacturing and farm sectoral figures from total equipment estimates. There are no outside pieces of evidence which can be used as a check on the validity of the data for this sector.

III. STRUCTURES

The Definition of Structures

Structures include all parts of buildings which are essential to their general use and are usually included in a building's contract price. Excluded is equipment installed for the specific needs of the user. Thus structures include heating, plumbing, and lighting equipment since buildings cannot be used for any purpose without them. Immobile operating equipment constructred as an integral part of the building is also included, e.g., pipes and vats in chemical plants and refineries, and blast furnaces in steel plants.

Gross capital formation includes expenditures on new structures and on major additions and alterations, but excludes repairs and maintenance. Since the omitted maintenance spending acts as an offset to deterioration, this exclusion strengthens our earlier decision to represent capital input by the gross stock of capital without any allowance for deterioration. The inclusion of maintenance would be valid only if maintenance increased the ability of a structure to produce output. The Department of Commerce thus excludes from new construction all expenditures which merely offset deterioration, e.g., "repainting, repapering, reroofing, redredging...." and includes additions and alterations like "the additions of a wing, story or stories, or retaining wall... or initial installation of building service equipment in existing structures."[49]

Construction statistics refer to the value of new construction "put in place." Expenditures on a building are counted in the construction statistics over the entire period of construction and not just when the building is completed. The statistics are thus inappropriate for cumulation into capital stocks since they include spending on buildings which are not yet producing output. This inconsistency is not important over the long-run but should be recognized by economists planning to do studies of changes in productivity in the short-run. In periods of rapid growth in the value of construction, the official statistics overestimate the

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[49]U.S. Department of Commerce, Business and Defense Services Administration [1966a], p. 75.

value of structures actually available for production.

Statistics on structures are compiled by the Business and Defense Services Administration (BDSA) of the Department of Commerce and are available since 1915 in the recent publication Construction Statistics, 1915-1964 [1966a]. Most of the published figures have been accepted by Wasson for use in both the official NIP estimates and the back-room data, but, as we shall see below, several major changes have been applied.[50]

Methods of Estimation

Structures are much more subject to measurement errors than equipment, for there is no regular production census to serve as a benchmark. Because the total of private nonresidential construction cannot be directly compared with any reliable data, it is only as accurate as its constituent parts. As we have seen, the equipment totals are more accurate than the sectoral data, but in structures the situation is reversed, because some of the sectoral and industry estimates are more reliable than the whole.

Table 3 illustrates the relative importance of the main types of structures under discussion and segregates them by the method of data collection. The most reliable are figures on public utility construction, which (at least since World War I)

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[50] In addition to revisions discussed below, Wasson makes a minor adjustment for transfers of structures from private to government owners (e.g., prior to demolition for highway or urban renewal projects.)

TABLE 3

COMPONENTS OF PRIVATE NONRESIDENTIAL CONSTRUCTION ACTIVITY, CLASSIFIED BY PRINCIPAL DATA SOURCE, 1960

	Value Put In Place ($ Million)	Per Cent of Total
1. Direct Reports of Work Done or Paid For	4,641	25.7
a. Public Utilities	4,641	25.7
2. Contract Awards	10,430	57.4
a. Industrial	2,851	15.7
b. Commercial	4,180	23.0
c. Other Nonresidential	3,118	17.1
d. All Other Private	281	1.6
3. Other Sources	3,059	16.9
a. Farm Nonresidential	821	4.6
b. Oil and Gas Well Drilling	2,238	12.3
4. TOTAL	18,130	100.0

Sources by Line:

(1)-(3a) U. S. Department of Commerce, Business and Defense Services Administration [1966a], pp. 2-5.

(3b) U. S. Department of Commerce, Office of Business Economics [1966b], p. 102.

Note: The layout of this table was suggested by Exhibit 1 in U. S. Department of Commerce, Office of Business Economics [1954], p. 123.

have been based on direct reports. Coverage is quite complete since these industries are dominated by large firms and there are hardly any small firms whose construction escapes detection. Contract award data are less reliable. The completeness of coverage is uncertain and the timing of actual expenditures is determined by out-of-date standardized activity patterns rather than actual facts. The third category, as we shall see, is the least reliable of all.

Manufacturing structures. Expenditures on manufacturing structures, like manufacturing equipment, are reported annually by the Bureau of the Census. These reports provide benchmarks for 1939, 1947, and every year from 1949 to 1963. The published figures, as in the case of equipment, have been increased somewhat by Wasson to allow for private purchases of used structures from the government and for the pre-1951 omission of construction expenditures on unfinished establishments. A completely independent set of estimates for the same universe is the BDSA series on private industrial construction, which for years before 1962 was based on contract awards reported by the F. W. Dodge Company for projects awarded in the 37 Eastern States.[51] The award reports were increased by the

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[51]The universe covered in the BDSA series is roughly comparable to that of the Census of Manufactures, since it includes "Production, assembly, and warehousing buildings and structures at manufacturing establishments..." --U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 76.

BDSA to adjust for the omission of the Western states (on the basis of the ratios of the values of building permits issued in the West to those issued in the East), to include estimates for the cost of architectural and engineering work, and to allow for undercoverage.[52] Since 1962 the Census Bureau, perhaps dissatisfied with the Dodge blow-up method, has conducted its own sample survey and the previous technique has been discontinued.[53]

The resulting BDSA industrial construction series, shown in Figure 5 as the dashed line, is considerably smaller for years before 1960 than the Census of Manufactures data on new structures expenditures, available since 1939 and shown by the circled X's. Since these Census reports may be assumed to be reasonably accurate, the pre-1960 BDSA deficiency must be due to undercoverage in the Dodge data which is not corrected sufficiently. After 1960 the BDSA series is close to the Census reports. I have been unable to find anyone who knows why the BDSA values coincide with the Census reports in 1960 and 1961, when the changeover in the new BDSA method did not occur until 1962. It is interesting to note that the BDSA-Census discrepancy gradually declines in size from 1947 to 1960, and one possible cause may have been an improvement in coverage by

[52] U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 81.

[53] U. S. Department of Commerce, Business and Defense Services Administration [1966b].

Figure 5

EXPENDITURES ON STRUCTURES
IN MANUFACTURING, 1915-1963
($ Million, Original Cost)

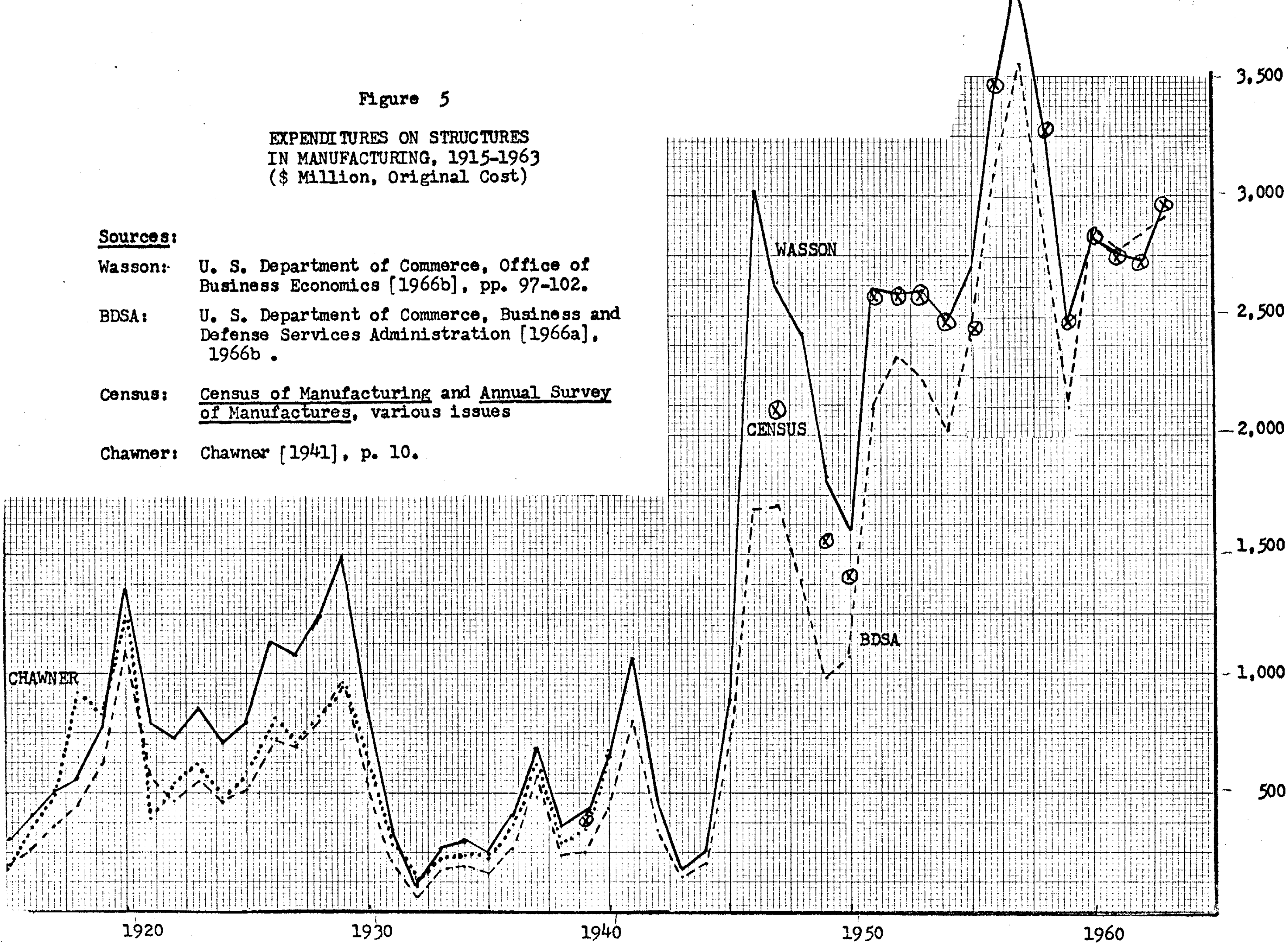
Sources:

Wasson: U. S. Department of Commerce, Office of Business Economics [1966b], pp. 97-102.

BDSA: U. S. Department of Commerce, Business and Defense Services Administration [1966a], 1966b .

Census: Census of Manufacturing and Annual Survey of Manufactures, various issues

Chawner: Chawner [1941], p. 10.



by the Dodge reporters without any corresponding adjustment in the raising ratio used by the BDSA.[54]

The importance of the Census-BDSA discrepancy becomes crucial for the years before the first Census report in 1939. Estimates of manufacturing structures must be raised above the BDSA industrial construction series to retain comparability with the post-1939 data. Wasson's totals for manufacturing structures are greater than BDSA industrial construction by 1.56, a fraction eqaul to the average of the ratios of the Census to BDSA series for the years 1939, 1947, 1949, and 1950.[55] But Wasson's acceptance of the Census level is carried out in a peculiar way. Table 4 is a reproduction of Wasson's unpublished expenditure data for the years of 1955-65. The first line of data, "Industrial," is the BDSA series. The "Manufacturing Total" is the adjusted Census figure. The difference is not simply labeled "undercoverage" but is allocated to "All other private" and a portion of "Commercial and Miscellaneous", which by definition should be part of the NFNM sector, not of manufacturing. Thus Wasson has "borrowed" from NFNM to resolve the Census/BDSA discrepancy,

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[54]Wasson suggested this hypothesis, which is supported by the BDSA statement that the raising ratio " has been unchanged for many years," U.S. Department of Commerce, Business and Defense Services Administration [1966a], p. 81.

[55]After the Census has been adjusted for establishments under construction.

INDUSTRY AND TYPE OF STRUCTURE		CODE	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
MANUFACTURING													
INDUSTRIAL	(32)	13041	2,528	3,223	3,580	2,398	2,089	2,823	2,756	2,731	2,860	3,071	3,546
COMMERCIAL AND MISC	(32)	13044	12	120	109	694	182	--	--	--	--	--	--
ALL OTHER PRIVATE	(32)	13055	154	127	199	189	206	--	--	--	--	--	--
MANUFACTURING TOTAL			2,694	3,470	3,888	3,281	2,477	2,823	2,756	2,731	2,860	3,071	3,546
NONFARM NONMANUFACTURING													
INDUSTRIAL	(37)	23041	--	--	--	--	--	40	35	221	171	258	280
COMMERCIAL AND MISC	(31)	23043	27	36	40	40	44	49	54	57	60	66	72
COMMERCIAL AND MISC	(37)	23044	1,030	1,321	1,550	1,360	1,408	1,678	1,937	2,037	2,142	2,317	2,510
COMMERCIAL AND MISC	(46)	23045	2,140	2,520	2,080	1,755	2,483	2,709	2,976	3,160	3,332	3,619	3,921
INST EXCL SOC AND REC	(56)	22046	1,487	1,695	1,916	2,039	2,019	2,182	2,378	2,549	2,744	3,120	3,380
SOC AND REC:(INST)	(56)	22047	68	86	93	127	164	206	185	230	187	160	173
(NONINST)	(31)	23047	158	202	218	297	384	482	431	538	435	375	406
LOCAL TRANSIT	(46)	23048	19	16	10	5	--	--	--	--	--	--	--
PIPELINES	(27)	23049	124	129	159	156	130	132	109	203	260	166	180
RAILROAD:IN IRS	(60)	23050	219	261	264	173	143	168	131	127	152	164	178
NOT IN IRS	(60)	22051	84	163	123	94	74	102	82	74	88	95	103
TEL AND TEL	(23)	23052	758	1,113	1,068	904	947	1,088	980	996	1,128	1,263	1,368
OTHER PUBLIC UTIL	(35)	23053	2,361	2,884	3,284	3,356	3,208	3,131	3,033	2,930	2,968	3,162	3,426
PETROL AND NAT GAS:CCE	(19)	22054	2,090	2,194	2,140	1,916	2,069	1,989	2,000	2,042	1,871	1,918	2,078
CAP	(19)	23054	351	376	384	347	371	349	337	339	315	331	359
ALL OTHER PRIVATE	(37)	23055	--	--	--	--	--	281	250	277	310	338	366
NONFARM NONMANUFACTURING TOTAL			10,916	12,996	13,329	12,567	13,444	14,586	14,918	15,780	16,163	17,352	18,800
FARM NONRESIDENTIAL	(45)	04056	700	780	763	737	741	718	711	696	677	663	656

TABLE 4

REPRODUCTION OF OBE UNPUBLISHED DATA SHEET,
TOTAL EXPENDITURES ON STRUCTURES
($ Million, Original Cost)

Source: U. S. Department of Commerce, Office of Business Economics [1966b], pp. 101-2.

but this causes a corresponding underestimate in the NFNM sector. After 1960 the "borrowing" changes to "lending" and some of industrial construction suddenly appears as part of NFNM. This procedure is abandoned in my estimates, which return all of the Commercial, Miscellaneous, and All Other Private categories back into the NFNM sector where they belong. Similarly, I exclude from NFNM that part of industrial construction which Wasson "loans" after 1960 from manufacturing to the NFNM sector. These adjustments are shown in column 6 of Table 7, p. 96b.

Thus manufacturing construction after 1939 is based on Census of Manufacturing reports and is extrapolated backwards from 1939 to 1915 as a constant fraction (1.56) of the BDSA industrial construction series. Is there any way to judge the validity of Wasson's 56 per cent mark-up for the 1915-38 period? The only other estimate of industrial construction for these years was made by Chawner [1941]. His series is shown in Figure 5 by the dotted line and appears to be quite close to the BDSA series in the 1920's. This is not coincidental since he uses a similar method of adjusting Dodge contract reports (although his exact procedures differ). Note, however, that his 1939 estimate is much closer to the Wasson/Census benchmark than is the BDSA estimate. The 1939 ratio of Wasson to BDSA is 1.73. This suggests that the 1939 BDSA estimate may be abnormally low and consequently Wasson's raising fraction of 1.56 (based on an average of 1939, 1947, 1949, and 1950) may be too high.

The BDSA estimates for any single year like 1939 may be inaccurate since in the BDSA method the lag between contract and actual construction spending is estimated with obsolete and never-changing "activity patterns." The ratios of the adjusted *Census* totals to the BDSA series for all *Census* years from 1939 to 1959 are shown in Table 5. The ratio shows two obvious patterns: it becomes lower fairly steadily and it reaches cyclical peaks in recession years (1949, 1954, and 1958). One hypothesis to explain the cyclical behavior might be that the standard BDSA activity patterns ignore the possibility that the construction process takes longer in a boom. Materials and labor shortages cause projects contracted for during the boom to be stretched out, and they may not actually be finished until the next year, which may be a recession or depression year. Thus actual construction expenditures, as measured by the *Census* questionnaire, may be higher in recession years than the BDSA series, which assumes that the contracts made in the previous boom year are already completed.

Whatever the reason, the data in Table 5 suggest that the *Census*-BDSA ratio in 1939 and 1949 may be abnormally low, and this is confirmed for 1939 by Chawner's estimate. Wasson's ratio of 1.56 used for years before 1939 is not an average over a business cycle but includes two years of relative inactivity in construction: 1939 and 1949. My suggestion is to lower Wasson's 1.56 mark-up fraction to 1.37, which is the average of column (3)

TABLE 5

ADJUSTED CENSUS EXPENDITURES ON
MANUFACTURING STRUCTURES
AND BDSA INDUSTRIAL CONSTRUCTION,
CENSUS YEARS, 1939-1963
($ Million, Original Cost)

	Census (1)	BDSA (2)	Ratio of (1)/(2) (3)
1939*	425	247	1.72
1947*	2340	1740	1.37
1949	1720	972	1.77
1950	1456	1062	1.37
1951	2593	2117	1.23
1952	2579	2320	1.12
1953	2585	2229	1.16
1954*	2475	2030	1.22
1955	2425	2399	1.01
1956	3471	3084	1.12
1957	3865	3557	1.09
1958*	3265	2382	1.37
1959	2487	2106	1.18
1960	2811	2851	.98
1961	2745	2780	1.00
1962	2728	2842	.96
1963*	2965	2906	1.02

Sources by Column:

(1) U. S. Department of Commerce, Bureau of the Census, *Census of Manufactures and Annual Survey of Manufactures*, various issues. Figures before 1951 were raised 10 per cent to adjust for construction expenditures in establishments not yet in operation.

(2) U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 2, and [1966b].

Note: *Census* years denoted by an asterisk. Other years were covered by the *Annual Survey*.

in Table 5 for the first complete postwar business cycle, the years 1949 to 1953. This revision is shown in Table 7, p. 96b in the column labelled "undercoverage".

For years before 1915 all construction statistics are unreliable and there are no solid figures avilable to check the validity of structures expenditures series. Estimates for total construction for these years were made by Kuznets as a constant ratio to Shaw's data on the output of construction materials.[56] There is no certain way of appraising the validity of Kuznets' construction estimates, although Kuznets himself suggests that they may be too low for the early years.[57] Wasson obtains his estimate

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[56]Actually two constant ratios were used. First, the cost to consumers of construction materials was assumed to be 1.4576 of output, a ratio representing an allowance for transportation and distribution costs based on 1929 data. Second, new construction was assumed for all years before 1919 to be 1.4036 of the cost of construction materials, which was the average value of the ratio during 1919-33. For further details see Kuznets [1946], notes to Table II-5, pp. 100-101.

[57]Kuznets' mark-up, the difference between total consstruction and the flow of construction materials, rises much faster than Martin's estimate of income originating in contract construction. The discrepancy is particularly important between 1869 and 1879. See Kuznets [1946], Table II-c, p. 69.

of manufacturing construction as a residual after subtracting farm and NFNM construction from the Kuznets total. This method is crude but at least is preferable to that of Goldsmith, who simply assumes that industrial construction was a constant fraction of total construction before 1915.[58]

Nonfarm Nonmanufacturing Structures Estimates

As shown above in Table 3 on p. 79, two different methods are used for the NFNM sector. The commercial, "other nonresidential buildings", and "all other private" categories (comprising 62 per cent of the NFNM sector in 1960) are estimated in the same way as industrial structures, based on Dodge contract reports before 1962 and a direct survey afterwards. The remaining 38 per cent, public utility construction, is based on direct company reports.

Our first adjustment to the NFNM sector has already been discussed above. Wasson "borrowed" from the NFNM sector before 1960 to fill the gap between the BDSA industrial structures series and *Census* reports on manufacturers' expenditures on structures, and "lent" the BDSA excess after 1960. This practice in the pre-1960 years resulted in a reduction of the NFNM total below the values reported by BDSA and has been eliminated in my estimates.

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[58]Goldsmith [1955], Vol. I, notes to Table R-13, p. 598. An attempt has been made to improve pre-1915 construction data through the use of assessment reports from Ohio. See Gottlieb [1964] [1965] [1966], and the comments on his work by David [1966].

But a more difficult question is raised by the Census-BDSA discrepancy in manufacturing. If the real cause was Dodge undercoverage before 1960, would not this discrepancy have occurred also in the NFNM categories based on Dodge contract reports? One course of action might be to increase the BDSA data for these categories by the same mark-up ratio as that used in manufacturing. This would involve adding about $680 million to construction, gross capital formation, and GNP in 1929. But since the national accounts use a double-entry bookkeeping system, GNP would be raised without increasing national income. Thus the statistical discrepancy in the NIP accounts would be raised significantly, from $695 million in 1929 to $1,375 million. Such tampering with the GNP accounts is inadvisable without a much more thorough investigation than time allows.[59] Thus the NFNM categories based on BDSA-adjusted Dodge reports will be left unchanged.[60]

While total BDSA NFNM construction is not changed, one switch in classification must be made. Hotels and motels are part of private capital input like any other commercial building, but they have been overlooked in Wasson's back-room data since they are classified

[59]Siskind [1954], pp. 4-14, states that the BDSA estimate for commercial construction in 1947 was 25 per cent too low, but from context this appears to be an unsubstantiated guess.

[60]Before 1915 these NFNM categories are extrapolated back by Wasson as a constant fraction of total nonresidential construction.

by the BDSA as residential structures. These buildings are included in my NFNM revisions, as shown in Table 7, and raise NFNM construction by a substantial 10 per cent or more in some years. In fact, these structures should be permanently removed from the residential housing category component of the NIP accounts, since the behavior and motivation of purchasers is much closer to nonresidential commercial construction than to private home-building.

Estimates for privately-owned public utilities are the most reliable of any of the construction statistics. Since World War I annual reports have been submitted by companies in the electric power, gas, telephone, railroad, pipeline, transit, and telegraph industries. Only minor adjustments are necessary for coverage. For prior years Wasson's data are, with one exception, extrapolated on the basis of Ulmer's [1960] data.[61] The exception is the important railroad category, which accounted for the bulk of public utility construction in the 19th century. For this category Ulmer's estimates are quite obviously wrong. He publishes figures for gross capital expenditures on structures and equipment together and presents no data on structures alone. But since railroad equipment estimates for these early years are based on <u>Census of Manufacturing</u> reports and are fairly reliable, it is

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[61] The series used for extrapolation are:

Local Transit:	Table F-1, p. 405
Telephone:	Table E-1, p. 374
Electric Power:	Table D-1, p. 320

possible to calculate the values for structures expenditures implied by the Ulmer estimates. This series is shown in Figure 6 as the dashed line and appears quite unreasonable when compared with a crude index of railroad construction, the annual increase in railroad mileage multiplied by an index of railroad costs, as shown by the dotted line.[62] The years from 1900 to 1908 were a period of rapid expansion of railroad mileage, as shown by the dotted line, but Ulmer's series indicates no railroad construction at all during these years! Wasson's series shown by the solid line is extrapolated on the basis of mileage completed and appears much more reasonable than the Ulmer figures.[63] Why did Ulmer err? His data on gross capital expenditures are based on state data, but he did not obtain his data for the 1900-1910 period from states where the main expansion of railroads was taking place. Most expansion during this period was in the Northwest, but his expenditure data for 1904 are based just on reports for New York, Ohio, and Wsconsin, and for 1907 just for Ohio and Wisconsin.[64] It is odd that Ulmer, after years of slaving over his data appen-

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[62] The series is copied from Ulmer [1960], Table C-9, pp. 270-271, column (3).

[63] Wasson's solid line differs somewhat from the dotted line because he used a different mileage series as an extrapolator, but he cannot remember exactly which one.

[64] Ulmer, note to Table C-5, p. 266.

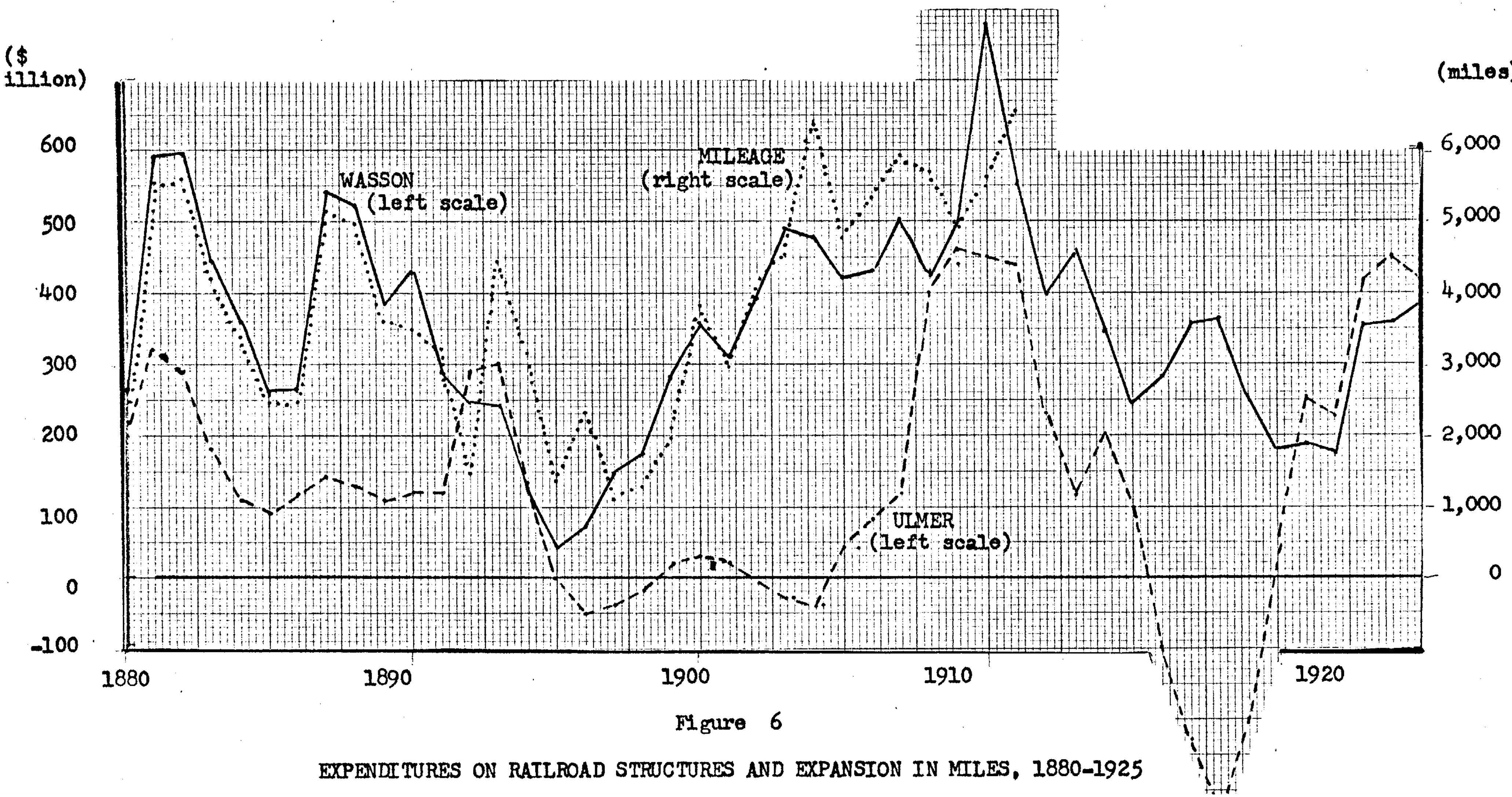

Figure 6

EXPENDITURES ON RAILROAD STRUCTURES AND EXPANSION IN MILES, 1880-1925

<u>Sources:</u> Wasson: U. S. Department of Commerce, Office of Business Economics [1966b], pp. 94-98.

Ulmer: Ulmer [1960], Table C-10, column 3, p. 272 minus OBE series on expenditures on railroad equipment, same source as Wasson data on this chart, pp. 36-44.

Mileage: Ulmer [1960], Table C-9, column 3, p. 270--Fiscal year data, annual increase in track mileage times index of railroad construction costs.

dix, did not notice the discrepancy exhibited in Figure 6.[65]

Wasson's estimates of gas and oil well drilling expenditures were obtained neither by the the Dodge contract nor direct report methods but were calculated instead by a crude extrapolation. Precise estimates are available only for 1939, based on the Census of Mineral Industries taken in that year. The 1939 total is extrapolated forwards and backwards with data on the number of wells completed and the average cost per well.

Farm Structures Estimates

The farm structures sector includes structures used by farmers for production purposes and thus excludes dwellings. The Wasson series is prepared by the DoA by an amazingly crude method.[66] A cross-section survey in 1955 reported average annual construction expenditures for farmers in different income classes, yielding an income-elasticity parameter for farm construction. Then farm construction before and after 1955 was obtained by multiplying this income-elasticity parameter by total net realized farm income. The resulting value in 1955 prices was then multiplied by a construction cost index (an average of wage rates and materials costs) to yield the current dollar figure.

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[65] Fishlow ([1966], pp. 589-612) has made similar and more extended criticisms of Ulmer's capital data (his paper was discovered after this section was written and there was insufficient time to incorporate his results).

[66] Wasson makes a small adjustment to exclude estimated expenditures for building repairs.

This series is obviously worthless for use in serious economic studies.[67] It is calculated on the assumption of an unchanging income elasticity and a price elasticity of zero. The behavior of the capital-output ratio for farm structures should not be a subject for investigation, since the ratio depends on the artificial assumptions which have been used.

IV. SUMMARY AND CONCLUSIONS

After a thorough inspection tour in, on, around, and under every piece of furniture in Wasson's back room, it is time to clean the dust off our hands and evaluate the trip. In comparisons with the Wasson data, earlier estimates by pioneers like Kuznets, Ulmer, Goldsmith, and Chawner have been weighed in the balances and found wanting. It is natural that Wasson should emerge almost unscathed from the comparisons, since his work is the most recent, incorporating improvements in information which have become available since the pioneer era.

It is impossible to leave these basic statistics, however, without an overwhelming impression of basic weakness in the organization of the Federal government's statistical services. Estimates for subcategories are gathered by isolated bureaucrats in separate agencies who never pay attention to each other's work.

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[67] The description of the methods used was obtained from William Paddock of the Department of Agriculture in a telephone interview, February 8, 1967.

In innumerable instances interviewees were unaware of discrepancies between their statistical series and related ones and had no idea how the differences had arisen, often because historical estimates had been made decades earlier and had been accepted without question by each succeeding generation. The state of the agriculture and construction statistics is especially deplorable in this respect.

Most of this is not the fault of Wasson nor his colleagues in the National Income division, who bear the day-to-day burdens of compiling current statistics, and who don't have enough time to investigate the quality of the series they inherit from other agencies. The moral of the story is a clear need for a central Federal Statistical Office responsible for all data and endowed with a research bureau actively engaged in improving the historical record of the American economy.

At present this research task is carried on by isolated academics who can only tackle bits and pieces of the task to be performed. As in the case of this study, the basic process of learning the statistical ropes often takes so long for an economist outside the government that there is little time for a complete investigation. In this chapter an attempt has been made, with about one man-month of effort, to review the statistical methods used in the OBE back-room data and to reveal the main areas of weakness. But, because of the limited time available, many of the revisions made here are only slightly less crude than the procedures they replace, and they can doubtless be improved by future investigators. Several topics discussed in Chapter II deserve substantially greater research effort than has been possible here, especially the estimates of construction expenditures for the entire historical period through 1962, which are seriously in need of a detailed investigation.

The revisions made here to Wasson's data are limited to a few basic changes summarized in Tables 6 and 7. Automobile purchases by business have been reduced for most years before 1954, some early manufacturing expenditures have been reallocated to the NFNM sector to take account of the changing proportion of output originating in manufacturing, and tractor expenditures have been reallocated between the farm and NFNM sectors. The net result is a slight reduction in total equipment purchases. Revisions in structures, shown in Table 7, have been more substantial, involving a decrease before 1939 for the manufacturing sector and an increase for all years before 1960 in the NFNM sector.

The total effect of the revisions on the final capital stock estimates will be calculated in Chapter V, where perpetual inventory computations are performed. In the meantime we turn to a major conceptual error in previous capital estimates which has led investigators to overlook many billions of productive tangible assets.

TABLE 6

REVISIONS TO WASSON'S EQUIPMENT EXPENDITURE DATA
($ Million, Original Cost)

	MANUFACTURING				NONFARM NONMANUFACTURING				FARM		
	Total	Total	Autos	Growth of Output	Total	Autos	Tractors	Growth of Output	Total	Autos	Tractors
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1869	0	-4		-4	4			4			
1870	0	-5		-5	5			5			
1871	0	-5		-5	5			5			
1872	0	-7		-7	7			7			
1873	0	-6		-6	6			6			
1874	0	-4		-4	4			4			
1875	0	-3		-3	3			3			
1876	0	-8		-8	8			8			
1877	0	-8		-8	8			8			
1878	0	-11		-11	11			11			
1879	0	-17		-17	17			17			
1880	0	-23		-23	23			23			
1881	0	-43		-43	43			43			
1882	0	-46		-46	46			46			
1883	0	-34		-34	34			34			
1884	0	-30		-30	30			30			
1885	0	-23		-23	23			23			
1886	0	-26		-26	26			26			
1887	0	-45		-45	45			45			
1888	0	-52		-52	52			52			
1889	0	-51		-51	51			51			
1890	0	-19		-19	19			19			

(continued on next page)

TABLE 6 (con'd)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1891	0	- 19		- 19	19			19			
1892	0	- 22		- 22	22			22			
1893	0	- 24		- 24	24			24			
1894	0	- 29		- 29	29			29			
1895	0	- 24		- 24	24			24			
1896	0	- 24		- 24	24			24			
1897	0	- 32		- 32	32			32			
1898	0	- 31		- 31	31			31			
1899	0	- 23		- 23	23			23			
1900	0	- 32		- 32	32			32			
1901	0	- 43		- 43	43			43			
1902	0	- 44		- 44	44			44			
1903	0	- 22		- 22	22			22			
1904	0	- 34		- 34	34			34			
1905	0	- 28		- 28	28			28			
1906	0	- 48		- 48	48			48			
1907	0	- 51		- 51	51			51			
1908	0	- 54		- 54	54			54			
1909	0	- 44		- 44	44			44			
1910	0	- 41		- 41	41			41			
1911	0	- 62		- 62	62			62			
1912	0	- 31		- 31	31			31			
1913	0	- 32		- 32	32			32			
1914	0	- 14		- 14	14			14			
1915	0	24		24	- 24			- 24			
1916	0	58		58	- 58			- 58			
1917	0	118		118	-118			-118			
1918	-120	44	- 6	50	-125	- 75		- 50	- 39	- 39	
1919	-174	-111	- 9	-102	- 1	-103		102	- 62	- 62	
1920	-222	- 71	- 14	- 57	-107	-164		57	- 44	- 44	

(continued on next page)

TABLE 6 (con'd)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1921	- 64	-141	- 5	-136	83	- 53		136	- 6	- 6	
1922	-155	- 36	- 11	- 25	- 96	-121		25	- 23	- 23	
1923	-314	- 69	- 21	- 48	-194	-242		48	- 51	- 51	
1924	-233	-110	- 16	- 94	- 89	-183		94	- 34	- 34	
1925	-318	- 65	- 22	- 43	-207	-250		43	- 46	- 46	
1926	-388	- 77	- 27	- 50	-264	-314		50	- 47	- 47	
1927	-265	- 67	- 19	- 48	-172	-220		48	- 26	- 26	
1928	-302	- 47	- 21	- 26	-215	-241		26	- 40	- 40	
1929	-418	- 9	- 28	19	-337	-318		- 19	- 72	- 72	
1930	-143	- 46	- 9	- 37	- 72	-109		37	- 25	- 25	
1931	- 18	- 79	- 1	- 78	66	- 12		78	- 5	- 5	
1932	39	- 78	2	- 80	106	26		80	11	11	
1933	58	- 27	4	- 31	77	46		31	8	8	
1934	42	- 39	2	- 41	68	27		41	13	13	
1935	39	6	3	3	30	33		- 3	- 3	3	
1936	- 15	29	- 1	30	- 41	- 11		- 30	- 3	- 3	
1937	- 68	36	- 5	41	- 95	- 54		- 41	- 9	- 9	
1938	21	-106	1	-107	124	17		107	3	3	
1939	- 6	0	0		- 4	- 4			- 2	- 2	
1940	- 63	- 5	- 5		- 91	- 51	- 40		33	- 7	40
1941	-206	- 15	- 15		-196	-163	- 33		5	+ 28	33
1942	0				-150		-150		150		150
1943	0				- 91		- 91		91		91
1944	0				-104		-104		104		104
1945	0				- 16		- 16		16		16
1946	-145	- 12	- 12		-131	-119	- 12		- 2	- 14	12
1947	-288	- 23	- 23		-262	-237	- 25		- 3	- 28	25
1948	-188	- 15	- 15		-179	-148	- 31		6	- 25	31
1949	-1011	- 78	- 78		-813	-766	- 47		-120	-167	47
1950	-1023	- 74	- 74		-847	-847	0		-202	-202	0

(continued on next page)

TABLE 6 (con'd)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1951	-604	-46	-46		-422	-415	-107		-36	-143	107
1952	-296	-14	-14		-350	-239	-111		68	-43	111
1953	-567	-38	-38		-468	-384	-84		-61	-145	84
1954	0				-70		-70		70		70
1955	0				-78		-78		78		78
1956	0				-42		-42		42		42
1957	0				-7		-7		7		7
1958	0				-104		-104		104		104
1959	0				-101		-101		101		101
1960	0				-47		-47		47		47
1961	0				0		0		0		0
1962	0				0		0		0		0
1963	0				-7		-7		7		7
1964	0				-12		-12		12		12
1965	0				-148		-148		148		148

Sources by column:

(1) Sum of columns 2, 5, and 9.

(2) Sum of columns 3 and 4.

(3)(6)(10) The new estimates of total producers' expenditures on automobiles are derived by applying ratios to total automobile sales. The ratios are as follows.

1918-1941. Ratio (R_t) ranges between 20 per cent and 35 per cent in proportion to the unemployment rate (U_t) in each year:

$$R_t = 20 + \frac{U_t - 3.2}{24.9 - 3.2}(35 - 20)$$

where 3.2 is the unemployment rate in 1929 and 24.9 is the rate in 1933. Unemployment rates from Statistical History [1965], Series D47, p. 73.

(continued on next page)

TABLE 6 (con'd)

1946-1948. 25 per cent.

1949-1953. 17 per cent.

The new total for automobiles is allocated among the three sectors in the same proportion as Wasson's data.

(4)(8) Wasson's unpublished total for manufacturing is multiplied before 1939 by the ratio of manufacturing output to real U. S. gross product on a 1939 base. Index of manufacturing output from Kendrick [1961a], Table D-II, pp. 465-66. Real Gross Product from the same source, Table A-XXII, pp. 333-35.

(5) Sum of columns 6, 7, and 8.

(7)(11) Wasson's unpublished expenditures on farm tractors minus those reported in the U. S. Department of Agriculture [1966], Table 18-H.

TABLE 7

REVISIONS TO WASSON'S STRUCTURES EXPENDITURES DATA
($ Million, Original Cost)

		MANUFACTURING			NONFARM NONMANUFACTURING			
	TOTAL	Total	Under-coverage	Stat-istical	Total	Eliminate Borrowing	Hotels	Stat-istical
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1865	4	- 2	- 2		6	6		
1866	5	- 2	- 2		8	8		
1867	7	- 3	- 3		10	10		
1868	9	- 4	- 4		13	13		
1869	11	- 5	- 5		16	16		
1870	46	- 7	- 7		53	21	32	
1871	43	- 6	- 6		49	17	32	
1872	51	- 6	- 6		57	17	40	
1873	48	- 7	- 7		55	21	34	
1874	36	- 6	- 6		40	17	23	
1875	18	- 3	- 3		21	9	12	
1876	19	- 3	- 3		22	9	13	
1877	19	- 3	- 3		22	9	13	
1878	24	- 3	- 3		27	9	18	
1879	20	- 3	- 3		23	9	14	
1880	31	- 3	- 3		34	9	25	
1881	64	- 7	- 7		71	21	50	
1882	69	- 9	- 9		78	26	52	
1883	59	- 9	- 9		68	26	42	
1884	53	- 9	- 9		62	26	36	
1885	41	- 7	- 7		48	22	26	

(continued on next page)

TABLE 7 (con'd)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1886	41	- 7	- 7		48	22	26	
1887	63	- 9	- 9		72	22	50	
1888	61	- 9	- 9		70	22	48	
1889	72	- 14	- 14		86	43	43	
1890	95	- 19	- 19		114	59	55	
1891	86	- 21	- 21		107	63	44	
1892	84	- 21	- 21		105	63	42	
1893	85	- 21	- 21		106	63	43	
1894	77	- 19	- 19		96	59	37	
1895	78	- 22	- 22		100	69	31	
1896	98	- 29	- 29		127	88	39	
1897	102	- 28	- 28		130	84	46	
1898	84	- 19	- 19		103	59	44	
1899	95	- 20	- 20		115	60	55	
1900	106	- 20	- 20		126	60	66	
1901	109	- 30	- 30		139	75	64	
1902	158	- 38	- 38		196	115	81	
1903	173	- 38	- 38		211	115	96	
1904	151	- 28	- 28		179	85	94	
1905	148	- 30	- 30		178	90	88	
1906	173	- 38	- 38		211	115	96	
1907	186	- 41	- 41		227	122	105	
1908	164	- 41	- 41		205	118	87	
1909	189	- 44	- 44		233	133	100	
1910	210	- 55	- 55		265	138	127	
1911	218	- 50	- 50		268	153	115	
1912	228	- 83	- 83		311	196	115	
1913	229	- 72	- 72		301	186	115	
1914	171	- 40	- 40		211	123	88	
1915	113	- 35	- 35		148	108	40	

(continued on next page)

TABLE 7 (con'd)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1916	162	- 42	- 42		204	144	60	
1917	151	- 63	- 63		214	149	65	
1918	91	- 69	- 69		160	115	45	
1919	134	- 94	- 94		228	153	75	
1920	221	- 161	- 161		382	252	130	
1921	256	- 98	- 98		354	229	125	
1922	377	- 85	- 85		462	257	205	
1923	432	-100	-100		532	302	230	
1924	425	- 83	- 83		508	253	255	
1925	539	- 88	- 88		627	272	355	
1926	678	-132	-132		810	400	410	
1927	589	-124	-124		713	383	330	
1928	558	-143	-143		701	441	260	
1929	598	-170	-170		768	523	245	
1930	399	- 95	- 95		494	294	200	
1931	150	- 41	- 41		191	121	70	
1932	65	- 16	- 16		81	41	40	
1933	99	- 33	- 33		132	97	35	
1934	116	- 36	- 36		151	106	45	
1935	100	- 31	- 31		131	88	50	
1936	158	- 49	- 49		207	147	60	
1937	262	- 13	- 13		275	195	80	
1938	159	- 45	- 45		204	129	75	
1939	268				268	178	90	
1940	309				309	219	90	
1941	351				351	256	95	
1942	158				158	108	50	
1943	44				44	29	15	
1944	76				76	51	25	
1945	194				194	154	40	

(continued on next page)

TABLE 7 (con'd)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1946	830				830	685	145	
1947	799				799	674	125	
1948	972				972	817	155	
1949	938				938	753	185	
1950	654				654	479	175	
1951	666				666	476	190	
1952	444				444	259	185	
1953	623				623	356	267	
1954	725				725	429	296	
1955	505				505	166	339	
1956	694				694	247	447	
1957	809				809	308	501	
1958	1516				1516	883	633	
1959	1150				1150	388	762	
1960	825				825	- 40	865	
1961	1025				1025	- 35	1065	
1962	1002				1002	-221	1223	
1963	1166	105		105	1061	-171	1341	-109
1964	1377	501		501	876	-258	1457	-323
1965	3348	1540		1540	1808	-280	1486	602

Sources by column:

(1) Sum of columns (2) and (5).

(2) Sum of columns (3) and (4).

(3) The new manufacturing series is 1.37 times Wasson's unpublished series on industrial construction from U. S. Department of Commerce, Office of Business Economics [1966b], pp. 92-102, which after 1915 is equal in most years to the private industrial

(continued on next page)

TABLE 7 (con'd) construction series in U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 2. Because deductions of government purchases in 1917-21 were not made in the industrial construction series (unlike World War II, for which a separate public industrial construction series is available), a different procedure was used. For these years Wasson's manufacturing total was multiplied by 1.37/1.56.

(4) Wasson's data were compiled in early 1966 and do not take account of the July, 1966 GNP revisions. New figures are equal to the Census of Manufactures total for 1963 and the series for 1964 and 1965 from U. S. Department of Commerce, Business and Defense Services Administration [1966b].

(5) Sum of columns 6, 7, and 8.

(6) For 1865 to 1959 the revision is the difference in Wasson's data between manufacturing structures and industrial construction (see illustration of his data in Figure 4, p. 85). For 1960-63 the revision is the portion of industrial construction included by Wasson under the nonfarm nonmanufacturing sector (his series 23041).

(7) 1870-1914: The average ratio of nonhousekeeping private residential construction to total NFNM structures expenditures from 1915 to 1925 was about .08. This ratio was multiplied by Wasson's total of NFNM structures for 1865-1914.

1915-1928: U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 2.

1929-1965: U. S. Department of Commerce, Office of Business Economics [1966a], Table 5.2, pp. 80-81, line 8.

(8) Total expenditures on nonresidential structures from U. S. Department of Commerce, Office of Business Economics [1966a], Table 5.2, pp. 80-81, line 12 minus industrial structures , line 15, and farm, line 27.

CHAPTER III

GOVERNMENT-FINANCED CAPITAL OPERATED BY PRIVATE FIRMS

I. INTRODUCTION

Most productivity studies are rightly confined to the private sector and ignore government output, which is omitted because of its artificial treatment in the National Income and Product (NIP) accounts. Government output, which cannot be valued at a market price because it is not sold, is measured simply as the compensation of government employees, and real government output, displayed in the national accounts in "1958 dollars," is a completely bogus concept. Since the deflator is average employee compensation rather than an actual price, real government output grows by definition at exactly the same rate as labor input, and productivity by definition never changes. Thus the government sector must be excluded in any project which intends to study productivity.

All of this is well known, of course, and most productivity studies consequently limit their analysis to private output, which is assumed to be produced with private inputs. Unfortunately the Wasson/NIP data do not define government and private capital by the sector in which they are used, as required for productivity analysis, but rather by the sector which finances them. While government output is not directly produced by privately financed capital, structures and equipment financed by the government have played a surprisingly important role during the last 25 years in the production of private output.

Government capital is operated by private firms under varying types of agreements. During World War II many firms operated on a normal profit-making basis using government-owned machinery in their own factory buildings. In other cases the government owned the building and the equipment, and the firm operated the plant for the government for a fixed fee, with any profits or losses accruing to the government.[1] After the war another method was used when many plants, which the government had been unable to sell, were leased to private firms who operated them on a profit-making basis. All of these cases, despite their differences, have a crucial similarity. The wages and salaries of employees of these government-owned plants are paid by private firms, and the payments are counted, along with the fees or profits earned by the operators, as part of national income originating in the <u>private</u> sector. Any productivity study is misleading if it includes all of private output but neglects part of the capital

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[1]The cost-plus-fixed-fee (CPFF) contract was considered more efficient than the cost-plus-percentage-profit scheme which was more common in World War I. The latter arrangement, of course, gave profit-maximizing munitions makers an incentive to keep costs as high as possible. More than $50 billion in CPFF contracts were signed in World War II. See Hewlett and Anderson [1962], p. 86; Tybout [1956], and Orlans [1967].

which was used to produce that output. Unfortunately that fate has befallen all previous studies, because our national accounts have failed to keep track of government capital. Government purchases of industrial structures and equipment are lumped in with all other government current purchases of goods and services, and there is no published series on the amount of government capital which has been used during the past 25 years to produce private output.

And the amounts involved are not trivial. In the spring of 1945 private firms were producing steel ingots at a full-capacity rate, but they owned only 90 per cent of their fixed capital input; the other 10 per cent was owned by the government. Boeing, Grumman, Republic, and other private firms were rolling out aircraft at an unprecedented pace, but the planes were rolling out through government-owned doorways and the supervisors congratulated each other from government-owned chairs and desks. Nor were government facilities merely a wartime phenomenon which can safely be ignored by those economists who believe that the world began with the first quarterly GNP statistics in January, 1946. Even after the war in 1947, for example, Alcoa, Reynolds, and Kaiser produced half of the nation's aluminum output in government-owned plants. In 1951 about half of our rubber supply was synthetic, and all synthetic rubber was produced by private firms in government-owned plants. Even today 123,000 employees of private firms work in plants and laboratories owned by the Atomic Energy Commission having a gross book value of over $8 billion.[2]

The majority of the government industrial facilities in question were constructed during World War II. To account for all of the government capital which has been used since then to produce private output, three separate questions must be answered: How much government capital was used by private firms during World War II? How much of that capital continued in operation by private firms after the war? And how much capital has been built by the government since the war for private operation? The distinction between World War II facilities and capital built after the war is dictated by the inadequacy of the available statistics. No complete record is avilable which traces the eventual disposition

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[2]Sources for facts in this paragraph:

Iron and Steel. Capacity was expanded from 81.6 million tons in 1940 to 95.5 million tons in 1945. See Cook [1948], p. 19. Of total expenditures on basic iron and steel facilities expansion from 1940 to the end of 1944, the government-financed share was 66 per cent--see U. S. War Production Board [1945b], inside front cover. 66 per cent of the expansion of 13.9 million tons is 9.2 million tons, or roughly 10 per cent of 1945 capacity.

Aircraft. The government financed 88 per cent of the World War II expansion of aircraft plants. U. S. War Production Board [1945b], inside front cover.

Aluminum. U. S. War Assets Administration [1946-49], Second Quarter 1947, p. 8.

Rubber. Production figures from U. S. Director of Defense Mobilization [1951-53], April 1, 1951, p. 16.

Atomic Energy. U. S. Atomic Energy Commission [1965], p. 9.

of all World War II facilities, and a large part of the work reported in this chapter is an attempt to infer from scattered pieces of evidence what has happened to these plants since 1945.

At present the Wasson/NIP accounts, the official estimates of war and postwar capital formation, do not include government capital used by private firms but only privately-financed structures and equipment purchases. Government-financed facilities enter the private capital stock only when they are sold to private firms and at the time of sale are added to private capital formation at the sales price, not at original cost. Obviously this approach results in a completely inappropriate measure of the capital actually used by private firms, for several reasons:

1. The timing in the Wasson/NIP accounts is wrong for productivity analysis. The World War II facilities were used by private firms from the date of construction, mainly in 1941-43, not from the date of sale in 1946-48. Thus the capital available for private use during the war has been understated by a large amount.

2. The official valuation at the time of sale is wrong. Wasson/NIP have valued the facilities at their sales price, not at original cost. Since average sales prices after the war averaged only about 30 per cent of original cost, their estimates seriously

understate the cost of the assets, which have thus been included in gross capital formation at their net depreciated value.[3] In the investment statistics they are completely merged with all new capital built in the year of sale, e.g. 1947, and for depreciation and discard calculations are treated as if their age was the same as new 1947 assets.

3. In addition, since used goods sold by the government in 1947 are merged with new capital built in 1947, they are deflated in 1947 prices. This is wrong, of course, since they were built in 1941-45 and should be deflated in the prices of the year of construction.

4. The procedure makes no allowance for capital which was not sold. Many of the World War II facilities, as we shall see, were either leased to private operators or continued to be operated by private firms for the government on a fixed-fee basis.

5. No account is taken of the government industrial structures and equipment which were built after the war. These have become a more and more important part of the capital stock in the late 1950's and 1960's as some of the World War II equipment wears out and is abandoned.

Only one previous investigator has made any sort of allowance

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[3]For 30 per cent figure see Table 10, p. 120.

for the peculiarities of wartime facilities expansion. In his Ph.D. dissertation Patrick Huntley [1960] does not make any allowance for the faulty NIP treatment of government capital but does take a step backwards by excluding part of wartime private investment from the postwar capital stock. During World War II manufacturers were allowed five-year amortization when they expanded facilities for war purposes. They were allowed to decide for themselves whether their investment was in a "normal" peacetime or "extraordinary" wartime pattern. Using statistics on wartime amortization, Huntley excludes fully half of 1940-45 private investment from his estimates on the grounds that:

> A manufacturer who elected to 'amortize' his entire plant and equipment expenditure made during the war presumably registered the opinion that his entire expenditures were for manufacturing facilities of war-time usefulness having limited peacetime use.[4]

But a private manufacturer would have had every incentive to reduce his tax payments by declaring that his facilities were for war-time purposes. He doubtless would have assumed that tax rates would be reduced after the war and that he should try to maximize his amortization deductions during the high-tax war years. Furthermore, he would have tended to underestimate the peacetime usefulness of his newly expanded plant. Profoundly discouraged by vivid memories of the Depression, most manufacturers in the early 1940's

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[4] Huntley [1960], p. 72.

never dreamed that war-time levels of demand would continue after the war. The return of "normal peacetime conditions" could only bring profitless excess capacity to their expanded 1943 plants.

Another authority disagrees with Huntley. After the war Deming and Stern made a careful study of the peacetime uses of plants built during the war in the Southern states and wrote that "private industry in most cases financed facilities that were closely related to normal operations."[5] An inspection of the industrial composition of public and private wartime expansion confirms that almost all "extraordinary" wartime needs were financed by the government. In the war-oriented explosives, ammunition, ordnance, aircraft, and ships categories, for instance, the government financed 93 per cent of facilities expansion and private firms the remainder. Over 90 per cent of privately financed expansion was in the food, textiles, paper, basic chemicals, petroleum, rubber, basic metals, and machinery industries, and these expanded facilities were available to meet the surprisingly buoyant demands for civilian goods in the prosperous postwar economy.[6]

Nor should the Korean war practice of five-year amortization mislead us into thinking that plants expanded during 1951-53 were discarded after five years. While amortized over five years, new

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[5] Deming and Stern [1949], p. 24.

[6] Industrial composition figures are from U. S. War Production Board [1945b], inside front cover.

capacity in steel, aluminum, and other basic industries, constructed in 1951-53 to meet the Korean War emergency, was just as useful as plants built during any other period in meeting the needs of the post-Korean economy. In both wars rapid amortization was a device to induce investment in industries in which there seemed a large possibility of a postwar slump in demand. Thus, contrary to Huntley's procedures, no special allowance will be made here for the premature discarding of privately-financed facilities built in either war.

The aim of this chapter is to uncover the data necessary to calculate the long-overlooked government-financed stock of capital which since 1940 has helped to produce private output. For each type of capital we must ascertain the initial year of private operation, the year of construction (so that the proper price deflator can be applied in the conclusion), and the year of retirement. Most of the results are necessarily subject to a substantial margin of error. The requisite data are scattered and have been difficult to find. One government agency after another has spent a brief period collecting figures, and each during its tenure has changed definitions and lost track of some assets. Responsibility for data collection shifted from the War Production Board to the Civilian Production Board, the War Assets Administration, and later the Defense Department and other branches. Many of the records legalistically divide assets into "real property" and "personal property," which are useless distinctions and, unfortunately, do not correspond to structures and equipment. When an entire plant was sold to one bidder, its installed equipment was considered real property, but if the same equipment was removed to be sold separately, it was tallied as personal property. Nor does all personal property consist of equipment but also includes both consumer goods and intermediate products. Because of these difficulties, our breakdown into structures and equipment is only partly based on hard facts, and many of the estimates rest instead on an intricate web of guesses, extrapolations, and blow-ups based on scattered hints in obscure publications.

To correspond neatly to the categories of Wasson's back-room data, the structures and equipment estimates of this chapter must be further broken down into the manufacturing, farm, and nonfarm nonmanufacturing sectors. This is not quite as difficult as some of the other steps because the facilities are overwhelmingly in manufacturing. The exceptions are few and fairly easy to identify, e.g., airline transport planes, tractors, and nuclear research laboratories.

II. WARTIME PLANT EXPANSION

Between 1941 and 1945 American manufacturers spent more on new plant and equipment than they had purchased in the entire pre-war decade--a total of $10.5 billion. While substantial, this expenditure in real terms was only 16 per cent of the 1940 manufacturing capital stock, a moderate increase compared to the 95 per cent rise in real manufacturing output from 1940 to 1944.[7] This incredible expansion of production with so little new capacity, long considered the epochal American Wirtschaftswunder, actually may have been more myth than miracle. For conventional statistics on private investment by manufacturers seriously understate the growth of the manufacturing capital stock during the war, completely ignoring almost 60 per cent of the wartime expansion of privately operated facilities. The forgotten $16 billion of plant and equipment purchased by the government for private contractors is a very large skeleton in the closet of the Department of Commerce.

Few of the figures reported in this chapter are measured without a considerable margin of error, and there are some problems even in calculating the total amounts presented in Table 8. The first difficulty is that wartime statisticians had never heard of the Manhattan District and omitted expenditures on plants constructed

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[7]Actually, this 16 per cent increment was not enough to offset retirements in calculations of the capital stock based on constant lifetimes, and estimates of the manufacturing capital stock show a decline from 1941 to 1944 (see the unrevised estimates in Appendix Tables D-1 and D-2, column 1). In real life, of course, many retirements may have been delayed during these years, and the actual capital stock (based again on unrevised investment data) probably rose. The 16 per cent capital expansion mentionned in the text was calculated from Appendix Tables C-2, D-1, and D-2. Output estimates are from Kendrick [1961a], Table D-II, p. 466.

TABLE 8

GOVERNMENT-FINANCED STRUCTURES AND EQUIPMENT
BUILT BETWEEN JULY 1, 1940 AND DECEMBER 31, 1945
($ Million, Original Cost)

	TOTAL	STRUCTURES	EQUIPMENT
1. TOTAL	17,641	8,695	8,946
2. Government-Operated	1,657	1,029	628
3. Privately-Operated	15,984	7,666	8,318

Sources by line:

(1) Table 9, p. 115, line 1.

(2) Structures: Table 16, p. 142, line 4, plus .456 of government-operated plant in 1945 from Table 22, p. 161, column 4.

Equipment: Table 16, p. 142, line 8, plus .544 of the government-operated plant in 1945 from Table 22, p. 161, column 4. The source of the structures/equipment ratio is described in the notes to Table 23, p. 162, columns 1 and 4.

(3) Line 1 minus line 2.

to produce the first atomic bomb from their compilations of government-financed capital formation. This omission is natural, since nuclear appropriations were completely secret during the war and were hidden in scattered parts of the War Department budget.[8] Official statistics on wartime construction have been revised to include atomic plant structures, and the structures total of $8,695 million in Table 8 has been taken from a recent source.[9] The revised equipment total is not so easily available, for the standard of statistical reporting in this regard has retrogressed since 1945. Although published during the war, government-financed expenditures

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[8]The omission was confirmed by a search through the complete list of all wartime government-financed plant projects, which revealed no nuclear plants at all. See U. S. War Production Board [1945b].

[9]Current data on government-financed industrial construction in U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 6, were compared with wartime figures published in U. S. War Production Board [1945a], pp. 16-17. The more recent figures are about $500 million higher for 1944 and $100 million higher for 1945, and it is assumed that this represents an adjustment for nuclear plants. The total upward revision, about $600 million, is fairly close to our own estimate of wartime nuclear structures expenditures (See Table 9, line 8). There was substantial atomic plant construction in 1943 which is not reflected in a difference between the 1943 figures in the two sources but may have been concealed by offsetting downward revisions in the more recent statistics.

on producers' durables have not been reported separately since then.[10] The latest available wartime report on equipment expansion is dated June 15, 1945, at which time Los Alamos scientists were feverishly struggling to achieve the first A-bomb explosion, and it is safe to assume that Manhattan Project expenditures were excluded.

Accounting procedures in the early nuclear projects were extremely primitive and evidence is hard to find. Fortunately the original cost of atomic energy plant and equipment at the end of 1945 was reported in the official history of the Atomic Energy Commission.[11] The same source also gives a monthly record for 1942-46 of total atomic energy expenditures on the Manhattan Project, which can serve to allocate construction costs to separate years on the crude assumption that the time pattern of construction and operating costs was the same. Nowhere in any official AEC document is the plant total decomposed into separate figures for structures and equipment, but figures are available in the Dawson Committee's inventory of government assets, and these proportions are assumed to apply to wartime expenditures.[12] The resulting total

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[10] The public industrial construction category in the official construction statistics includes some publically-financed government equipment. Telephone conversation with Joseph T. Finn, Bureau of the Census, March 7, 1967.

[11] Hewlett and Anderson [1962], pp. 723-4.

[12] U. S. Congress, House Committee on Government Operations [1960], pp. 20 and 209.

of all government-financed machinery and equipment built during World War II is the sum of reported non-atomic purchases and estimated atomic expenditures, as shown in Table 8.

Some of the government-financed facilities were operated by the government itself and are of no interest here, for their output was not classified in the private sector. Workers in government-operated arsenals and shipyards are on government payrolls, and their wages are part of national income originating in the government sector. A breakdown of plant expenditures by the industry of the operator and, conveniently, by structures and equipment separately is given in a wartime report on facilities authorized through October, 1944. While use of this report may cause some error due to the omission of facilities authorized after October 1944, this is largely offset by the facilities which were authorized but never completed.[13] The value of government-operated plants authorized is taken from this report and raised slightly to allow for facilities in the wartime A-bomb project which were operated by public agencies rather than by private contractors (mainly the Los Alamos testing site operated by the University of California).

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[13]Total government-financed industrial facilities authorized through October, 1944, were 97.5 per cent of total facilities estimated to be in place by the end of 1945. See U. S. War Production Board [1945b], inside front cover, and [1945a], p. 13.

Thus we arrive by subtraction at $15.9 billion in the third line of Table 8, a fairly reliable estimate of the original cost of government-financed plants built during the war for operation by private firms. Since we know the approximate year-by-year distribution of these expenditures between 1940 and 1945, it will be easy later to apply the appropriate price deflators and add the cumulated expenditures to the gross capital stock. But it is much less easy to find out what happened to all of these assets after the war. How many of them were specially built for war purposes and were tossed onto the scrap heap during the post-V-J-day reconversion, and what proportion remained in the capital stock to produce private output after the war?

III. THE POSTWAR DISPOSAL OF WAR-BUILT ASSETS

One method of tracing the disposition of these facilities is obvious--a complete list of the plants and their original cost is available and a man with lots of time and pockets stuffed with airline tickets could set out across the country to find out what has happened to them since 1945. He would find the plants in a variety of uses: some may be producing the same product as in wartime, some may have been transferred to operators in completely different industries or to public agencies, and others may have been subdivided among a number of users.[14] While most of the structures could probably be tracked down in this way, nothing could be discovered about the disposition of the equipment, much of which was removed from government-financed plants and sold after the war to private users (resulting among other things in seven lean years for the U. S. machine tool industry between 1944 and 1951). Also, of course, a great deal of the unsold machinery has by now become obsolete and has been scrapped. Thus our man-in-the-field would be able to obtain information only about structures, and the disposition of government-financed equipment would have to be estimated by indirect methods. Time and money are important constraints, of course, and we shall have to leave traveling expeditions to others. In this chapter we shall employ indirect methods for estimating the postwar disposition of both structures and equipment.

The nature of this undertaking is shaped by the available statistics, which are fragmentary, incomplete, and difficult to

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[14] Consider the varied fates of several aircraft plants. The Lockheed plant in Burbank (Cost: $46 million) was partly sold to Lockheed and partly to smaller companies in other industries. The Consolidated-Vultee plant in San Diego (Cost: $46 million) was used in 1948 by several private companies, the County of San Diego, and the San Diego baseball club. In the 1950's, however, the plant was again producing aircraft. The Boeing plant in Wichita (cost: $32 million) was retained in the ownership of the Air Force for continued production by Boeing. Cost figures are from U. S. War Production Board [1945b], pp. 478-485, and disposition facts from U. S. War Assets Administration [1946-49], Fourth Quarter 1948, pp. 52-74.

use. For reports of postwar sales of structures and equipment we are dependent on the progress reports of the War Assets Administration, a temporary body which vanished in the middle of 1949. Information on sales after this date is almost nonexistent. Many unsold assets have remained in government ownership, and a substantial portion of these have continued to be operated by private firms. Occasional hints about the value of these industrial reserves are scattered through several government publications, but almost always in obscure form. Atomic Energy Commission plants built during the war are much easier to account for, since they have in general remained in government ownership since the war with continued operation by the same private contractors.

The results of the study are summarized in Table 9, which shows that it has been possible to identify the postwar disposition of about 83 per cent of the government-financed facilities built during World War II. The remainder, the "residual" of $2,927 million listed on the bottom line of the Table, represents facilities which were privately operated during the war but not after 1945. Some of these were plants which were taken over by public operators, but most probably represent machinery specially designed for weapons which were never produced again.

The non-residual facilities listed on lines 2 through 8 of Table 9 are merely those which can be traced to one use or another and include a considerable number which are not part of private

TABLE 9

DISPOSITION OF GOVERNMENT-FINANCED STRUCTURES AND EQUIPMENT BUILT FROM JULY 1, 1940 TO DECEMBER 31, 1945
($ Million, Original Cost)

	TOTAL (1)	STRUCTURES (2)	EQUIPMENT (3)
1. Total Wartime Government-Financed Expenditures on Industrial Structures and Equipment	17,641	8,695	8,946
2. Plants Sold to Private Firms through 1954	3,516	2,557	959
3. Synthetic Rubber Plants (Sold in 1955)	488	424	64
4. Machinery and Equipment Sold Separately from Plant (to 6/30/49)	2,447	---	2,447
5. Defense Department Machine Tool Reserve, 1949	650	---	650
6. Plants in Departmental Industrial Reserve, 1949	5,901	4,402	1,499
7. National Industrial Reserve	330	182	148
8. Atomic Energy Construction Through 1945	1,382	630	752
9. Residual. Assumed Scrapped at End of War or Transferred to Public Agencies	2,927	500	2,427

(continued on next page)

TABLE 9 (con'd)

Sources by line:

(1) Structures: Total for 1940-45 from U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 6. 75 per cent of structures built in 1940 assumed to have been put in place in the second half of that year.

Equipment: 1940-1944: U. S. War Production Board [1945a], Table 6, pp. 16-17;
1945: Estimated value published in U. S. War Production Board [1945a], Table 4, p. 13.
Then to these reported non-atomic equipment values was added Project Manhattan equipment expenditures as shown in line 8.

(2) Total: Table 11, p. 123, line 6, plus Table 12, p. 127, line 3.

Structures and Equipment: Line 1 minus lines 3 to 9.

(3) Table 13, p. 130, lines 4, 5, and 6.

(4) Table 14, p. 132, line 6.

(5) Table 14, p. 132, line 5.

(6) Structures: The assumption was made that no structures were built between 1945 and 1950. Strcutures built during World War II are thus the value for 1950 from Table 15, p. 138, column 1, minus the value of structures built before 1940 from Table 16, p. 142, line.5.

Equipment: Same procedure as for structures. Table 17, p. 145, column 1 value for 1949 minus Table 16, p. 142, line 9.

(7) Total: Table 11, p. 123, line 4.

Structures and Equipment: Ratio from Table 15, p. 138, column 2.

(8) Total: Table 20, column 1, value for 1945.

Structures: For source of structures/equipment ratio see Table 23, p. 162, notes to columns 1 and 4.

Equipment: Column 1 minus column 2.

(9) Total: Line 1 minus lines 2 through 8.

Structures: Assumed to be $500 million.

Equipment: Column 1 minus column 2.

capital input. In reviewing the steps used to estimate the categories of Table 9, we shall first concentrate merely on finding war-built facilities in postwar use, and only later will we take the next step of excluding government-operated capital. In the end the amount added to the postwar private capital stock will consist of total wartime construction minus line 9's residual, government-operated capital, and subsequent retirements of worn-out or obsolete assets. Assets sold to private firms are assumed to be indistinguishable from plants built with private financing, and retirements will be calculated later on the assumption that service lifetimes are unaffected by the source of financing. Occasional inventories have been taken of facilities remaining in government ownership, and from these stock estimates it is possible to construct some rough estimates of retirements.[15]

Inevitably our procedure will result in an overestimate of the private capital stock in some years. Some of the included facilities produce only war material and were idle during peacetime, particularly between 1946 and 1950. Perhaps it would have been preferable to distinguish a "war-concept" and "peace-concept" of

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[15]If retirements are only of interest because they must be known to calculate the capital stock, why not just accept the reported stocks of government-owned capital and skip the discard step? Unfortunately all statements of government stocks of plant and equipment, like the private book values of the Statistics of Income, are stated in original cost. Price deflation must be performed if real capital input is to be estimated, and this requires estimates of annual expenditures and retirements.

the capital stock to avoid the illusion that capital was not fully utilized in prosperous postwar years like 1947 and 1948. But from 1951 on weapons production was continuous with remarkably little reduction after the Korean War, so that it would be hard to characterize the interlude between Korea and Vietnam as "peace."[16] Thus our private capital stock includes facilities which may have been more useful in some years than in others, but almost all of which were actually in production during the Korean war.[17]

We now turn to the detailed methods of estimation used to derive the separate categories of Table 9, and these techniques will be discussed in the order in which they appear there.

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[16] The following are Federal government purchases of war goods from private firms (national defense expenditures excluding employee compensation and expenditures on structures ($ billion):

1952	27.1	1959	27.0
1953	30.0	1960	25.9
1954	23.7	1961	27.9
1955	21.5	1962	31.0
1956	23.0	1963	30.0
1957	26.3	1964	28.3
1958	27.2	1965	27.8

Source: U. S. Department of Commerce, Office of Business Economics [1966a], Table 3.11, p. 69.

[17] 92 per cent of the plants in the Departmental Industrial Reserve were in operation in 1952, according to the U. S. Department of Defense Annual Report [1952], p. 40.

Postwar Sales of Real Property

On V-J day the government owned billions of dollars of plants, equipment, and an almost infinite variety of other goods which it no longer needed. Warehouses bulged with trucks and tanks, trousers and toothpicks. More than $27 billion of goods, equal in value to about 15 per cent of the 1946 GNP, was declared surplus by the War Assets Administration, which had been created in 1945 and charged with this immense $27 billion sales job. At the peak of its activity the WAA had almost 60,000 employees busy trying to attract buyers for items in its vast storehouse.

The composition of WAA acquisitions is shown in Table 10, which is drawn from the last report published by the WAA before it closed up shop and disappeared. The "Consumer and Producer Goods" category includes consumer, intermediate, and producer goods. While some are materials like wood or steel which are not part of fixed capital, a substantial amount consists of machinery and equipment which were removed from government-financed plants and producer durables (e.g., trucks) which had been operated during the war by the Army and Navy. "Real Property" includes structures and all equipment therein disposed of with the plant--equipment sold to a separate bidder is classified in the "Consumer and Producer Goods" category. Most of the "Aircraft and Components" category, of course, is made up of combat aircraft which were scrapped (hence the large entry in line 3 under "miscellaneous

TABLE 10

POSTWAR DISPOSAL OF GOVERNMENT PROPERTY BY
THE WAR ASSETS ADMINISTRATION THROUGH JUNE 30, 1949
($ Million, Original Cost)

Category	Acquisitions	Sales	Leases	Miscellaneous Disposals	Property Available For Disposal	Sales Realization	Realization As Per Cent Of Sales
Consumer and Producer Goods	9,719	8,242	---	1,477	---	2,443	29.7
Real Property	7,786	3,771	649	2,630	737	1,211	32.1
Aircraft and Components	7,858	1,798	23	5,643	395	187	10.4
Other	1,835	1,241	---	569	24	304	20.4
TOTAL	27,198	15,052	672	10,319	1,156	4,145	27.5

Source: U. S. War Assets Administration [1946-49], Second Quarter 1949, Tables 1-6, pp. 41-46.

disposals"), but many planes were sold to private firms as airline transports, corporate planes, and training planes in private flying schools and hence should be included in the postwar private capital stock.

By June 30, 1949, as shown in Table 10, the WAA had completed most of its job. More than half of its acquisitions, about $15 billion worth, had been sold for 27.5 per cent of their acquisition cost. The relatively high sales realization for long-lived real property was to be expected, as was the extremely poor return on sales of evanescent aircraft. The WAA's job was made easier by the ease with which free "miscellaneous disposals" out the back door of the store reduced the size of the inventory which had to be sold to paying customers through the front door. About half of the "miscellaneous disposals" consisted of combat aircraft which were junked after the war (proceeds for the sale of scrap metal are not included in either the sales or sales realization column). Other disposals were mainly to public agencies--army hospitals became state hospitals and even school buildings, camps and reservations were transferred to school districkts, and hundreds of army airfields were donated to municipalities, making possible a vast increase in the number of cities receiving commercial air service.[18]

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[18]Because of airport transfers, the bargain-basement sales prices of used air transports, and the release from the armed services of thousands of pilots who had been trained at government expense, much of the postwar private air transport industry was established practically without cost to the private sector.

How many of the assets listed in Table 10 correspond to the government-financed industrial structures and equipment displayed in Table 8? In this section we concentrate first on sales of real property. The $649 million worth of real property on lease in mid-1949 is not taken into account at this stage to avoid double-counting, because these assets reappear in the tabulations below of the government-owned industrial reserve.

There are two main obstacles to an estimate of the war-built industrial facilities which were sold by the WAA. First, the official tabulations, as shown in Table 10, do not subdivide real property into its industrial and nonindustrial components. A substantial fraction of the real property into its industrial and nonindustrial components. A substantial fraction of the real property acquisitions do not represent the industrial plants we are searching for, but rather hospitals, barracks, airfields, and training camps. While most of these were simply given to local governmental agencies, some were sold and are thus included in Table 10 in the $3,771 million total sales of real property. The second difficulty is that not all industrial property was sold to private firms; some was sold to local governments for nonindustrial purposes.

Table 11 outlines the steps necessary to isolate industrial real property sales to private firms. Scattered remarks in the WAA's progress report for the fourth quarter of 1948 suggest that by that time $3,200 million of industrial real property had

TABLE 11

POSTWAR SALES TO PRIVATE FIRMS OF
GOVERNMENT-FINANCED INDUSTRIAL
REAL PROPERTY (INCLUDING EQUIPMENT
SOLD TO SAME BIDDER) AS OF JUNE 30, 1949
($ Million, Original Cost)

1.	Industrial Real Property Acquired by W. A. A.	4,356
2.	Inventory on Lease to Private Firms	614
3.	Remaining Inventory	257
4.	Disposed of to Federal Works Agency for National Industrial Reserve	353
5.	Disposals to other Public Agencies	202
6.	Sales to Private Firms	2,930
7.	Total Sales of Real Property	3,771
8.	Per Cent Industrial	77.7%

Sources by line:

(1) U. S. War Assets Administration [1946-49], Fourth Quarter 1948, p. 6, lists following disposition of real property:

Disposed of	$ 3,200 million
Placed on Lease	679
Inventory	477
Implied Acquisitions	$ 4,356 million

Net acquisitions of real property were negligible between December 31, 1948, and June 30, 1949--see same source, Second Quarter 1949, Table 4, p. 44, column 1.

(2) Total industrial property on lease as of June 30, 1949, is not available. Total real property on lease at the end of the first quarter was $700 million, from U. S. War Assets Administration [1946-49], First Quarter 1949, Table 4, p. 41, column 7, of which $664 million was industrial

(continued on next page)

(p. 4). Applying this industrial/real ratio of 664/700 or 94.6 per cent to total real property leased at the end of the second quarter of $648 million from same source, Second Quarter 1949, Table 4, p. 44, column 7, yields industrial leases of $614 million.

(3) Industrial property inventory as of June 30, 1949 is not available. Industrial property inventory as of March 31, 1949 was $374 million, from U. S. War Assets Administration [1946-49], First Quarter 1949, p. 4. All second quarter sales of $117 million from same source, Second Quarter 1949, Table 4, p. 44, column 4, are assumed to have been industrial. Subtracting, the implied remaining industrial inventory as of June 30 was $257 million.

(4) U. S. War Assets Administration [1946-49], Fourth Quarter 1948, p. 1.

(5) Line 1 minus lines 2, 3, and 4 yields a residual of $3,132 million. This is to be allocated among disposals to public agencies and sales to private firms. U. S. War Assets Administration [1946-49], Fourth Quarter 1948, Appendix D, pp. 52-74 lists 520 representative industrial real property disposals by name of purchaser and proposed use but not by value. I counted 33 disposals to public agencies. Assuming public and private disposals had the same value, 6.4 per cent of the value of disposals was public. This percentage applied to the $3,132 million total residual yields $202 million.

(6) Line 1 minus lines 2 through 5.

(7) U. S. War Assets Administration [1946-49], Table 4, p. 44, col. 4.

(8) Line 6 divided by line 7.

been disposed of either as sales or miscellaneous disposals. Combined with the information that $679 million of industrial property was leased at the same time and that $477 million remained in the WAA's inventory, it is possible to deduce that the total amount of real industrial property acquired by the WAA was $4,356 million (as shown in line 1 of Table 11) or about 56 per cent of the $7,786 million of all real property acquisitions (the latter figure is listed in Table 10). There were practically no real property acquisitions over the first six months of 1949, so that the estimated figure of $4,356 million for the end of 1948 is assumed to apply equally to June, 1949.

The next step is to estimate the disposition of the industrial assets acquired by the WAA. No information is available on leases and inventory at the end of the second quarter of 1949 (typical of the disorganized style of the WAA reports), so that the first quarter information has to be extrapolated, yielding figures for leases and inventory, respectively, of $614 million and $257 million (as shown in lines 2 and 3 of Table 11). Another important destination for government-owned plants was the new "National Industrial Reserve", created in 1948 as the tightening Russian grasp on Eastern Europe spurred American officials to start thinking about the threat of another war. As shown in line 4, $353 million in plants were transferred in late 1948 to the Federal Works Agency to be maintained as reserve facilities in continual readiness to convert quickly for war production. The reserve was established to prevent important plants being permanently converted from military to civilian production.

Of total industrial acquisitions of $4,356 million, $1,224 million is accounted for by mid-1949 inventory, assets on lease, and the Industrial Reserve. It is more difficult to be absolutely sure about the disposition of the remaining $3,132 million. Fortunately, the WAA progress report for the fourth quarter of 1948 published a long list of "representative industrial real property disposals," showing the name of the purchaser and the proposed use. No value figures were given for the listed plants, but it is possible to count up the number of plants which were sold to private industrial users--about 93 per cent. On the assumption that the average value of plants sold to private firms and disposed of to public agencies was the same, the remaining $3,132 million can be divided into $202 million of miscellaneous disposals and $2,930 of sales to private firms (as shown in lines 5 and 6).

Were any sales made after June 30, 1949? A table in one of the 1955 Hoover Commission task force reports listed sales of industrial real property for fiscal years from 1950 to 1954. As shown in Table 12, we take this sales total and assume that the same percentage was industrial as in the WAA reports, resulting in an additional $586 million of sales after the WAA shut its doors in mid-1949. Almost all of these sales were in fiscal 1950, for surplus plants were retained for production after the Korean

TABLE 12

POSTWAR SALES TO PRIVATE FIRMS OF
GOVERNMENT-FINANCED INDUSTRIAL REAL PROPERTY
(INCLUDES EQUIPMENT SOLD TO SAME BIDDER) FROM
JUNE 30, 1949 TO JUNE 30, 1954
($ Million, Original Cost)

1.	Total Sales of Real Property	755
2.	Ratio of Industrial Real Sales to Total Real Sales as of June 30, 1949	.777
3.	Total Sales of Real Industrial Property	586

Sources by line:

(1) U. S. Commission on Organization of the Executive Branch of The Government [1955], Table II-12, p. 47, col. 2.

(2) Table 11, line 8.

(3) Line 1 times line 2.

war broke out at the end of the fiscal year. WAA sales of $2,930 calculated in Table 11 and the post-1949 figure of $596 million from Table 12 together equal $3,516, the grand total for industrial real porperty sales listed in the summary Table 9. The subtotals for structures and equipment in this category are obtained as a residual after all the other categories have been estimated.

Postwar Sales of Synthetic Rubber Plants

At the close of the war the government owned 44 synthetic rubber plants which had cost $670 million to build during the preceding four years.[19] These plants contributed almost 100 per cent of our rubber supply after the Japanese conquest of Malaya in 1942. Disposal of the plants was delayed for many years after the war because of uncertainty about the future price of natural rubber. It was difficult to determine how much of the capacity should be kept in active operation when it was not known whether synthetic rubber could be permanently sold at a profit.

Eventually the doubt about the future of synthetic rubber was resolved in 1950 when natural rubber prices spiralled to many times the cost of the synthetic article. Synthetic production mounted rapidly and by 1951 amounted to over 50 per cent of the toal U.S. rubber supply.[20] Finally, in 1955, almost all of

[19] Cook [1948], pp. 24-26.

[20] Director of Defense Mobilization [1951-53].

the remaining capacity was sold. Most of the sales were to the firms which had operated the plants since they were first built during World War II. These firms had operated the plants without interruption for ten years or more, for even at its low point in 1949 synthetic rubber capacity utilization was about 50 per cent and government policy was to operate all plants at half-throttle rather than to close down any facilities.[21]

A 1956 M.I.T. M.S. thesis describes the sale of the synthetic rubber plants, the original cost of which is stated to be $488 million. The division of this total into structures and equipment is based on an estimate by Wasson, as outlined in Table 13.

Machinery and Equipment Sold Separately from Plant

Part of the government's $17 billion wartime investment in facilities was spent on machinery which was subsequently removed from its wartime location and sold. These assets were submerged by the WAA reports within the much larger class of Consumer and Producer Goods. In earlier WAA reports producer goods were shown separately from consumer goods, but this is little help because the WAA definition is inappropriate for our needs. WAA "producer goods" include not just finished machinery and equipment but also intermediate goods like steel plate. In addition the "consumer goods"

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[21]Production figures from Director of Defense Mobilization [1951-53], April 1, 1951, p. 16. Government policy discussed in U.S. War Assets Administration [1946a], p. 3.

TABLE 13

SALES OF EQUIPMENT AND STRUCTURES
IN THE SYNTHETIC RUBBER INDUSTRY
($ Million, Original Cost)

1.	Sales Price of Synthetic Rubber Plants	310
2.	Value of Structures Sold	269
3.	Value of Equipment Sold	41
4.	Original Cost of Plants Sold	488
5.	Original Cost of Structures Sold	424
6.	Original Cost of Equipment Sold	64

Sources by line:

(1) Salisbury [1956], p. 50.

(2) Wasson's total for gross expenditures on manufacturing structures for most years agrees closely with the total shown in the Annual Survey of Manufactures. In 1955, however, the Wasson figure is $269 million higher. Questioned about this discrepancy, Wasson attributed it to the sale of the synthetic rubber plants.

(3) Line 1 minus line 2.

(4) Salisbury [1956], p. 50. This value corresponds exactly to the value of the synthetic rubber plants held by the government in 1946, as reported in U. S. War Assets Administration [1946a].

(5) Ratio of line 2 to line 1, times line 4.

(6) Line 4 minus line 5.

category cannot be ignored, because it contains several items of machinery, e.g. farm tractors.

Our estimate of the machinery segment of Consumer and Producer Goods depends entirely on a detailed breakdown of early WAA acquisitions by three-digit industry published in 1946. We are forced to assume that the pattern of sales to June, 1949, was the same as that of acquisitions up to February 28, 1946. Only for machine tools is it possible to take account of a differing time pattern of disposals. The extrapolation of the 1946 figures is probably not an important source of error, for, unlike real property, very few consumer and producer goods were "miscellaneous disposals" and most were sold to private buyers.

The technique of estimation, as presented in Table 14 is simply to add up the value of all types of machinery acquisitions from the detailed, three-digit industry list. This sum is then blown up by the ratio of total 1945-49 WAA sales of consumer and producer goods to total early acquisitions, and a deduction of $650 million is made for equipment withdrawn in 1948-49 into a government-maintained machine tool reserve. (Machine tools had been one of the main bottlenecks of World War II production, and the increasing tension of the Cold War in 1948 induced officials to begin planning ahead for another big war.) The $650 million estimate is based on reported statements of the number of tools withdrawn multiplied by implicit price per tool. The final adjustment is a substantial deduction for foreign sales, which is arbitrary

TABLE 14

MACHINERY AND EQUIPMENT FINANCED
BY THE FEDERAL GOVERNMENT IN WORLD WAR II
AND SOLD TO PRIVATE BUSINESS BEFORE JUNE 30, 1949
($ Million, Original Cost)

1.	Total Sales of Consumer and Producer Goods to June 30, 1949	8,242
2.	Total W. A. A. Acquisitions of These Goods as of February 28, 1946.	2,776
3.	Machinery Estimated Acquired as of February 28, 1946	1,015
4.	Other Producers' Durables Acquired by the W. A. A. as of February 28, 1946	538
5.	Transfers of Machine Tools to U. S. Department of Defense	650
6.	Total Sales of Machinery to June 30, 1949	2,447
7.	Exports and Sales to Public Agencies	735
8.	Total Domestic Private Sales of Machinery to June 30, 1949	1,712
9.	Total Domestic Private Sales of Other Producers' Durables to June 30, 1949	1,119
10.	Of Which:	
	a. Manufacturing	181
	b. Nonfarm Nonmanufacturing	816
	c. Farm	122

Sources by line:

(1) U. S. War Assets Administration [1946-49], Second Quarter 1949, Table 3, p. 43, column 4.

(continued on next page)

(2) U. S. War Assets Administration [1946-49], First Quarter 1946, Table 6, p. 47, col. 1, plus Table 8, p. 59, col. 1.

(3) A detailed classification of the value of consumer and capital goods acquired by three-digit industry is given in U. S. War Assets Administration [1946-49], March 1946, Table 18, pp. 69-78. Machinery assumed acquired from government-financed plants was calculated from the total of the following categories: Fabricated Metal Basic Products, General Purpose Industrial Machinery and Equipment, Electrical Machinery and Apparatus, Special Industry Machinery, Metalworking Machinery, Instruments, and Miscellaneous Unclassified Capital Goods.

(4) Same source as line 3, the total of Agricultural Machinery, Construction Machinery, Tractors, Office Machines, Communication Equipment, Railroad Equipment, half of Motor Vehicles excluding Combat Vehicles and Motorcycles, all Full and Semi-trailers except Ordnance, Ordnance Service and Repair Trucks and Trailers and Combat Motor Vehicles, Air-conditioning and Refrigeration Equipment, Lighting Fixtures, and Office Furniture.

(5) Estimate of number of machine tools transferred through June 30, 1949, is 145,000 from U. S. Department of Defense Annual Report [1949], p. 76. The estimated average value per machine was $4,150, derived by dividing total transfers through the end of 1947 of $262 million by the total of 63,105 units transferred, both from U. S. War Assets Administration [1946-49], Fourth Quarter 1947, p. 6.

(6) Ratio of line 3 to line 2, times line 1, less line 5.

(7) Assumed 30 per cent of line 6. No evidence is available, but the $735 million estimate looks reasonable in the light of total 1945-49 exports of used machinery of $284 million, from U. S. Department of Commerce, office of Business Economics [1966a], Table 5.4, pp. 84-85. The exports are valued at their sales price, of course, and the total would be higher when valued in original cost. One offsetting factor is that some exports were of used machines originally financed by private firms before or during World War II rather than by the government.

(8) Line 6 minus line 7.

(9) Ratio of line 4 to line 2, times line 1, less 30 per cent to account for exports and sales to public agencies.

(10) Allocated to sectors in proportion to each sector's total equipment expenditures in 1947, from U. S. Department of Commerce, Office of Business Economics [1966b], p. 48.

but at least appears from export statistics to be roughly the right order of magnitude.[22]

The Departmental Industrial Reserve

Lines 2 through 5 in Table 9 on p. 115 summarize the results of our study of the WAA data. They are quite surprising, for postwar sales account for only about $7.1 billion, less than half of the wartime government-financed industrial facilities expansion of $17.6 billion. Where are all of the missing plants? There is no mention in any of the WAA progress reports of the billions of dollars worth of plants which were built during the war but were never acquired by the WAA.

After a long search some evidence on the missing plants has been found, allowing a crude estimate of their value and date of construction. The study reveals an enormous industrial empire which most economists have never heard of. The industrial plants owned by the Department of Defense, called the Departmental Industrial Reserve (DIR), had a 1960 book value of more than $11 billion of structures and equipment. Since many of the plants were constructed decades ago, this original cost valuation is a coniserable understatement of replacement cost. The DIR includes many plants operated by private firms in addition to the government

[22]Export statistics cannot be used as-is, for they value the goods at the sales price, which as we have seen is less appropriate than an original cost valuation for the purpose of constructing a capital stock estimate.

operated arsenal system and Navy industrial facilities. Most of the plants were built during World War II, and the facilities constructed before 1939 are mainly old government-operated arsenals (most established between 1777 and 1863). The plants are retained in government ownership to assure supplies of essential weapons and explosives in wartime without any lag for the construction of new plants or the conversion of civilian factories, as was necessary during the early days of World War II. About 80 per cent of the value of the DIR is accounted for by four industries--explosives and ammunition, weapons, aircraft, and shipyards. The aircraft industry, in particular, is a virtual ward of the government, having contributed only about 10 per cent of the funds for its own expansion in World War II and only about one-third for Korea.[23]

The DIR showed its worth in the Korean war, when defense purchases on ordinance and weapons suddenly inundated the economy. It often seems surprising that American manufacturing output was able by 1953 to climb 40 per cent over its 1948 level, when the earlier year had appeared at the time to be characterized by shortages and full capacity operation.[24] Part of the climb in

[23]The general description in these paragraphs is based on U.S. Commission on Organization of the Executive Branch of the Government [1955], pp. 61-62.

[24]The production comparison is based on the U.S. Federal Reserve Board Index of Industrial Production for the manufacturing sector, Economic Report of the President [1967], Table B-32, p. 250.

capacity, of course, was due to new construction between 1948 and 1953, but a substantial amount was due to the reactivation of DIR plants, many of which had rested dormant since World War II. Reactivated DIR plants, for instance, added 10 per cent to aluminum capacity in 1951, contributed substantially to increased nitrogen production, and counnted for almost all of the Korean war increase in magnesium production.[25] The number of aircraft plants in operation doubled between 1950 and 1953 as old DIR plants came into the active list again. "Such famous World War II aircraft plants as those at Marietta, Ga., Tulsa, Okla., and Kansas City are again in production."[26] By 1952 92 per cent of the DIR plants were in operation, as opposed to only around 60 per cent in 1950.[27]

The DIR plants have remained unknown because of the incredibly primitive statistical reporting standards of the Department of Defense. In most cases government regulation increases statistical information available to the public, but government ownership is often an excuse for secrecy. In the case of the Department Industrial Reserve practically no solid information is available. For many years the Department of Defense Annual Reports stated only

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[25]Director of Defense Mobilization [1951-53], January 1, 1952, pp. 15-17.

[26]Director of Defense Mobilization [1951-53], January 1, 1953, p. 27.

[27]Department of Defense Annual Report [1952], p. 40.

the number of the plants (subdivided into three classes--government-operated, private-operated, and inactive), not their value, and after the arrival of the New Frontier in 1961 even this regular information seems to have disappeared. The complicated methods used here to guess some basic facts about the DIR are made necessary by the vagueness and erratic appearance of official information. Our aim is twofold--first, in order to complete our search for World War II plants, we need to know how many of the plants in the DIR in the mid-1950's were built between 1940 and 1945. Second, of course, we must decide how much of the expansion in the value of the DIR after the beginning of the Korean war represented growth in the capital input of private contractors.

The calculations for structures are shown in Table 15. The book value of DIR structures is available from Department of Defense Annual Reports for 1957 and 1960 but not for other years. The Hoover Commission gives a value figure for the end of 1953 for 249 of the 304 DIR plants, and this can be blown up to a total for all plants on the assumption that the plants omitted in the Task Force report have the same average value as the included plants. The 1953, 1957, and 1960 figures are shown in Column 1 of Table 15 and can be considered fairly reliable. Turning to the sources for expenditures in Column 2, it is surprising to learn that the available statistics are faulty--DIR construction expenditures are not readily available and must be estimated. The official government-financed industrial construction series, as published in the

TABLE 15

DEPARTMENTAL INDUSTRIAL RESERVE
STRUCTURES
($ Million, Original Cost)

Year	Stock of Structures (1)	Expenditures on Structures (2)	Apparent Sales or Retirements (3)
1949			
1950	4,780		
1951		120	
1952		350	
1953	5,600	350	
1954		290	- 70
1955		95	- 70
1956		95	- 70
1957	5,900	100	- 70
1958		50	
1959		100	
1960	6,150	100	

Sources by column:

(1) 1950: On the assumption of no retirements during the Korean War between 1950 and 1953, expenditures in column 2 for 1951-53 are subtracted from the 1953 stock value in column 1.

1953: For 1953 the U. S. Commission on the Organization of the Executive Branch of the Government [1955], p. 3, reports that 44.8 per cent of the industrial reserves consisted of equipment and 55.2 per cent of struc tures. Applying the structures percentage to total DIR structures and equipment of $8,330 million (same source, p. 63) yields $4,580 million for DIR structures in the Commission report. But only 249 plants are included in the Commission report, whereas the Department of Defense Annual Report [1953] lists 304. The Commission structures total is thus raised to allow for 304 plants rather than 249, assuming the same value of structures per plant. This yields a structures total of $5,600 million (304/249 times $4,580 million).

TABLE 15 (con'd)

1957 and 1960: Figures given explicitly in U. S. Department of Defense Annual Report, various issues.

(2) 1951-57: U. S. Department of Defense Annual Report [1957], p. 44 states that since 1950 the Department had spent $1.5 billion on plant facilities (excluding equipment). This total is spread over the years 1951-1957 in proportion to annual Defense Department expenditures on industrial structures as given in U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 6 (after deduction of AEC construction as given in Table 20, p. 156, column 2.)

1958-60: Assuming no retirements, expenditures are the amount necessary to bring the reported stock from the 1957 to the 1960 level.

(3) 1954-57: Cumulative expenditures in column 2 less growth in stock from column 1, spread evenly over the four years.

NIP accounts, is a surprisingly untrustworthy series. Much of the total is accounted for by Atomic Energy Commission (AEC) construction, but the AEC construction figures include all producers' durable equipment purchased as well as structures built![28] Thus the public industrial construction series is a considerable overestimate of actual spending on structures. Another problem is that the official NIP statistics on Department of Defense industrial construction, obtained by subtracting AEC expenditures from public industrial construction, do not agree with statements in the Department of Defense Annual Report. For 1951-57 the subtraction method yields construction expenditures of $2.3 billion, but the 1957 Annual Report states the total to have been $1.5 billion (p. 44). For the estimates in Table 15 the latter figure was chosen, because it was clearer from context that all equipment purchases had been omitted, and the $1.5 billion was spread over the years 1951-1957 in proportion to the annual NIP figures obtained by the subtraction method.

The stock of structures in 1953, 1957, and 1960, and construction between 1951 and 1957 are the only entries in Table 15 based on published reports, and all of the remaining figures are derived from these. Retirements between 1953 and 1957 are the difference between the growth of the stock in column 1 and investment expenditures in column 2, and they are arbitrarily assumed to be the same each year. The small post-1957 growth in the stock was assumed to be due to new investment, and no retirements were assumed because of the small

[28] Telephone conversation, Joseph T. Finn, Bureau of the Census, March 7, 1967.

amounts involved. The 1950 stock was obtained by subtracting 1951-53 investment from the 1953 stock on the assumption that the pressing demands of war production during this period prevented any retirements.

Our aim has been to discover how many unsold war-built plants remained in the capital stock after the war. The $4,780 of DIR structures in 1950 is an overestimate of the plants built during 1941-45 because some were built during other years. There was practically no public industrial construction between 1945 and 1950, but it is necessary to make an estimate of the structures which were built before 1940. This procedure is explained in Table 16 and is based on the assumption that all of the plants built before 1940 or after 1945 were government-operated. This seems reasonable, for in the early years the DIR consisted almost exclusively of Army arsenals and Navy-operated defense plants, leaving the government to finance only government-operated plants. Since information is available on government-operated plants built between 1940 and 1945, it is easy to deduce the value at original cost of the plants built before 1940.[29]

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[29]The resulting estimate of $378 million is shown in Line 5 of Table 16. It appears to be roughly the right order of magnitude, for the Commission Report [1955] states that 10 per cent of the 1953 DIR plants were acquired before 1939. 10 per cent of the $5,660 million stock of structures in 1953 (Table 15) would be $566 million, but the actual book value of these facilities would have been considerably less since they would have been built when construction costs were lower.

TABLE 16

DEPARTMENTAL INDUSTRIAL RESERVE
STRUCTURES AND EQUIPMENT
OPERATED BY THE GOVERNMENT
($ Million, Original Cost)

Structures:	
1. Structures and Equipment in Government-Operated Plants in 1955	4,430
2. Structures in Government-Operated Plants in 1955	2,445
3. Structures in Government-Operated Plants in 1950	1,380
4. Built 1940-1950.	1,002
5. Built before 1940.	378
Equipment:	
6. Equipment in Government-Operated Plants in 1955	1,985
7. Equipment in Government-Operated Plants in 1950	595
8. Equipment Built 1940-1950	594
9. Built Before 1940	1

Sources by line:

(1) According to the U. S. Department of Defense Annual Report [1955], p. 35, the Departmental Industrial Reserve contained 70 government-operated plants. The U. S. Commission of the Organization of the Executive Branch of the Government [1955], Table III-13, p. 72, states that 46 government-operated plants in 1953 had an acquisition cost of $2,910 million, or $63.3 million per plant. Applying this average value to the 1955 total

(continued on next page)

TABLE 16 (con'd)

of 70 plants results in a 1955 value of $4,330 million.

(2) U. S. Commission on the Organization of the Executive Branch of the Government [1955], p. 3, reports that structures accounted for 55.2 per cent of the industrial reserve. Applying this fraction to the government-operated portion yields a total of $2,445 million.

(3) Assuming all structures expenditures and retirements between 1950 and 1955 (as shown in Table 15) applied to government-operated structures, the value of structures increased by $1,065 million. Subtracting this from the 1955 value of $2,445 million yields a 1950 value of $1,380 million.

(4) Value built between 1940 and 1945 approximated by value authorized in October, 1944, from U. S. War Production Board [1945b], inside front cover. It was assumed that no structures were built between 1945 and 1950.

(5) Line 3 minus line 4.

(6) Line 1 minus line 2.

(7) The proportion of government-operated equipment in 1955 was $1,985 million (line 6) divided by $5,000 million (Table 17, p. 145, column 1, value for 1955), or 39.6 per cent. Applying this percentage to total 1950-1955 equipment expansion of $3,500 million (from Table 17) yields a government-operated equipment share of $1,390 million. This is then subtracted from line 6 to yield $595 million.

(8) Same source as line 4.

(9) Line 7 minus line 8.

Subtracting this estimate of $378 million from the 1950 book value of DIR structures of $4,780 million yields the $4,402 million of government-financed industrial structures built during World War II which were in the DIR in 1950.

Thetreatment of equipment is similar and is explained in Table 17. The stock of equipment for 1953 and later years is based on published reports and is available more frequently than figures on the stock of structures. Total 1951-57 equipment investment was reported in the 1957 Department of Defense <u>Annual Report</u>, and is distributed annually in proportion to expenditures on structures. For the years after 1957 retirements are estimated at roughly their 1951-57 annual average rate, and expenditures are then the sum of retirements and the annual change in the stock. In addition to expenditures on new equipment, another source of post-1950 equipment expansion was the $650 million machine tool reserve which in 1948 had been withdrawn by the Army and Navy from the War Assets Administration's inventory. When the Korean war broke out these tools helped to overcome a severe machine shortage, and after the Korean War this special machine tool reserve was no longer reported separately and the tools were probably merged into the overall reports on industrial machinery owned by the Department of Defense.[30] The calculations in Table 17 allow us to estimate the 1950 stock of

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[30] Department of Defense, <u>Annual Report</u> [1953], p. 43.

TABLE 17

DEPARTMENTAL INDUSTRIAL RESERVE
EQUIPMENT
($ Million, Original Cost)

Year	Stock of Equipment	Machine Tool Reserve	Expenditures on Equipment	Apparent Sales or Retirements
	(1)	(2)	(3)	(4)
1949	1,500	650		
1950				
1951			500	- 50
1952			1,450	-150
1953	4,550	650	1,450	-150
1954			600	-500
1955	5,000		200	-500
1956			200	- 50
1957	5,300		200	- 50
1958	5,500		300	-100
1959	5,300		0	-200
1960	5,200		100	-200
1961	5,200		200	-200
1962	5,750		750	-200
1963	5,950		400	-200

Sources by Column:

(1) 1949: The U. S. Department of Defense Annual Report [1949], p. 329, states that the acquisition cost of all plants in the National Industrial Reserve (NIR) and Departmental Industrial Reserve (DIR) was $7,787 million. The closest year for which the number of plants in the NIR could be determined was 1952, when the total was 181 (Annual Report [1952], p. 40). In the U. S. Commission on the Organization of the Executive Branch of the Government [1955], p. 63, the average cost in 1953 of the remaining NIR facilities was $8.5 million. Applying this average value to 1952 NIR plants yields a total acquisition cost for plant and equipment of $1,530 million. Assuming that this is a valid approximation for 1949, since no new plants were built for the NIR during this period, this value is subtracted from $7,787 million to yield a DIR structures and equipment

TABLE 17 (con'd)

total of $6,257 million. Structures, from Table 15, column 1 for 1950, are subtracted, yielding an equipment total of $1,477 million, which is rounded up to $1,500 million to avoid the illusion of accuracy.

1953: Same method as Table 15, column 1 for 1953.

1955, 1957-1960: Values reported in Department of Defense Annual Report, various issues.

1961-1963: After practically no change for years, the reported 1961 value for equipment jumped from $5.2 billion to $7.6 billion. It is assumed that this does not represent a real change but rather a switch in definition initiated by New Frontier bureaucrats. The 1961 figure was linked to the reported 1960 figure, and the 1962-1963 data were adjusted proportionately.

(2) See Table 14, p. 132, line 5.

(3) 1951-1957: The U. S. Department of Defense Annual Report [1957], p. 44 stated that since 1950 the Department had spent $4.4 billion on industrial equipment. This total is spread over the years 1951-57 in proportion to annual Defense Department expenditures on industrial structures as given in U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 6 (after deduction of Atomic Energy Commission construction as given in Table 20, column 2), with the additional stipulation that 3/4 of this equipment expenditure was assumed to have occurred before the end of 1953.

1958-1963: Rough estimates, given the reported stock data in column 1 and the assumption that retirements were about the same each year at $200 million.

(4) 1951-1957: The difference between the reported $4,400 billion expenditure and the $2,850 million change in the value of stocks was distributed arbitrarily over the period on the assumption that retirements would have been highest at the end of the war.

1958-1963: In lieu of evidence an arbitary assumption was made.

government-owned machinery, almost all of which appears to have been built after 1940.

Summary of Postwar Disposition of War-Built Structures and Equipment

With the addition of the DIR plants our job of accounting for the whereabouts of government-financed industrial facilities built during World War II is nearly complete. Two additional categories are listed on lines 7 and 8 of the summary Table 9 on p. 115. A smaller plant reserve, the National Industrial Reserve (NIR) was managed by the General Services Administration and its composition is reported separately. All plants in the $330 million total are assumed to have been built during World War II--none was built nor acquired later. In the next line are listed the production plants owned by the Atomic Energy Commission which were built during the frantic 1943-45 rush to develop a working A-bomb. These facilities have all remained in AEC ownership and private operation throughout the postwar period. The AEC structures-equipment breakdown is based on 1960 data and is subject to a large margin of error.

The residual in line 9 of almost $3 billion represents assets not accounted for by our search and includes buildings and equipment both scrapped and disposed of to public agencies. The decomposition of the residual into structures and equipment estimates rests on the simple presumption that equipment was much more likely to have been scrapped than factory buildings; machinery may have been built for a specialized war-time role, whereas structures are generally adaptable. An arbitary $500 million guess of the value of residual structures allowed estimates to be made for residual equipment and for the structures-equipment breakdown of plants sold to industrial firms (line 2).

IV. FACILITIES WHICH BEGAN PRIVATE OPERATION AFTER 1945

The completed estimates of the disposition of World War II plants, summarized in Table 9 on page 115, will be used again at the end of the chapter when we shall sort out the facilities which remained in private operation after the war. First, however, we must take account of several other classes of assets which were not included in wartime industrial facilities expansion but which have entered the private capital stock since the end of the war. These consist of assrted producers' durables other than manufacturing machinery which were sold to private firms by the War Assets Administration, and also new Department of Defense and Atomic Energy Commission facilities built after 1945.

Other Producers' Durables Sold by the Government

Many goods used in combat operations by the Army and Navy were useful articles in peacetime, especially construction and mining machinery, office equipment, railroad locomotives, trucks, and electronic equipment. We estimate sales of these items to private firms in exactly the same way as manufacturing production machinery in the previous section. A detailed list of WAA acquisitions by three-digit industry was published in early 1946. The goods which appeared to be producers' durables (and which had not been previoulsy counted as sales of manufacturing machinery) are tallied up, and the resulting sum is blown up to allow for later acquisitions and sales. As before, a 30 per cent deduction is made for sales to public agencies and overseas. The resulting estimate of sales to domestic private firms is $1,119 million, as shown in Table 14 on page 132.

The previous sections of this chapter were concerned with the disposition of war-built manufacturing plants, and none of the structures and equipment were allocated to the farm of nonfarm nonmanufacturing (NFNM) sector. Obviously this is necessary for "other producers' durables," which in line 10 of Table 14 are divided among the three sectors in proportion to the expenditures on each type of new equipment by sector in 1947 (from Wasson's unpublished annual breakdown--U.S. Department of Commerce, Office of Business Economics [1966b]).

Aircraft sales were classified separately by the WAA. The vast majority of World War II planes were combat types and were scrapped in 1946, but the WAA managed to sell over $1 billion of small training and reconnaissance plans and larger transport craft. A WAA study, The Buyers of Surplus Aircraft, disclosed the distribution of early sales between private individuals and other purchasers. The 1946 proportion of sales to individuals is adjusted in Table 18 for the obvious fact that individuals bought smaller planes than firms, and an estimate of sales to persons is then deducted from the 1945-49 WAA sales total. A further deduction of 40 per cent is then made for exports and sales to local government, leaving $535 million, slightly less than half of total sales, as our estimate of sales to domestic private industry. All of these sales are assumed to be in the nonfarm nonmanufacturing sector, which includes airlines, aviation training schools, and other important purchasers.

Industrial Facilities Built After 1945 for Private Operation

Estimates for Department of Defense facilities constructed after 1945 were estimated previously (see pp. 134-47), when we were tracing the disposition of government-financed plants built during the war. The expansion of privately-operated Department of Defense facilities appeared to be concentrated in equipment; the construction of new structures was fairly limited and seemed to be largely for government-operated facilities. The Atomic Energy Commission (AEC), however, financed a large program of postwar construction, the bulk of it in the years 1951-55. The huge production complexes originally built during World War II at Oak Ridge and Hanford were joined by many new facilities, including three which cost more than $750 million apiece. Production facilities have not been expanded much since 1956, but recently there has been a substantial amount of construction of research facilities, many of

TABLE 18

AIRCRAFT SOLD TO DOMESTIC PRIVATE FIRMS AFTER WORLD WAR II ($ Million, Original Cost)

1.	Total Sales of Aircraft by W. A. A. as of June 30, 1949	1,141
2.	Percentage of Sales to Private Firms and Institutions	78%
3.	Sales to Private firms and Institutions	892
4.	Sales to Domestic Private Firms and Institutions	535

Sources by line:

(1) U. S. War Assets Administration [1946-49], Second Quarter 1949, Table 5, p. 45, column 4.

(2) The disposition of early aircraft sales is reported in U. S. War Assets Administration [1946b], p. 2. Of the total of 16,097 planes sold up to that time, 5,142 had been sold to private individuals and the remainder to firms and institutions. The ratio fo business to total sales was thus .683. Assuming each plane sold to business cost origiaally twice as much to build as the planes sold to private individuals, this ratio is raised to .78.

(3) Line 1 times line 2.

(4) Line 3 minus an arbitrary 40 per cent decuction for sales to state and local governments and overseas.

which are operated by private institutions (e.g., Harvard and M. I. T.).

Since 1950 the AEC has published an annual financial report which, despite all of its deficiencies, puts the Defense Department to shame. Each year figures are reported for plant and equipment expenditures and the book value of production plants, research labs, and other facilities. In recent years the reports have included a complete list of all AEC facilities, showing for each the book value of completed projects and the cost of work under construction. While the AEC information is more adequate than most in this chapter, there are nevertheless several deficiencies which force us to make some guesses. The years before 1950 are a statistical Dark Age on which practically no information exists. Accounts were in chaos in early 1947 when the AEC inherited its multi-billion dollar legacy from the Army-managed Manhattan Project. Four years were necessary for accountants to unravel the tangle before the first financial report was published in 1951. In addition to the lack of data before 1950 none of the AEC reports makes any distinction between structures and equipment. All of our estimates which divide AEC expenditures between structures and equipment are based on a single inventory taken for the Dawson committee in 1960. Finally, we must make an attempt to identify facilities which are privately operated and which thus contribute to private output from those which, operated by state universities or the AEC itself, belong in the government sphere. To make proper amendments to the OBE Capital Goods Study the private facilities must be further subdivided into manufacturing and non-manufacturing locations. While some of the estimating procedures may seem arbitrary, they are certainly preferable to the current practice, which is to ignore the AEC facilities entirely. And the sums involved are not trivial, for the total book value of AEC in 1965 was over $8 billion in original cost, and the replacement cost was considerably greater.

The steps in our estimating procedure are displayed in Tables 19 through 23. The first step, shown in Table 19, is simply to calculate retirements as the difference between expenditures and the yearly change in the book value of plant and equipment. For this purpose book value includes construction work in progress but not completed, just as construction expenditures include spending on incompleted plants. For the pre-1950 era we are limited to a single book value figure for late 1945 printed in the official history of the AEC, and a rough estimate of the annual distribution of pre-1946 construction expenditures based on AEC purchases for both construction and operating purposes. Next, in Table 20, the fiscal year values are converted into calendar year figures to be comparable with our other data.

The complications begin in Table 21, where an attempt is made to establish the distribution of facilities between the manufacturing, NFNM, and public sectors. The first is easy, since AEC reports give the annual book value of "production plants." The other two classes pose a difficult problem, for the AEC distinguishes between research labs and "other facilities", each operated both by

TABLE 19

ATOMIC ENERGY COMMISSION
PLANT AND EQUIPMENT EXPENDITURES
ON FISCAL YEAR BASIS
($ Million, Original Cost)

Year	Investment in Plant and Equipment	Plant Construction Expenditure	Retirements
	(1)	(2)	(3)
1942*		11.7	
1943*		250.0	
1944*		680.0	
1945*	1,382.0	440.3	
1946		177.3	
1947		75.0	
1948		205.0	- 226.1
1949	1,891.2	338.0	
1950	2,104.4	256.1	- 42.9
1951	2,516.0	459.2	- 47.6
1952	3,497.0	1,082.2	- 101.2
1953	4,579.1	1,125.6	- 43.5
1954	5,705.4	1,215.1	- 88.8
1955	6,487.3	842.5	- 60.6
1956	6,713.1	301.7	- 75.9
1957	6,907.9	317.0	- 122.2
1958	7,110.9	289.7	- 86.7
1959	7,292.8	299.0	- 117.1
1960	7,344.8	331.5	- 279.5
1961	7,664.7	432.7	- 112.8
1962	7,869.3	423.8	- 219.2
1963	8,233.5	409.1	- 44.9
1964	8,578.2	376.9	- 32.2
1965	8,871.0	371.5	- 78.7

*Note: The years 1942-45 are on a calendar year basis.

Sources by column:

(1) 1945: Hewlett and Anderson [1962], p. 723.

1949-1965: U. S. Atomic Energy Commission Annual Report,

(continued on next page)

TABLE 19 (con'd)

various issues. In these reports the total book value of plant and equipment includes construction in progress, and the figures thus differ from Table 21, column 5, which excludes this item.

(2) 1942-1946: Hewlett and Anderson [1962], p. 724, gives monthly expenditures for both construction and operations. The 1942-45 totals are given on p. 723. The four-year average ratio of construction to total expenditures is 72.5, and this is applied to the monthly totals to yield annual expenditures on plant and equipment.

1947: (first half). Estimated on basis of statement (in U. S. Atomic Energy Commission *Fourth Semiannual Report*, that construction was slow in 1947.

1948-1949: Estimated values from *Fifth Semiannual Report*, 1948, p. 35, and *Seventh Semiannual Report*, 1949, p. 28.

1950-1965: *Annual* and *Semiannual Reports*, financial reports, various issues.

(3) 1942-1945: Assumed no retirements.

1946-1965: Column 1 minus the difference between the value in column 1 for the current year and its value in the previous year.

TABLE 20

ATOMIC ENERGY COMMISSION
PLANT AND EQUIPMENT EXPENDITURES
ON CALENDAR YEAR BASIS
($ Million, Original Cost)

Year	Investment Plant and Equipment	Plant Construction Expenditure	Retirements
	(1)	(2)	(3)
1942		11.7	
1943		250.0	
1944		680.0	
1945	1,382.0	440.3	
1946		177.3	- 67.5
1947		140.0	- 67.5
1948		271.5	- 67.5
1949	1,997.8	297.1	- 67.5
1950	2.310.2	357.7	- 45.3
1951	3,006.5	770.7	- 74.4
1952	4,038.1	1,103.9	- 72.3
1953	5,142.2	1,170.4	- 66.3
1954	6,096.4	1,028.8	- 74.6
1955	6,600.2	572.1	- 68.3
1956	6,810.5	309.4	- 99.1
1957	7,009.4	303.4	- 104.5
1958	7,201.9	294.4	- 101.9
1959	7,319.8	315.3	- 197.4
1960	7,504.8	382.1	- 197.1
1961	7,767.0	428.3	- 166.1
1962	8,051.4	416.5	- 132.1
1963	8,405.9	393.0	- 39.5
1964	8,774.6	374.2	- 5.5
1965	9,139.1	370.0	- 5.5

Sources by column:

(1) 1942-46: Table 19, column 1.

1947-1964: Averages of adjacent fiscal years from Table 19, column 1.

1965: Calculated on the basis of expenditure and retirement assumptions explained in columns 2 and 3.

(continued on next page)

TABLE 20 (con'd)

(2) 1942-1946: Table 19, column 2.

1947-1964: Averages of adjacent fiscal years from Table 19, column 2.

1965: Construction in progress was almost the same as of June 30, 1965 as it was a year earlier. Thus calendar 1965 construction was assumed to be almost the same as in calendar 1964.

(3) 1946-1949: Assumed to be the same each year.

1950-1964: Same method as Table 19, column 3.

1965: Assumed to be the same as in 1964.

TABLE 21

COMPLETED ATOMIC ENERGY FACILITIES
AS OF JUNE 30
BY SECTOR OF OPERATOR
($ Million, Original Cost)

Year	Private Manufacturing	Private Non-Manufacturing	Total Private	Public and Foreign	TOTAL
	(1)	(2)	(3)	(4)	(5)
1945	1,145.8	176.7	1,322.5	59.6	1,382.1
1946					
1947					
1948					
1949					
1950	1,251.0	361.6	1,612.6	197.0	1,809.6
1951	1,287.0	424.9	1,711.9	212.9	1,924.8
1952	1,327.3	492.4	1,819.7	314.2	2,133.9
1953	2,118.1	707.8	2,825.9	323.6	3,149.5
1954	2,957.8	756.0	3,713.8	376.5	4,090.3
1955	4,645.8	851.5	5,497.3	361.0	5,858.3
1956	5,212.8	903.2	6,116.0	350.0	6,466.0
1957	5,392.5	862.2	6,254.7	342.0	6,596.7
1958	5,494.4	954.3	6,448.7	391.0	6,839.7
1959	5,552.6	1,093.4	6,646.0	397.0	7,043.0
1960	5,458.2	1,207.9	6,666.1	352.0	7,018.1
1961	5,453.6	1,326.3	6,779.9	422.0	7,201.9
1962	5,344.5	1,560.1	6,904.6	460.0	7,364.6
1963	5,447.5	1,685.0	7,132.5	519.1	7,651.6
1964	5,497.4	2,044.3	7,541.7	627.9	8,169.6
1965	5,464.0	2,335.8	7,799.8	670.6	8,470.4

Sources by year:

1945: A list of plant expenditures by facility is given in Hewlett and Anderson [1962], p. 723.

1956 and 1963-65: Calculations were made from a detailed list of plant book values by contractor in U. S. Atomic Energy Commission Annual Report, financial report, various issues. The lists for 1963-65 are complete, but the 1957

(continued on next page)

TABLE 21 (con'd)

is partial and some guessing was necessary to split the non-manufacturing total between the private and public sectors. In the calculations the public sector includes AEC headquarters, the nuclear ship Savannah, all facilities operated by state universities and other governmental bodies, and facilities overseas.

1950-1955, 1957-1962: Private manufacturing book value figures are available in various issues of the Annual Report, but the other categories shown do not correspond to the desired breakdown between public and private operation. Interpolation of public facilities between 1945 and 1956 and between 1956 and 1963-1965 was based on the "other facilities" category of the financial reports, assuming that the ratio of public book value to the value of "other facilities" moved linearly between the benchmark years for which detailed lists are available. After the published figures for private manufacturing were copied and the public sector estimated, values for the private nonmanufacturing sector were obtained as a residual.

government agencies (e.g., the University of California's Berkeley and Livermore labs) and by private organizations (Stanford's linear accelerator).

The method of estimation of public sector book values in Table 21 is interpolation between benchmark years--1945, 1957, and 1963-65--for which complete lists of facilities could be located. The interpolation was based on the annual value of the AEC's "other facilities" category, the ratio between the two being assumed to move linearly between benchmark years. After total AEC book value and the stock of assets in the manufacturing and public sectors are obtained, the NFNM sectoral value follows as a residual. The resulting figures, shown as estimated in Table 21, are converted in Table 22 to a calendar year basis.[31]

The final job, outlined in Table 23, is to segregate expenditures and retirements by two different criteria--into structures and equipment on the one hand, and by sector on the other. This problem has more unknowns than equations, for our retirement and expenditure data from the earlier tables are not decomposed at all. Extremely arbitrary additional assumptions are introduced so that the problem can be solved. The proportion of structures in the

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[31]It should be noted that the total book value figures in Tables 21 and 22 exclude construction work in progress and thus do not agree with book value totals listed in Tables 19 and 20. The sectoral book values shown in the later tables represent facilities which were actually in operation at the end of each year.

TABLE 22

COMPLETED ATOMIC ENERGY FACILITIES
AS OF DECEMBER 31 BY SECTOR OF OPERATOR
($ Million, Original Cost)

Year	Private Manufacturing	Private Non-Manufacturing	Total Private	Public and Foreign	TOTAL
	(1)	(2)	(3)	(4)	(5)
1945	1,145.8	176.7	1,322.5	59.6	1,382.1
1946					
1947					
1948					
1949					
1950	1,269.0	393.3	1,662.3	205.0	1,867.3
1951	1,308.2	458.7	1,765.9	263.6	2,029.5
1952	1,722.7	600.1	2,322.8	318.9	2,641.7
1953	2,538.0	731.9	3,269.9	350.1	3,620.0
1954	3,801.8	803.8	4,605.6	368.8	4,974.4
1955	4,929.3	877.4	5,806.7	355.5	6,162.2
1956	5,302.7	882.7	6,185.4	346.0	6,531.4
1957	5,443.5	908.3	5,351.8	366.5	6,718.3
1958	5,523.5	1,023.8	6,547.3	394.0	6,941.3
1959	5,505.4	1,150.7	6,656.1	374.5	7,030.6
1960	5,455.9	1,267.1	6,723.0	387.0	7,110.0
1961	5,399.1	1,443.2	6,842.3	441.0	7,283.3
1962	5,396.0	1,622.5	7,018.5	489.6	7,508.1
1963	5,477.5	1,864.7	7,342.2	578.5	7,920.7
1964	5,480.7	2,190.1	7,670.8	649.3	8,320.1
1965	5,500.0	2,435.0	7,935.0	720.0	8,655.0

Sources by column:

(1)(2)(4) 1945: Table 21, column 1.

1950-1964: Averages of adjacent fiscal years from Table 21, column 1.

1965: Estimates based on detailed list of projects under construction in AEC Annual Report, 1965, pp. 402-408.

(3) Column 1 plus column 2.

(5) Column 3 plus column 4.

TABLE 23

EXPENDITURES AND RETIREMENTS,
ATOMIC ENERGY FACILITIES, CALENDAR YEARS
($ Million, Original Cost)

	MANUFACTURING			NONMANUFACTURING		
	Expenditures		Retirements	Expenditures		Retirements
	Structures	Equipment	Equipment	Structures	Equipment	Equipment
	(1)	(2)	(3)	(4)	(5)	(6)
1942	4.3	5.0		.7	.8	
1943	95.0	112.5		14.6	17.3	
1944	258.0	306.0		39.7	47.4	
1945	167.0	198.0		25.6	30.6	
1946	7.8	46.0	55.9	14.1	23.0	8.6
1947	5.3	33.4	55.9	11.2	18.2	8.6
1948	11.9	70.3	44.9	21.7	35.0	8.6
1949	13.1	76.9	56.0	23.8	38.6	8.6
1950	16.9	96.0	30.7	28.2	46.8	9.6
1951	17.0	69.0	47.8	30.0	52.2	16.8
1952	190.0	272.6	47.1	65.0	92.8	16.4
1953	368.0	493.7	46.4	60.0	85.2	13.4
1954	582.0	738.8	57.0	32.0	51.9	12.0
1955	515.0	667.0	54.5	34.0	49.2	9.6
1956	170.0	284.1	80.7	3.0	15.7	13.4
1957	60.0	165.5	84.7	12.0	27.7	14.1
1958	40.0	121.0	81.0	42.0	88.5	15.0
1959		136.9	155.0	68.0	91.3	32.4
1960		101.8	151.3	55.0	96.6	35.2
1961		66.4	123.3	73.0	136.1	33.0
1962		91.6	94.7	87.0	120.9	28.6
1963		108.7	27.2	110.0	141.5	9.3
1964		6.8	3.6	150.0	176.8	1.4
1965		22.9	3.6	108.0	138.3	1.4

Sources by column:

(1)(4) 1942-1945: The only available breakdown of structures and equipment for the AEC is given in U. S. Congress, House Committee on Government Operations [1960], where the book value of structures on June 30, 1960, was reported to have been $3,141 million (p. 209) and the book value of machinery and equipment to have been $3,661 (p. 20).

(continued on next page)

TABLE 23 (con'd)

The 1960 structures-to-total ratio of .456 is applied to 1945 book value (Table 22, columns 1 and 2), and the resulting values are distributed over the years 1942-45 in proportion to total AEC construction expenditures during those years (Table 20, column 2).

1946-1965: Book value of structures for each sector is assumed to be equal in every year to .456 of total sectoral book value, which is shown in Table 22, columns 1 and 2. Assuming no discards of structures, expenditures on structures are thus simply .456 of the annual increase in total sectoral book value. The 1946-50 increase was distributed in proportion to total AEC construction expenditures during those years (Table 20, column 2).

(2)(5) 1942-45: Same as for Columns 1 and 4, using the 1960 equipment percentage of 54.4 from the source cited above.

1946-1965: Book value of equipment for each sector is assumed to be equal in every year to .544 of total sectoral book value, which is shown in Table A-13, columns 1 and 2. Equipment expenditures are thus .544 of the annual increase in total sectoral book value plus retirements as given in columns 3 and 6. The 1946-1950 increase was distributed in proportion to total AEC construction expenditures during those years (Table 20, column 2).

(3)(6) Retirements as listed in Table 20, column 3 are divided among the manufacturing and nonmanufacturing sectors in proportion to the share of those sectors each year in total AEC book value from Table 22. Thus 1951 manufacturing retirements are 1307.2/2029.5 = 57 percent of total 1951 retirements.

total stock of structures and equipment for each sector is assumed to be the same each year, a simplification which ignores the changing cost of construction relative to producers' durables during these years as well as the possible consequences of the rising proportion of production plants to total capital during the first half of the 1950's and of research laboratories since then. In addition all structures, probably rightly, are assumed to have useful lives longer than 25 years and thus to have remained intact throughout the post-war years, and all retirements are assumed to be of equipment. Retirements as enumerated in Table 20 are allocated to the three sectors in proportion to each sector's share in the total book value of AEC facilities.

V. SUMMARY AND CONCLUSION

The findings of this chapter are gathered together and summarized in Table 24. Listed by sector are all of the expenditures on government-financed structures and equipment which at some time since 1940 have contributed to private output. The first three lines, a total of $5.7 billion, are facilities which have been in private operation continuously with a brief transitional lapse after the war. Machinery sold to the public sector and overseas was operated by the domestic private sector during the war but not later, while machine tools placed on reserve in 1948 were idle between 1945 and the expansion of defense production in the first year of the Korean war. "Other

TABLE 24

TOTAL EXPENDITURES ON
GOVERNMENT-FINANCED
STRUCTURES AND EQUIPMENT
FOR OPERATION BY PRIVATE BUSINESS
($ Million, Original Cost)

Sector and Types	Total (1)	Structures (2)	Equipment (3)
A. Manufacturing			
1. Real Property Later Sold	3,516	2,557	959
2. Synthetic Rubber Later Sold	488	424	64
3. Machinery Sold to U. S. Private Business	1,712	---	1,712
4. Machinery Sold to U. S. Public Sector and Overseas	735	---	735
5. Department of Defense Machine Tool Reserve	650	---	650
6. Other Durables Sold to U. S. Manufacturing Firms	181	---	181
7. National Industrial Reserve Plants	330	182	148
8. Privately-Operated Departmental Industrial Reserve Plants	8,145	3,400	4,745
9. AEC Production Plants	6,709	2,518	4,291
10. Retired after World War II	2,927	500	2,427

(continued on next page)

TABLE 24 (con'd)

	(1)	(2)	(3)
B. Nonfarm Nonmanufacturing			
1. Other Durables Sold to U. S. NFNM Firms	816	---	816
2. Aircraft Sold to U. S. NFNM Firms	535	---	535
3. Privately Operated AEC Research Labs	2,731	1,109	1,622
C. Farm			
1. Other Durables Sold to U. S. Firms	122	---	122
TOTAL	29,597	10,690	19,007

Sources by Line:

(A1) Table 9, p. 115, line 2.

(A2) Table 13, p. 130, lines 4-6.

(A3) Table 14, p. 132, line 8.

(A4) Table 14, p. 132, line 7.

(A5) Table 14, p. 132, line 5.

(A6) Table 14, p. 132, line 10a.

(A7) Total: U. S. Commission on the Organization of the Executive Branch of the Government [1955], p. 63.

Structures and Equipment: Proportion given in same source, p. 3, as 55.2 per cent, which is multiplied by column 1 to obtain column 2. Equipment is the remainder.

(A8) Structures: Value of all DIR structures in 1950, from Table 15, p. 138, column 1, minus those operated by the government

(continued on next page)

TABLE 24 (con'd)

in the same year (Table 16, p. 142, line 3). As explained in the notes to Table 16, it was assumed that none of the structures built after 1950 or before 1940 were for private operation.

Equipment: Total equipment investment from 1951 to 1963 was $6,350, given in Table 17, the sum of all entries in column 3. Together with the 1949 stock of $1,500 million given in column 1 of that table, the total cumulated investment was $7,850 million. Deducting the 39.6 per cent government-operated share (see Table 16, p. 142, line 7), the resulting privately-operated share is $4,745 million.

(A9) Cumulated Expenditures from Table 23, p. 162, columns 1 and 2.

(A10) Table 9, p. 115, line 9.

(B1) Table 14, p. 132, line 10b.

(B2) Table 18, p. 151, line 4.

(B3) Cumulated expenditures from Table 23, p. 162, columns 4 and 5.

(C1) Table 14, p. 132, line 10c.

durables" in all three sectors, in contrast, were sold for private operation after the war but were in combat operation by the government before 1945. This was true also of aircraft sold. The industrial reserve plants and atomic energy categories in Table 24 include only facilities which were operated by private firms; naturally the rates of utilization of these plants varied during the postwar years, reaching a peak during the Korean war years (and presumably for the DIR plants again in 1965-66). The residual category in line 10, plants sold to agencies in the public sector or discarded, were in operation by private firms only during the few years between their construction and the end of World War II.

All of this adds up to almost $30 billion of expenditures valued at original cost, representing a substantial stock of facilities most of which, while it has helped to produce private output, has never before been included among the factors of production in the private sector. Obviously the discovery of this vast amount of previously unmeasured capital explains in part how the American economy produced so much during the war and early postwar years with such a small measured increase in the stock of capital relative to the level of the late 1920's. These government-financed facilities are obviously of great importance in manufacturing but play a much smaller role in the nonmanufacturing sectors. Exactly how much the chapter's estimates contribute to changes in the capital-output ratio is impossible to determine from Table 24, for the values, expressed in the prices of many different years, are virtually meaningless as they stand. Analysis of the value of these facilities in constant prices awaits the discussion of investment price indexes in Chapter IV. In anticipation of the need there for year-by-year deflation, the expenditures shown in Table 24 have been allocated to individual years in Tables 25 and 26.

Here it should be pointed out that the facilities shown in Tables 25 and 26 do not all represent a net addition to the private capital stock as previously calculated by Wasson. After price deflators have been applied, it will be necessary to take account of purchases of used structures and equipment sold to private firms after the war which are already included in the Wasson data. The Wasson/NIP values are substantially less than the amounts calculated here for similar assets, however, for our amounts are expressed in original cost and the Wasson figures are valued at the low depreciated WAA sale price.

After the deflated annual expenditure estimates of Tables 25 and 26 have been reduced by the amounts already included by Wasson, our series of assets later sold to private firms will be treated in a perpetual inventory capital stock calculation just like any other privately-financed asset. Retirements will be estimated by the usual crude methods of approximation. Government-financed assets which have remained in government ownership, however, will be kept separate because retirements have already

TABLE 25

EXPENDITURES ON GOVERNMENT-FINANCED
EQUIPMENT OPERATED BY PRIVATE BUSINESS,
ANNUALLY, 1917-18 and 1940-65
($ Million, Original Cost)

	MANUFACTURING					NONFARM NONMANUFACTURING				FARM
	SOLD POSTWAR TO PRIVATE FIRMS		UNSOLD POSTWAR			SOLD POSTWAR TO PRIVATE FIRMS		UNSOLD POSTWAR		SOLD POSTWAR
	Machinery	Other Durables	Atomic Energy	Non-Atomic	Retire-ments	Other Durables	Air-Craft	Atomic Energy	Retire-ments	Other Durables
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1917	184									
1918	184									
1940	45			54						
1941	361			430						
1942	1,280		5	1,476				1		
1943	1,132		113	1,351				17		
1944	413		306	493				47		
1945	274	13	198	326		62	65	31		9
1946		74	46		-3,218	330	256	23	- 9	50
1947		73	33		- 56	327	143	18	- 9	49
1948		18	70		- 56	81	71	35	- 9	12
1949		3	77		- 56	16		39	- 9	2
1950			96		- 31			47	- 10	
1951			69	302	- 78			52	- 17	
1952			273	874	- 137			93	- 16	
1953			494	874	- 136			85	- 13	
1954			739	362	- 359			52	- 12	
1955			667	121	- 357			49	- 10	

(continued on next page)

TABLE 25 (con'd)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1956			284	121	- 110			16	- 13	
1957			166	121	- 115			28	- 14	
1958			121	181	- 141			89	- 15	
1959			137		- 276			91	- 32	
1960			102	60	- 272			97	- 35	
1961			66	121	- 244			136	- 33	
1962			92	452	- 216			121	- 29	
1963			109	242	- 148			142	- 9	
1964			7		- 4			177	- 1	
1965			23		- 4			138	- 1	

Sources by column:

(1)(4) 1917-1918: See text, p. 173.

1940-1945: Total government-financed equipment expenditures from 1940 to 1944 are given in U. S. War Production Board [1945a], Table 6, pp. 16-17. The source for 1945 is an estimated value in Table 4, p. 13, of the same volume. The proportions of equipment purchased in each year from this source are applied in column 1 to the total amount of machinery purchased by the government during the war for use by private firms and later sold, including that sold as part of plants (Table 24, column 3, lines A1 and A2), and that sold separately from plants (Lines A3 and A4). The same procedure is followed in column 3 for the 1940-45 values. The total is the sum of lines A5, A7, and A10, plus equipment built during the war and remaining in privately-operated Departmental Industrial Reserve plants in 1950 (Table 15, p. 138, 1950 value in column 1) minus Table 16, p. 142, line 8.

(2) (6) (10) The totals are from Table 24, p. 164, lines A6, B1, and C1, divided among the years 1945-49 according to the date of sale of consumer and producer goods by the WAA. From U. S. War Assets Administration [1946-49], various issues.

(continued on next page)

TABLE 25 (con'd)

(3) Table 23, column 2, p. 162.

(5) The sum of AEC equipment retirements, from Table 23, p. 162, column 3, and industrial reserve equipment discards from privately-operated firms, assumed to be 60.4 per cent of Table 17, p. 145, column 4. The source of this ratio is discussed in the notes to Table 17. For 1946 additional discards are recorded for machinery sold to state and local government or overseas, from Table 24, line A4, and also for machinery which was apparently withdrawn from operation after the war, from Table 24, line A10.

(7) The total is from Table 24, line B2, divided among years in proportion to the date of sale of aircraft and aircraft components from U. S. War Assets Administration 1946-49, various issues.

(8) Table 23, column 5.

(9) Table 23, column 6.

(10) Table 24, line C1.

TABLE 26

EXPENDITURES ON GOVERNMENT-FINANCED
STRUCTURES OPERATED BY PRIVATE BUSINESS
($ Million, Original Cost)

	MANUFACTURING				NFNM
		Unsold Postwar			Unsold Postwar
	Sold Postwar to Private Firms	Atomic Energy	Non-Atomic	Retirements	Atomic Energy
	(1)	(2)	(3)	(4)	(5)
1917	49				
1918	49				
1940	47		61		
1941	474		649		
1942	1,270	4	1,733		1
1943	650	95	891		15
1944	340	258	466		40
1945	206	167	282		26
1946		8		- 500	14
1947		5			11
1948		12			22
1949		13			24
1950		17			28
1951		17			30
1952		190			65
1953		368			60
1954		582			32
1955		515			34
1956		170			3
1957		60			12
1958		40			42
1959					68
1960					55
1961					73
1962					87
1963					110
1964					150
1965					108

(continued on next page)

TABLE 26 (con'd)

Sources by column:

(1)(3) Atomic energy plants are the only class of structures for which we have approximate year-by-year wartime construction data, derived for 1942-45 by taking .456 of the expenditure totals in Table 20, p. 156, column 2. Total government-financed industrial construction for the war years is given in U. S. Department of Commerce, Office of Business Economics [1966a], Table 5.2, pp. 80-81, line 36. Subtracting atomic energy construction from the total gives us annual wartime expenditures on non-nuclear structures. Total wartime construction on plants sold after the war to private firms is $2,981, from Table 24, column 2, lines A1 and A2. The annual figures shown here in column 1 are derived by applying the annual proportions of expenditures on non-nuclear structures. Column 3 is derived in the same way from a total of $4,082 million, the sume of column 2, lines A7, A8, and A10 in Table 24.

(2) Table 23, column 1, p. 162.

(4) Table 24, column 2, line A10.

(5) Table 23, p. 162, column 4.

been estimated in this chapter.

While Chapter III has concentrated on the great majority of government-financed facilities which were constructed after 1940, brief mention should be made of the situation in World War I. Between 1917 and 1919 the government invested about $600 million in industrial plants. Some were retained in government ownership and operation, but $467 million worth were sold for about 4 per cent of acquisition cost. (The low sales returns were due to chaotic control and lack of planning--many goods were sold by one agency to a private buyer who then turned around and sold them for a higher price to another public agency).[32] In lieu of detailed figures on the dates of construction, half of the value of these plants will be added to investment expenditures for 1917 and half for 1918. The division of structures and equipment is the same as that of private investment in 1917-1918. The resulting figures are set forth in Tables 25 and 26.

The reliability of our final results is not very easy to evaluate. Since all of the available evidence has been used to construct the basic estimates, nothing remains to serve as a cross-check. The figures must be regarded as tentative, since they are subject to changes and improvements as further data discoveries are made. The Atomic Energy Commission estimates are probably the most reliable, for the total amounts involved are

[32] Cook [1948], pp. 60-66.

all based on published reports. The order of magnitude of the estimates of expenditures on Departmental Industrial Reserve Plants is doubtless roughly right, and important errors in the estimation procedure are presumably confined to the allocation of construction expenditures between the World War II and Korean years. As suggested above, the inclusion of some of the DIR plants producing ammunition and weapons gives the postwar capital stock an upward bias during 1946-50 when Defense Department procurement was very low. Purchases were at a high level throughout the 1950's and 1960's, reducing the bias substantially and eliminating it completely during the Korean and Vietnam wars.

Another possible bias, much harder to assess, may be caused by the valuation of all assets at their original cost. The returns received by the WAA on plants sold after the war were bound to be below original cost because of depreciation, of course, but a more important cause of the low realizations (32 per cent for real property) was undoubtedly a general lack of certainty that wartime prosperity could be maintained. Businessmen were hesitant to commit large sums on war-built plants which they feared might be badly underutilized as peace broke out.[33] Thus many firms acquired modern, well-equipped plants in 1946 at bargain prices which seriously understate their full-capacity

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[33] The lack of confidence during the early postwar years was also evidenced by the large gap between high dividend yields on equities and the low interest rates on long-term bonds.

ability to produce. If some war-built plants were unsuitable for postwar production and may be overvalued when stated in their original cost of construction, this bias is not as serious as the undervaluation in the present Wasson/NIP estimates. Part of this plant capacity may have gone unutilized at first, but utilization doubtless improved in later years as private demand and output increased far above 1946 expectations.

Any upward bias in our estimates for these reasons could not be large relative to the total amounts listed in Table 24, since it only applies to the $2.6 billion of structures sold after the war. Pieces of equipment, unlike structures, are movable and many were taken from war production plants and sold to other users. These machines were obviously easy to substitute for new machines built immediately after the war, and the machines purchased from the government took away the markets of the machine tool industry, leaving it in a depressed condition until 1951.

CHAPTER IV

THE DEFLATION OF INVESTMENT EXPENDITURES

I. THE DEFLATION DISPUTE

Capital goods price deflators have not always been the subjects of suspicion and mistrust. The absence of any discussion on the meaning of these indexes in the studies of Kuznets, Goldsmith, and other pioneers testifies to a widespread innocence in their era of the problems involved.[1] More recently, however, a number of economists have noticed the rising price of capital relative to consumer goods and have called attention to the methods used to construct the investment deflators.[2]

The contrasting 1929-1966 trends of several price indexes are shown in Table 27. The prices of both major components of fixed nonresidential investment have increased relatively rapidly. The price of producers' durable equipment has risen only slightly faster than GNP, to be sure, but its rate has been almost twice as rapid as that of consumer durables. The prices of non-

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[1]Among the studies which give no attention to this issue are Kuznets [1946] [1961], Goldsmith [1955] [1963], Ulmer [1960], Creamer [1960], and the review article on capital-output ratios by Domar [1961b].

[2]Among the most prominent of these are Gordon [1961], Anderson [1961], Kendrick [1961], Denison [1962], Griliches [1964], Grebler, Blank, and Winnick [1956], U.S. Congress, Joint Economic Committee [1959], the report of the NBER Price Statistic Review Committee [1961], and the much earlier work of Colean and Newcomb [1952].

TABLE 27

PRICE INCREASES IN DEFLATORS
FOR COMPONENTS OF GNP

Deflator	Percentage Increase, 1929-1966
1. Gross National Product	126
2. Consumer Durables	74
3. Producers' Durable Equipment	136
4. Nonresidential structures	232
5. Highways	116
6. Government Expenditures	222

Sources by line:

(1-4) (6) Economic Report of the President [1967], Table B-3, pp. 216-217

(5) Appendix Table A-4, column 1. 1966 data from same sources listed in that table.

residential structures have increased much more rapidly than the GNP deflator, and, in fact, have risen even faster than the deflator for government expenditures. This result looks particularly suspicious, since it is well known that the government deflator is based on average employee compensation and assumes no productivity improvement at all. Can we really believe that, during a forty-year period of technical progress and growing capital intensity in the rest of the economy, construction has remained an isolated backwater continuously operating at 1929 levels of productivity?

Most of the recent critics of capital goods price indexes have concentrated their fire on the official construction defaltors, which have been described as "defective in almost every possible way."[3] They have been assumed to contain a serious upward bias, because they are for the most part simple averages of labor and materials costs and fail to take acccount of improvements in labor productivity. The apparent absence in Table 27 of any increase in construction productivity, then, appears to be a tautological result of the procedures of estimation and is not an observation about any fact concerning the real world.

In their 1966 evaluation of productivity change in the American economy, Griliches and Jorgenson (G-J) claim that important "errors" in the measurement of capital input can be

[3] National Bureau of Economic Research [1961], p. 87.

eliminated with new deflators. Giving little explanation or analysis, G-J simply substitute the consumers' durable deflator for the official equipment index.[4] Further, the official construction deflator is replaced by an index which takes account of the effects of productivity change, the Bureau of Public Roads composite index for a "standard mile" of highway construction. G-J's "corrections" make a tremendous difference in the rate of growth since 1929 of investment and capital. The official national (NIP) accounts, for instance, claim that real fixed nonresidential investment in 1966 was 172 per cent higher than in 1929, but when G-J retell the story with new price deflators the increase leaps to 296 per cent. In other words, the official NIP accounts have underestimated real 1966 fixed investment, when measured in constant 1929 prices, by an immense 37 per cent, and the 1929-66 increase in real fixed investment by an even greater 59 per cent![5]

Should we then toss all of our issues of the Survey of Current Business, the Statistical Abstract, and the Economic

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[4] "Since expenditures on the wholesale price index are less than those on the consumers' price index, adjustments for quality change are less frequent and less detailed. To eliminate this source of bias, we replace the implicit deflator for producers' durables by the corresponding deflator for consumer durables." Griliches and Jorgenson [1966], p. 55.

[5] These calculations are based on the current dollar values of GNP components shown in the Economic Report of the President [1967], Table B-10, p. 225 and the price deflators shown in Table 27.

Report of the President into the bonfire? Not necessarily, for the G-J equipment adjustment is highly debatable, and the claim of an upward bias in the official construction deflators conflicts with several pieces of evidence which suggest that these are not seriously inaccurate.[6] Since all of our conclusions about the rate of growth of the real capital stock and the time path of the real capital-output ratio depend crucially on the choice of investment expenditure deflators, this chapter is devoted to a careful review of the conflicting data on the deflation debate. Guided by the conceptual discussion of Chapter I, our statistical goal is a set of capital goods deflators which accurately reflect all cost-changing factors, including varying factor prices, productivity, and profit margins, but which do not further adjust for costless improvements in quality. The shortcomings in the deflators for structures are judged much more serious than those for equipment and consequently receive the bulk of our attention.

II. EQUIPMENT PRICE DEFLATORS

Prices of many types of producers' durable equipment are collected by the Bureau of Labor Statistics (BLS) as components of the misnamed Wholesale Price Index (WPI). The index--despite its name--does not cover wholesale transactions at all but is restricted to prices at the first sale, usually at the manufacturing plant. Mail questionnaires are sent to machinery producers

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[6] R.A. Gordon [1961], pp. 942-945.

who are asked each month to report on the current price of machines which correspond to detailed BLS specifications. The individual machinery indexes are combined into machinery groups and then into the overall WPI with fixed weights which are currently based on value of shipments data from the 1958 Census of Manufactures. Since coverage is not complete, each priced item is assigned the weight of other related types of machinery which are assumed to have similar price movements.

The defects of the WPI have been described in the 1961 NBER evaluation and other sources and require only a brief review here. As in any Laspeyres index, excessive weight is given to obsolete goods subject to low productivity gains and above-average price increases, while new goods with expanding volume and falling prices are underrepresented or completely absent. Thus the WPI contains an inherent upward bias which would be expensive to remedy, since an improved index based on current-period weights would require continual production censuses published with lightning speed. An additional upward bias is created by inertia in the rewriting of specifications so that within any product class obsolete models linger on as representatives of new varieties.

A source of unknown secular bias is the changing coverage of the index. Presently 35 to 40 per cent of equipment investment is accounted for by seven-digit products directly priced in the WPI, while the remaining 60 to 65 per cent are unpriced and their weights are assigned to related priced items assumed to have similar price movements. The absence of many of the omitted types of machines probably does not seriously affect the trend of the overall equipment index, since prices of closely related items in the same four-digit industry are available. The most significant four-digit industries which are completely un-represented are aircraft, ships, special tools and dies, and miscellaneous electronic components. No matter how great the deviation of the price trends of these items from the priced products to which their weights are applied, their share of total equipment investment is relatively small and the distortion imparted to the overall implicit deflator is probably not significant.[7]

The present extent of coverage applies only for years since 1947, and before that date the WPI is much less adequate as a source of equipment price information. For the early years the official deflators were gathered from scattered sources, priced directly a much smaller sample of products, and may contain biasses of unknown magnitude and direction.[8]

In addition to a possible secular bias, the WPI contains a spurious rigidity over the business cycle. Sellers report

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[7]For a list of four-digit machinery industries and the percentage of priced items in each, see Searle [1964], pp. 358-59.

[8]For an example of the variety of sources used, see Shaw [1947], notes to Table IV-1, pp. 296-302.

list prices and do not bother or are reluctant to report discounts given during periods of slack business. Questionnaires submitted by buyers would be preferable, reporting actual prices paid, and would contain fluctuations presently ignored by the WPI. In a 32-product comparison of official BLS prices with prices actually bid on government contracts, John Flueck found that

> a. The average levels of the BLS series are above those of the contract price series...,
>
> b. The BLS series change less frequently than the contract price series...,
>
> c. and the BLS series change by smaller magnitudes in the short run than the contract price series.[9]

The cyclical inaccuracy of the WPI may also cause secular distortions if there have been long-run trends in the factors which cause cyclical fluctuations. For instance, if discounting has become more common over the years, list prices quoted by the BLS may have risen faster in the long run than actual prices paid, although this conclusion is not obvious for wholesale prices, since the main area of secular growth in discount operations has been in the retail sector. Also, there is evidence that the frequency of price changes in WPI components increases as the number of reporting sellers is increased, so that any long-run trend toward more reporters per commodity increases the sensitivity

[9] Flueck [1961], pp. 427-428.

of the index. Unfortunately it is impossible to assess the importance of these sources of bias without a full-scale government effort to obtain price reports from buyers.[10] At least we can minimize possible errors in this study if we carefully form our conclusions about secular events on the basis of comparisons between years at roughly the same stage of the business cycle.

How adequately does the implicit equipment index based on the WPI correspond to the desired "ideal" capital goods deflator which equates pieces of equipment if they have the same base-period cost of production? While this is the conceptual goal of the BLS, actual methods are erratic. Consider the introduction of a costlier and more comfortable tractor seat accompanied by a price increase. Proper BLS procedure would be to ask the manufacturer for an estimate of the proportion of the price increase attributable to the added cost of the new seat and to adjust the reported price index increase downward by this amount. According to a BLS spokesman, however, in practice

> the introduction of a more comfortable seat in a tractor would not be subject to adjustment normally. If, however, tractors of identical specification other than the seat were selling in the same market at the same time--or if the comfortable seat were a separately priced option--we would bow to the judgment of the market and make the adjustment.[11]

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[10] An initial attempt is being made by the National Bureau of Economic Research. See Kindahl [1967].

[11] Searle [1964], p. 363.

Apparently the change of a tractor seat is not important enough to warrant adjustment, but in contrast the same spokesman later says

> In practice, the Bureau often obtains from reporters the cost of added (or deleted) features on machinery, autos, trucks, and a variety of other goods and makes an appropriate adjustment by adding (or subtracting) the cost to the price of the earlier model to attain price comparability with the new model. Where this is not possible, a judgment is made and either a direct price comparison or a link is taken depending on whether the reported price change is deemed mostly due to the genuine price change or to quality change.[12]

Note that the BLS allowance for "quality change" is consistent with our conceptual discussion, for adjustments are made only in the case of "added features" which would increase the base-period cost of production. The quotation implies that the BLS does not make any adjustment for <u>costless</u> increases in quality, e.g., increases in allowable operating machinery speeds or longer elapsed intervals between aircraft overhauls made possible by the gradual accumulation of operating experience.

But no matter how good the intentions of the BLS, there is no specific evidence on the relative importance of cost-increasing and costless quality change or of the effectiveness with which the BLS succeeds in adjusting prices for the former while avoiding corrections for the latter. Thus it is impossible to assess the degree to which incorrect equipment deflators impart a bias to our investment and output estimates, and we will not attempt

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[12] Searle [1964], p. 364.

any adjustment of the equipment indexes. In light of this absence of evidence, Griliches and Jorgenson are without support in claiming that the "less frequent and less detailed" adjustments for quality in the WPI compared to the Consumers' Price Index (CPI) justifies the replacement of the producers' equipment deflator with the consumer durable index. Considering the widely acknowledge failure of the CPI to take adequate account of continuous and gradual quality change and its consequent inadequacy as a constant utility index, it is possible that the official investment statistics based on the WPI may err not by overestimating but rather by underestimating the rise of "true" investment goods prices relative to a "true" index for consumers' goods.[13] Part of the eagerness of Griliches and Jorgenson to downgrade the WPI is attributable to their differing conceptual framework, which calls for a measure of capital input as a flow of services rather than as a constant-cost stock. Thus G-J would adjust the capital goods deflator downward for any quality improvement, whether cost-increasing or costless. As explained in Chapter I, this procedure underestimates the increase in productivity attributable to costless technical advance, since it assumes that there are no costless improvements in the ability

[13]On the inadequacies of the allowance for quality change in the CPI, see NBER [1961], p. 53, and Griliches' own quality adjusted hedonic price index for autos [1961b].

of the constant-cost capital stock to provide capital services.

III. THE CONCEPTUAL FRAMEWORK OF STRUCTURES DEFLATION

The differences between various construction price deflators are clarified with the aid of a conceptual framework, suggested by Norman Kaplan, which distinguishes between construction projects, components, and inputs.[14] The terms projects and inputs are given their conventional meanings--the final products of construction and the factors of production used to produce them. Components are completed intermediate products which are assembled into projects--e.g., six square feet of floor in place or 17 1/2 bricks laid. Components can be given either broad definitions (a whole wall in place) or narrow ones (one pane of glass inserted into a window in a wall) depending on the exigencies of the task at hand. A component can be completely analyzed in terms of its inputs, and productivity improvement continually changes the input requirements for the production of given components. Similarly, projects can be analyzed in terms of their components, and the quantities of components prescribed for a project are called its specifications.

[14] Kaplan [1959]. In what follows the conceptual distinction between projects, components, and inputs is Kaplan's. His inpenetrable notation, however, has been completely changed, and the application to actual U. S. indexes is new.

In the following notation *b* denotes the base and *t* the current period. As many as three dates are enclosed in parentheses--the first stands for the date of the specifications, the second to the year for which input requirements are expressed, and the final one for the date of measurement of factor prices and total quantities. The subscripts refer to individual components, inputs, or projects. Thus $p_k(b,b,t)$ is the price using input prices in the current year of project *k* which has base-year specifications and input requirements. The following is a complete list of the notation:

$x_{ij}(t)$ is the requirement of input *i* in component *j* at time *t*.

$w_{jk}(t)$ is the specification for component *j* in project *k* at time *t*.

$q_i(t)$ is the price of input *i* at time *t*.

$r_j(t,t)$ is the price of component *j* produced at time *t* with the input requirements of period *t*.

$p_k(t,t,t)$ is the price of project *k* at time *t* with the input requirements and specifications of period *t*.

$D_k(t)$ with appropriate superscripts is an index number showing the relation of current and base-year project prices.[15]

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[15]For an economy-wide implicit deflator the current value of construction would be deflated by the sum of the constant dollar project values obtained after the deflation of current project values by each $D_k(t)$.

The basic assumption that projects can be analyzed in terms of their components, and components in terms of inputs, can be expressed as follows, using base-period prices, input requirements, and specifications:

$$(1) \qquad r_j(b,b) = \sum_i x_{ij}(b)\, q_i(b)$$

$$(2) \qquad p_k(b,b,b) = \sum_j w_{jk}(b)\, r_j(b,b)$$

An ideal construction price index would compare the price charged by a current-year contractor with the price which would have been charged by a base-year contractor using base-year technology. The price relatives $D_k^*(t)$ in this ideal world would be similar to the indexes for individual commodities in the Wholesale Price Index:

$$(3) \qquad D_k^*(t) = \frac{p_k(t,t,t)}{p_k(b,b,b)} = \frac{\sum_j w_{jk}(t)\, r_j(t,t)}{\sum_j w_{jk}(b)\, r_j(b,b)}$$

$$= \frac{\sum_j \sum_i w_{jk}(t)\, x_{ij}(t)\, q_i(t)}{\sum_j \sum_i w_{jk}(b)\, x_{ij}(b)\, q_i(b)}$$

where the projects compared are assumed to have roughly the same specifications during each time period, so that

$$(4) \qquad w_{jk}(t) \cong w_{jk}(b)$$

Input requirements, however, would be assumed to change between the two periods. Even though wage rates and materials prices are much higher in 1967 than in a base-year like 1929, a 1967 contractor might still manage to bid less on a given project if his input requirements $x_{ij}(t)$ had declined sufficiently.

But in practice the ideal price relative (3) is almost impossible to calculate because the output of construction is so heterogeneous. Almost every structure is different (except for ticky-tacky housing developments, but even in that field specifications change over the years) and 1967 contractors do not construct 1929-style buildings. The Federal government could have performed economists a great service if it had regularly built sample structures of given types and had kept track of the prices. Even if Congress had been unwilling to finance "wasteful" reduplication of similar structures year after year, an acceptable low-cost alternative would have been the regular submission of detailed plans to contractors so that the annual succession of their bids might be made into an index (new types of structures would have to be introduced frequently to keep pace with changing specifications, and the price indexes linked to those computed for older types of buildings).

But unfortunately there has been no comprehensive federal effort to collect price information on structures of standard specifications. The principal alternative has been to deflate different types of projects not by price indexes at all but by naive indexes of input <u>costs</u>, many of which are simple averages of wage rates and the prices of a few standard materials. An input-cost relative $D_k^C(t)$ for a project assumes that there has been no change in input requirements and hence no change in productivity, as shown in the following expression in which all elements except input costs are expressed in the values of the base period.

$$(5) \qquad D_k^C(t) = \frac{p_k(b,b,t)}{p_k(b,b,b)} = \frac{\sum_j \sum_i w_{jk}(b)\ x_{ij}(b)\ q_i(t)}{\sum_j \sum_i w_{jk}(b)\ x_{ij}(b)\ q_i(b)}$$

Originally developed before World War I to take advantage of the scant data then available, the input-cost approach has maintained its importance in the national accounts largely because of inertia and an unwillingness to sacrifice comparability with earlier periods.

In addition to the input-cost indexes used for the bulk of construction deflation, two other more satisfactory approaches have been used. The <u>component-price</u> method assumes that the heterogeneity of construction projects over time and space results from the different combinations of components which are used, but that the basic components themselves are homogeneous. "600 bricks in place," in other words, means exactly the same thing in 1967 as it did in 1929, irrespective of any intervening changes in the use of brick relative to other components. In the component-price approach the relative price index $D_j^{CP}(t)$ for a component would be:

$$(6) \qquad D_j^{CP}(t) = \frac{r_j(t,t)}{r_j(b,b)} = \frac{\sum_i x_{ij}(t)\ q_i(t)}{\sum_i x_{ij}(b)\ q_i(b)}$$

The input requirements in the two periods are now allowed to vary, so that the component-cost index allows for changes in productivity. Note than an implicit deflator for the entire economy could be developed from the $D_j^{CP}(t)$ by deflating each component separately and summing over all components, thus eliminating any need for project data.

An equivalent index could in theory be obtained by adjusting each factor's input-cost index by an index of its productivity improvement, yielding an input-productivity price relative $D_j^P(t)$ for each component:

$$(7) \qquad D_j^{P}(t) = \frac{r_j(t,t)}{r_j(b,b)} = \frac{\sum_i x_{ij}(b)\ \frac{x_{ij}(t)}{x_{ij}(b)}\ q_i(t)}{\sum_i x_{ij}(b)\ q_i(b)}$$

Even though it appears to be algebraically equivalent to $D_j^{CP}(t)$, the $D_j^P(t)$ method uses quite different data. $D_j^{CP}(t)$ is usually based on average bid prices for standard components, so that input quantities and prices do not enter into the calculation at all. $D_j^P(t)$, on the other hand, supplements standard input-cost data with figures on the changing productivity of inputs. Most input-productivity indexes actually calculated in the United States are only rough approximations to (7), since they only adjust input requirements for one factor--labor--and ignore variations in profit margins and the efficiency of use of materials and capital which are automatically taken account of in the component-price approach.

As we shall discover below, a final difficulty in the use of a correctly calculated component-price or input-productivity index is that data on the relative importance of components are unavailable and suitable price relatives are computed for only a small selection of components. Thus evidence can be obtained on productivity gains in individual components, but this does not completely pin down the true movement of construction prices in the entire economy.

IV. AN INPUT-COST INDEX FOR U. S. CONSTRUCTION

Before turning to the series used in the U. S. National Accounts to deflate construction, a simple index of input costs should be selected to serve as a point of comparison with the others. After a pair of weights has been chosen, an average of wage rates and materials prices can serve as a naive first approximation to the cost of construction. The wage and materials indexes will be useful not only for the simple input-cost index but will be required later in the chapter for our extension of Dacy's method.

Simple as it sounds, the compilation of an adequate input-cost index is a surprisingly difficult job. Official data on wage rates and the prices of building materials contain serious biasses which must be corrected before a valid input-cost index can be calculated.

Wage Rates

The official wage rate index compiled by the Bureau of Labor Statistics (w_t^L) refers to "union wages in the building trades" and is available for every year since 1907.[16] The series is imperfect for several reasons. The wages of unskilled "common labor" have increased relative to those of union craftsmen, so that the union series probably understates the rise of average wages.[17] This tendency is doubtless intensified to the extent that the composition of the construction labor force has shifted from low-paid common labor to highly paid skilled workers.

The only other long-term wage data are compiled by the National Income Division of the Department of Commerce, which publishes a series on the average compensation of employees (C_t/E_t) for each year since 1929. Since data refer to all contract construction employees, union and nonunion, they should allow a judgment on the extent to which the BLS union wage series (w_t^L) understates the rise in average construction labor costs. The Commerce series on annual

[16]And can be extended back to 1890 with a BLS index of average wages per hour in the building trades from Ulmer [1960], Table D-6.

[17]Unskilled workers are unionized now in the building trades, but before the spread of unionization in the 1930's and 1940's, unions in the building trades consisted mainly of craftsmen.

average payments must first be adjusted for the secular decline in hours worked (H_t) to be put on a comparable basis with the BLS average <u>hourly</u> wage rate data. The Commerce series, then, becomes

$$(8) \qquad w_t^C = \frac{C_t}{H_t \; E_t}$$

which is compared to w_t^L in Figure 7. The two appear to move in lock-step after 1946, but there are large discrepancies before then. In 1929 the Commerce index is only 82 per cent of w_t^L, which appears to support the hypothesis of an understatement in the rate of growth of the BLS series.

It is not immediately obvious how to adjust w_t^L, for w_t^C differs from it in both trend and cyclical movements. We need to correct w_t^L for the former but not the latter. The steep decline of w_t^C during the Depression is misleading, due to the imperfection of the available hours data (H_t), which refer to "standard" hours per week. This is an unsatisfactory series for the adjustment of annual payments data because it ignores cyclical variations in <u>actual</u> hours worked per week and in weeks worked per year. Thus the denominator of (8) assumes that construction employees worked a standard 39 hours per week throughout the year, while payments in the numerator declined much more steeply during the Depression as each employee in reality worked substantially fewer hours per year.

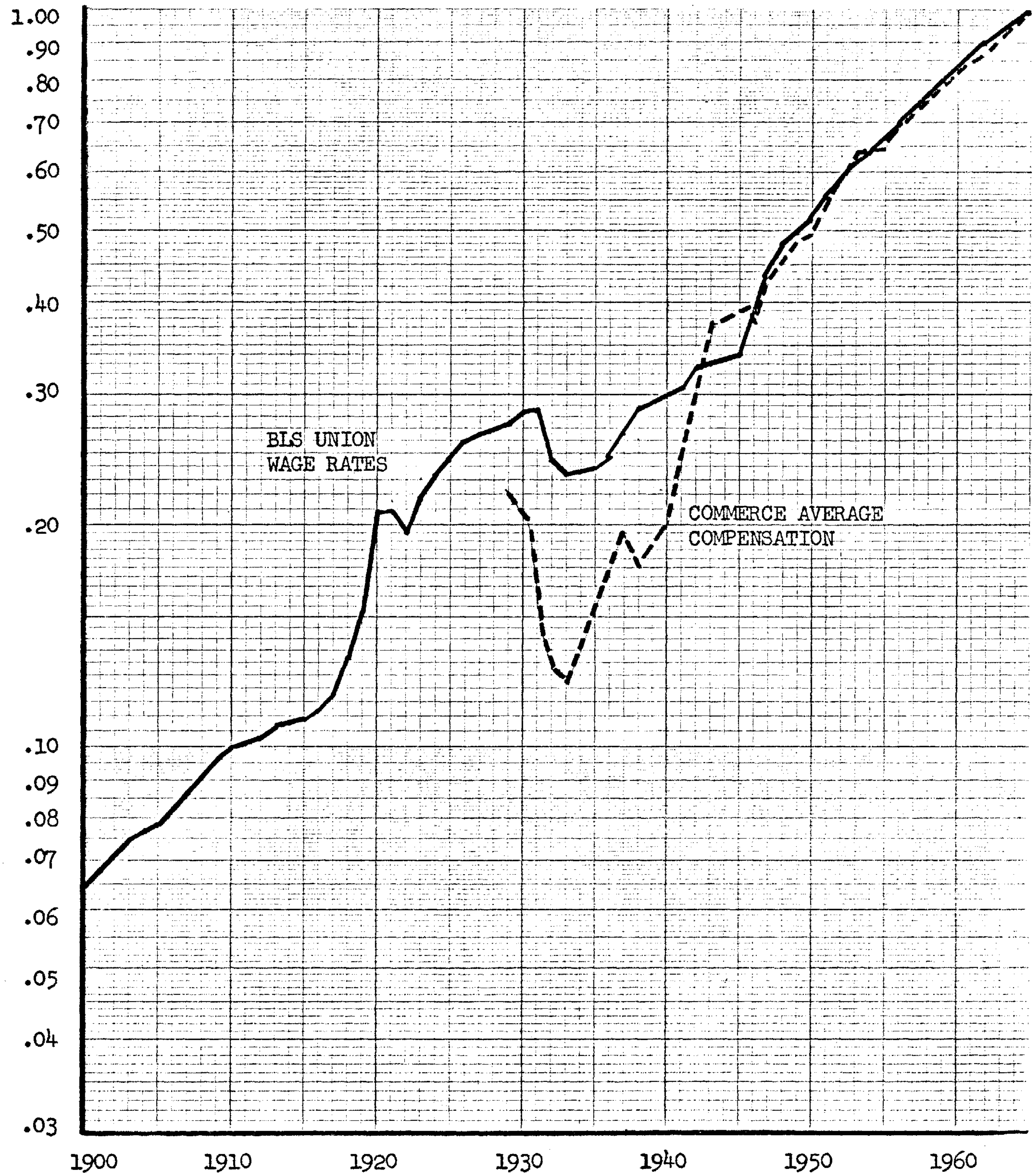

Figure 7

TWO CONSTRUCTION COMPENSATION SERIES (1965 = 1.00)

Sources: Union wage rates. Appendix Table A-1.

Average Compensation. U. S. Department of Commerce [1966b], Table 6.5, pp. 108-9.

Thus the index of w_t^C was smaller than that of w_t^L in 1929, as shown in Figure 7, because of both a more rapid secular rate of growth and a cyclical understatement reflecting the decline in the utilization of the construction labor force from the 1926 peak of the building boom. Since data on actual hours worked are unavailable, a crude utilization variable can be constructed as the ratio of contract construction output to "capacity," which is assumed equal to contract construction output in the peak years 1926, 1942, 1948, 1950, 1955, 1959, and 1965, and is linearly interpolated in between.[18] A regression of the ratio w_t^C/w_t^L on utilization (U_t) and time (t) for the years 1929-65 indicates that both independent variables are significant in explaining the differences in the two wage series:[19]

$$(9) \qquad \frac{w_t^C}{w_t^L} = \underset{[6.688]}{.2540} + \underset{[8.057]}{.5545}\,U_t + \underset{[3.065]}{.0048}\,t \qquad R^2 = .9053 \quad DW = .7868$$

An adjusted wage series w_t^*, displaying the secular trend

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[18] For this comparison the Department of Commerce Composite was used to deflate contract construction--a possible secular inaccuracy in this index would not affect utilization (U_t) in any important way. Construction output data from Appendix Table A-7, column 1.

[19] The numbers in brackets are t coefficients; time runs from 1 in 1915 to 51 in 1965; the years 1943 to 1946 are omitted. The reason for the low Durbin-Watson, interestingly enough, is postwar monetary policy. After the war the wage ratio appears to decrease during periods of high unemployment, which also tend because of low interest rates to be boom years for residential construction and periods of peak utilization in the construction industry.

of w_t^C and the cyclical behavior of w_t^L, can be computed from (9) and is used throughout the rest of this chapter whenever a wage rate series is needed.[20] The switch from w_t^L to w_t^* is reasonably important, lowering reported wages in the 1920's by an average of about 15 per cent.

Materials Prices

The official BLS price index for building materials, long compiled as part of the WPI, has been accepted without question by previous investigators. Gordon and Colean-Newcomb cite the rapid rise in the materials price index as an important cause of the increasing relative price of construction.[21] The same official materials price index, which plays a crucial role in Dacy's indirect method for estimating the price of construction output, is accepted by him as the most reliable of the data series with which he works.[22] But a close look at the BLS index indicates that it contains a significant upward bias because of the use during the crucial World War II and postwar period of an unbelievably unrepresentative set of weights.

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[20] First, w_{1926}^C was computed from (9). The increase in w_t^C from .866 in 1926 to 1.00 in 1965 was assumed to have occurred linearly. Thus $r = (.866)^{(1/(1965-1926))}$ and $w_t^* = w_t^L\ (r)^{1965-t}$ for 1890-1965.

[21] Gordon [1961], p. 943; Colean and Newcomb [1952], pp. 60-61.

[22] Dacy [1962].

The purpose of a price index for materials is the conversion of current-dollar value data ($p_t q_t$) into a measure of real inputs in the prices of a base year ($p_o q_t$). We are interested in the base-period cost of the particular mixture actually purchased in each current year, and so the quantities used to combine prices for different segments of construction into an aggregate index should be current-year weights. A Laspeyres index weighted with base-year quantities is inappropriate, since it measures the price of an irrelevant composite of materials. A rapid increase since a base year in the price of ornamental scrollwork, for instance, would not signify an increment in the base-year cost of producing today's buildings if in the meantime the use of ornamental scrollwork had ceased.

For many years the weights in the official BLS index were not only ancient but inaccurate as well. During the period of its great rise between 1940 and 1951 the index used obsolete 1929-31 weights which did not remotely resemble the relative importance of different materials even in 1929-31, much less in 1940 or 1950. This amazing discrepancy is illustrated in Table 28. The BLS index is dominated by the movements of lumber prices, which receive a weight of almost half despite a share of only 10 per cent in actual 1929 construction materials outlays. This discrepancy would not be serious if there had been no changes in relative prices between the 1920's and the 1950's, but it was the price

TABLE 28

ALTERNATIVE VALUE WEIGHTS
FOR MATERIALS, 1929-31
(percentages)

Products	Official BLS Weights	Proportion of Expenditures in 1929	Percentage Price Increase, 1940-1951
	(1)	(2)	(3)
Lumber and Wood	49.0	10.4	252
Paints	21.2	2.1	102
Bricks and Tile	6.2	4.1	63
Cement	4.9	8.9	51
"Other"	17.7	74.5	103
	100.0	100.0	

Source by Column:

(1) U. S. Department of Labor, Bureau of Labor Statistics, Wholesale Prices 1947 [1949].

(2) U. S. Department of Commerce, Bureau of the Census [1933], Table XIII, p. 27.

(3) Sources listed in Appendix Table B-1. The price of bricks and tile is represented by the index for stone and clay products.

of lumber which spiralled up much faster than that of any other product, rising 252 per cent between 1940 and 1951. Thus the BLS building materials index receives a strong upward bias from the predominant lumber series, and many other products with less rapidly rising prices are given small weights or are ignored altogether. The important categories of metals, metal products, and machinery are completely omitted and the minerals industry, with a relatively small price rise between the 1920's and 1950's, is given only a quarter of the weight to which it is entitled on the basis of 1929 purchases.

Even if its weights were accurate for the base period to which they refer, the BLS index would contain a bias of uncertain direction due to the infrequency with which weights have been changed. While indexes for today's prices may justifiably have out-of-date weights because of lags in the publication of production censuses, there is no excuse for the failure periodically to revise historical series in the light of improved information.[23]

The only solution to the inadequacy of the official deflator is a new index constructed by reweighting the prices of individual materials. This involves two steps--the choice of weights and

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[23]This is another area in which we suffer from the lack of a Federal statistical research bureau.

the compilation of price indexes for each major product. Reports on purchases of materials are the basic source of data for weights and are available for 1929 (from the 1929 Census of Construction) and for 1947 and 1958 (from the postwar input-output studies). Commodity classes in the prewar and postwar reports differ, and the necessity to combine sub-groups limits the maximum number of comparable categories to ten. The current dollar coefficients for 1929, 1947, and 1958 are then divided by the price for each year, resulting in the quantity weights shown in Table 29.[24]

The time path of the final all-materials index is compared in Figure 8 with the official BLS materials index. The long-accepted rise in the relative price of building materials over this period appears to have been greatly exaggerated. Compared to a 1929-51 increase in the WPI of 85 per cent, the change in the official BLS materials index is 141 per cent, much greater than the 96 per cent rise in our new index. The increase in the relative price of construction materials over this period is thus reduced from 30 to 5 per cent. In fact the relative price of building materials appears to have risen more after 1951 than

[24] The prices by which each current-dollar coefficient is divided are indexes with 1958=100. Details on the sources of weights and of price indexes for the individual commodities are given in Appendix Tables B-1 and B-2. Quantity weights for years other than 1929, 1947, and 1958 were obtained by linear interpolation between weights for the three base years.

TABLE 29

QUANTITY WEIGHTS BY
CLASS OF PRODUCT

Product	1929	1947	1958
1. Lumber and Wood	.1773	.2161	.1575
2. Paints, glass	.0180	.0267	.0135
3. Petroleum	.0124	.0343	.0473
4. Stone and Clay	.2401	.1787	.2261
5. Iron and Steel	.1782	.1255	.1068
6. Nonferrous	.1011	.0713	.0417
7. Heating, plumbing	.1274	.1956	.2493
8. Other Fabricated Metal Products	.0429	.0649	.0459
9. Electrical	.0452	.0372	.0684
10. Other Machinery	.0568	.0492	.0428
	1.0000	1.0000	1.0000

Sources: Sources of value weights given in Appendix Table B-2. Value weights are deflated by separate commodity price indexes for each year compiled from the sources listed in Appendix Table B-1.

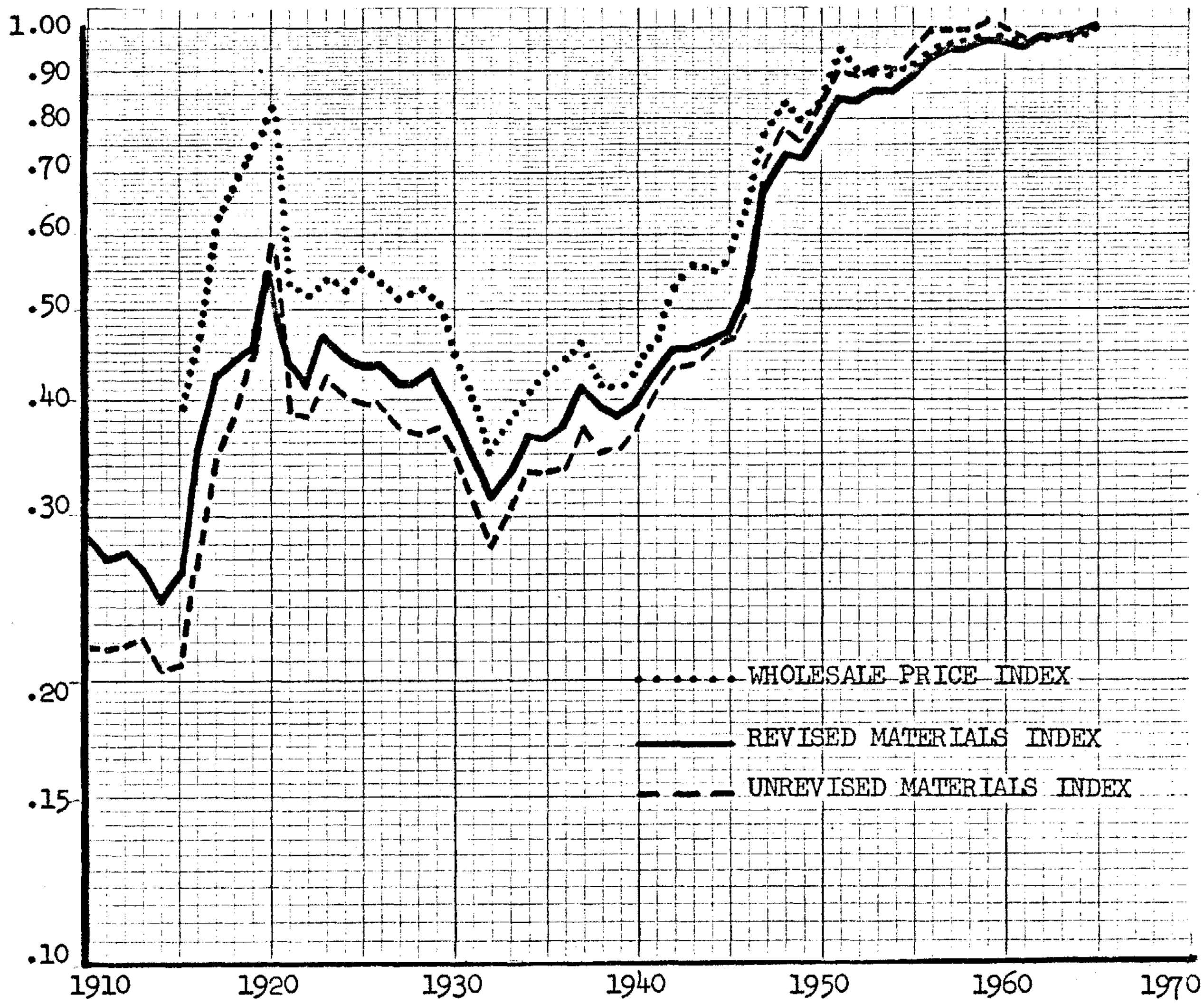

Figure 8

REVISED AND UNREVISED CONSTRUCTION MATERIALS PRICE INDEX
COMPARED WITH WHOLESALE PRICE INDEX (1965 = 1.00)

Source: Appendix Table A-1.

before, contrary to the impression given by the old index.[25]

The new wage rate and building materials indexes can be combined into an index of average input costs, using weights on the relative importance of labor and materials costs in 1965.[26] The resulting index, of course, cannot be viewed as a serious contender in the search for a proper construction deflator, since it ignores changes in productivity, profit margins, overtime pay, and discounts on materials. Its purpose is to serve as a reference point for comparison in the next section with the indexes actually used to deflate construction in the National Accounts and as a base later in the chapter for the compilation of two more sophisticated deflators.

V. THE DEPARTMENT OF COMMERCE COMPOSITE AND ITS COMPONENTS IN DETAIL

The official U.S. index for the prices of new construction, the "Department of Commerce Composite Cost Index," is neither an

[25]Witness the following relative prices, with 1929 = 1.00.

	Old Index/WPI	New Index/WPI
1929	1.00	1.00
1951	1.30	1.05
1965	1.38	1.18

[26]The materials, wage, and input cost indexes have been calculated for all years between 1890 and 1965. See Appendix Table A-1.

input-cost, component-price, nor input-productivity index, but a moving-weight average of components deflated by all three methods. It is the ratio of current-dollar value of new construction divided by the sum of the separately deflated constant-dollar components. The rapid rise of the Composite relative to the GNP deflator is illustrated in Figure 9; the comparison suggests a rapid and steady increase in the relative price of construction since 1929. Surprisingly, the Composite appears to rise even more rapidly than the naive input-cost index calculated in the last section. Since the input-cost index is not adjusted for productivity at all, the more rapid rise of the Composite implies that productivity in construction has declined since 1929.

Input-Cost Indexes in the Composite

Eleven separate indexes contribute to the Composite, and Table 30 shows the importance in 1965 of the sectors of constructiion for which they are used. None of the first five, which together received 52.8 per cent of the total 1965 weight in the Composite, make any adjustment for productivity. It is the importance of these naive indexes which is largely responsible for the extensive criticism which the Composite has received.

1. The E.H. Boeckh Residential Index (with a 1965 weight in the Composite of 37.8 per cent) is an average of wage rates and materials prices for two kinds of houses--frame and brick--

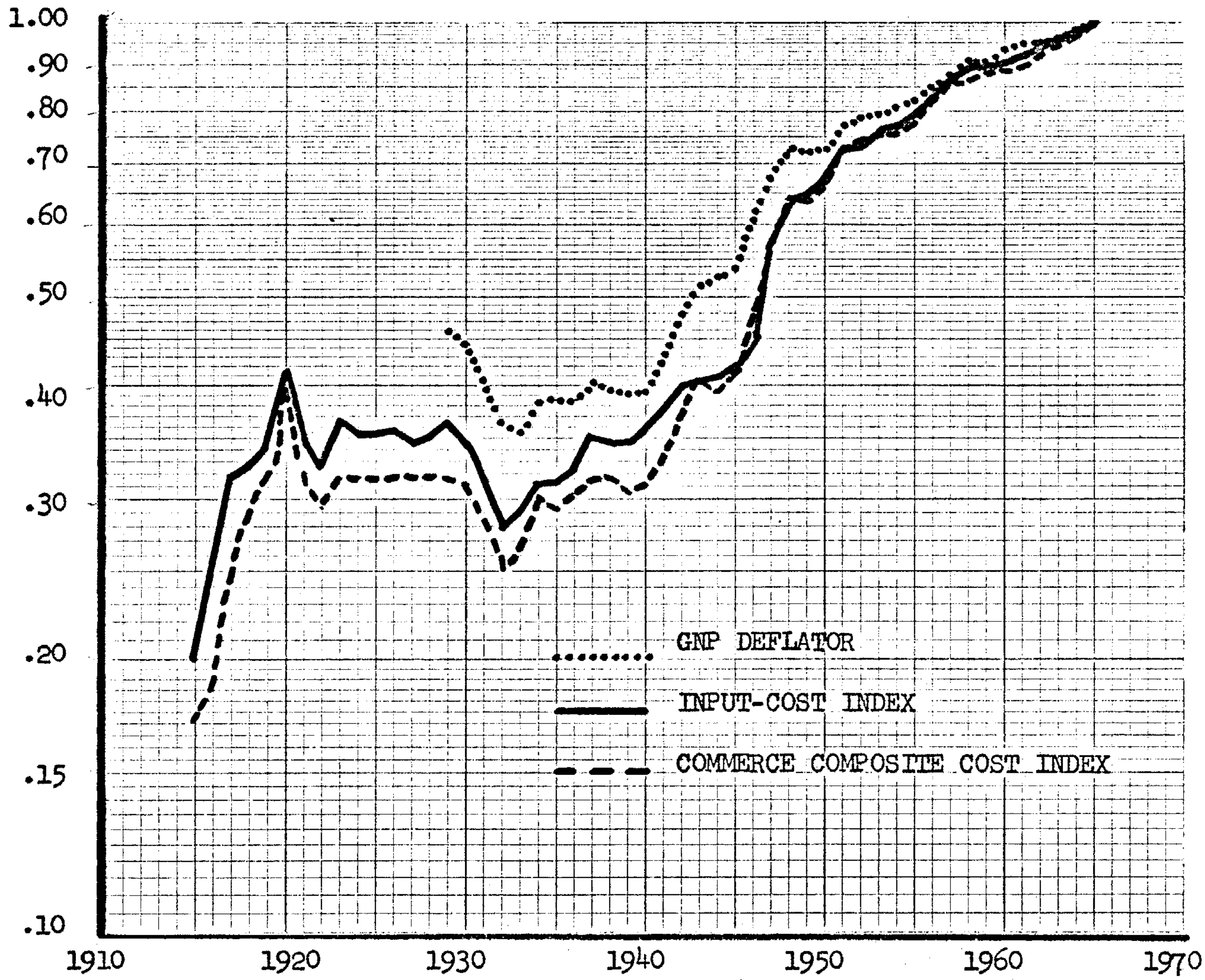

Figure 9

GNP DEFLATOR AND NAIVE INPUT-COST INDEX COMPARED WITH
COMMERCE COMPOSITE COST INDEX (1965 = 1.00)

Sources: GNP Deflator. Economic Report of the President [1967], Table B-3, p. 216.

Input-Cost and Commerce Composite. Appendix Table A-2.

TABLE 30

SECTORAL INDEXES IN THE
DEPARTMENT OF COMMERCE
COMPOSITE COST DEFLATOR, 1965
($ Million, Current Prices)

Index and Construction Sector to Whitch Applied	Private	Public	Value Put In Place In 1965	Percentage
(1)	(2)	(3)	(4)	(5)
INPUT-COST INDEXES			37,978	52.8
1. Boeckh Nonfarm Residential	x	x	27,153	37.8
2. Handy-Whitman			3,888	5.4
a. Electricity	x		2,271	
b. Gas	x		1,064	
c. Public Enterprises		x	473[a]	
d. 3/4 of pipelines	x		80	
3. Associated General Contractors			2,871	4.0
a. 1/2 of sewer and water		x	1,235	
b. 1/2 of conservation		x	1,016	
c. 1/2 of all other	x	x	620[b]	
4. Engineering News-Record			2,871	4.0
a. 1/2 of sewer and water		x	1,235	
b. 1/2 of conservation		x	1,016	
c. 1/2 of all other	x	x	620[b]	
5. Farm Construction	x		1,195	1.7
INPUT-PRODUCTIVITY INDEXES			25,857	36.0
1. American Appraisal			14,681	20.4
a. Stores, restaurants, garage	x		2,874[c]	
b. Institutional	x	x	11,586	
c. 1/4 of military		x	221	

2. Turner			5,671	7.9
a. Industrial	x	x	5,451	
b. 1/4 of military		x	221	
3. Fuller			4,051	5.7
a. Office buildings & warehouses	x		3,830	
b. 1/4 of military		x	221	
4. ATT for Telephone and Telegraph	x		1,454	2.0
COMPONENT-PRICE INDEXES			8,069	11.2
1. Bureau of Public Roads			7,760	10.8
a. Highways		x	7,539	
b. 1/4 of military		x	221	
2. ICC Railroad Composite			309	.4
a. Railroads	x		270	
b. 1/4 of Pipelines	x		39	
TOTAL VALUE OF NEW CONSTRUCTION PUT IN PLACE			71,905	

Sources by column:

(1)-(3) U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 89.

(4) U. S. Department of Commerce, Office of Business Economics [1966a], Table 5.2, pp. 80-81.

Notes:

[a]Value put in place for Public enterprises not separately given for 1965 in OBE [1966a]. The 1964 value from BDSA 1966a was used instead.

[b]"All other public" is the 1965 value of "Miscellaneous Public Construction" minus the 1964 value for "public enterprises" shown above in line 2c.

[c]The 1965 value for commercial construction was split into its two subsectors by applying the ratio of their 1964 ratios from BDSA [1966a].

with weights based on 1926-1929.[27] Both common and skilled labor are included, and wage rates are adjusted for payroll taxes. The official U.S. government description of the Boeckh methodlogy states that input-productivity techniques are being used: "...(the individual indexes) are also adjusted to reflect the effects of labor shortages and labor efficiency, as determined by monthly studies in each of the 20 areas."[28] But, according to one of the compilers of the Boeckh index, this official statement is completely wrong and in fact "wage rates and materials prices are fed into the computer without any adjustment at all."[29]

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[27]Except where other sources are mentioned, the subsequent descriptions of methods are obtained from U.S. Department of Commerce, Business and Defense Services Administration, [1966], pp. 87-90.

[28]U.S. Department of Commerce, Business and Defense Services Administration, [1966], p. 87.

[29]Telephone conversation with Miss Y. Wheeler, Statistical Department, E.H. Boeckh and Associates, Washington, D.C., April 10, 1967. Douglas Dacy reached the same conclusion by the more laborious method of reading through the Boeckh Manual of Appraisals, which mentions procedures used in constructing the index. No mention of efficiency or productivity was found. Dacy [1962], pp. 27-28. Also in agreement is the NBER study on residential housing, which states that "a detailed examination of the derivation of the Boeckh construction cost index suggests that long-term changes in productivity (and possible long-term changes in builders' profit margins) are not reflected in any significant measure in the index." Grebler, Blank, and Winnick [1956], p. 353.

John Kendrick failed to check into the validity of the official description of the Boeckh index, leading others to accept his conclusion that it is adjusted for productivity. Kendrick uses the following words to compare the Boeckh index with that of the

(to be continued on next page)

2. The Handy-Whitman Indexes (5.4 per cent) are used to deflate the important electricity and gas sectors. They use ancient 1911 and 1911-1914 weights to combine indexes of labor rates, and the prices of basic materials and mechanical equipment. The input prices are not actual prices paid by contractors but are WPI-type sellers' list prices obtained from published sources. No productivity adjustment is made.

3. The Associated General Contractor Index (4.0 per cent) is even simpler, combining on a 1913 base an average of labor rates and materials prices with respective weights of 40 and 60. Wage rates are only for unskilled labor (even though skilled workers are much the most significant component of construction labor cost) and the materials included are limited to just nine, which with two exceptions are averaged together without any weights at all.

4. The Engineering News-Record Indexes (4.0 per cent) are the simplest of all, averaging on a 1913 base one wage rate

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(continued from previous page)
Engineering News-Record (ENR), which everyone agrees is a simple input-cost index:

"Although the product mix underlying the two indexes differs somewhat, the fact that the Boeckh index rises as much as the ENR building cost index between 1913 and 1947 also suggests that productivity advance has not been important in residential building....There are divergences in shorter periods, notably in 1948-57, when the lesser rise of the Boeckh index suggests some real increases in productivity." Kendrick [1961a], p. 492.

with the prices of only three types of materials. The ENR index of construction-cost-in-general, for some reason, uses just the rate for common labor, while the building index takes account only of skilled labor. Since wage differentials have narrowed since 1913 the construction index rises much faster than the building index, and it is this rapidly rising version which is employed in the Commerce Composite.

5. Farm Construction Indexes (1.7 per cent) follow similar procedures, with a base period of 1910-14, a materials weight of 73 per cent and a wage weight of 27 per cent.

Figure 10 plots the time pattern of the ratio of four of these input-cost indexes to our own overall input-cost series, which is an average of the BLS union wage rate data adjusted for secular drift and the new reweighted materials price index. The four fall into two groups--the Boeckh residential and the others. The ratio of the Boeckh residential to the overall index increases significantly between 1935 and 1945 and drifts downward thereafter. This is probably due to the relatively heavy weight in residential construction of lumber, the relative price of which increased rapidly in the 1940's and has declined since then. The ratios of the other three to the overall series are fairly level between 1921 and the Korean war and drift upwards after that. It is difficult to pinpoint the exact reasons without a detailed list of the weights used for each type of labor and materials. The 40 per cent weight for

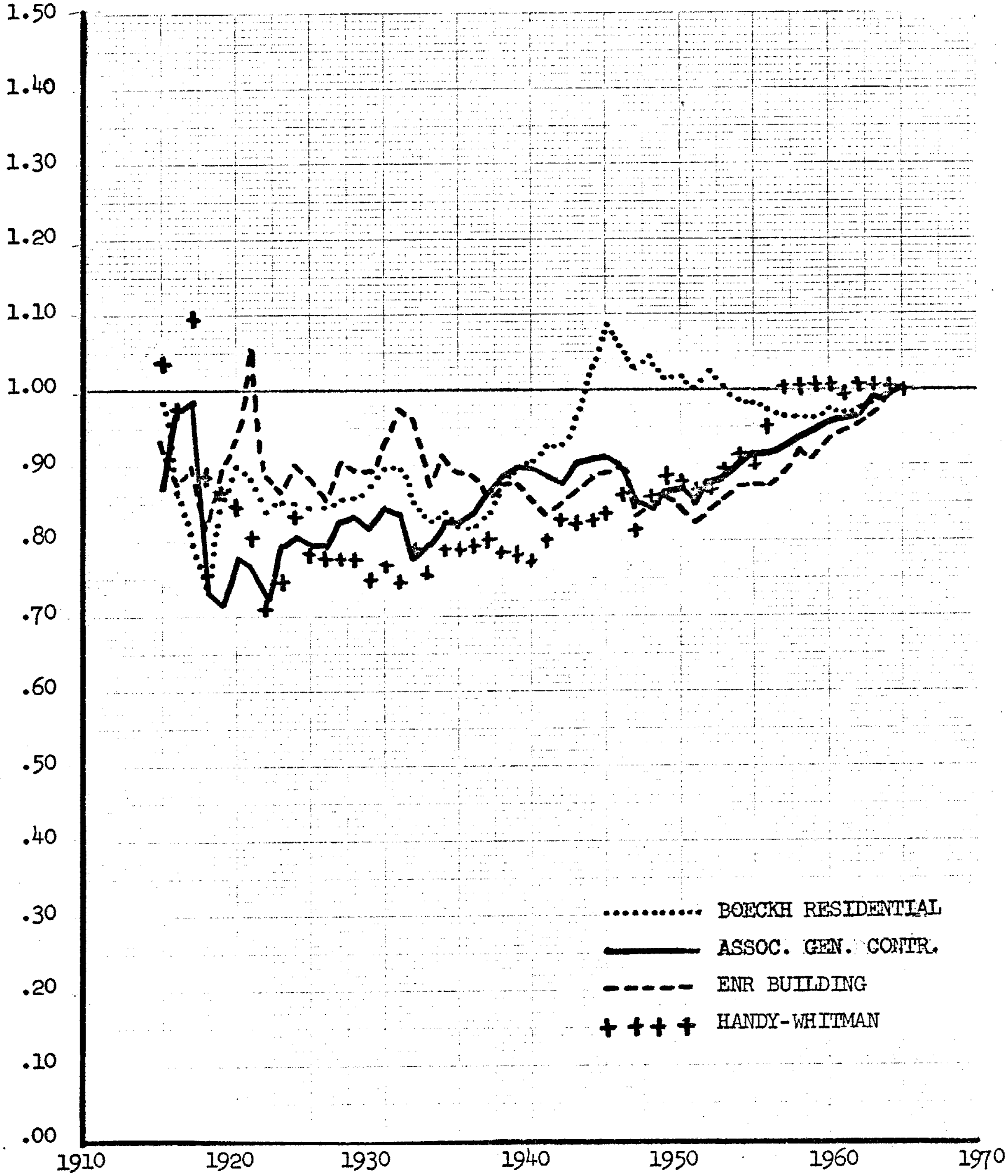

Figure 10

RATIO TO NAIVE INPUT-COST INDEX OF FOUR INPUT-COST COMPONENTS OF COMMERCE COMPOSITE (1965 = 1.00)

Source: Appendix Table A-2.

labor used in the Associated General Contractors index is high, and this may explain the steady upward drift of the ratio during the postwar years. The uptrend in the ratio of the Handy-Whitman index in 1955-58 reflects the relatively heavy weight given to the prices of steel and metal products, which had unusually large price increases during this period and which are much more important in public utility construction than in construction as a whole.

Input-Productivity Indexes

Most previous investigators seem to have been unaware that almost half of the new construction is deflated by methods other than input-cost which do include adjustments for productivity change. The most important of these are the input-productivity indexes which, as shown in Table 30 on p. 208, are used to deflate sectors which in 1965 accounted for 36 per cent of new construction. Their share of private nonresidential construction, the area of concern in this thesis, is a much more significant 72 per cent.

1. The American Appraisal Company Index (20.4 per cent) is compiled on a 1913 base for four different types of buildings--frame, brick, concrete, and steel. Many input prices are weighted together for each building index, including 20 kinds of labor, 77 types of materials, and seven varieties of purchased "equipment and fabrication services" (Cost per hour of excavation equipment, elevator electricians not employed by the contractor etc.). Materials prices are F.O.B. list prices plus separate

components for freight and local sales taxes.[30] Basic hourly wage rates are adjusted for employer insurance premiums and fringe benefits but not for overtime rates. Since variations in profit margins, overtime wages, and discounts from list prices on materials are not taken into consideration, the index is probably more accurate as a trend indicator than as a reflection of short-run movements in prices.

The interesting aspect of the American Appraisal index is the regular and detailed adjustment for productivity which has been ignored by several previous investigators.[31] The compilers send regular questionnaires to contractors on the productivity of workers in producing given components--e.g., the number of hours required by a mason to lay 1000 bricks or by a plumber to install a bathroom sink. Occasional supplemental studies are carried out by the company itself. These productivity ratios, available back to 1913, are multiplied by average labor rates

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[30] U. S. Department of Commerce, Business and Defense Services Administration [1966a], p. 87, contains the incorrect statement that building fixture items like plumbing, heating, lighting, sprinkler systems, etc., are not included in the index. But an unpublished list obtained from the company clearly lists these items as among the 77 materials included.

[31] Dacy [1962] does not make any reference to the productivity adjustment in his description of the American Appraisal index. Kendrick [1961], p. 494, states that "The construction cost indexes in the Commerce Department composite deflator that are not contrived so as to make allowance for productivity change are those prepared by W. W. Handy..., the Associated General Contractors, the Engineering News-Record, the American Appraisal Company [sic], and the farm construction cost indexes of the Department of Agriculture."

(adjusted for fringe benefits) to derive a unit labor cost index. The resulting input-productivity deflator differs from a true component-price index because capital costs and profit margins are ignored, and factors other than production workers (e.g. capital and non-production workers) are not adjusted for changes in their efficiency.[32]

2. The Turner Construction Index (7.9 per cent) uses a somewhat less ancient base period, 1939, and makes several adjustments to basic input prices. In addition to a productivity ratio which is applied to wage rates for each type of skilled labor, an additional correction is made for variations in the efficiency of the contracting firm. Even if workers never improved their own efficiency, unit costs at the firm level might decrease if management developed improved methods for organizing and scheduling various tasks. A further adjustment is made for "competitive conditions," reflecting the tendency of the company to pare costs in periods of slack business when there is more pressure to submit the low bid on projects, a correction which is roughly equivalent

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[32]Information on American Appraisal procedures was obtained by means of a letter from and telephone conversation with Tor Skogstad, Assistant Vice President, American Appraisal Company, Milwaukee, Wisconsin, April 10, 1967.

to an adjustment for changing profit margins.[33]

3. The Fuller index (5.7 per cent) is based on 1914 input weights and is adjusted for changes in labor requirements in the same way as the American Appraisal and Turner indexes. In all three cases, in fact, one of the examples given of a standard component for which labor requirements were computed was "bricks laid per eight-hour day." "Job-cost reports" on labor requirements in given components are compiled quarterly. The Fuller index does not, unlike Turner, take any account of changes in managerial efficiency or "competitive conditions."[34]

4. The American Telephone and Telegraph Building Cost Index (2.0 per cent) is calculated by the American Appraisal Company which uses roughly the same methods as in its own index. Thirteen component indexes are constructed as weighted averages of wage rates and materials prices, and the wage rates are adjusted for changes in fringe benefits, overtime pay, and

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[33]The information in this paragraph is unavoidably vague because of the uncooperative attitude of the spokesman for the Turner company. Turner and Fuller (discussed below) seem to regard their construction cost indexes as competitive tools and jealously guard procedural details as if they were entries in the company president's secret diary. This is inappropriate behavior since these indexes are used to compute the official National Income Accounts of the U.S. government and their methodology should be publically revealed. Turner information from a telephone conversation with Jack Quinn, Contract Engineer, Turner Construction Company, New York, April 6, 1967, who gave the impression that several of the adjustments to input costs are quite subjective.

[34]Information was obtained from a telephone conversation with an uncooperative vice-president named O'Neill, George A. Fuller Company, New York, April 6, 1967.

productivity. The ATT index differs slightly from the contractor input-productivity indexes since changing weights rather than fixed Laspeyres weights are used to combine the components into the building cost index. These component weights are based on studies of the proportion of book dollar investment in each component class from a sample of Bell System buildings. The labor adjustment factors have reflected a very slow gain in productivity during the postwar period at an average rate of about.2 per cent per year.[35]

Figure 11 shows the ratio of several input-productivity indexes to our overall input-cost index. The ratios would be expected to have declined over the past 50 years if component labor requirements had fallen, but all show a surprising increase occuring for the most part between the late 1930's and late 1940's. The ratios also exhibit cyclical fluctuations which roughly resemble cycles in aggregate output, reaching relative peaks during World War I, the years of the early postwar inflation, the Korean war, and the 1955-57 boom.

One of the basic causes of both trend and cycles appears to be the sensitivity of worker efficiency to conditions in the labor market, as illustrated in American Appraisal data for carpenters in Figure 12. There appears to be a tendency for productivity

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[35]ATT index information based on a telephone conversation with John D. Russell, Vice-President, American Telephone and Telegraph, New York, April 10, 1967, and on copies of two letters written to Professor Zvi Griliches of the University of Chicago by Walter A. Stevens, Director of Business Research for ATandT, dated January 4 and April 1, 1966

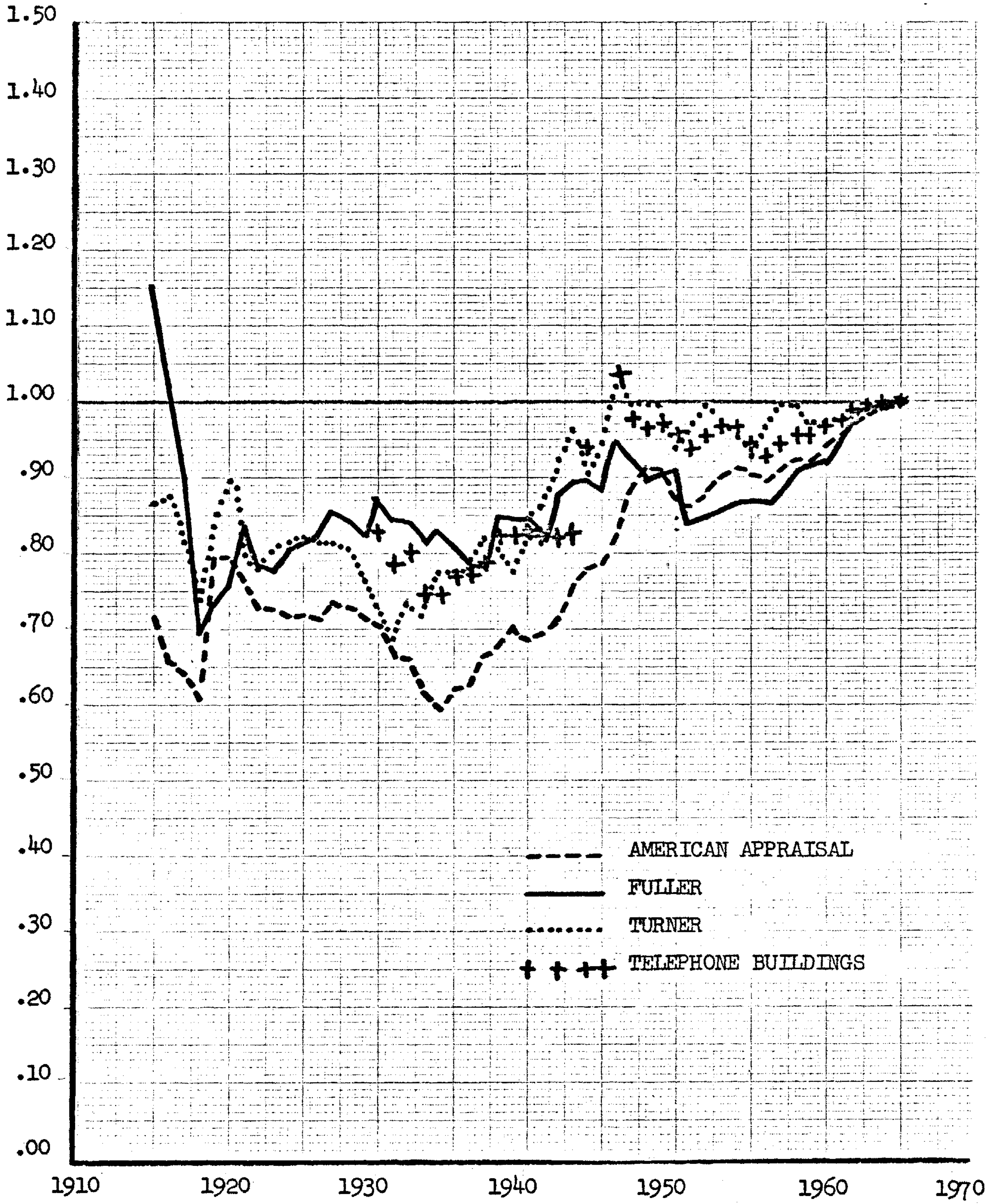

Figure 11

RATIO TO NAIVE INPUT-COST INDEX OF FOUR
INPUT-PRODUCTIVITY INDEXES (1965 = 1.00)

Source: Appendix Table A-3.

Figure 12

AMERICAN APPRAISAL INDEX FOR THE
EFFICIENCY OF CARPENTERS (1965 = 1.00)

Source: Appendix Table A-3.

to fluctuate counter-cyclically, in contrast to the observed cum-cyclical variations in productivity for the whole economy.[36] When jobs are hard to get, as during the Depression, employed craftsmen seem to put more effort into their work. Also, the most experienced and productive workers may be the last to be fired. Tight labor markets during years of booming construction, in contrast, may induce worker slackness and cause reduced productivity through the employment of inexperienced workers.[37] Since labor efficiency (at least for carpenters) was about the same in the 1920's as in the 1960's, other factors must be responsible for the secular uptrend of the input-productivity indexes to the input-cost series--perhaps declines in efficiency of other types of labor, higher weights on the labor components, and adjustments made for sales taxes, fringe benefits, and transportation costs.

Component-Price Indexes

Input-productivity indexes are likely to be inadequate because of the failure to consider discounts on materials prices, capital costs, changes in the productivity of capital

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[36] Gallaway [1964]; Kuh [1965]; Wilson and Eckstein [1964].

[37] This view was suggested by Skogstad of the American Appraisal Company on the basis of all of his company's labor efficiency factors, not just the evidence on carpenters shown in Figure 12.

and materials, and changing profit margins.[38] A more accurate approach is the calculation of indexes from actual prices paid by buyers of standardized components. The Composite includes two such component-price deflators, those compiled by the U.S. Bureau of Public Roads and the U.S. Interstate Commerce Commission. In addition the U.S. Bureau of Reclamation publishes a similar index which is not widely known, since it is not used by the Department of Commerce in the Composite.

1. The Bureau of Public Roads (BPR) Composite Highway Index (10.8 per cent) is designed to show changes in the cost of building a "standard mile" of roadway, which is made up of five different components--excavation, paving, reinforcing steel, structural steel, and structural concrete. The separate price indexes for each of these five are combined with fixed weights, based on 1925-29 expenditures for the period before 1950, and on 1957-59 weights since then. The five components are treated as a valid sample of all components, and the weight applied to each is determined from total expenditures on it and all related components in the base periods.

The price index for each component reports bid prices at which construction has been undertaken and presents the long-sought ideal of a price index based on the price actually paid by buyers. Unlike other indexes in which materials prices are sellers' reports copied down from the Wholesale Price Index, the BPR reflects discounts made available when the highway con-

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38 (see next page)

tractor buys his materials, as well as changes in labor productivity, capital costs, and profit margins. (The indexes for steel and structural concrete refer to a standard amount put in place and therefore reflect changes in the productivity of transporting and handling the materials.)[39]

2. The Insterstate Commerce Commission (ICC) Railroad Index (.4 per cent) is the most comprehensive component-price index available, yet it has been ignored in the construction deflation debate because details of its methodology have not been published. Compiled by the Bureau of Accounts of the ICC, the railroad index is a chain-weighted average of the indexes for 30 separate components. Weights are based on the importance of each component in railroad construction expenditures and are based on 1930 for the years 1915-35, on 1935 for 1936-48, on 1949 for 1949-52, and on 1953 for 1953-65. Separate component indexes are available for eight U. S. regions.[40]

Components are somewhat more broadly defined than in the

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[38] This stricture applies even to the Turner index, because its adjustment for "competitive conditions" appears to be subjective and is probably not an adequate approximation of actual changes in profit margins.

[39] The basic methodology of the BPR is explained in Harrison [1933], and the 1957-59 revision is reported in Stern [1961].

[40] The component indexes are available in U. S. Interstate Commerce Commission, Bureau of Accounts [1966].

BPR index and are really equivalent to "projects" in the terminology developed above. Examples of ICC components are tunnels and subways, ties, rails, ballast, tracklaying and surfacing, station and office buildings, power plants, roadway buildings, etc., in contrast to the more closely defined BPR components like "14,583 cubic yards of structural concrete in place." Since "roadway buildings" doubtless change in specifications over the forty-year period covered by the index, there may be some danger that effects of quality changes in buildings have disguised true price movements.

But a closer look reveals that the broad component indexes are themselves weighted averages of subcomponent indexes, and these in most cases are delimited very closely.[41] Prices for individual sub-components are averages per specified unit values (tons, board feet, etc.,) as reported by all U. S. railroads. Most sub-components are so closely specified that it is unlikely that

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[41]Category 6, "Bridges, trestles, and culverts," contains separate indexes for the following subcomponents: Price per cubic yard of dry, wet, and pneumatic excavation, per cubic yard of plain, reinforced, balustrade, encasement, and ready-mixed concrete, per barrel of cement, per ton of cast-iron pipe, per hundredweight of six kinds of steel, per pound of movable bridge machinery, per linear foot of wood for piling, per ton-mile of culvert pipe, and many more. Almost all prices refer to materials put in place and thus take account of labor costs and productivity change. Details were obtained from U. S. Interstate Commerce Commission, Bureau of Valuation [1955], pp. 7-23.

changes in quality or specifications disguise true price movements.[42]

3. The Bureau of Reclamation Composite Cost Index is another deflator largely based on actual bid prices paid but is not used by the Commerce Department to deflate any portion of U. S. construction activity, possibly because it is not available before 1940.[43] Separate indexes are calculated for 30 different types of structures and equipment, and each of these is broken down into sub-components. The Reclamation procedure differs from that of the ICC and BPR at the sub-component level, where indexes are averages of materials prices and "unit value-added cost." Materials prices are copied from Wholesale Price Index reports, and the value-added cost is based on abstracts of actual contractor bids for project subcomponents with given specifications. Thus the Reclamation subcomponent indexes are a hybrid between the input-cost and component-price approaches. The index takes into account changes in labor productivity and contractor profit margins but, since it is based on list materials prices as reported by sellers, ignores possible cyclical price flexibility. The sub-component indexes are combined into project average indexes with fixed weights based on a study of expenditures in 1949-51. For several types of

[42]A possible exception is the important category of buildings, which are too broadly specified to eliminate the possibility that quality change may creep in. Information on the ICC index was obtained in the publications cited and in telephone conversations with Joseph M. Morgan, Chief Valuation Engineer, Bureau of Accounts, U. S. Interstate Commerce Commission, on February 8 and April 6, 1967.

[43]See U. S. Department of Interior, Bureau of Reclamation [1966b].

structures almost as many subcomponent indexes are calculated as in the ICC index, e.g., 15 for concrete dams, nine for earth dams, and six for highway steel bridges.[44]

The ratio of the component-price indexes to the simple overall input-cost index is shown in Figure 13. The BPR ratio declines substantially, an indication of considerable productivity improvement in highway construction. It was this strong evidence of productivity growth in the BPR index which led Griliches and Jorgenson to substitute it as a deflator for all construction on the grounds that the Commerce Composite neglects productivity improvement. In addition to the obvious downward trend, the BPR ratio in Figure 13 exhibits pronounced cyclical fluctuations. Peaks occur during the early 1920's, World War II, the Korean War, and the 1956-57 investment boom. Troughs are evident during World War I, the early and late years of the Depression, the short business recessions of 1949 to 1954, and the period of prolonged weakness in business from 1958 to 1965. The major anomaly is the peak between 1933 and 1936, which makes no sense since the post-Depression recovery of road building did not <u>begin</u> until 1936. The fluctuations reflect the combined influence

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[44]General information on the Reclamation index was obtained in a letter dated December 22, 1966 from R. A. Gullett, Chief Construction Engineer of the Bureau and in a telephone conversation with R. F. Potter, Head of the Analysis and Data Section, April 5, 1967. Information on subcomponents is not shown in the published quarterly pamphlet and was obtained in an unpublished table titled "Breakdown of Typical Reclamation Construction Work in Percent of Cost." [1966a]

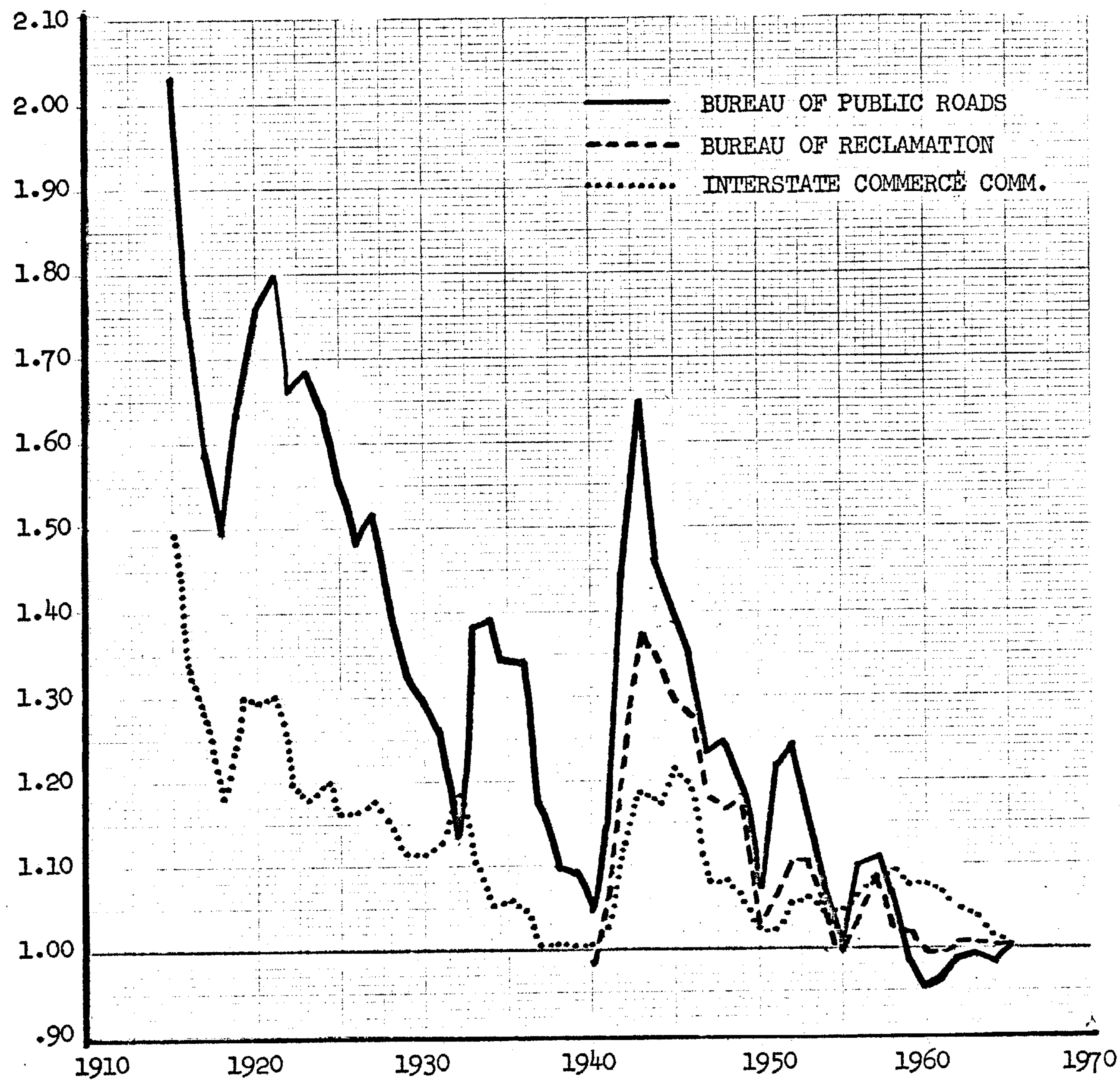

Figure 13

RATIO TO NAIVE INPUT-COST INDEX OF THREE
COMPONENT-PRICE COMPOSITE INDEXES (1965 = 1.00)

Source: Appendix Table A-4.

of cycles in productivity, profit margins, and discounts on materials. As Murray Foss has pointed out, since the prices of basic construction materials (concrete and steel) are relatively inflexible and the demand for roads is cyclically insensitive compared to that for other types of construction, it is possible that the BPR index understates the amplitude of the true fluctuations in the prices of other structures.[45]

The ICC ratio declines, indicating some productivity improvement, although considerably less than in highway construction. In addition the cyclical movements in the ICC ratio are less pronounced than in the BPR and do not coincide closely with those of the nationwide economy (except during and immediately after World War II). It is particularly interesting that the price of railroad construction in postwar recessions does not exhibit the flexibility shown by the BPR index. Another postwar difference is that most of the postwar growth of productivity in highway construction appears to have occurred before 1960 and in railroad construction after that date.[46]

The movements of the Reclamation ratio are very similar to those of the BPR index, exhibiting the same tendency toward secular productivity improvement and cyclical fluctuations which are coincident

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[45] Foss [1961].

[46] For more on the postwar growth in highway construction productivity, see Stern [1965].

with the general business cycle. The fluctuations are somewhat smaller in amplitude than those of the BPR, probably because the Reclamation methodology does not reflect changing premiums and discounts on materials.

Evaluation of the Commerce Composite

The preceding discussion should leave most readers gasping with disbelief. It is ludicrous that the Federal government, after expending great effort in the collection of primary data for the estimation of current dollar investment series, should deflate expenditures on structures by this heterogeneous and inconsistent set of price indexes. The Commerce Composite index, the only official comprehensive price index for all construction, is fully deserving of the accolade bestowed by the NBER Price Statistics Review Committee [1961], which called it "defective in almost every possible way."

The index is notable simply for the fact that, unlike the Wholesale, Consumer, and Prices Paid by Farmers indexes, the government devotes to it no resources whatsoever. Reports from private compilers are copied down mindlessly and are published in official government publications without any check on the consistency or validity of the data or in the methodology underlying them. As we have seen, some of the descriptions of the methodology published in official government reports are simply wrong. This situation alone is ample support for the establishment of a central Federal Statistical Office responsible for economic statistics as urged at the end of Chapter II; such an agency endowed with a respectable research department would never have allowed the Composite index to persist in its present form.

The separate indexes used to deflate the individual sectors of construction (e.g., residential, industrial, highways) give a misleading impression of differing sectoral price trends. In most cases the revealed "differences" do not represent any tendency for true sectoral prices to diverge but can be traced to differing procedures underlying the individual indexes. The faster rise of the public utility index than that for railroads, for instance, mainly reflects the simple fact that input-cost procedures were used in the former and the more accurate component-price method in the latter. Our principal task in trying the untangle the true trend of construction prices should be to concentrate on the aggregate price of all construction and to defer the problem that diverging price trends in individual sectors may warrant separate sectoral deflators.

If a "true" construction price index could be computed, most economists would expect it to exhibit a slower rate of increase over the last forty years than the Commerce Composite because of the failure of the latter to take sufficient account of productivity improvement. The NBER Review Committee, for instance, states that the individual cost indexes in the Composite "for the most part are, instead, indexes of wage rates and building materials prices... [and] assume that there is no change in productivity in construction. Over a considerable period of time this tends to impart a strong upward bias to the cost indexes."[47] Similarly, Griliches and Jorgenson assume that the Commerce Composite is completely inaccurate because of the failure to adjust for productivity gains and in place of the Composite simply substitute the Bureau of Public Roads Highway index, the slowest rising of all, as a deflator for all of construction. Yet it is an overstatement to imply that the Composite is almost completely without any productivity adjustment, since almost half of the value of new construction (47.2 per cent in 1954 as shown in Table 30 on p. 208) is deflated by adjusted indexes of the input-productivity or component-price variety. Nor have several previous studies, reviewed in 1961 by R. A. Gordon, concluded that there is a serious upward bias in the Composite.[48]

The conflict between the evidence reviewed by Gordon and the position of Griliches and Jorgenson is sharpened by Dacy's recent work on postwar construction prices, which supports the position that the Bureau of Public Roads index is more accurate than the Commerce Composite as a deflator for all construction.[49]

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[47]National Bureau of Economic Research [1961], pp. 87-88.

[48]R. A. Gordon [1961], pp. 943-44.

[49]Dacy [1962] [1964] [1965].

The next few pages undertake a reconciliation of the opposing views and pay particular attention to evidence on price trends in construction sub-components and to an extension and modification of Dacy's suggested input-productivity method.

VI. EVIDENCE SUPPORTING THE VALIDITY OF THE OFFICIAL CONSTRUCTION DEFLATORS

There has been no new evidence on the validity of the construction price indexes for more than ten years. Two or three specific comparisons have been cited repeatedly in evaluations by Gordon [1961], Kendrick [1961a], and Powell [1957].

Comparisons of Indexes Computed by Different Methods

1. In their 1956 NBER volume Grebler, Blank, and Winnick constructed a price index for one-family owner-occupied families from the 1937 Financial Survey of Urban Housing.[50] Owners were asked about the current (1934) value of their house and the year and cost of acquisition. A housing price index was calculated for each year between 1890 and 1934 as the average acquisition cost divided by 1934 value, adjusted for a compound 1.375 per cent rate of depreciation. Thus, for example, the 1934 value of homes purchased in 1904 was reported to be 15 per cent higher than the estimated 1904 purchase price, and the price of a younger home in 1934 would have been still higher by the added depreciation on

[50] Grebler, Blank, and Winnick [1956], pp. 345-58.

the old house. Thus the price of a house of _given_ age rose between 1904 and 1934 according to the formula:

$$D_{1904} = \frac{p_{1904}}{(p_{1934})\ (1.01375)^{1934-1904}}$$

The index is an average for all houses surveyed in 1934, whether they were purchased new or old, and thus reflects the assumption that homes of different ages are closely substitutable and have constant _relative_ prices. The depreciation rate was calculated from FHA data and represented the net effect of loss of value from depreciation and a partially offsetting increase in value due to additions and alterations.

The surprising result of the calculation was a price index which coincided almost exactly over the entire pre-1934 era with a simple input-cost index. The comparison of the two completely independent indexes, one of actual prices and the other of factor costs, implied that there were no changes at all in labor productivity over the entire pre-1934 period. The Grebler, Blank, Winnick comparison is not conclusive, of course, for nothing is indicated about the true price of _non_residential construction, the relevant sector for productivity analysis, and the evidence does not eliminate the possibility that productivity in all sectors may have increased after 1934.

2. In 1952 Colean and Newcomb compared a simple input-cost

index to the average of four contractor indexes calculated "on the basis of actual estimates for building comparable structures" and concluded that there was no evidence of significant productivity improvement since the two indexes coincided almost exactly.[51] The contractor indexes used were of the input-productivity type and adjust wage rates for changes in the production worker efficiency. Since variations in profit margins, discounts on materials prices, and the productivity of nonproduction workers are not reflected, they are not "actual estimates" of building prices. Thus the Colean-Newcomb finding is irrelevant and proves nothing about the behavior of true construction prices.

The close coincidence of the input-cost and input-productivity indexes in the Colean-Newcomb comparison is surprising, since the input-productivity indexes examined above diverged considerably from our overall input-cost series. Figure 14 brings the Colean-Newcomb comparison up to date by illustrating the ratio of the average of four input-productivity indexes to our overall input-cost index. Rather than coinciding closely, the input-productivity ratio rises between the 1920's and the 1950's, indicating if anything a decline in productivity over that period. This conclusion differs from that of Colean-Newcomb partly because some of the divergence between the two series occurs after their

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[51]Colean and Newcomb [1952], pp. 72-73.

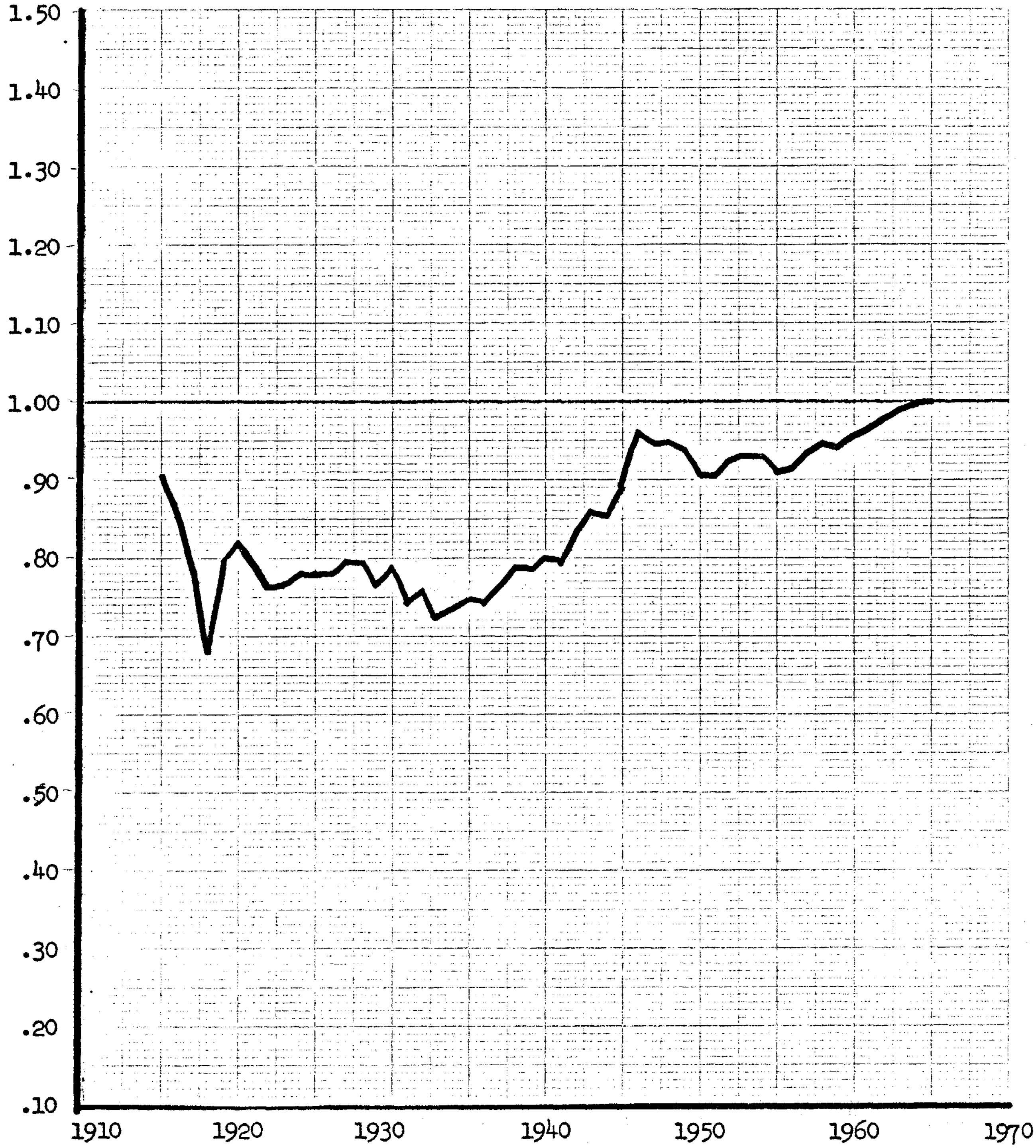

Figure 14

RATIO TO NAIVE INPUT-COST INDEX OF AVERAGE OF
FOUR INPUT-PRODUCTIVITY INDEXES (1965 = 1.00)

Source: Appendix Table A-3.

study was made, and partly because of the new wage and materials price series in our overall input-cost index.

Further Support for the Composite

Colean-Newcomb made a set of observations (later referred to by Gordon) in support of their surprising conclusion that true construction prices had risen as rapidly as a simple index of input costs.

1. In the pre-1951 period examined by Colean and Newcomb there was an increase in the price of building materials as measured by the BLS. Even if productivity had increased rapidly enough to keep the growth of construction unit labor costs in line with that in the rest of the economy, the rapid advance of materials prices alone would have caused a substantial rise in the relative price of construction. But the phenomenon of soaring increases in materials prices during the pre-1951 period, as we saw above on pp. 198-205, is largely an illusion. Our new index, calculated with a more representative set of weights than the official BLS series, grew only 6 per cent faster than the WPI between 1929 and 1951, as opposed to a 30 per cent relative rise in the official index. Increasing relative materials prices, then, should not have been cited by Colean-Newcomb (and indirectly by Gordon) as a major cause of the rapid rise of construction prices.

2. The use of union wage rates in input-cost indexes is

held by Colean-Newcomb to impart a downward bias to the rate of growth of wage rates.[52] While the Commerce Composite may have overstated the rise in unit labor cost by its failure adequately to consider productivity gains, this was considered to have been offset by the understatement of the growth of average wage rates, caused by the use of a union wage rate series which ignored the increase in the proportion of well-paid union labor in the construction labor force. The wage series used in our input-cost index was adjusted above for this bias (see pp. 194-198) and hence is not subject to the same comment, and there is nothing to offset the upward bias in the rate of growth of the input-cost index due to its failure to consider productivity gains.

3. Colean-Newcomb cite the worker efficiency studies of the American Appraisal Company as evidence that there has been no significant improvement in labor productivity.[53] They attribute this surprising fact to restrictions on entry into the construction trades during the long slump in construction between 1927 and 1947, which led to a labor force in the late 1940's characterized by "increasing age and decreasing strength."[54]

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[52]Colean and Newcomb [1952], pp. 67-68.

[53]See above, Figure 12, p. 220.

[54]Colean and Newcomb [1952], p. 69.

The case for the validity of the Commerce Composite does not appear as strong in this review as in Gordon's 1961 summary. The apparent agreement of input-productivity and input-cost indexes is not as close as claimed by Colean and Newcomb and in any case is inconclusive, since input-productivity indexes do not measure true prices. Furthermore, the increase in the relative price of materials has been substantially exaggerated and cannot be cited as a major cause of the rapid growth of the Composite. On the other hand, the Grebler, Blank, and Winnick index of house prices is impressive evidence on prices actually paid by buyers, and the American Appraisal worker efficiency studies, while not conclusive, at least suggest that productivity gains in construction may have been substantially less than in other sectors of the economy.

Griliches and Jorgenson claim that final conclusions on the trend of construction prices can only be judged by reference to component-price indexes which measure prices actually paid by buyers, and point to the relatively slow rise in the Bureau of Public Roads highway index as evidence that the Commerce Composite substantially exaggerates the rate of growth of construction prices. Their argument is only valid to the extent that price trends in highway construction are representative of other sectors, and a detailed look at some of the components of the BPR and similar indexes casts considerable doubt on this assumption.

VII. THE PRICES OF EXCAVATION, STEEL, AND CONCRETE COMPONENTS

The component-price indexes measure true prices paid by buyers, reflecting variations in discounts on materials, overtime pay, productivity, and other factors not taken into account by simple input-cost indexes. Their allowance for productivity is superior to that of the input-productivity indexes, taking into account changes not just in the time taken by a skilled mason to lay his bricks, but in the efficiency of non-production workers in organizing his schedule and in bringing his bricks and mortar to him. The only limitation on the use of component-price deflators as general construction price indexes is the possibility that the measured components are not representative of unmeasured ones because of differing trends in productivity or the prices of materials used. Indexes for several important components are available from the three main compilers of component-price indexes--the Bureau of Public Roads (BPR), the Interstate Commerce Commission (ICC), and the Bureau of Reclamation (BR)--and these can be compared to sort out elements which are not typical of construction as a whole.

Excavation

Of all the components of construction projects, excavation has been most susceptible to productivity improvement. Earth-moving has been a principal benefactor of the replacement of animal power by machines, and today's immense pieces of heavy machinery would have been impossible without the development of the internal combustion engine. The cost of earthmoving is almost entirely labor and equipment rental, since no important materials are used, and any productivity improvements have a large effect in reducing prices.

Figure 15 compares three component-price indexes for heavy earthmoving--the BPR common excavation, ICC grading, and BR earth dam series (the latter is 80 per cent excavation) with our adjusted wage rate series. The movements of the three series are quite close and tell a consistent story of regular and substantial productivity improvement over the last fifty years.[55] Despite rapid increases in wage rates, the cost per cubic yard of excavation in 1965 was actually lower than its level in the mid-1920's according to the ICC index and only slightly higher according to the BPR.

Equally interesting in Figure 15 is the evidence of substantial cyclical fluctuations in prices, with an especially pronounced peak during World War II. Obviously firms were able to increase prices from 1939 to 1943 much more rapidly than the average rise of union wage rates, suggesting that wartime controls on wages, prices, and profits may not have been very effective against some excavation contractors. The cyclical variation in

[55]A similar comparison was published 32 years ago by Chawner [1935].

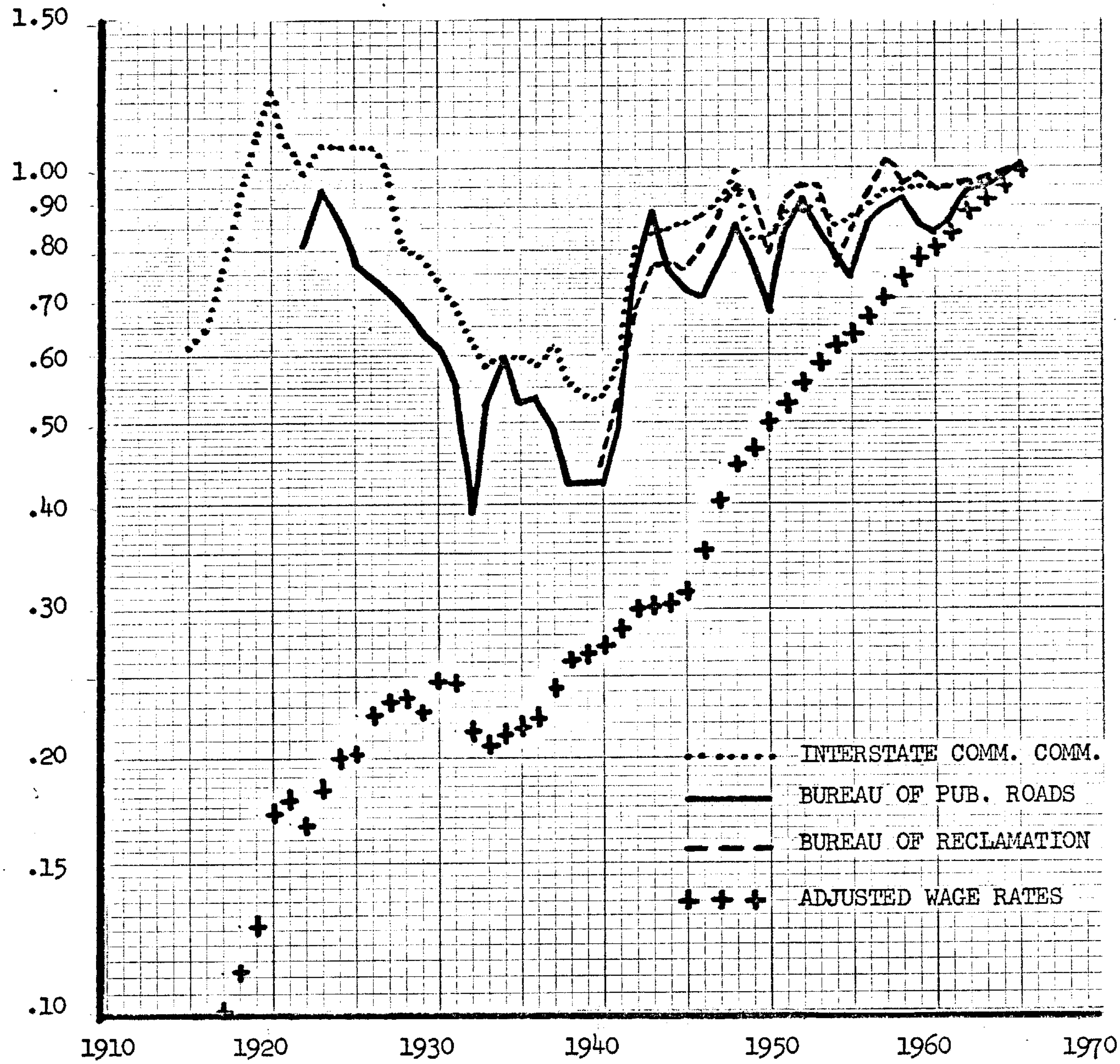

Figure 15

THREE COMPONENT-PRICE INDEXES FOR EXCAVATION COMPARED WITH ADJUSTED UNION WAGE RATE INDEX (1965 = 1.00)

Source: Appendix Tables A-1 and A-4.

prices has continued in the postwar period with a discernible drop during recessions.

But the favorable price trends in excavation do not by themselves indicate similar movements in the prices of buildings, for excavation is only a trivial part of the cost of private nonresidential buildings. Unfortunately there are no genuine bid-price indexes for entire buildings with given specifications. The ICC index for offices and stations is not a price index but a unit value index, stating the average price per cubic foot of all offices and stations. Changes in unit value due to changes in the quality of buildings, e.g., trends to new materials or improvements in heating and air conditoning, are counted as changes in price. The Bureau of Reclamation publishes indexes for pumping and power stations, but these consist mainly of concrete and are not typical of the materials composition of an "average" building. Another BR index for "general property" does not reflect bid-prices at all but is a simple input-cost index.

Since no bid-price data are available for representative buildings with fixed specifications, a second-best test for the presence of productivity change is a comparison of component-price and input-cost indexes for specified types of components. Of the major categories of building components--lumber, plumbing-heating equipment, steel, and concrete--component-price indexes are available for the last two.[56]

[56] The ICC timber components measure F.O.B. prices of materials, not the total cost put in place. See U.S. Interstate Commerce Commission [1955].

Structural Steel in Place

A naive estimate of the cost of erecting structural steel is an input-cost index, a weighted average of our adjusted wage rate index and American Appraisal indexes for the price of structural steel.[57] Weights are those reported by the American Appraisal Company for the structural steel components of various projects. A comparison of this input-cost series with component-price indexes for structural steel in place should allow us to gauge the importance of changes in productivity, profit margins, overtime pay, and discounts on materials, all of which are neglected by the simple index.

Several component-price indexes are available for the comparison. The ICC and BPR have both compiled series on the price of structural steel in place (although the former is only available for the period 1928 to 1953). Two other series give prices of projects in which structural steel is an important component and may provide useful independent evidence--the ICC bridges component and BR's index for steel bridges.[58] In Figure 16 the movements of the four component-price indexes are roughly similar to the input-cost series in the long-run alhtough they display different short-run cyclical patterns. The ratio of the four to the input-cost

[57] American Appraisal [1967].

[58] The proportion of structural steel in the BR steel bridge index is 38 per cent.

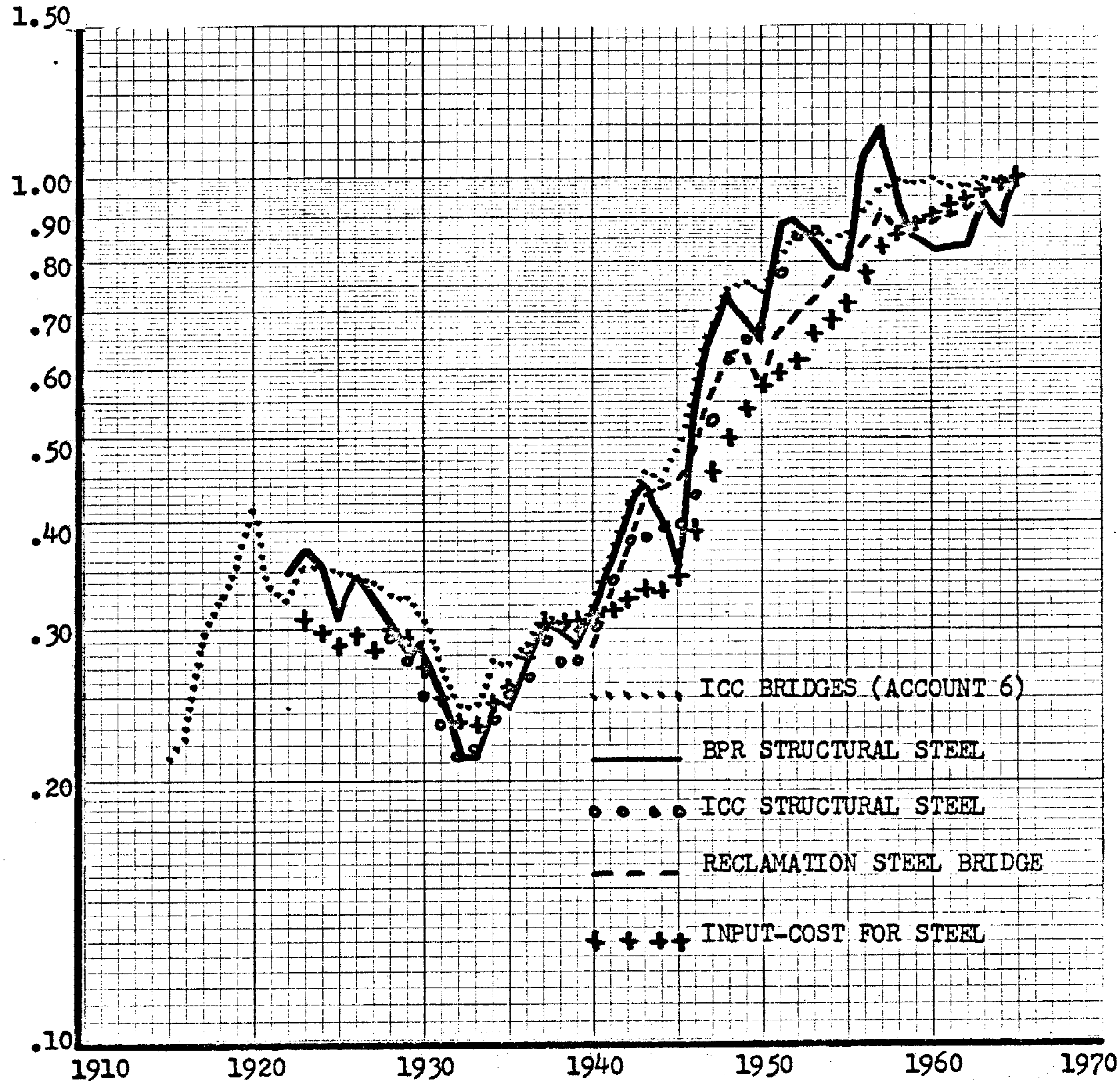

Figure 16

FOUR COMPONENT-PRICE INDEXES FOR STRUCTURAL STEEL
COMPARED WITH INPUT-COST INDEX FOR STRUCTURAL STEEL
(1965 = 1.00)

<u>Source</u>: Appendix Tables A-5 and A-6

index is slightly lower in the 1960's than in the 1920's, implying moderate secular productivity improvement, although long-run movements are difficult to discern because of the large cyclical fluctuations in the ratio.

The differences among the four indexes may be due more to differing materials mixes and methodology than to conflicts on "true" price movements. The relatively small fluctuations of the ICC and BR bridge indexes, for instance, probably reflect the fact that steel is not the only material included. The BR index reports the actual bid price only on the value-added portion, and materials prices are inflexible sellers' list prices as reported by the BLS, so that it is not surprising that its fluctuations are smaller than those of the BPR structural steel index, which reflects discounts and premiums on list prices. ICC's structural steel index follows the path of the BPR series quite closely, particularly during the Depression years.

Structural Concrete in Place

Concrete is the only other item for which reliable component-price indexes exist. Figure 17 compares an input-cost index for concrete with three component-price series--BPR for structural concrete, ICC for plain concrete (available only for 1928-53), and the BR index for pumping stations (in which concrete makes up 69 per cent of the cost and which is available only since 1940). The three component-price indexes move together very closely,

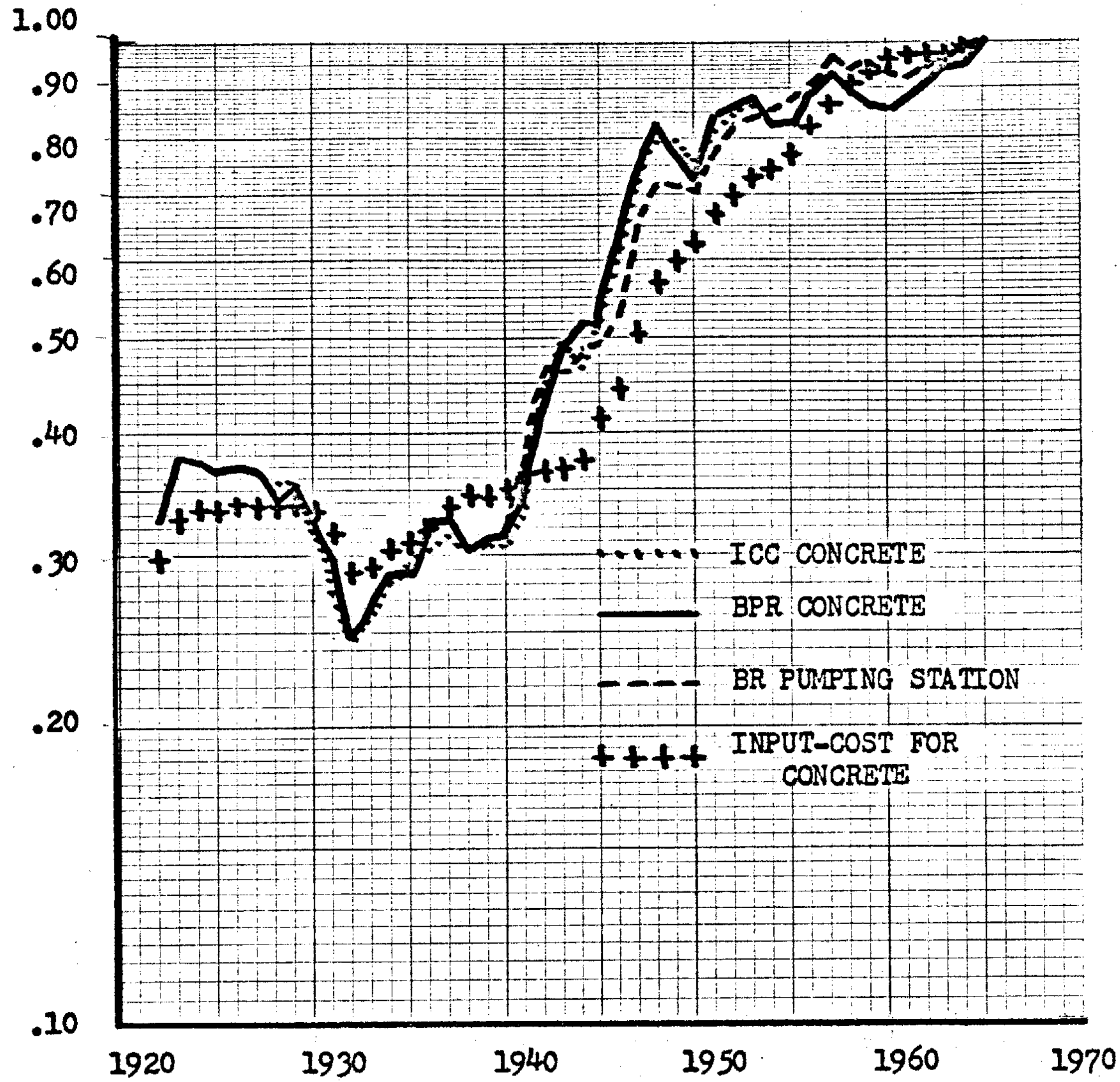

Figure 17

THREE COMPONENT-PRICE INDEXES FOR STRUCTURAL CONCRETE COMPARED WITH INPUT-COST INDEX FOR STRUCTURAL CONCRETE (1965 = 1.00)

Source: Appendix Tables A-5A and A-6

and in particular the ICC index follows the BPR with the tenacity of a bloodhound.

Again there is some slight evidence of secular productivity improvement which as before is obscured by the fluctuations of the ratios. The component-price indexes fall below the input-cost series during the Depression years but exhibit a familiar excess between 1942 and 1960. (If the data had been continued into 1966 this excess would have reappeared, for in that year the BPR concrete index rose more than 6 per cent over its 1965 value and the structural steel figure rose more than 12 per cent).

What was responsible for the significant gap between the steel and concrete component price indexes and equivalent input-cost indexes between 1942 and 1960? The differences of up to 56 per cent are too great to be accounted for by fluctuations in profit margins alone. But a hint on the probable cause is given in Figure 18, where the ratios between the input-cost series and the averages of the various component-price indexes for steel and concrete are compared with the American Appraisal labor efficiency factor for carpenters (the inverse of the series in Figure 12 on p. 220 above). There is a strong resemblance between the three plotted lines, suggesting that fluctuations in labor efficiency may have been an important cause of deviations between actual bid prices and unadjusted input costs.

The component-price ratios of Figure 18 can be converted into a rough indication of price trends in total new construction.

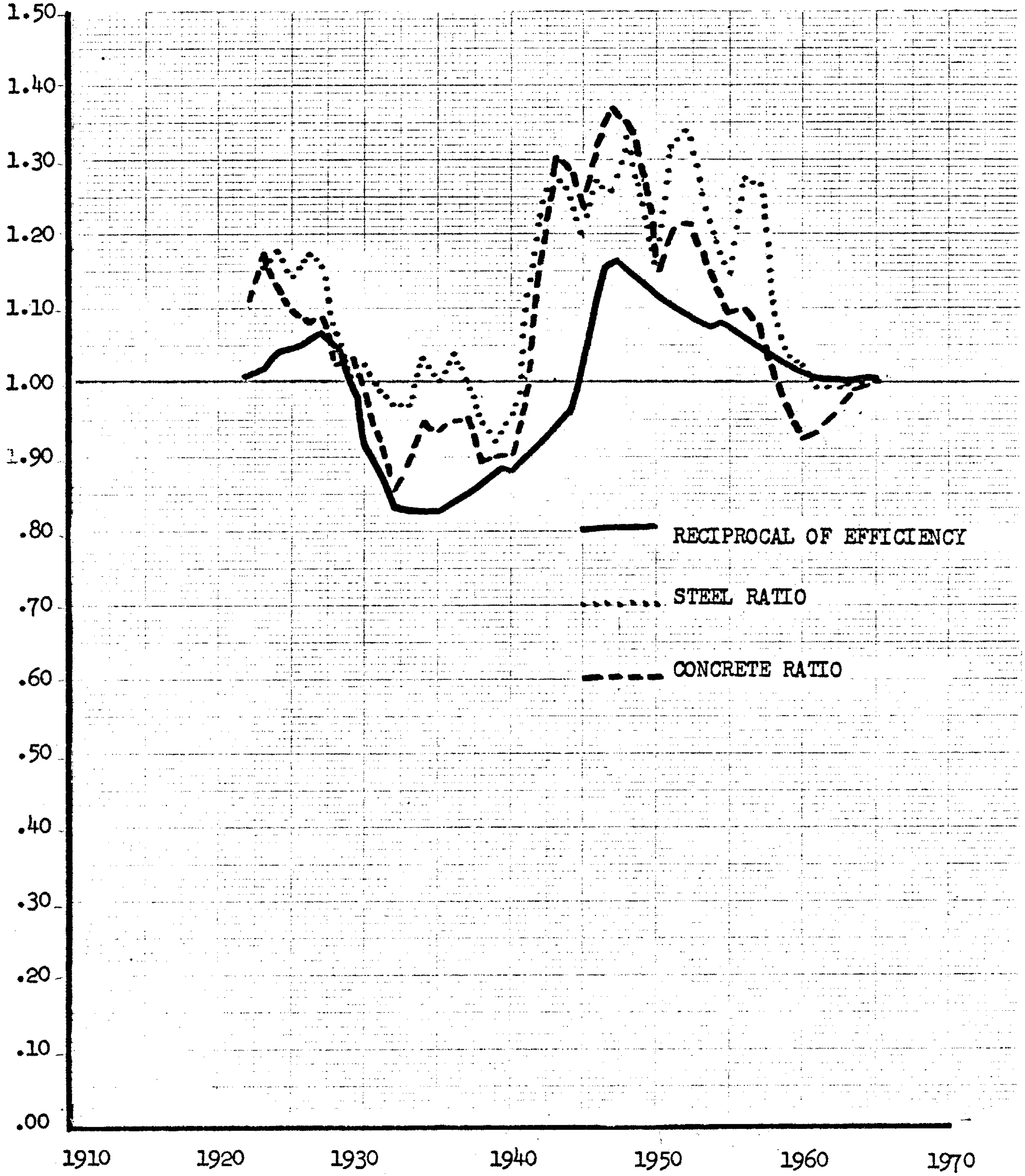

Figure 18

RATIO OF COMPONENT-PRICE INDEXES TO INPUT-COST INDEXES FOR STEEL AND CONCRETE, COMPARED TO RECIPROCAL OF AMERICAN APPRAISAL EFFICIENCY FACTOR FOR CARPENTERS (1965 = 1.00)

<u>Source</u>: Appendix Tables A-3 and A-6.

While the structural steel and concrete series cannot be used in their present form for this purpose because of possible deviations of steel and concrete prices from the average price of all materials, the ratios of Figure 18 can be multiplied by our all-materials input-cost index, which in this way is adjusted for variations in productivity, discounts, overtime, and profit margins. This new index is called the "Component-Price-Hybrid" (CPH) and is compared in the next section with a body of independent evidence on the price of construction.

VIII. DACY'S INDIRECT METHOD

It is evident from the preceding section that Griliches and Jorgenson err in using the BPR highway index to represent the price of all construction; the slow rise of that index is largely caused by the heavy weight given to excavation and paving, which have been subject to rapid productivity gains but are not representative of other construction components. Although they might be willing to admit the inadequacies of the BPR composite as a deflator for total construction, Griliches and Jorgenson would object to our CPH index, which is based on evidence of very little long-run growth in construction productivity. They would point to Dacy's recent work, which reaches the conclusion that "the (Commerce) composite has grossly overstated the construction price rise with the attendant effect that almost every economist who has dealt with construction as a sector has understated productivity."[59] It is important to examine Dacy's method to see if this apparent conflict can be

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[59] Dacy [1965], p. 411.

resolved. Unfortunately Dacy's work covers only the period 1947-63, and for a judgement on long-term productivity growth it is necessary to extend his estimates back to the 1920's.

The Dacy Model

The intractibility of price estimation in the building industry is attributable to the absence of any physical measure of real output, due to the heterogeneity of construction. Dacy leaps over this obstacle by making the simple assumption that real output is proportional to real materials input. While permitting substitution between capital and labor, and between different kinds of materials, his assumption disallows any substitution between materials and other factors:

> ...a contractor cannot replace concrete blocks in a building with a cement mixer. Likewise, it is impossible to substitute labor time for shingles or steel. One can use more or fewer labor hours in putting up a house, but that same house will not have more nails, and the use of more hours of labor will result only in reduced productivity. More or less labor time will usually follow from the substitution of one type of material for another as, say, gypsum board for plaster, but the absolute amount of materials in physical terms has not been reduced.[60]

This is undoubtedly an overstatement, since the increasing relative use of components which are largely preassembled in factories (e.g., prefabricated doors, windows, and wall sections; air conditioners; built-in kitchen appliances, etc.) involves the substitution of materials for on-site labor and capital and an increase

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[60] Dacy [1964], p. 471.

in the ratio of real materials input to real construction output. This problem will be referred to later as a possible source of bias in Dacy's results.

Accepting the materials assumption for the moment, we can examine Dacy's model. First we write an identity between the value V_t of construction output Q_t, value added I_t, materials prices m_t, and real materials inputs M_t:[61]

$$(10) \qquad V_t \equiv p_tQ_t \equiv I_t + m_tM_t$$

The problem concerning us in this chapter is that we know V_t, but we cannot separate it into its ingredients p_t and Q_t. Dacy suggests that a solution of (10) is possible if two assumptions are made. First, the assumption that materials input is proportional to output can be written:

$$(11) \qquad M_t = a\,Q_t$$

Second, Dacy assumes that there are only two factors, labor and materials, so that all of value-added is contributed by labor:

$$(12) \qquad I_t = w_tL_t$$

where w_t is the wage rate and L_t is labor input, measured in man-hours. Substituting (11) and (12) into (10), and dividing through by Q_t,

[61] In reality some expenses, e.g., power and fuel costs, are included neither in value added nor in the materials covered by our materials price index.

we obtain:

$$(13) \qquad p_t = \frac{w_t L_t}{Q_t} + a\, m_t$$

This is an expression for price which takes full account of changes in productivity Q_t/L_t and can be rewritten in index form:

$$(14) \qquad p' = \frac{b\, w'\, L'}{Q'} + (1-b)\, m'$$

where b is the base-period ratio of the wage bill $w_o L_o$ to the value of construction $w_o L_o + m_o M_o$. This expression is an obvious improvement over the simple input-cost indexes used throughout this chapter:

$$(15) \qquad p' = b\, w' + (1-b)\, m'$$

Taking advantage of the obvious identity

$$(16) \qquad Q' \equiv V'/p'$$

we can solve (14) for p' and obtain an expression in which construction output Q' does not appear:

$$(17) \qquad p' = \frac{(1-b)\, m'}{1 - \frac{bw'L'}{V'}}$$

In common sense terms, (17) tells us that the price of construction increases at the same rate as the price of materials unless there has been a change in the ratio of the wage bill to the value of output. In that case

$$w'L' \lesseqgtr V' \Rightarrow p' \lesseqgtr m'$$

Dacy's Data for 1947-63

The estimation of the price of construction by means of (17) requires indexes for the value of construction, wage rates, manhours, and the price of materials. This approach had never been attempted before Dacy's study, because the published data on the value of construction put in place cover total construction and are incompatible with the wage and employment data, which refer to just contract construction and thus exclude the portion of total construction built by unpaid workers and employees of non-construction firms. The contract proportion of new construction is very high, but a majority of maintenance and repair work is done by employees of the firms occupying buildings without the help of an outside contract construction firm. The data gap was bridged by Dacy with new estimates of the value of contract construction which are compatible with the labor data for contract construction. This was judged an easier job than solving the problem the opposite way by estimating labor data for total construction.

1. Value of Contract Construction Put in Place. While data on new construction are available for each major sector, estimates of maintenance and repair expenditures (M and R) are published only for the economy as a whole. Dacy computed M and R by sector by applying the annual economy-wide proportions to every sector. Then data on the share of contractors in new con-

struction and M and R for each sector were obtained from the 1947 input-output study. The 1947 contract shares for new construction and M and R were then applied in each sector annually between 1947 and 1963, and the sectoral estimates of contract construction were summed into an estimate of contract construction for the economy. While the contract share in each sector and type was thus assumed constant in each year, the overall contract share in total construction increased during the postwar period as a reflection of the declining relative importance of maintenance-repair work and of construction in the public utilities and farm sectors where unpaid and force-account work are particularly common.

The trend of the resulting "first approximation" (V_t^*) was considered generally satisfactory, although the year-to-year movements were slightly different than those of the Commerce series on National Income Originating in Contract Construction. (N_t). Since it was felt that the income data probably reflect the timing of construction better than value estimates, a "second approximation of value" V_t^{**} was calculated by the following formula to approximate more closely the year-to-year movements of N_t:

$$(18) \qquad V_t^{**} = \frac{3\,N_t}{\left(\frac{N_t}{V_t^*} + \frac{N_{t-1}}{V_{t-1}^*} + \frac{N_{t+1}}{V_{t+1}^*}\right)}$$

2. <u>Manhours</u>. Two sets of employment data are available

for contract construction, the BLS series on employment (E_t) and the NIP estimates of the number of persons engaged (P_t). A series on standard hours per week (H_t) of union workers in the building trades was used to convert the employment data into a man-hours series, with the additional assumption that non-employees (e.g., small proprietors who work for themselves) work 1.145 times as many hours as employees.[62] The final man-hours per week series is:

$$(19) \qquad MH_t = E_t H_t + 1.145 (P_t - E_t) H_t$$

3. <u>Wage rates and materials prices</u>: These were obtained directly from published BLS indexes on union wage rates in the building trades and materials prices. Dacy did not notice the biasses in these indexes which led us above to calculate new estimates, although this did not have an important effect on his results since the biasses become important only before 1947.

4. <u>The b weight</u>, the share of the wage bill in the sum of wage payments and materials purchases, was obtained by Dacy from the 1947 input-output study.

<u>Dacy's Price Index, 1947-63</u>

Dacy's index calculated from (17) appears to justify the doubts expressed by the NBER Price Statistics Review Committee about

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[62] Kendrick [1961a], pp. 496-7.

the upward bias in the Composite. From 1947 to 1963 the Composite rises by 68 per cent, but Dacy's productivity-adjusted index rises by only half as much. Dacy seems quite justified in stating that "every economist who has dealt with construction as a sector has understated productivity."[63]

Griliches and Jorgenson, who needed a price index available back to the 1920's, noticed that the 1947-63 rise in Dacy's "true index" (34 per cent) was much closer to that of the BPR composite (32 per cent) than to the Commerce composite (68 per cent). Thus they accepted the BPR composite for the entire period back to 1929. As a result they attributed a serious "error in measurement" to previous economists who had deflated investment by the Composite, which had an erroneous 1929-63 rise of 194 per cent, while their (BPR) index rose by less than half--only 94 per cent.

But we have seen that the slow rise of the BPR composite is largely due to rapid productivity gains in excavation and paving, which are not operations important in construction as a whole. It would have been preferable for Griliches and Jorgenson to have extended the Dacy approach for the desired span of years.

An Extension of Dacy's index

It is mysterious that Dacy should have begun his study only

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[63]Dacy [1965], p. 411.

in 1947, for all of his data series are available for earlier years. The value of construction series begins in 1915, and a series for contract value can be calculated using the 1947 input-output contract shares (requiring the assumption that the share of contractors in each sector of the economy has remained roughly constant). Indexes on union wage rates and hours are available back to 1907, and price indexes for building materials have been published for years even before that. The effective constraints are the employment series, which begin in 1919 for employees and 1929 for nonemployees. The simplest compromise is to begin the calculation in 1919, assuming that the ratio of non-employees to employees was constant from 1919 to 1929. In this extension we change Dacy's data sources slightly by substituting our improved materials price index and wage series for the inaccurate BLS data. The labor weight b is the 1965 share of total employee compensation in the sum of employee compensation and materials purchases, which in turn is equal to contract value put in place minus value added.

The result of the calculation, in which (17) is again used to estimate a productivity-adjusted price index, is shown in Figure 19, where it is compared with our suggested CPH index. During the Depression years the Dacy index looks distinctly odd, rising higher and higher as construction enters its post-1926 decline. Do contractors really raise their prices as demand falls?

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[63] Dacy [1965], p. 411.

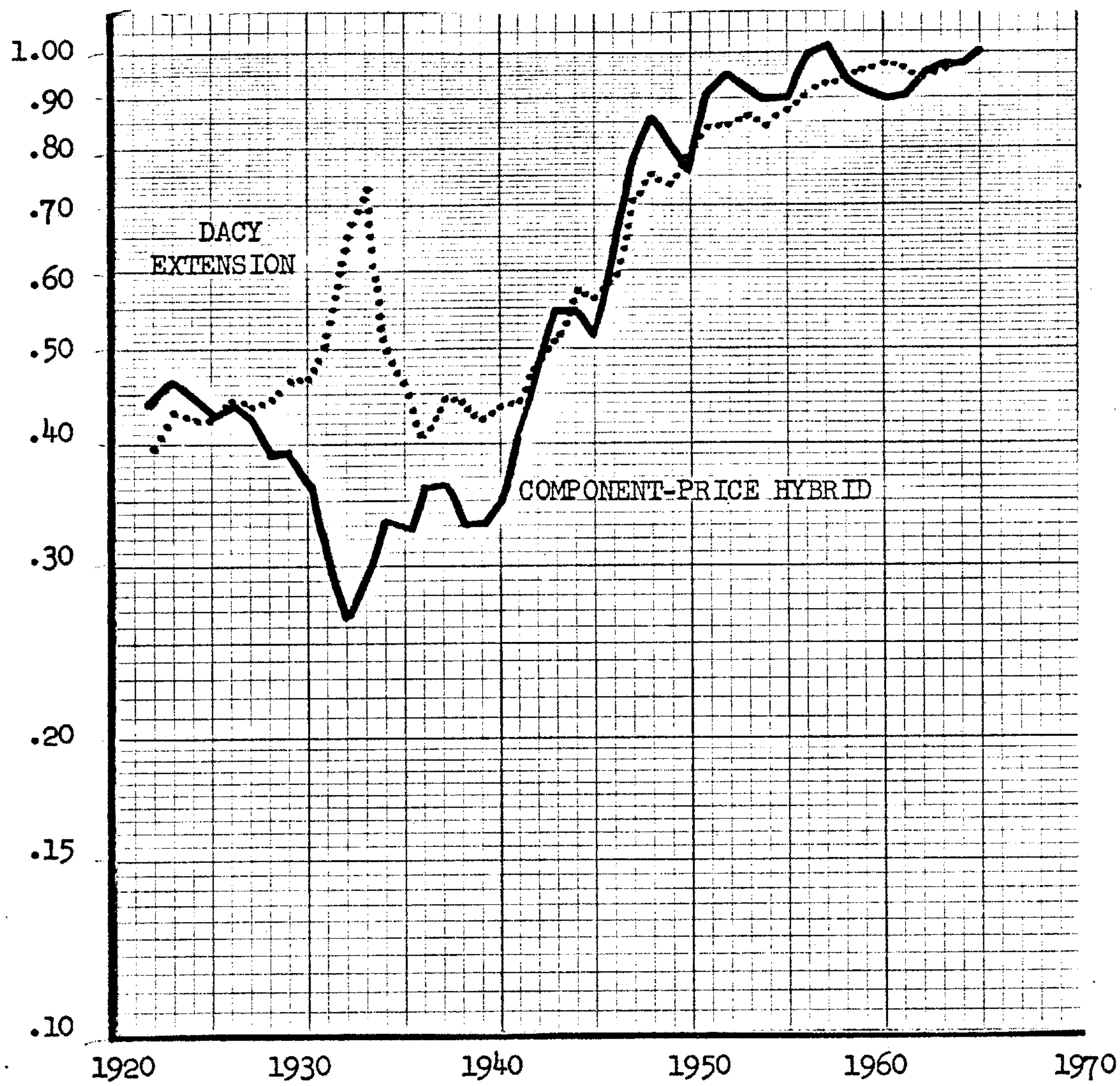

Figure 19

COMPARISON OF EXTENDED DACY INDEX USING WAGE-BILL DATA
WITH COMPONENT-PRICE HYBRID (1965 = 1.00)

Source: Appendix Tables A-6 and A-7.

In an industry full of small entrepreneurs, the maxims of perfect competition should have more validity than <u>that</u>. Common sense alone should indicate that the 1933 index value of .703 (1965 = 1.00) is simply wrong, and there is no evidence of a mid-Depression price surge in wages, materials prices, nor any of the component-price indexes examined in this chapter.

What has gone wrong? Let us examine the way the variables fit together in 1933 in equation (17). The relevant data are (all in index form with 1965 = 1.00):

$$V' = .0399 \qquad m' = .3326 \qquad w'L' = .0804$$

And the calculation is:

$$p' = \frac{(.658)\ (.3326)}{1 - \frac{(.342)\ (.0804)}{(.0399)}} = .703$$

Notice that the index of the wage bill (.0804) is quite high relative to the index of the value of product (.0399). How could contractors afford to pay such wages? The problem is in Dacy's unrealistic model, which represents an inflexible two-factor world in which there is no room for profit margins to vary. Thus, to maintain their 1965 profit margins with their crushing 1933 wage bill, Dacy's contractors were forced to raise their 1933 prices sky-high.

In the real world, of course, profit margins were cut during the Depression. This is an especially important factor in construction because of the importance of small proprietors who work for themselves and whose "profits" (income) are extremely vulnerable to a downturn in construction. In 1929, for example, fully one-third of national income originating in contract construction was accounted for by "Income of Unincorporated Enterprises."[64] By 1933 the income of these victims of the Depression had fallen to only 18.1 per cent of its 1929 level, while the wage bill used in the extended Dacy calculation fell to 43.8 per cent of its 1929 value.

Another reason for the odd performance of the Dacy index, besides the omission of profit data, is the inaccuracy of the wage-bill data, which understate the decline in the true wage bill because of a spurious inflexibility in each of its components--wages, employment, and hours. The wage series refers to union employees whose rates of pay are probably less flexible than those of common labor. The employment series is based on the Commerce Department "persons engaged" data which falls much less in the Depression than the BLS employees series, a discrepancy doubtless due to the legions of self-employed workers who are counted as "engaged" for the entire year even though they may have actually worked for only a few weeks. This would not be important if the hours series measured actual hours per year, but instead it represents the length of the <u>standard</u> work week.

Fortunately NIP data on national income originating in

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[64] U.S. Department of Commerce, Office of Business Economics [1966a], Table 1.12, p. 20, and Table 6.8, p. 114.

contract construction (N_t) are available beginning in 1929. These, of course, take into account wages and salaries, the income of unincorporated enterprises, corporate profits, and interest expense. Income payments declined much more during the Depression than the wage bill data used above, as shown in Figure 20. This comparison suggests an improved approach to the Dacy model. By using national income originating data in equation (17) to calculate the price of construction, we can take account not just of changes in unit labor cost but also in unit profit margins.[65] It is not clear why Dacy failed to adopt this solution, since it relieves his model of its restrictive constant profits assumption.

In the revised model, then, the price of construction is a weighted average of value added per unit of output N_t/Q_t and of the price of materials m_t. The index version of the model can be solved as follows:

$$(20) \qquad p' = \frac{(1-c)\ m'}{1 - \frac{cN'}{V'}}$$

New weights c̲ must be used since value added is a larger share of value put in place than is the wage bill. The only drawback of this approach is that national income data from the OBE extend back only to 1929, but Kuznets' national income originating series

[65]Depreciation charges by definition are excluded from national income.

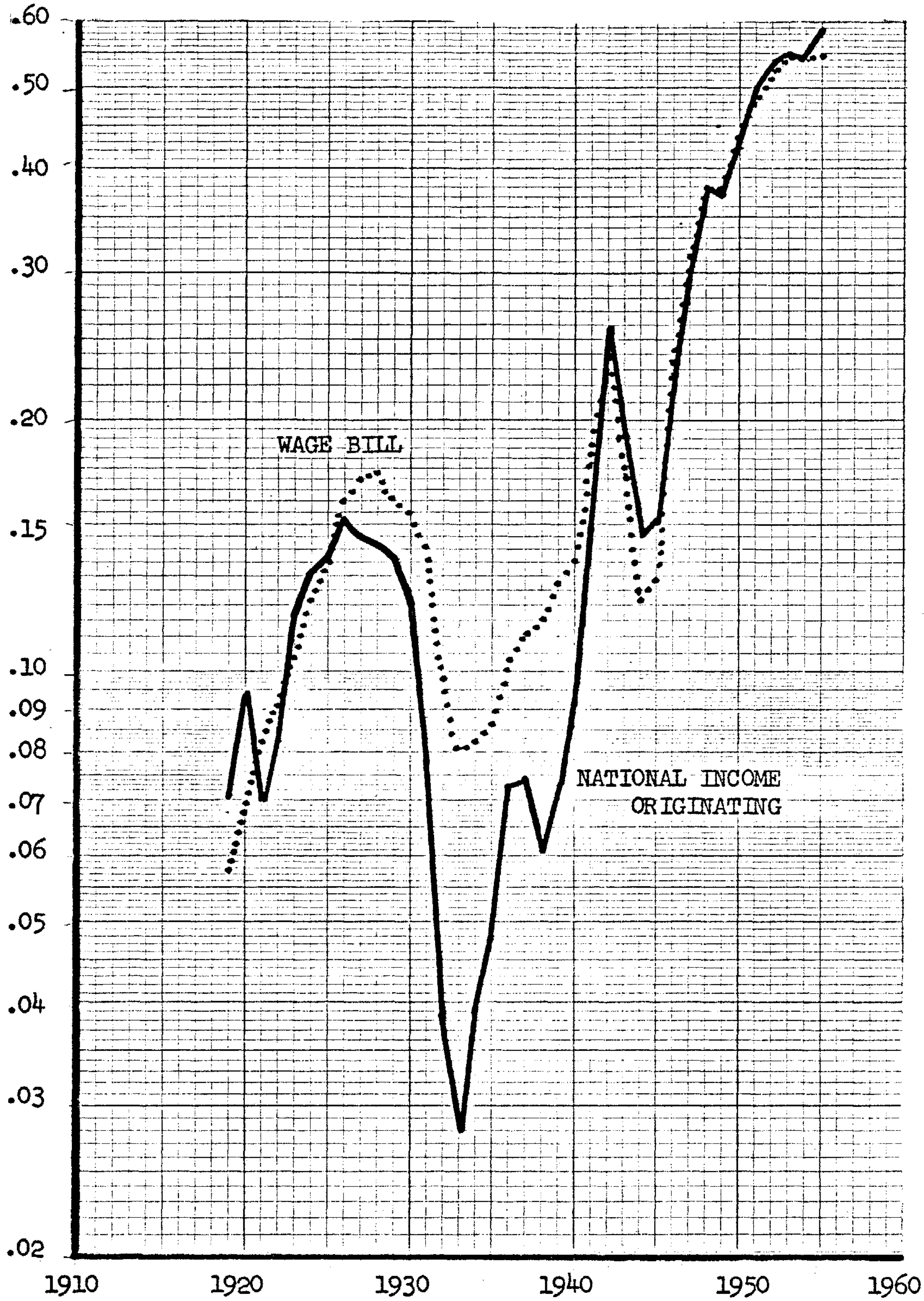

Figure 20

NATIONAL INCOME ORIGINATING COMPARED WITH EXTENSION OF DACY WAGE BILL DATA (1965 = 1.00)

Source: Appendix Table A-7.

is available for use back to 1919.[66]

As calculated in (20) the new "Income-Dacy" (ID) index for all contract construction cannot be compared with our component-price hybrid CPH developed in the last section from component-price <u>structures</u> deflators. Deflating non-structures construction by the BPR composite, it is possible to solve for a CPH index referring to all of construction ("CPHC").[67]

The results of the calculation are shown in Figure 21, where the new ID index is compared with CPHC. The two are calculated by completely different methods but appear to agree closely on the secular trend in structures prices. The short-run movements in the indexes are surprisingly close before 1943 and after 1958, although they diverge somewhat during the intervening period.

IX. A COMPROMISE AND ITS IMPLICATIONS

The ID and CPHC indexes are more satisfactory construction

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[66] The value figures V_t used in (20) are the "first approximation" V_t^* described on p. 255 and naturally are not adjusted to follow the year-to-year movements of N_t.

[67] Thus CPHC = a BPH + (1 - a) CPH where
CPH is the component-price-hybrid for structures;
CPHC is the component-price-hybrid for all construction;
BPH is the Bureau of Public Roads composite highway index;
and <u>a</u> is the 1965 share of highways, conservation and development, and sewers and water in total contract construction.

This calculation ignores non-structures expenditures in the public utilities, the magnitude of which cannot be judged from available data.

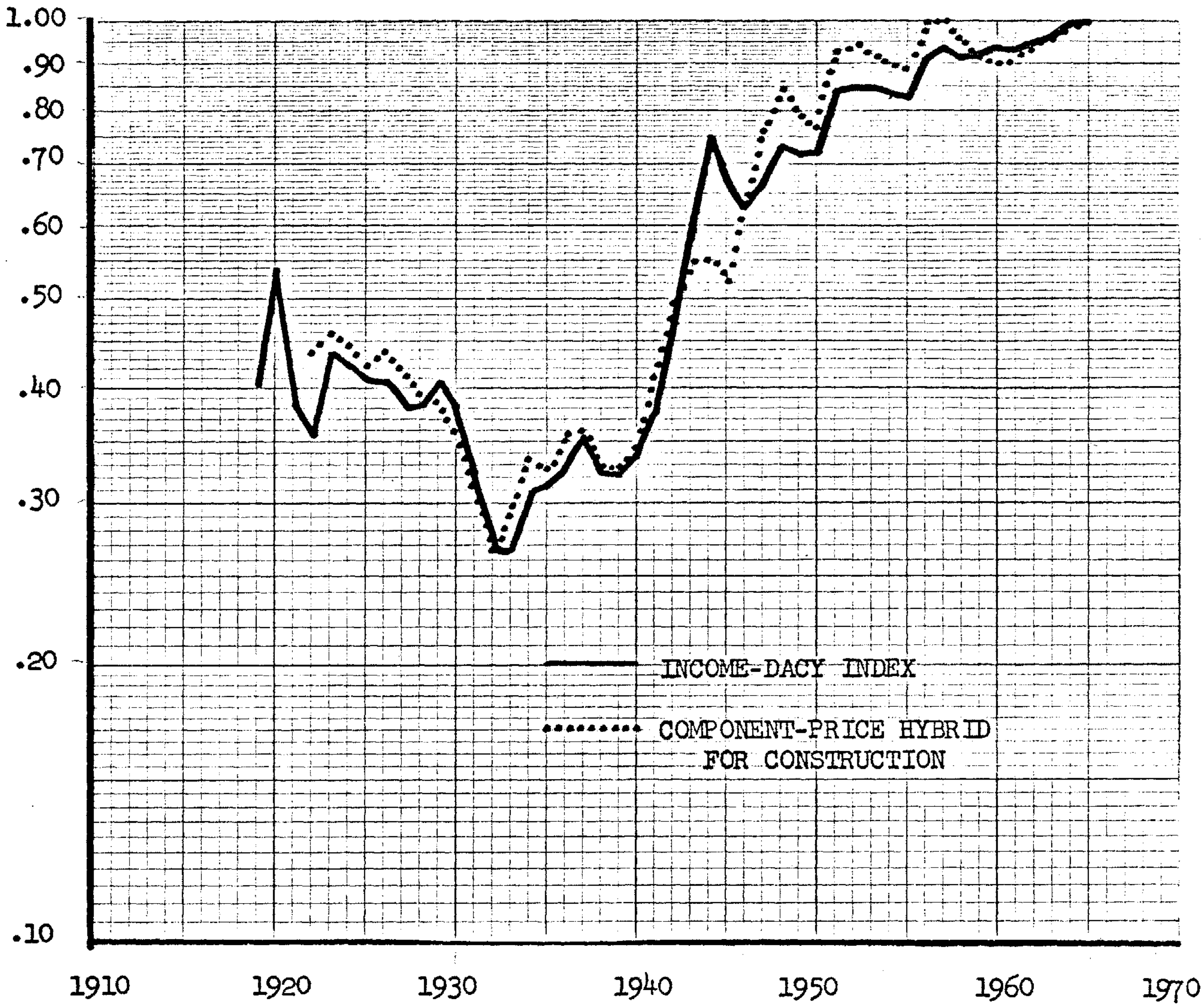

Figure 21

THE NEW INCOME-DACY AND COMPONENT-PRICE-HYBRID INDEXES (1965 = 1.00)

Source: Appendix Table A-8.

deflators than any of the existing partial series or the Department of Commerce Composite. Both avoid the most damaging criticisms of the official indexes since they allow for changes in productivity, profit margins, overtime premiums, and other factors ignored in the input-cost approach. Each requires its own set of restrictive assumptions, and a brief review of these may point out possible sources of long-term bias and of the cyclical discrepancies between 1943 and 1958 shown in Figure 21.

Sources of Secular Bias

While it drops the restriction of fixed profit margins, ID retains Dacy's original assumption that real output is proportional to real materials input and thus ignores the probable uptrend in the share of materials over the last forty years due to the increased use of prefabricated components built by factory rather than on-site labor. Since value added by the fabricator is counted not as income originating in contract construction but in the manufacturing sector, the share of materials in construction output increases.[68]

Assume that the share of real materials input has increased

[68] Data on prefabricated components is not available, but there is no doubt that their importance has been growing since World War II. From nothing before the war, for instance, the share of prefabricators in the single family housing market had risen by 1956 to ten per cent. See Kelly [1959], pp. 160ff.

steadily at rate r. Then

$$(21) \qquad M_t = Q_t (1+r)^t$$

and the reduced-form expression for the ID price index becomes:

$$(22) \qquad p' = \frac{(1-b)\, m' \,(1+r)^t}{1 - \frac{b\, I'}{V'}}$$

Thus if $r > 0$ the Dacy assumption that $r = 0$ results in the underestimation of the true rate of price increase for given values of m', I', and V'. Unfortunately r cannot be identified unless we know the level of real output, but <u>that</u> is just what we have been trying to determine throughout this chapter.

An offsetting secular bias in ID may be caused by the assumption that the share of contractors in each sector of total construction has remained constant over the entire period. If contractors have increased their share, our estimates of the values of contract construction in the 1920's are too high, V' in (20) and (22) is too high, and the calculated price in the 1920's is too low. It is impossible to tell whether the possible upward bias from this source in the rate of growth of ID is of anything like the same magnitude as the downward bias stemming from the materials assumption. At least it is comforting to observe that the two sources of bias tend to offset each other.

A possible secular improvement in reporting practices is another factor which may have caused the true value of contract construction to grow more rapidly than our estimates, which are based on the Commerce (BDSA) estimates of new construction put in place.[69] In Chapter II we observed a gradual increase since 1939 in the ratio of BDSA industrial construction to the totals reported in the Census of Manufactures. A general improvement in reporting would have biassed upwards the rate of growth of ID. It is difficult to believe that this factor could be very large, however, for any increase in estimates of spending on GNP without a corresponding increase in national income would increase the statistical discrepancy in the National Income Accounts.

The main source of secular bias in CPHC is the assumption that evidence on structural steel and concrete prices can be applied to construction as a whole. Even if profit margins and productivity in the production of other components have changed in similar ways, CPHC ignores the possibility of substitution among components. Two components might exhibit precisely the same trends in materials prices, wage rates, and productivity, but differing labor intensities could cause different rates of price increase in the two components. The shift away from the use of brick since the 1920's, for instance, has not been due to unusually large increases in the price of bricks or in the wages of masons but in the high labor coefficient of brick laying. Substitution

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[69] U.S. Department of Commerce, Business, and Defense Services Administration [1966a], pp. 2-12.

among components would result in a less rapid overall rate of price increase than that indicated by CPHC.

Possible Sources of Discrepancies Between 1942 and 1958.

The large excess of ID over CPHC in 1943-45 may have been partly due to the underreporting of value put in place during those years. In 1944, for instance, value put in place in contract construction was only 31 per cent of its 1947 value, but national income originating was a much larger 49 per cent. Since national income is mainly composed of wages and salaries, which after 1939 are considered the most reliable components of the national income estimates, it is possible that a substantial part of the value of construction was not reported during the latter part of the war. This suspicion is confirmed by revisions which have raised the value of construction for years after 1945 considerably above previous estimates, but which have not been attempted for earlier years. The 1946 construction value figures, for instance, were revised upwards by 13 per cent.[70] A similar increase in the 1944 construction total, for which no revision has so far been attempted, would suffice to lower the 1944 value of the ID index from .751 to .635.

While ID may be too high for 1943-45, CPHC may be too low, for the steel and concrete components on which CPHC is based

[70]Lipsey and Preston [1966], Series C 65, p. 30, and explanation on p. 272.

may not have been representative of other construction components in which price and wage controls may have been less effective. Note, for instance, the strong wartime peak in the ratio of the excavation component-price indexes to the union wage rate index (see Figure 15, p. 241 above).

There are two obvious reasons for the greater amplitude of fluctuations in CPHC than in ID between 1945 and 1958. The most important is that ID is calculated from list prices for materials and does not take into account the cyclical behavior of discounts and premiums. CPHC, on the other hand, is based on actual bids and represents true prices paid for materials.

While ID may be too stable during this period, the higher level and greater fluctuations of CPHC may be due to unusual conditions in the building of concrete and steel components which may not have been representative of construction as a whole. Steel may have been more subject than other materials to price premiums in booms and discounts in recessions (note the very dramatic postwar fluctuations in the Bureau of Public Roads structural steel index in Table 16 on p. 244).

These considerations suggest that ID is too high and CPHC too low for the 1943-45 period, while CPHC may be too high and ID too low for the 1945-58 period. Thus an appropriate compromise as our choice for the "Final Price of Construction," (FPC) is to take a simple average of the two. The FPC index is probably not seriously inaccurate between 1943 and 1958, and the closeness of

ID and CPHC both before 1943 and after 1958 lends some plausibility to the secular behavior of FPC.

Conclusions, Implications, and Loose Ends

What is the verdict of FPC on the debate between Griliches and Jorgenson, who advocate the use of the BPR composite as a deflator for structures, and Gordon and others who have defended the time trend of the Commerce Composite? The three indexes are compared in Figure 22. The contest, appropriately enough, can be judged a draw. The FPC index has a trend which is close to that of the Commerce Composite from the 1920's to the late 1940's, while since then both its trend and fluctuations have closely resembled those of the BPR composite.

Table 31 summarizes the trends of the three indexes for the subperiods 1929-48 and 1948-65. The long-accepted phenomenon of an increasing price of construction relative to the GNP deflator declines after 1948 and does not rise as does the Commerce Composite.

The comparison in line 3 of Table 31 suggests that the U.S. National Accounts underestimate the growth of construction output by about 45 per cent over the entire 1929-65 period. A substantial part of productivity improvement in construction has likewise been overlooked. A striking feature in Table 31 is that productivity in construction grew at a snail's pace between 1929 and 1948 during a period of substantial productivity gains in the rest of the economy, but since 1948 the growth of construction productivity has been almost as rapid as in private GNP.

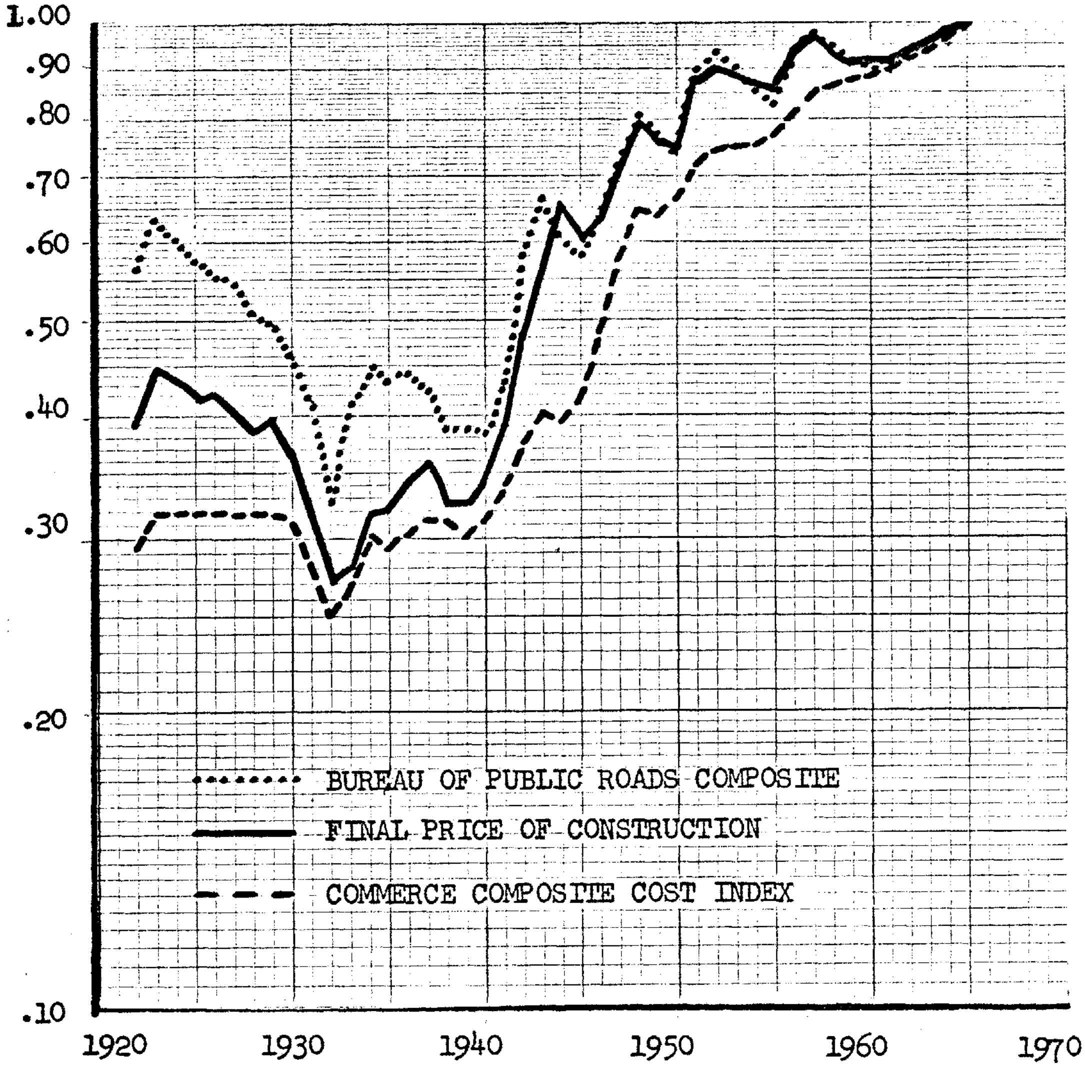

Figure 22

FINAL PRICE OF CONSTRUCTION COMPARED WITH BUREAU OF PUBLIC ROADS COMPOSITE AND COMMERCE COMPOSITE INDEXES (1965 = 1.00)

Source: Appendix Table A-8.

TABLE 31

INCREASE IN CONSTRUCTION PRICES, OUTPUT, AND PRODUCTIVITY 1929-48 and 1948-65

(Percentage Change Over Interval)

	1929-48	1948-65
1. Construction deflators		
Commerce Composite	102	55
Final Price of Construction	96	27
Public Roads Composite	65	24
2. Ratio to GNP Deflator		
Commerce Composite	29	11
Final Price of Construction	26	-9
3. Output in Contract Construction		
Commerce Composite	25	70
Final Price of Construction	28	108
4. Productivity in Contract Construction		
Commerce Composite	0	44
Final Price of Construction	4	71
5. Productivity for Private GNP	48	74

Sources by Line:

(1-4) Computed from Appendix Tables A-7 and A-8.

(5) 1929-48: Manhours from Kendrick [1961a], Table A-XXII, pp. 334-335. Private GNP from *Economic Report of the President* [1967], Table B-8, p. 223.

1948-65: Output per manhour from *Economic Report of the President* [1967], Table B-31, p. 249.

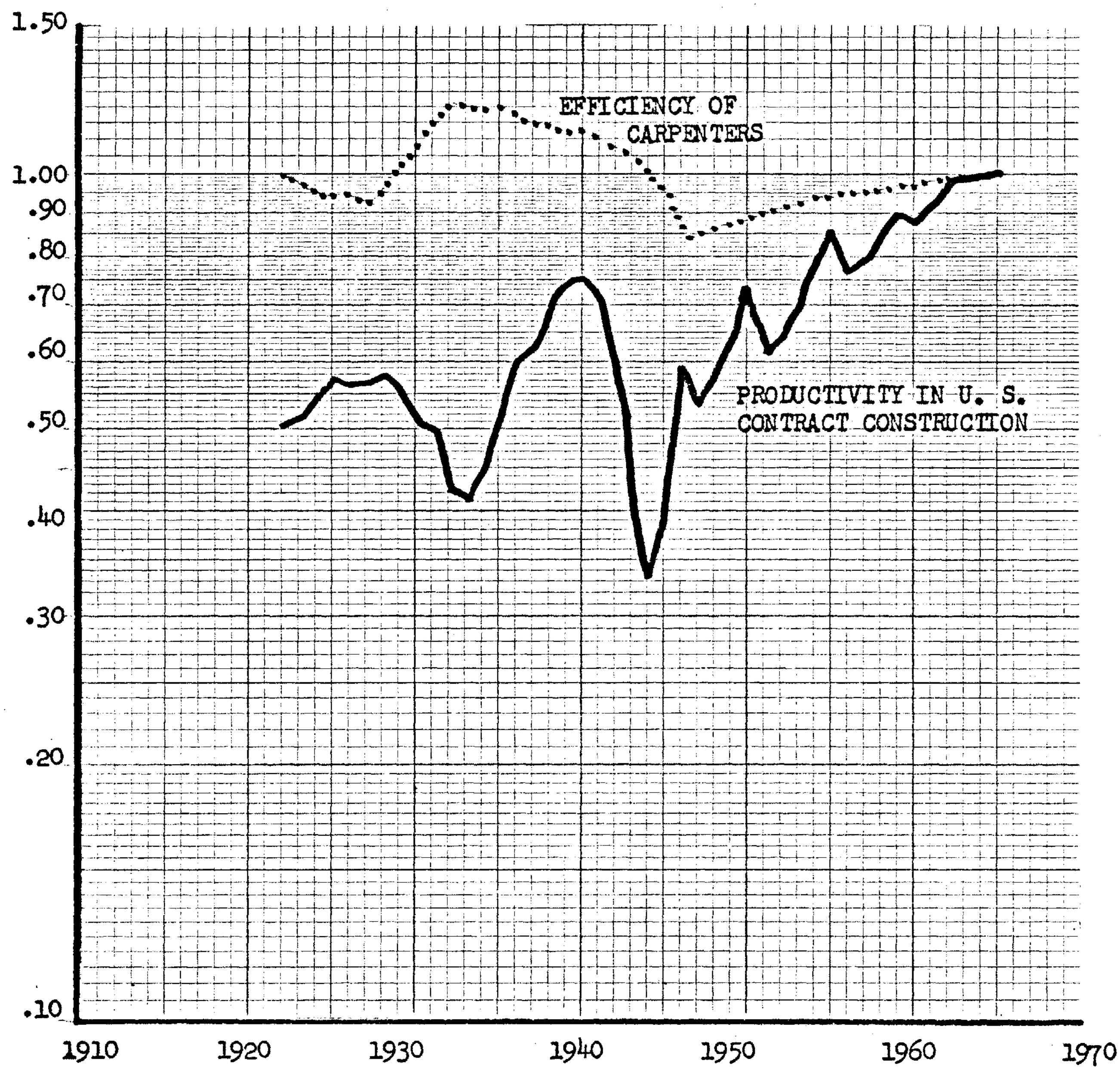

Figure 23

FINAL PRODUCTIVITY INDEX FOR CONTRACT CONSTRUCTION COMPARED WITH AMERICAN APPRAISAL INDEX OF EFFICIENCY FOR CARPENTERS (1965 = 1.00)

<u>Source</u>: Appendix Tables A-3 and A-8.

The time has finally arrived for us to dispense with the myth that productivity in construction never changes.

The evidence on productivity change in Table 31 leaves us with several loose ends which should be tied together:

1. The 1929-65 rise in the FPC productivity index is 73 per cent and thus conflicts with the American Appraisal efficiency factors which deny the presence of significant productivity change over this period. The American Appraisal efficiency index for carpenters and the FPC productivity measure are brought together in Figure 23. The disagreement there suggests that only part of productivity improvement occurs in the ranks of the "front-line troops"--carpenters, masons, plumbers, electricians. Most of it is probably achieved by improvements in materials handling and organization (e.g. moving workers faster from job to job) and by shifts from low productivity operations to higher productivity ones (e.g. the shift from brick to concrete facades). This confirms our earlier criticism of the input-productivity price indexes which adjust only for the efficiency of "front-line" craftsmen and fail to reflect productivity gains in other parts of the contractor's organization or shifts in the mix of components.

The cyclical variations in front-line efficiency suggested by the American Appraisal carpenters index may help to explain the major fluctuation in FPC productivity. Some of the cyclical fluctuations in FPC productivity are spurious because the man-hours data are computed with a series on "standard hours" which does not represent actual hours worked. One way of interpeting the 1934-44 FPC efficiency bulge is that the increase in the productivity of individual workers shown in the American Appraisal index after 1927 was disguised in the early years of the Depression by the low utilization of the construction labor force and asserted itself only in the late 1930's as building staged its recovery. Productivity may also have been aided in the late 1930's by an exodus of small proprietors and contractors who, discouraged by the long slump in construction, may have shifted to other industries which achieved an earlier recovery (e.g. manufacturing, which had re-achieved its 1929 level of production by 1937, whereas in that year construction was operating at only 70 per cent of its peak 1928 output.) The postwar spurts in FPC productivity during peak years may be spurious, reflecting overtime work which is not adjusted for by the standard hours series.

2. In addition to the constancy of the American Appraisal front-line productivity factors, the only other impressive support of the Composite cited by Gordon was the Grebler, Blank, and Winnick [1956] index of housing prices for 1890-1934, which closely approximated an input-cost index. But this does not necessarily contradict our evidence which confirms the absence or permanent productivity improvement before 1947.

3. At first glance there appears to be a contradiction between the substantial FPC productivity gains indicated in Figure 23 and the steel and concrete component-price indexes, which appeared

to increase almost as rapidly as input-cost indexes for steel and concrete. This is not a serious conflict, however, for the input-cost indexes are biassed towards slow growth; a "true" input-cost index would have grown considerably faster than the component-price indexes and the increasing gap between them would have reflected productivity improvement. The underestimation of the growth of input costs is due to two related factors:

a. Value Added per worker increased faster than wage rates from the 1920's to 1965, reflecting relatively rapid growth in depreciation, corporate profits, and the income of noncorporate enterprises. Thus the input-cost index computed just with wage rates grows too slowly and disguises part of the effect of productivity improvement.

b. Not only would the value-added component in a comprehensive input-cost index have risen more rapidly than the index of wage rates, but the broader input-cost series would have been given another boost since a higher weight would have been given to rapidly growing value added and a relatively lower weight to slow-growing materials prices.

4. A fascinating result in Table 31 is the 44 per cent growth in postwar construction productivity obtained when output is deflated with the Commerce Composite. Although many of its sub-indexes <u>assume</u> no productivity change, the Commerce Composite thus <u>implies</u> substantial productivity growth. This internal contradiction should have been evident to prior investigators in

the field and should have led them to be less complacent about the Composite. With the FPC index, of course, the rates of productivity growth shown in Table 31 are consistent by definition with the data used to compute the index.

A Deflator for Structures

The purpose of this study is to improve the official series on fixed nonresidential private investment. The FPC index must be slightly modified for use in the deflation of nonresidential structures, since it is based on all sectors of construction including non-structures public works expenditures. A FPS index for structures can be obtained by excluding the public works sector.[71]

Should the same FPS index be used to deflate all nonresidential private structures regardless of type? Unfortunately sufficient evidence is not available to justify separate indexes for residential, public utilities, commercial, industrial, and other types of construction. The use of the FPS index for all structures will be fairly accurate in the long-run if the composition of structures expenditures does not change extensively. Over the cycle, of course, the countercyclical behavior of housing induced by monetary policy may introduce a bias if the true prices of

[71] The procedure in computing FPS from FPC is exactly the opposite of the computation of CPHC from CPH, as described above on p. 263.

residential structures diverge significantly from FPS.

In the calculation of perpetual inventory capital stocks, we need a price index for structures extending much further back than 1922. Because some of the data used to construction FPC are not available before that date, our pre-1922 extension must be quite crude:

1. For 1919-1922, we use the Income-Dacy index converted to exclude public works expenditures (the same procedure as for the calculation of the post-1922 FPS from FPC).

2. For 1890-1919, we use our naive input-cost index NIC (calculated above on pp. 194 to 205), adjusted for the post-1919 secular drift between it and FPS.[72]

3. For the years 1865-1890 (for which a structures deflator is necessary for a perpetual inventory capital stock beginning in 1910, given a 45-year lifetime for some structures) Wasson's existing deflator was simply linked to NIC^* in 1890. This crude procedure should be replaced whenever better data become available on nineteenth century construction prices.

---

[72]Thus the adjusted index NIC^*_t is calculated as follows:

$$NIC^*_t = NIC_t \ (r)^{1965-t} \qquad (1890 < t < 1919)$$

where

$$r = \left(\frac{FPS_{1919}}{NIC_{1919}}\right)^{[1/(1965-1919)]}$$

X. A POSTSCRIPT ON QUALITY CHANGE

For many years the F.W. Dodge Company has collected data on the value and floor area of construction contracts. Value per square foot figures, of course, are not price indexes for buildings with given specifications, since they are not adjusted for changes in the construction mix nor for quality changes in buildings of given types. But to the extent that changes in mix within Dodge categories have not been too important and that our compromise FPS index measures the price of structures of constant quality, the ratio of Dodge unit value to FPS provides interesting evidence of changes in the quality of construction.[73]

The Dodge value and square feet of floor area data are available since 1919 for four sectors--industrial, institutional, commercial, and residential. The industrial index is the most interesting for productivity analysis but is subject to extremely erratic movements due to the changing mix of industrial construction. The industrial index reaches implausible peaks during the Korean war, a probably reflection not of fantastic price inflation but of the importance of expensive steel and chemical plants in the expansion of industrial capacity during the Korean war. These changes in mix prohibit generalizations about the causes of fluctuations in the series, but it is interesting to note (see appendix Table A-9, column 2) that

[73]The following discussion implies that FPS can be applied with equal validity to residential, industrial, commercial, and institutional structures.

the secular trend in unit value from the 1920's to the 1960's is similar to that of the FPS index.

The other three Dodge unit value categories, the ratios of which to FPS are depicted in Figure 24, are not subject to the sharp fluctuations of the industrial series, a suggestion that changes in mix in these categories have been more gradual. The three ratios move together closely and imply that the quality of buildings has not changed significantly since the late 1920's, although there was a sharp decline in quality during World War II followed by a gradual return to previous levels by the 1960's. The postwar quality recovery appears to have been accomplished earlier in commercial and institutional building than in residential construction. An apparent bulge in quality during the early 1930's may be the result of a changing mix to relatively expensive buildings, possibly as a result of a relatively low income elasticity for expensive types of structures--it is likely that building during the early 1930's was dominated by projects in which cost was a secondary object, e.g., Rockefeller Center and the Harvard houses. The decline in quality during World War II was doubtless due to the pressing wartime shortages of time and materials which led to buildings with fewer frills. The frenetic 1941-43 wartime construction boom appears to have been accomplished at a considerable sacrifice in quality.[74]

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[74]The quality improvement of the early postwar years has been referred to previously by Benjamin Kaplan, but he failed to look at data over a sufficiently long period and failed to notice that quality improvement had been preceded by a quality deterioration. See Kaplan [1958], pp. 4-9.

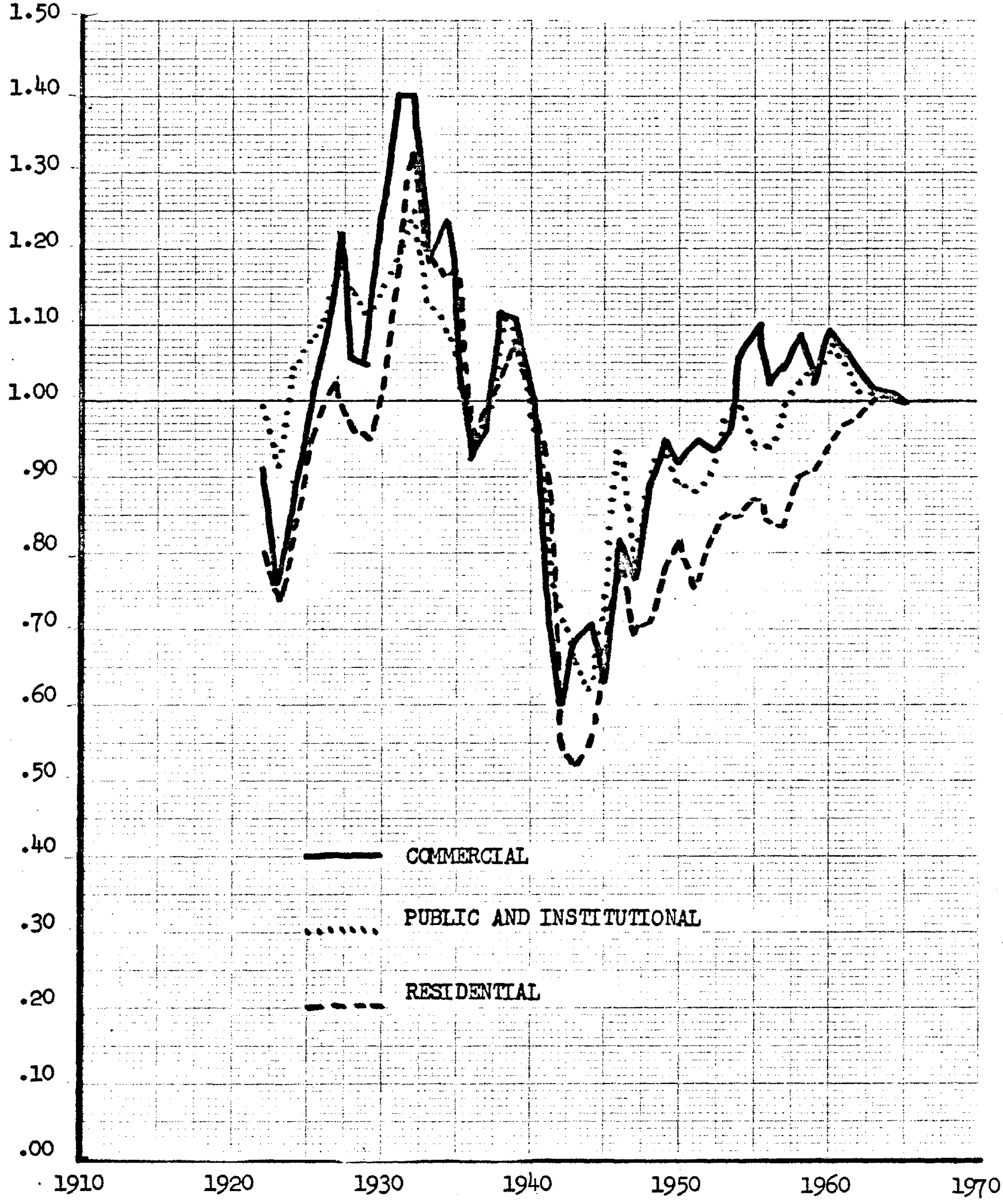

Figure 24

RATIO OF THREE F.W. DODGE UNIT VALUE INDEXES TO FINAL PRICE OF STRUCTURES (1965 = 1.00)

Source: Appendix Table A-9.

The trends in Figure 24 remind us that although today's buildings may be different from those in the 1920's, they are not necessarily better. Improvements in heating and lighting and the introduction of air conditioning have been achieved at the price of lower ceilings, thinner walls, cheaper structural materials, fewer fireplaces, and less ornamentation.[75] Part of this substitution has been induced by shifts in relative prices, but most of it probably represents the introduction of new products which were not available in the 1920's. Today's building may have the same base-period price as a 1929-style buidling, but it presumably yields more satisfaction since consumers have selected air conditioning in preference to high ceilings and thick walls.[76]

Changes in quality per square foot raise a difficult question for production analysis: what is the concept of structures which actually produces output and should thus enter the production function--constant-quality buildings measured in base-period prices or variable-quality square feet? The argument for the square foot

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[75]See Table 29 above, p. 203 for the relative quantities of materials used in construction in 1929 and 1958. The largest increase was in the plumbing and heating category, and this was offset by declines in the relative use of the structural materials--stone and clay products, lumber and steel.

[76]Figure 24 suggests the following description: the 1920's were an era of thick walls and no air conditioning, the 1940's a lean time of thin walls and no air conditioning, and the 1960's a period when air conditioners were purchased to drown out the noise seeping in through the thin walls.

measure is strongest in manufacturing, where it is really machinery which directly produces output. The function of industrial buildings is simply to provide space for equipment, and the marginal product of imporved quality in structures is probably lower than that of an extra piece of equipment. In commercial buildings it is clear that quality does increase "production", which may be the rent of a commercial office building or the sales of a retail store.

Unfortunately it is impossible to implement a floor area measure for industrial structures, for it is impossible to distinguish between changes in quality and changes in mix in the Dodge index, and the value and square foot figures are not consistently reported in the industrial sector.[77] But the possibility remains that in years like 1942 when quality was relatively low, more structures (measured in square feet of floor area) were built than are indicated by the value of construction as deflated by our FPC price index. If the wartime decline in quality did not affect output, it contributed to the decline in the capital-output ratio.

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[77] "The industrial building category comprises an extremely heterogeneous combination of structures ranging from conventional buildings to petroleum refineries and blast furnaces. In the case of the latter structures, square feet of floor area is a meaningless unit of measure." Kaplan [1958], p. 4. In fact for refineries and other "outdoor plants" only value figures are reported, so that in years of relatively heavy investment in refineries and chemical plants the mix of industrial structures shifts towards a category with an average value per square foot of infinity! Telephone conversation with John Morawetz, F.W. Dodge Company, New York, April 5, 1967.

CHAPTER V

CONCLUSION

The analysis of the preceding three chapters provides us with new estimates of real investment in the U.S. private economy. The revisions of Chapters II and IV apply to private investment as defined in the U.S. National Income and Product Accounts, while Chapter III goes beyond that definition to include structures and equipment which produce private output but are financed by the Federal government.[1] The aim has been to produce improved estimates of the capital stock used in the private sector, and it is appropriate to conclude the thesis with a demonstration of the effect of the investment revisions on capital stock estimates.

I. NEW CAPITAL STOCK ESTIMATES

The cumulation of real investment into capital stocks requires a measure of the period over which each capital good remains in the stock. Unfortunately evidence on useful lifetimes is almost nonexistent; there have been no periodic or systematic surveys of changes in the service lives of different types of capital goods. Lacking any better evicence, all previously

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[1]The investment series are given in Appendix Table C-3. Potential users of the investment data interested only in <u>privately financed</u> investment are cautioned to use the revised estimates of Appendix Table C-2 which exclude the estimates of government-financed structures and equipment developed in Chapter III.

published perpetual inventory studies have assumed constant lifetimes based on the U.S. Internal Revenue Service (1942) Bulletin "F" listing of asset lives.[2] No allowance has been made for the likelihood that service lifetimes have exhibited cyclical and secular variations which affect the size of a perpetual inventory capital stock calculated from a given investment stream.[3]

Until an investigation of changes in useful lifetimes can be made, the constant lifetime assumption must be used here to cumulate the investment estimates of the thesis into capital stocks. The calculations are performed to measure the effects of the revisions, and the resulting stocks must be viewed only as interim estimates. The constant service lifetimes employed here are based on the average Bulletin "F" values used in a previous study of Wasson's.[4] The capital stocks are calculated with these lifetimes on the "one-horse shay" assumption, in which a capital good retains its initial ability to produce until the end of its service life, at which date it vanishes instantaneously. No deduction is made for depreciation, which is assumed to represent a decline in value

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[2]The most recent perpetual inventory calculations by Wasson also present variants which are based on constant lifetimes, greater or less than Bulletin "F" by a given percentage. See Grose, Rottenberg, and Wasson [1966].

[3]A single exception is Huntley's unpublished thesis [1960] which presents estimates for only three years--1954-6--based on a variable lifetime calculation.

[4]Jaszi, Wasson, and Grose [1962]. The lifetime for manufacturing structures is 40 years, manufacturing equipment 17 years, farm structures 45 years, farm equipment 10 years, nonfarm nonmanufacturing structures 36 years, and NFNM equipment 13 years.

due to a capital asset's decreased future earning power but not a reduction in its ability to produce. The one-horse shay postulate is chosen for ease and speed of computation over more complex alternatives, e.g., that retirements are normally distributed around the mean life.

Figure 25 illustrates the results of the perpetual inventory calculation for manufacturing structures and equipment. The dotted line is the unrevised stock cumulated from Wasson's unpublished (1966) real investment data. The solid line represents the stock calculated with the same method and lifetimes from Wasson's investment data as revised in the three previous chapters. The revisions in manufacturing are very large, resulting in a real 1954 manufacturing capital stock which is 6.3 times its 1910 value, as opposed to a much smaller 3.5 ratio with the old data.

The three lower sections of Figure 25 show the contribution of each chapter to the difference between the revised and unrevised stocks. The revisions of Chapter II reduced manufacturing investment in the earlier years because (1) the Wasson equipment data do not take account of the growing importance of manufacturing in total output and (2) his structures series exaggerates the undercoverage of the Commerce industrial construction figures. The Chapter II investment revisions reduce the manufacturing capital stock by an amount which reaches a maxium of $10.1 billion (in 1958 dollars) in 1935 and shrinks gradually after that. The next frame in Figure 25 shows the real stock of government-financed

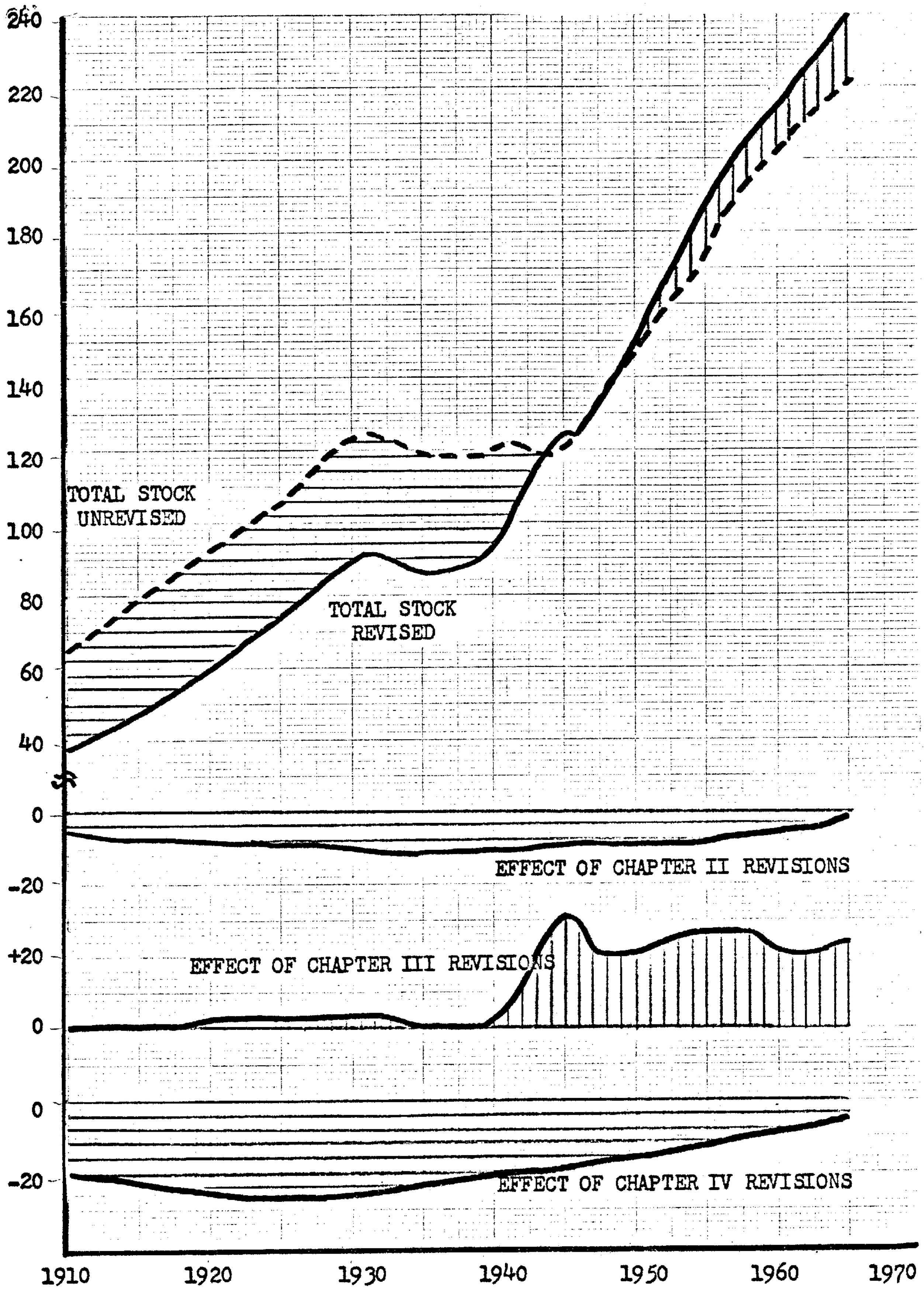

Figure 25

STOCK OF MANUFACTURING STRUCTURES AND EQUIPMENT,
TOTAL REVISIONS AND ORIGIN BY CHAPTER, 1910-1965
(Billions of 1958 Dollars)

Source: Appendix Tables D-1 and D-2.

assets cumulated from Chapter III and adjusted for the portion already accounted for by Wasson. This revision is insignificant before 1940, spurts to a peak of $30.7 billion in 1945, sinks in 1946 as war-built assets are retired, exported, or sold to government agencies, and exhibits a partial Korean war recovery during the early 1950's. The decline in the late 1950's is due to the retirement of equipment built during World War II. Finally, the effect of the new structures deflator developed in Chapter IV is shown in the bottom frame, reaching a maximum reduction of $27 billion in the mid-1920's. The net effect of the revisions is a reduction in the constant-dollar manufacturing capital stock before 1943, after which the upward revision of Chapter III more than offsets the downward corrections of Chapters II and IV.

While the revisions of Chapters II and IV influence the manufacturing capital stock in the same direction and produce a substantial downward correction before World War II, they operate in opposite directions in the nonmanufacturing sector, where, as shown in Figure 26, they almost cancel each other out. The revised nonmanufacturing stock in 3.74 times its 1910 value, which is somewhat greater than the 3.08 ratio of the unrevised figures but represents a less important revision than in manufacturing. In nonmanufacturing the corrections of Chapter II are uniformly upward, resulting largely from the addition of investment in hotels and the return to nonmanufacturing of the structures which Wasson "borrowed" for the manufacturing sector, and reach a peak of

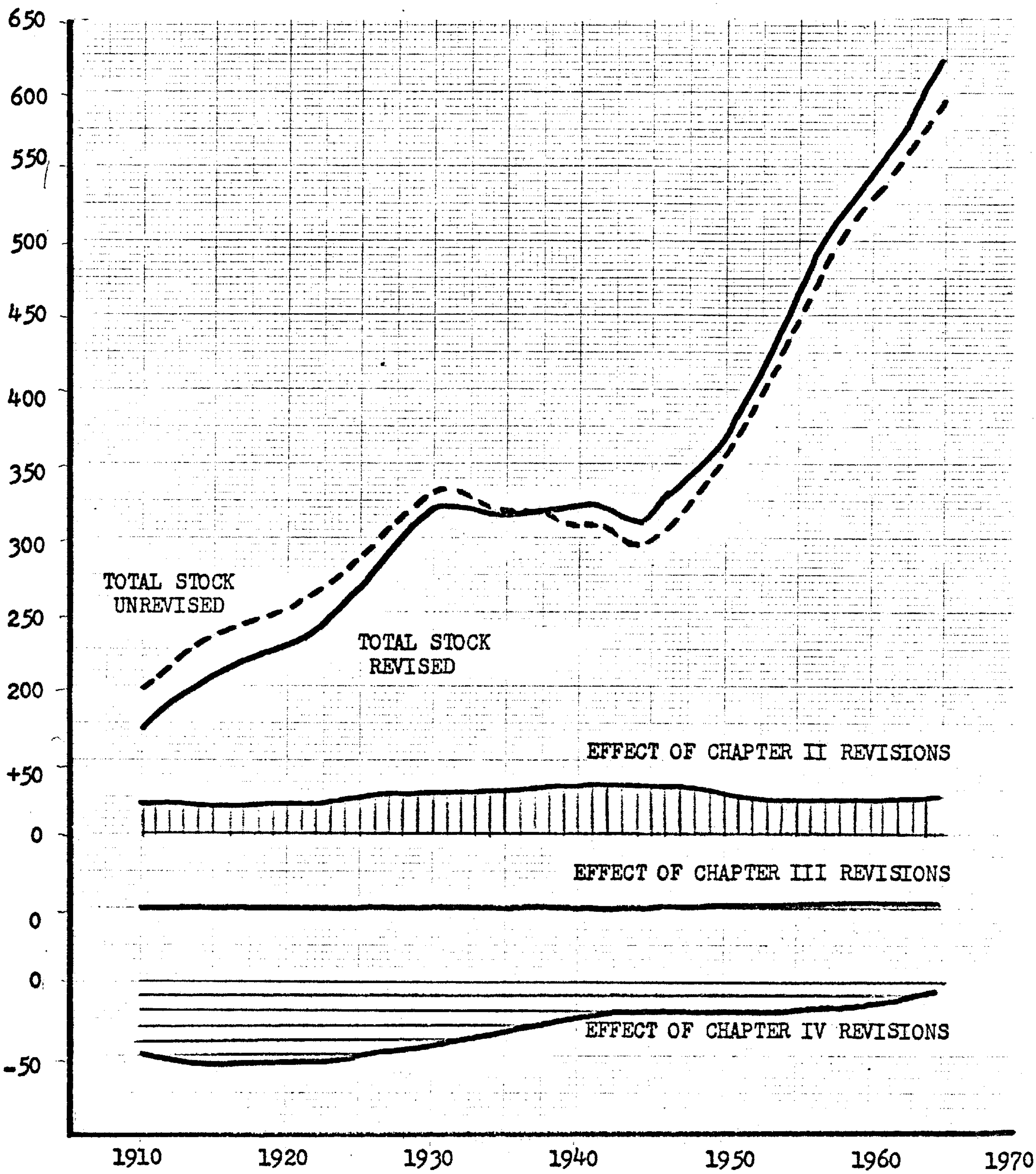

Figure 26

STOCK OF NONMANUFACTURING STRUCTURES AND EQUIPMENT
TOTAL REVISIONS AND ORIGIN BY CHAPTER, 1910-1965
(Billions of 1958 Dollars)

Source: Appendix Tables D-3 and D-4.

#34.3 billion in 1942. The partially offsetting downward revision caused by the new price deflator of Chapter IV reaches a maximum of $49.1 billion in 1916 and declines steadily thereafter. The stock of government-financed assets tabulated in Chapter III are unimportant in nonmnufacturing, reaching a peak of only $3.5 billion in 1955.

II. NEW MEASURES OF THE CAPITAL-OUTPUT RATIO

A further step in gauging the importance of the revisions is a calculation of capital-output ratios for the two sectors and the private economy as a whole.[5] Again the most important effects are in manufacturing, where the revisions significantly alter previous conceptions about the movements of the capital-output ratio. Figure 27 plots the revised and unrevised capital-output ratios in manufacturing for selected high-utilization years, i.e. years in which the capital-output ratio reached a cyclical minimum. The abnormal wartime years of 1916-18 and 1941-45 are excluded in the designation of these prosperous years.

Previously, as indicated by the dotted "unrevised" line at the top of Figure 27 showing the capital-output ratio for manufacturing structures and equipment, the ratio exhibited a gradual

[5]The figures which follow contain a minor inconsistency since output data have not been revised to take account of the new real investment series. A correction for this would have little effect on the results, raising the revised 1929 capital-output ratio in the private economy, for example, from 2.09 to 2.11.

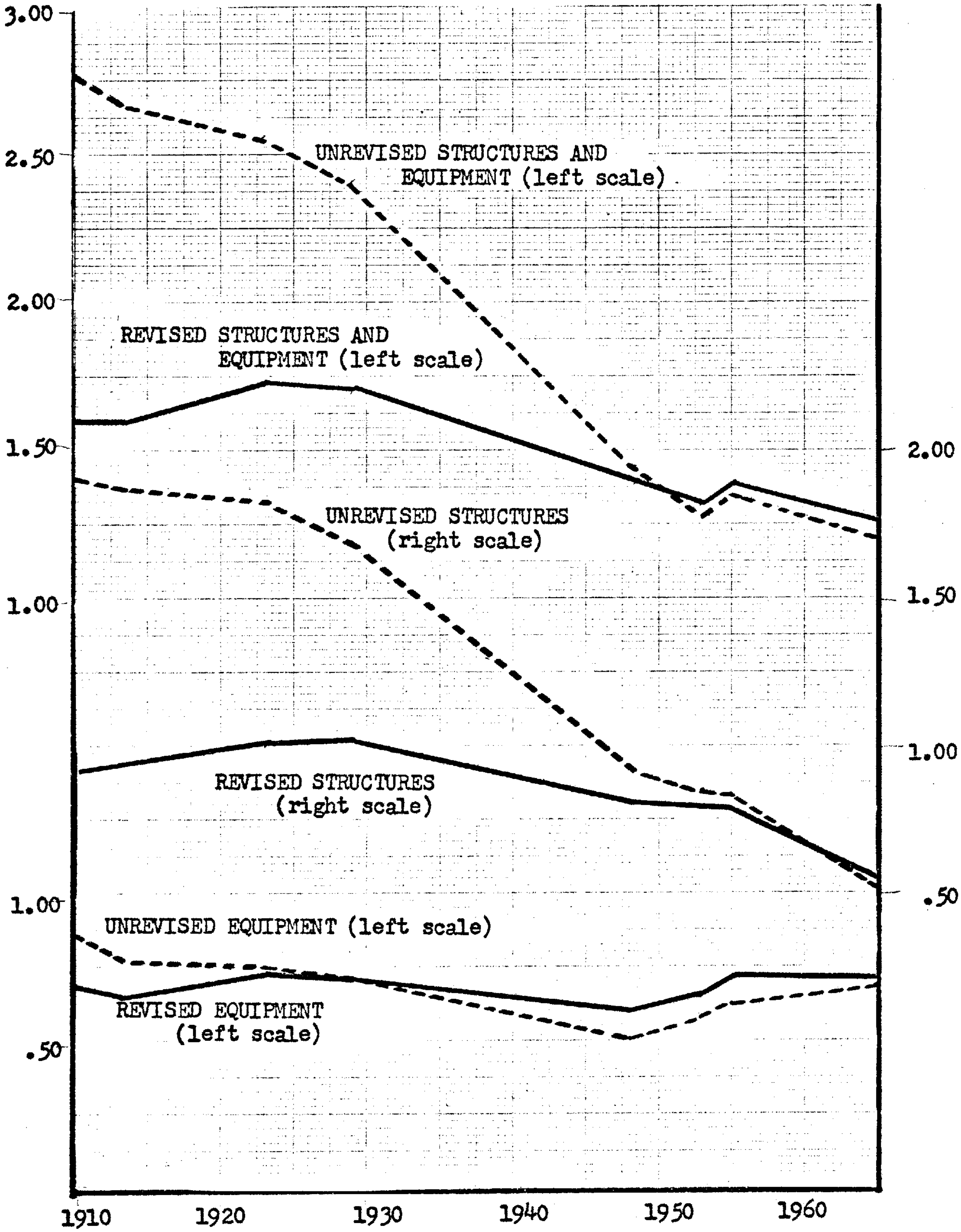

Figure 27

CAPITAL-OUTPUT RATIOS IN MANUFACTURING,
PEAK YEARS EXCLUDING WARTIME

Source: Appendix Table E-2

decline before 1923, followed by an extremely steep decline between 1923 and 1953, a levelling-off between 1953 and 1955, and a renewed decline between 1955 and 1965. As shown by the revised solid line the ratio appears to have risen between 1910 and 1923, then levelled off, and exhibits a decline between 1929 and 1953 which is little steeper than the rate of descent in 1955-65. The revised ratio in 1965 had fallen 20.1 per cent from its 1910 value, a much milder decline than the 56.6 per cent decline registered by the unrevised series.

As shown in the lower section of Figure 27, the revision in the structures-output ratio was more significant than in the equipment-output ratio, a natural result since the new deflator of Chapter IV applies only to structures. The changes in the time path of the structures-output ratio is similar to that of the overall capital-output ratio, and the 1910-65 decline is reduced from 72.5 to 37.3 per cent. The revisions in the equipment-output ratio are smaller but still substantial enough to convert a 20.4 per cent decline into a two per cent increase.

Figure 28 illustrates the nonmanufacturing capital-output ratios, for which the revisions are less dramatic than in manufacturing. Although the equipment series in Figure 28 emerges practically untouched, the decline in the nonmanufacturing structures-output ratio is moderated somewhat from a 1910-1965 drop of 53.5 per cent to one of 36.9 per cent. An interesting phenomenon in the chart is the sharp rise in the overall revised ratio during the 1926-29 pre-Depression years. This is possible evidence either that by 1929 the nonmanufacturing sector had overinvested, or that 1929 was not a year of high utilization

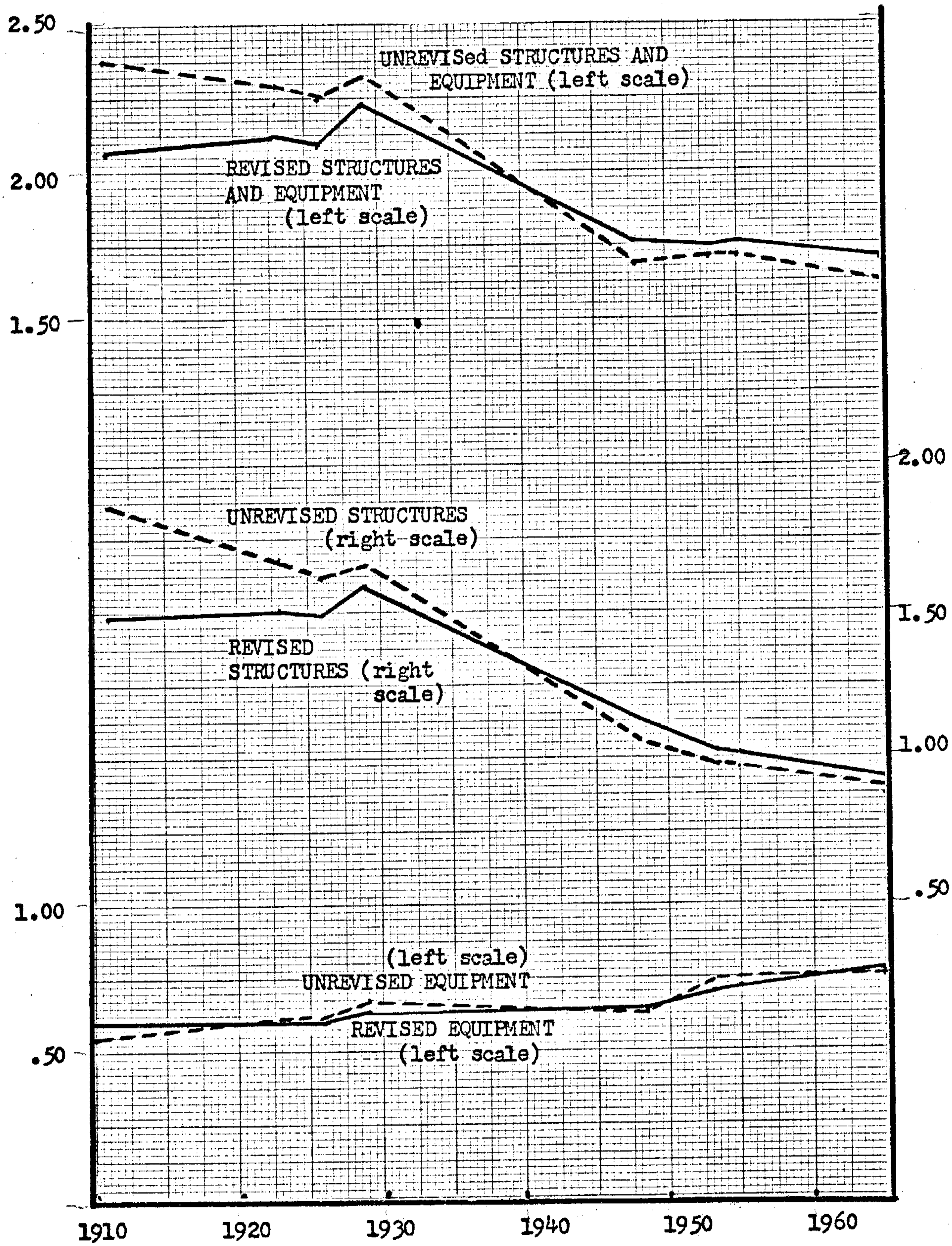

Figure 28

CAPITAL-OUTPUT RATIOS IN NONMANUFACTURING,
PEAK YEARS EXCLUDING WARTIME

<u>Source:</u> Appendix Table E-3

and that the economy had already weakened substantially from the more prosperous years of the mid-20's.[6] Our ability to interpret this period and to understand the causes of the Depression would be improved substantially if utlization data were available for the 1920's[7] If 1929 was not a full-utilization year, the decline in the nonmanufacturing capital-output ratio between the 1920's and 1950's should be measured by the 18.5 per cent 1926-55 decline, not the steeper 23.5 per cent 1929-55 descent.

Another interesting feature of Figure 28 is the steady increase in the equipment-output ratio to a 1965 level almost 30 per cent above its value during the 1910-26 period. Although this increase was not enough to offset the drop in the structures-output ratio over the long-term period, it did almost counterbalance the postwar 1948-65 decline of the latter. This time

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[6]Another possiblity is that the 1926-29 rise in the non-manufacturing capital-output ratio may be a statistical illusion. The constant-lifetime assumption may obscure a sudden decline in average service lives during the period which would have reduced the true capital stock below our estimates. There is no obvious reason why this should have happened, however, and in manufacturing the ratio's 1923-26 stability was continued during 1926-29.

[7]One study suggested that utilization in 1929 was only 80 per cent of capacity, but without a full-scale investigation it is impossible to determine whether this figure is equivalent to a postwar figure of 80 per cent. See Nourse [1934].

pattern in nonmanufacturing equipment is somewhat different than in manufacturing, where there was a postwar increase in the equipment-output ratio but a pre-1948 decline.

The revisions for the manufacturing and nonmanufacturing sectors are combined in Figure 29, which illustrates the trend of capital-output ratios for the private economy since 1910. The revised capital-output ratio for structures and equipment declines 21.4 per cent from 1910 to 1965 instead of the 40.8 per cent drop exhibited by the unrevised figures. The revisions are almost entirely in structures and have very little effect on equipment. The equipment revisions in the two sectors are in opposite directions and when combined almost cancel each other out. The overall effect of the revisions is to moderate the decline in the total private capital-output ratio for the period after 1929 and to convert the trend during the first 20 years from a six per cent decline to a six per cent rise.

The 1910-65 trends in the capital-output ratios are summarized in Table 32. One of its most interesting features is the apparent difference between the manufacturing and nonmanufacturing sectors in the <u>unrevised</u> trends as opposed to the similarity between the sectors in the <u>revised</u> trends. In the old version the decline of the structures-output ratio in manufacturing is much steeper than in nonmanufacturing, and the decline of the equipment-output ratio in the former sector is in sharp contrast to its increase in the latter. The new figures suggest a structures-

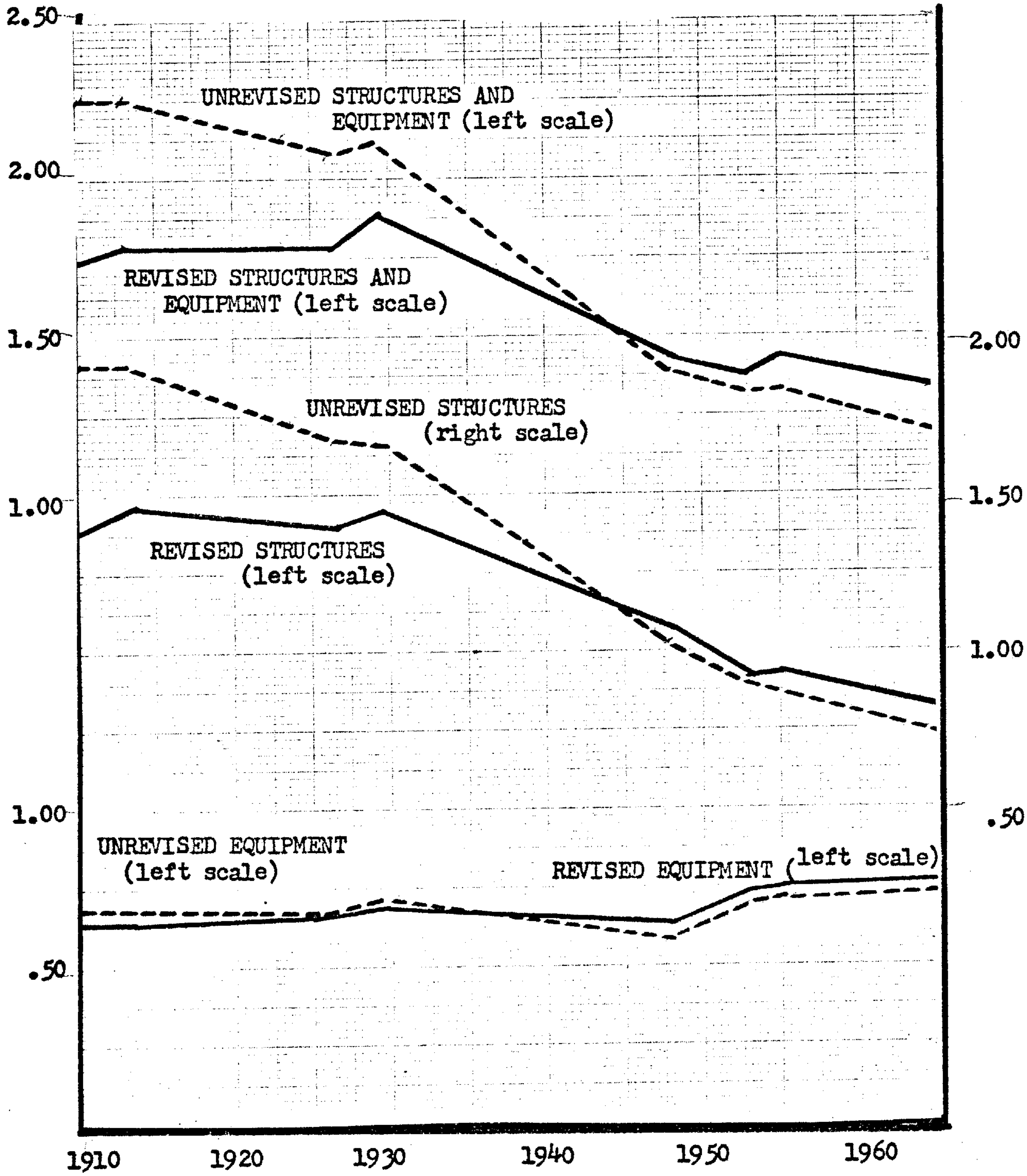

Figure 29

CAPITAL-OUTPUT RATIOS IN THE PRIVATE ECONOMY,
PEAK YEARS EXCLUDING WAR PERIODS

<u>Source</u>: Appendix Table E-4

TABLE 32

1965 CAPITAL-OUTPUT RATIOS
AS A PERCENTAGE OF 1910

	Revised	Unrevised
Manufacturing:		
Structures and Equipment	79.9	43.4
Structures	62.7	27.5
Equipment	102.0	79.6
Nonmanufacturing:		
Structures and Equipment	81.5	66.9
Structures	63.2	46.2
Equipment	126.5	132.8
Total Private Economy:		
Structures and Equipment	78.6	59.2
Structures	60.0	40.4
Equipment	119.9	115.5

Source: Appendix Tables E-2, E-3, and E-4.

output decline of almost exactly the same relative amount in the two sectors and equipment-output trends which are much closer together than before.[8]

III. SUGGESTIONS FOR FURTHER WORK

This study has suggested substantial changes in the investment data of the Department of Commerce, both that published in the National Accounts and the unpublished series underlying the 1966 Capital Goods Study. While there is ample room for disagreement with many of our conclusions and scope for improvements and refinements, there is no doubt that these suggestions should be carefully considered. Unfortunately most of the personnel of the National Income Division are preoccupied with the day-to-day problems of estimating and revising recent GNP figures, and there is little time available for a full-scale historical investigation. The task of introducing changes into the National Income Accounts could be considerably eased, as we have urged repeatedly above, by the establishment of a centralized federal statistical service with its own well-staffed research department.

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[8]The revised structures-output and capital-output ratios declines proportionately more in the total economy than in either sector because of the increased importance of manufacturing, which has a lower structures-output ratio throughout the period than nonmanufacturing.

This body could devote a continuing research effort to the improvement of the historical record of U.S. income and output. Several important jobs have been suggested in the preceding analysis.

1. It should consider the possibility, raised in Chapter II, that estimates of nonmanufacturing structures may be inaccurate because of changes in the reporting practices of the F.W. Dodge Company;

2. An effort should be made to locate the unpublished government documents necessary to improve the estimates in Chapter III of the government-financed capital used to produce private output, and this should be accompanied by an attempt to develop estimates of the government-financed assets used to produce government output.

3. Further study is needed of buyers' prices for producers' durable equipment to supplement the improvements in the structures deflators suggested in Chapter IV.[9]

4. An effort should be made to improve our present very crude data on pre-1915 construction expenditures, perhaps beginning with an attempt to reconcile Kuznets' data based on purchases of construction materials, Martin's figures on national income originating (the discrepancy between these two is mentioned in Kuznets [1946]), and Gottlieb's new series based on data for Ohio [1965].

More important than further refinements in real investment data, however, is the serious lack of data on changes in service

[9]New information on equipment prices may be forthcoming from the current NBER study of industrial prices under the direction of George Stigler and James Kindahl. See Kindahl [1967].

lifetimes, without which there is little basis for firm conclusions on trends in the capital stock or in capital-output ratios. Another worthwhile area for research effort is the utilization of the capital stock before World War II--while the ratio of capital stock to output may have declined between the 1920's and 1950's, an increase in utilization may have resulted in a rise in the ratio of capital services to output.[10] Utilization data for the 1920's might also improve our understanding of the causes of the Great Depression.

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[10] A beginning in this direction, which applies only to manufacturing equipment, is Murray Foss [1963].

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APPENDIX A

DATA ON THE PRICE OF CONSTRUCTION*

*To avoid repetition, the source notes omit the fact that all indexes have been recalculated on a 1965 base and have been linked to 1965 in all instances in which the series as published shifts from one base period to another.

TABLE A-1

BLS AND REVISED WAGE RATE
AND MATERIALS PRICE INDEXES,
AND 'NAIVE' INPUT-CØST INDEX
(1965 = 1.00)

CØLUMN

(1) BLS WHØLESALE PRICE INDEX

(2) BLS UNIØN WAGE INDEX FØR THE BUILDING TRADES

(3) REVISED WAGE INDEX FØR CØNSTRUCTIØN

(4) BLS PRICE INDEX FØR BUILDING MATERIALS

(5) REVISED MATERIALS PRICE INDEX (MØVING WEIGHTS)

(6) 'NAIVE' INPUT-CØST INDEX USING NEW MATERIALS AND WAGE INDEX

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1890	0.0000	0.0572	0.0437	0.1822	0.3214	0.2228
1891	0.0000	0.0578	0.0442	0.1732	0.2946	0.2057
1892	0.0000	0.0590	0.0453	0.1634	0.2875	0.2015
1893	0.0000	0.0590	0.0455	0.1630	0.2834	0.1990
1894	0.0000	0.0576	0.0446	0.1559	0.2630	0.1854
1895	0.0000	0.0581	0.0451	0.1520	0.2507	0.1777
1896	0.0000	0.0590	0.0460	0.1524	0.2487	0.1767
1897	0.0000	0.0598	0.0468	0.1465	0.2441	0.1741
1898	0.0000	0.0607	0.0476	0.1551	0.2512	0.1789
1899	0.0000	0.0622	0.0490	0.1708	0.3001	0.2110
1900	0.0000	0.0649	0.0513	0.1810	0.2989	0.2110
1901	0.0000	0.0676	0.0536	0.1735	0.2848	0.2027
1902	0.0000	0.0715	0.0569	0.1775	0.2961	0.2112
1903	0.0000	0.0749	0.0598	0.1829	0.2998	0.2146
1904	0.0000	0.0766	0.0614	0.1763	0.2652	0.1929
1905	0.0000	0.0780	0.0628	0.1884	0.2776	0.2013
1906	0.0000	0.0828	0.0669	0.2116	0.3071	0.2218

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1907	0.0000	0.0851	0.0690	0.2225	0.3182	0.2298
1908	0.0000	0.0907	0.0738	0.2037	0.2763	0.2044
1909	0.0000	0.0954	0.0779	0.2104	0.2791	0.2077
1910	0.0000	0.0991	0.0813	0.2166	0.2831	0.2115
1911	0.0000	0.1005	0.0827	0.2166	0.2701	0.2036
1912	0.0000	0.1029	0.0850	0.2190	0.2730	0.2062
1913	0.0000	0.1052	0.0872	0.2221	0.2644	0.2015
1914	0.0000	0.1075	0.0895	0.2065	0.2432	0.1886
1915	0.3707	0.1095	0.0906	0.2098	0.2610	0.2005
1916	0.4565	0.1117	0.0936	0.2647	0.3512	0.2598
1917	0.6273	0.1188	0.0999	0.3459	0.4290	0.3122
1918	0.6995	0.1319	0.1113	0.3865	0.4440	0.3259
1919	0.7395	0.1510	0.1279	0.4527	0.4578	0.3407
1920	0.8243	0.2039	0.1733	0.5881	0.5415	0.4108
1921	0.5209	0.2076	0.1772	0.3820	0.4316	0.3413
1922	0.5160	0.1950	0.1670	0.3813	0.4135	0.3260
1923	0.5375	0.2151	0.1849	0.4257	0.4596	0.3621
1924	0.5229	0.2324	0.2005	0.4008	0.4436	0.3573
1925	0.5521	0.2413	0.2089	0.3986	0.4380	0.3567
1926	0.5346	0.2596	0.2255	0.3918	0.4338	0.3599
1927	0.5102	0.2661	0.2320	0.3715	0.4143	0.3496
1928	0.5170	0.2675	0.2341	0.3685	0.4161	0.3515
1929	0.5082	0.2712	0.2382	0.3738	0.4281	0.3607
1930	0.4614	0.2825	0.2490	0.3519	0.3944	0.3428
1931	0.3892	0.2834	0.2507	0.3098	0.3528	0.3165
1932	0.3473	0.2422	0.2151	0.2797	0.3156	0.2799
1933	0.3521	0.2352	0.2096	0.3016	0.3326	0.2890
1934	0.4000	0.2371	0.2120	0.3377	0.3661	0.3114
1935	0.4273	0.2399	0.2153	0.3339	0.3633	0.3107
1936	0.4312	0.2483	0.2237	0.3392	0.3750	0.3212
1937	0.4604	0.2656	0.2401	0.3730	0.4105	0.3500
1938	0.4195	0.2890	0.2622	0.3535	0.3899	0.3446
1939	0.4117	0.2914	0.2653	0.3542	0.3882	0.3445
1940	0.4195	0.2960	0.2705	0.3715	0.3985	0.3531
1941	0.4663	0.3068	0.2814	0.4038	0.4233	0.3729

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1942	0.5268	0.3260	0.3000	0.4317	0.4500	0.3968
1943	0.5512	0.3283	0.3033	0.4362	0.4517	0.3990
1944	0.5551	0.3311	0.3070	0.4520	0.4635	0.4079
1945	0.5648	0.3377	0.3142	0.4610	0.4719	0.4159
1946	0.6448	0.3765	0.3516	0.5197	0.5170	0.4582
1947	0.7921	0.4308	0.4037	0.7070	0.6630	0.5709
1948	0.8575	0.4761	0.4478	0.7822	0.7317	0.6309
1949	0.8146	0.4962	0.4684	0.7671	0.7284	0.6361
1950	0.8468	0.5178	0.4905	0.8235	0.7701	0.6708
1951	0.9434	0.5510	0.5238	0.8995	0.8398	0.7277
1952	0.9170	0.5851	0.5583	0.8890	0.8321	0.7349
1953	0.9043	0.6155	0.5894	0.9018	0.8514	0.7584
1954	0.9063	0.6380	0.6132	0.9040	0.8571	0.7705
1955	0.9092	0.6604	0.6370	0.9439	0.8857	0.7974
1956	0.9385	0.6908	0.6688	0.9822	0.9266	0.8351
1957	0.9658	0.7264	0.7057	0.9822	0.9455	0.8604
1958	0.9795	0.7596	0.7406	0.8908	0.9451	0.8725
1959	0.9814	0.7965	0.7795	1.0128	0.9677	0.9009
1960	0.9824	0.8293	0.8145	0.9970	0.9623	0.9098
1961	0.9785	0.8620	0.8497	0.9781	0.9522	0.9158
1962	0.9814	0.8942	0.8845	0.9751	0.9756	0.9433
1963	0.9785	0.9246	0.9180	0.9771	0.9776	0.9564
1964	0.9804	0.9604	0.9569	0.9880	0.9883	0.9771
1965	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Sources by column:

(1) 1915-1962. Statistical History [1965], Series 25a, p. 130c, 1957-59 = 100.

1963-1965. Economic Report of the President [1967], Table B-45, p. 266, 1957-59 = 100.

(2) 1890-1906. Ulmer [1960], Table D-6, p. 327, column 3, 1911 = 100.

1907-1961. U. S. Department of Labor, Bureau of Labor Statistics [1962], Table 1, p. 6, 1947-49 = 100.

1962-1965. U. S. Department of Commerce, Bureau of the Census [1966], Table 344, p. 245, line 1, 1957-59 = 100.

(Continued on next page)

(3) See discussion in text, pp. 194-198. Column 3 = column 1 times $(.9964)^t$, where t runs backwards beginning with t = 0 in 1965.

(4) 1890-1914. Statistical History [1965], Series E21, p. 117, 1926 = 100.

1915-1956. U. S. Department of Commerce, Business and Defense Services Administration [1957], Table 16, p. 50, column 1, 1947-49 = 100.

1957-1965. U. S. Department of Commerce, Business and Defense Services Administration [1966c], 1947-49 = 100 and 1957-59 = 100.

(5) 1890-1961. See explanation in text on pp. 198-205 and sources cited in Appendix Tables B-1 and B-2.

1962-1965. Linked to column 4.

(6) .355 times column 3 plus .645 times column 5. Labor weight of .355 is the 1965 ratio of value added to value put in place for total construction, from Frumkin [1965], Table 2, p. 16, Line 84, column 1.

TABLE A-2

CØMMERCE CØMPØSITE AND ITS CØMPØNENT INPUT-CØST INDEXES (1965 = 1.00)

CØLUMN

(1) DEPARTMENT ØF CØMMERCE CØMPØSITE CØST INDEX

(2) ASSØCIATED GENERAL CØNTRACTØRS INPUT-CØST INDEX

(3) E. H. BØECKH INPUT-CØST INDEX FØR RESIDENCES

(4) ENGINEERING NEWS-RECØRD INPUT-CØST INDEX FØR BUILDINGS

(5) HANDY-WHITMAN INPUT-CØST INDEX FØR PUBLIC UTILITY BUILDINGS

DATE	(1)	(2)	(3)	(4)	(5)
1915	0.1724	0.1626	0.1727	0.1522	0.1801
1916	0.1896	0.1869	0.1840	0.2085	0.2072
1917	0.2413	0.2439	0.2152	0.2666	0.2972
1918	0.2844	0.2845	0.2560	0.2539	0.3063
1919	0.3189	0.3170	0.2977	0.2531	0.3063
1920	0.3965	0.3983	0.3836	0.3305	0.3603
1921	0.3189	0.3658	0.3081	0.2649	0.2792
1922	0.2931	0.3008	0.2838	0.2472	0.2432
1923	0.3189	0.3252	0.3177	0.2968	0.2792
1924	0.3189	0.3333	0.3133	0.2960	0.3063
1925	0.3189	0.3252	0.3098	0.2918	0.2882
1926	0.3189	0.3170	0.3133	0.2952	0.2882
1927	0.3189	0.3252	0.3090	0.2968	0.2792
1928	0.3189	0.3252	0.3098	0.3002	0.2792
1929	0.3189	0.3333	0.3237	0.3044	0.2792
1930	0.3103	0.3252	0.3151	0.2960	0.2702
1931	0.2844	0.3170	0.2907	0.2708	0.2432
1932	0.2500	0.2764	0.2456	0.2245	0.2252
1933	0.2672	0.2601	0.2456	0.2354	0.2252
1934	0.3017	0.2926	0.2673	0.2657	0.2522

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)
1935	0.2931	0.2845	0.2612	0.2649	0.2522
1936	0.3017	0.2926	0.2699	0.2750	0.2612
1937	0.3189	0.3089	0.3020	0.3128	0.2882
1938	0.3189	0.3089	0.3107	0.3137	0.2792
1939	0.3017	0.3089	0.3168	0.3153	0.2792
1940	0.3103	0.3089	0.3272	0.3238	0.2792
1941	0.3362	0.3170	0.3532	0.3372	0.3063
1942	0.3793	0.3414	0.3732	0.3549	0.3333
1943	0.4051	0.3495	0.3897	0.3650	0.3333
1944	0.3965	0.3658	0.4236	0.3751	0.3423
1945	0.4137	0.3739	0.4539	0.3818	0.3513
1946	0.4827	0.4227	0.4982	0.4188	0.4054
1947	0.5775	0.4878	0.6032	0.4995	0.4774
1948	0.6465	0.5447	0.6788	0.5500	0.5495
1949	0.6379	0.5609	0.6614	0.5618	0.5765
1950	0.6637	0.5853	0.6970	0.5988	0.6036
1951	0.7241	0.6178	0.7517	0.6391	0.6486
1952	0.7413	0.6341	0.7708	0.6627	0.6576
1953	0.7586	0.6666	0.7847	0.6871	0.6936
1954	0.7586	0.6910	0.7786	0.7115	0.7207
1955	0.7758	0.7154	0.8020	0.7485	0.7477
1956	0.8189	0.7479	0.8376	0.7830	0.8198
1957	0.8534	0.7886	0.8532	0.8116	0.8828
1958	0.8620	0.8130	0.8611	0.8376	0.9009
1959	0.8793	0.8373	0.8897	0.8738	0.9279
1960	0.8879	0.8699	0.9045	0.8923	0.9369
1961	0.8965	0.8861	0.9071	0.9066	0.9279
1962	0.9224	0.9024	0.9227	0.9251	0.9459
1963	0.9396	0.9268	0.9418	0.9478	0.9639
1964	0.9655	0.9674	0.9687	0.9764	0.9819
1965	1.0000	1.0000	1.0000	1.0000	0.0000

<u>Source</u>:

U. S. Department of Commerce, Business and Defense Services Administration [1966a], Table 33, pp. 58-59, 1957-59 = 100. (1965 values from same author [1966c]).

TABLE A-3

INPUT-PRØDUCTIVITY INDEXES IN
THE CØMMERCE CØMPØSITE
(1965 = 1.00)

CØLUMN

(1) AMERICAN APPRAISAL INPUT-PRØDUCTIVITY INDEX

(2) GEØRGE A. FULLER INPUT-PRØDUCTIVITY INDEX

(3) TURNER CØNSTRUCTIØN CØ. INPUT-PRØDUCTIVITY INDEX

(4) ATT INPUT-PRØDUCTIVITY INDEX FØR BUILDINGS

(5) AVERAGE ØF FØUR CØNTRACTØR INPUT-PRØDUCTIVITY INDEXES

(6) AMERICAN APPRAISAL LABØR EFFICIENCY INDEX FØR CARPENTERS

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1915	0.1239	0.2016	0.1504	0.0000	0.1586	1.0526
1916	0.1404	0.2177	0.1858	0.0000	0.1813	0.9900
1917	0.1735	0.2419	0.2212	0.0000	0.2122	0.9090
1918	0.2148	0.2419	0.2566	0.0000	0.2378	0.8403
1919	0.2809	0.2580	0.3008	0.0000	0.2799	0.8064
1920	0.3388	0.3225	0.3805	0.0000	0.3473	0.8064
1921	0.2644	0.2903	0.2743	0.0000	0.2763	0.9523
1922	0.2479	0.2661	0.2654	0.0000	0.2598	0.9900
1923	0.2727	0.2903	0.3008	0.0000	0.2879	0.9803
1924	0.2644	0.2983	0.3008	0.0000	0.2879	0.9615
1925	0.2644	0.2983	0.3008	0.0000	0.2879	0.9615
1926	0.2644	0.3064	0.3008	0.0000	0.2905	0.9523
1927	0.2644	0.3064	0.2920	0.0000	0.2876	0.9433
1928	0.2644	0.3064	0.2920	0.0000	0.2876	0.9615
1929	0.2644	0.3064	0.2831	0.0000	0.2847	1.0000
1930	0.2479	0.3064	0.2566	0.2905	0.2754	1.0752
1931	0.2148	0.2741	0.2212	0.2564	0.2416	1.1494
1932	0.1900	0.2419	0.2123	0.2307	0.2187	1.2048

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1933	0.1818	0.2419	0.2123	0.2222	0.2145	1.2048
1934	0.1900	0.2661	0.2477	0.2393	0.2358	1.2048
1935	0.1983	0.2580	0.2477	0.2478	0.2380	1.2048
1936	0.2066	0.2580	0.2566	0.2564	0.2444	1.1904
1937	0.2396	0.2822	0.2920	0.2820	0.2740	1.1764
1938	0.2396	0.2983	0.2831	0.2905	0.2779	1.1627
1939	0.2479	0.2983	0.2743	0.2905	0.2778	1.1363
1940	0.2479	0.3064	0.3008	0.2991	0.2886	1.1363
1941	0.2644	0.3145	0.3274	0.3076	0.3035	1.1111
1942	0.2892	0.3548	0.3716	0.3333	0.3372	1.0989
1943	0.3057	0.3629	0.3893	0.3333	0.3478	1.0752
1944	0.3223	0.3709	0.3716	0.3418	0.3517	1.0416
1945	0.3305	0.3709	0.3982	0.3931	0.3732	0.9615
1946	0.3884	0.4435	0.4867	0.4871	0.4514	0.8695
1947	0.5206	0.5403	0.5840	0.5726	0.5544	0.8620
1948	0.5950	0.5806	0.6460	0.6239	0.6114	0.8695
1949	0.5950	0.5887	0.6283	0.6324	0.6111	0.8849
1950	0.6033	0.5806	0.6460	0.6581	0.6220	0.9009
1951	0.6446	0.6209	0.7256	0.7008	0.6730	0.9090
1952	0.6694	0.6370	0.7522	0.7179	0.6941	0.9174
1953	0.7024	0.6612	0.7610	0.7521	0.7192	0.9259
1954	0.7190	0.6854	0.7522	0.7606	0.7293	0.9259
1955	0.7355	0.7096	0.7522	0.7692	0.7416	0.9433
1956	0.7685	0.7419	0.8230	0.7948	0.7821	0.9523
1957	0.8016	0.7741	0.8761	0.8290	0.8202	0.9615
1958	0.8264	0.8064	0.8849	0.8547	0.8431	0.9708
1959	0.8512	0.8387	0.8938	0.8803	0.8660	0.9803
1960	0.8760	0.8548	0.9026	0.9059	0.8848	0.9900
1961	0.8925	0.8870	0.9115	0.9145	0.9014	0.9900
1962	0.9173	0.9274	0.9203	0.9316	0.9241	1.0000
1963	0.9421	0.9516	0.9469	0.9487	0.9473	1.0000
1964	0.9669	0.9758	0.9646	0.9743	0.9704	1.0000
1965	1.0000	1.0000	1.0000	0.0000	1.0000	1.0000

<u>Sources by column</u>:

(1)-(4) See sources for Table A-2.

(5) Average of columns 1 through 4.

(6) American Appraisal Company [1967], Exhibit No. 15A, 1962 = 100.

TABLE A-4

THREE CØMPØSITE CØMPØNENT-PRICE INDEXES
AND THREE SUBCØMPØNENT INDEXES FØR EXCAVATIØN
(1965 = 1.00)

CØLUMN

(1) BUREAU ØF PUBLIC RØADS HIGHWAY CØMPØSITE INDEX

(2) BUREAU ØF RECLAMATIØN CØMPØSITE INDEX

(3) ICC RAILRØAD CØMPØSITE INDEX

(4) BUREAU ØF PUBLIC RØADS EXCAVATIØN INDEX

(5) BUREAU ØF RECLAMATIØN INDEX FØR EARTH DAMS

(6) ICC INDEX FØR GRADING AND EXCAVATIØN (ACCØUNT 3)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1915	0.3547	0.0000	0.2609	0.0000	0.0000	0.6118
1916	0.3755	0.0000	0.2842	0.0000	0.0000	0.6468
1917	0.4304	0.0000	0.3462	0.0000	0.0000	0.7601
1918	0.5203	0.0000	0.4108	0.0000	0.0000	0.8923
1919	0.5771	0.0000	0.4599	0.0000	0.0000	1.0859
1920	0.7483	0.0000	0.5529	0.0000	0.0000	1.2370
1921	0.6206	0.0000	0.4521	0.0000	0.0000	1.0623
1922	0.5648	0.0000	0.4082	0.8162	0.0000	0.9820
1923	0.6300	0.0000	0.4418	0.9473	0.0000	1.0623
1924	0.6045	0.0000	0.4418	0.8715	0.0000	1.0623
1925	0.5733	0.0000	0.4289	0.7850	0.0000	1.0623
1926	0.5515	0.0000	0.4315	0.7484	0.0000	1.0576
1927	0.5449	0.0000	0.4237	0.7154	0.0000	1.0009
1928	0.5099	0.0000	0.4160	0.6842	0.0000	0.8026
1929	0.4929	0.0000	0.4134	0.6422	0.0000	0.7884
1930	0.4578	0.0000	0.3927	0.6164	0.0000	0.7318
1931	0.4105	0.0000	0.3695	0.5530	0.0000	0.6997
1932	0.3263	0.0000	0.3385	0.3916	0.0000	0.6288

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1933	0.4115	0.0000	0.3281	0.5272	0.0000	0.5807
1934	0.4484	0.0000	0.3385	0.5950	0.0000	0.5939
1935	0.4304	0.0000	0.3385	0.5307	0.0000	0.5996
1936	0.4437	0.0000	0.3436	0.5334	0.0000	0.5882
1937	0.4238	0.0000	0.3669	0.4933	0.0000	0.6128
1938	0.3897	0.0000	0.3565	0.4264	0.0000	0.5524
1939	0.3878	0.0000	0.3540	0.4264	0.0000	0.5335
1940	0.3822	0.3555	0.3617	0.4219	0.4411	0.5335
1941	0.4342	0.4074	0.3901	0.4950	0.5294	0.5873
1942	0.5818	0.5037	0.4521	0.7421	0.6862	0.8016
1943	0.6669	0.5555	0.4806	0.8849	0.7598	0.8441
1944	0.6045	0.5555	0.4832	0.7591	0.7647	0.8498
1945	0.5827	0.5629	0.5090	0.7172	0.7549	0.8555
1946	0.6348	0.6000	0.5581	0.7065	0.7921	0.8781
1947	0.7237	0.6888	0.6330	0.7716	0.8794	0.9150
1948	0.8070	0.7555	0.7002	0.8501	0.9411	0.0944
1949	0.7710	0.7703	0.6976	0.7671	0.9362	0.8262
1950	0.7407	0.7037	0.7131	0.6752	0.7970	0.8309
1951	0.9091	0.7925	0.7674	0.8581	0.9117	0.8819
1952	0.9356	0.8296	0.7958	0.9134	0.9539	0.8847
1953	0.9016	0.8592	0.8217	0.8581	0.9539	0.9150
1954	0.8505	0.8222	0.8268	0.8153	0.7617	0.8545
1955	0.8259	0.8222	0.8527	0.7493	0.8421	0.8734
1956	0.9347	0.8814	0.9095	0.8563	0.9264	0.9017
1957	0.9754	0.9555	0.9560	0.8983	1.0245	0.9442
1958	0.9508	0.9185	0.9741	0.9179	0.9460	0.9442
1959	0.9120	0.9407	0.9948	0.8537	0.9705	0.9499
1960	0.8902	0.9259	1.0000	0.8367	0.9460	0.9499
1961	0.8987	0.9333	0.9948	0.8626	0.9460	0.9499
1962	0.9318	0.9555	0.9896	0.9473	0.9539	0.9556
1963	0.9555	0.9629	0.9896	0.9491	0.9539	0.9499
1964	0.9649	0.9851	0.9922	0.9723	0.9803	0.9726
1965	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Sources by column:

(1)(4) 1915-1961. Stern [1961], p. 199, 1925-29 = 100 and 1957-59 = 100.

(Continued on next page)

1961-1965. Obtained in a telephone conversation with Edwin L. Stern, Economic Research Division of the U. S. Bureau of Public Roads, April 5, 1967, 1957-59 = 100.

(2)(5) U. S. Department of the Interior, Bureau of Reclamation, [1966b], 1949-51 = 100. 1940-48 figures given in publication are for January; an average of successive January figures was calculated to obtain annual averages. For 1949-59 the July figure was used, and for 1960-65 an annual average of quarterly data was computed.

(3) U. S. Department of Commerce, Business and Defense Services Administration [1966a], Table 33, p. 59, 1957-59 = 100.

(6) U. S. Interstate Commerce Commission, Bureau of Accounts [1966], pp. 1-9, 1910-14 = 100.

TABLE A-5

SUBCØMPØNENT PRICE INDEXES FØR STRUCTURAL STEEL (1965 = 1.00)

CØLUMN

(1) BUREAU ØF PUBLIC RØADS INDEX FØR STRUCTURAL STEEL IN PLACE

(2) BUREAU ØF RECLAMATIØN INDEX FØR STEEL BRIDGES

(3) ICC STRUCTURAL STEEL INDEX

(4) ICC INDEX FØR BRIDGES AND TRESTLES (ACCØUNT 6)

DATE	(1)	(2)	(3)	(4)
1915	0.0000	0.0000	0.0000	0.2112
1916	0.0000	0.0000	0.0000	0.2233
1917	0.0000	0.0000	0.0000	0.2937
1918	0.0000	0.0000	0.0000	0.3259
1919	0.0000	0.0000	0.0000	0.3581
1920	0.0000	0.0000	0.0000	0.4144
1921	0.0000	0.0000	0.0000	0.3319
1922	0.3430	0.0000	0.0000	0.3219
1923	0.3625	0.0000	0.0000	0.3541
1924	0.3567	0.0000	0.0000	0.3480
1925	0.3109	0.0000	0.0000	0.3440
1926	0.3430	0.0000	0.0000	0.3420
1927	0.3294	0.0000	0.0000	0.3380
1928	0.3109	0.0000	0.2956	0.3299
1929	0.2738	0.0000	0.2887	0.3279
1930	0.2836	0.0000	0.2525	0.3018
1931	0.2504	0.0000	0.2369	0.2696
1932	0.2134	0.0000	0.2163	0.2454
1933	0.2134	0.0000	0.2183	0.2454
1934	0.2456	0.0000	0.2388	0.2736
1935	0.2407	0.0000	0.2506	0.2716
1936	0.2787	0.0000	0.2672	0.2837

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)
1937	0.3060	0.0000	0.2995	0.3118
1938	0.2923	0.0000	0.2790	0.3018
1939	0.2748	0.0000	0.2790	0.2997
1940	0.2923	0.2876	0.3054	0.3138
1941	0.3528	0.3292	0.3455	0.3501
1942	0.4171	0.3610	0.3876	0.4225
1943	0.4395	0.4309	0.3876	0.4567
1944	0.4132	0.4362	0.3994	0.4466
1945	0.3469	0.4442	0.3994	0.4828
1946	0.5243	0.4867	0.4356	0.5472
1947	0.6130	0.5619	0.5335	0.6579
1948	0.7329	0.6194	0.6265	0.7384
1949	0.6773	0.6194	0.6539	0.7525
1950	0.6442	0.5619	0.6617	0.7323
1951	0.8810	0.6699	0.7763	0.8148
1952	0.8898	0.6858	0.8663	0.8712
1953	0.8635	0.7176	0.8732	0.8732
1954	0.7943	0.7610	0.0000	0.8410
1955	0.7884	0.7876	0.0000	0.8611
1956	1.0614	0.8362	0.0000	0.9175
1957	1.1403	0.9070	0.0000	0.9698
1958	0.9327	0.8628	0.0000	0.9879
1959	0.8460	0.8849	0.0000	0.9839
1960	0.8343	0.8796	0.0000	0.9919
1961	0.8265	0.8955	0.0000	0.9778
1962	0.8333	0.9150	0.0000	0.9778
1963	0.9083	0.9460	0.0000	0.9859
1964	0.8752	0.9814	0.0000	0.9919
1965	1.0000	1.0000	0.0000	1.0000

Sources by column:

(1) Same as Table A-4, columns 1 and 4.

(2) Same as Table A-4, columns 2 and 5.

(3) U. S. Interstate Commerce Commission, Bureau of Accounts [1955], pp. 10-11, 1910-14 = 100, 1953 value linked to column 4.

(4) U. S. Interstate Commerce Commission, Bureau of Accounts [1966], pp. 1-9, 1910-14 = 100.

TABLE A-5A

SUBCØMPØNENT PRICE INDEXES FØR
STRUCTURAL CØNCRETE
(1965 = 1.00)

CØLUMN

(1) BPR STRUCTURAL CØNCRETE

(2) BUREAU ØF RECLAMATIØN INDEX FØR PUMPING STATIØNS

(3) ICC INDEX FØR PLAIN CØNCRETE IN PLACE

DATE	(1)	(2)	(3)
1915	0.0000	0.0000	0.0000
1916	0.0000	0.0000	0.0000
1917	0.0000	0.0000	0.0000
1918	0.0000	0.0000	0.0000
1919	0.0000	0.0000	0.0000
1920	0.0000	0.0000	0.0000
1921	0.0000	0.0000	0.0000
1922	0.3270	0.0000	0.0000
1923	0.3789	0.0000	0.0000
1924	0.3717	0.0000	0.0000
1925	0.3655	0.0000	0.0000
1926	0.3690	0.0000	0.0000
1927	0.3672	0.0000	0.0000
1928	0.3440	0.0000	0.3520
1929	0.3503	0.0000	0.3520
1930	0.3252	0.0000	0.3190
1931	0.2922	0.0000	0.2730
1932	0.2484	0.0000	0.2470
1933	0.2618	0.0000	0.2590
1934	0.2877	0.0000	0.2810
1935	0.2886	0.0000	0.2930
1936	0.3288	0.0000	0.3050
1937	0.3208	0.0000	0.3140
1938	0.3092	0.0000	0.3050

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)
1939	0.3100	0.0000	0.3050
1940	0.3109	0.3190	0.3050
1941	0.3476	0.3676	0.3390
1942	0.4244	0.4400	0.4320
1943	0.4897	0.4647	0.4880
1944	0.5183	0.4876	0.4630
1945	0.5129	0.4942	0.5210
1946	0.6291	0.5295	0.6140
1947	0.7435	0.6428	0.7280
1948	0.8275	0.7161	0.7980
1949	0.7685	0.7161	0.7980
1950	0.7238	0.7019	0.7520
1951	0.8364	0.7733	0.8190
1952	0.8614	0.8238	0.8600
1953	0.8713	0.8438	0.8600
1954	0.8275	0.8514	0.0000
1955	0.8248	0.8733	0.0000
1956	0.8865	0.9161	0.0000
1957	0.9231	0.9600	0.0000
1958	0.8927	0.9447	0.0000
1959	0.8686	0.9523	0.0000
1960	0.8534	0.9380	0.0000
1961	0.8802	0.9238	0.0000
1962	0.9008	0.9447	0.0000
1963	0.9472	0.9733	0.0000
1964	0.9615	0.9923	0.0000
1965	1.0000	1.0000	0.0000

<u>Sources by column</u>:

(1) Same as Table A-4, columns 1 and 4.

(2) Same as Table A-4, columns 2 and 5.

(3) U. S. Interstate Commerce Commission, Bureau of Accounts [1955], pp. 10-11, 1910-14 = 100, 1953 value linked to average of columns 1 and 2.

TABLE A-6

CALCULATIØN ØF NEW 'CØMPØNENT-PRICE-HYBRID' INDEX
(1965 = 1.00)

CØLUMN

(1) INPUT CØST INDEX FØR STRUCTURAL STEEL

(2) RATIØ ØF CØMPØNENT-PRICE TØ INPUT-CØST FØR STEEL

(3) INPUT CØST INDEX FØR CØNCRETE

(4) RATIØ ØF CØMPØNENT-PRICE TØ INPUT-CØST FØR CØNCRETE

(5) AVERAGE ØF CØLUMNS (2) AND (4)

(6) 'CØMPØNENT-PRICE-HYBRID'

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1922	0.2412	1.3780	0.2928	1.1166	1.2473	0.4066
1923	0.3094	1.1579	0.3238	1.1701	1.1640	0.4215
1924	0.2998	1.1754	0.3301	1.1258	1.1506	0.4111
1925	0.2873	1.1394	0.3329	1.0977	1.1185	0.3990
1926	0.2915	1.1749	0.3393	1.0873	1.1311	0.4071
1927	0.2879	1.1586	0.3368	1.0899	1.1243	0.3931
1928	0.2927	1.0662	0.3348	1.0272	1.0467	0.3679
1929	0.2940	1.0094	0.3394	1.0318	1.0206	0.3681
1930	0.2715	1.0284	0.3330	0.9765	1.0024	0.3436
1931	0.2548	0.9900	0.3190	0.9157	0.9528	0.3016
1932	0.2306	0.9753	0.2894	0.8582	0.9167	0.2566
1933	0.2310	0.9769	0.2906	0.9006	0.9388	0.2713
1934	0.2446	1.0329	0.3031	0.9489	0.9909	0.3086
1935	0.2521	1.0087	0.3073	0.9388	0.9737	0.3026
1936	0.2613	1.0578	0.3145	1.0453	1.0515	0.3378
1937	0.3012	1.0149	0.3356	0.9557	0.9853	0.3449
1938	0.3084	0.9434	0.3447	0.8969	0.9201	0.3171
1939	0.3062	0.9288	0.3418	0.9067	0.9177	0.3162
1940	0.3114	0.9625	0.3461	0.9000	0.9313	0.3288

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1941	0.3177	1.0838	0.3562	0.9862	1.0350	0.3860
1942	0.3248	1.2225	0.3663	1.1796	1.2011	0.4766
1943	0.3348	1.2803	0.3691	1.3022	1.2912	0.5152
1944	0.3364	1.2598	0.3766	1.2998	1.2798	0.5221
1945	0.3500	1.1951	0.4123	1.2353	1.2152	0.5055
1946	0.3910	1.2746	0.4461	1.3241	1.2994	0.5955
1947	0.4673	1.2659	0.5109	1.3791	1.3225	0.7551
1948	0.5084	1.3361	0.5770	1.3525	1.3443	0.8482
1949	0.5416	1.2477	0.5974	1.2735	1.2606	0.8019
1950	0.5612	1.1581	0.6258	1.1598	1.1589	0.7775
1951	0.5962	1.3174	0.6721	1.2042	1.2608	0.9175
1952	0.6185	1.3391	0.6983	1.2148	1.2769	0.9384
1953	0.6605	1.2593	0.7281	1.1777	1.2185	0.9242
1954	0.6850	1.1935	0.7459	1.1253	1.1594	0.8934
1955	0.7196	1.1461	0.7720	1.0996	1.1228	0.8954
1956	0.7782	1.2712	0.8217	1.0968	1.1840	0.9888
1957	0.8395	1.2566	0.8760	1.0747	1.1657	1.0029
1958	0.8646	1.1106	0.9086	1.0110	1.0608	0.9256
1959	0.8847	1.0340	0.9411	0.9674	1.0007	0.9016
1960	0.8896	1.0263	0.9634	0.9297	0.9780	0.8898
1961	0.9074	0.9941	0.9693	0.9305	0.9623	0.8813
1962	0.9141	0.9906	0.9605	0.9605	0.9756	0.9203
1963	0.9390	1.0085	0.9583	1.0020	1.0053	0.9615
1964	0.9729	0.9594	0.9763	1.0005	0.9799	0.9576
1965	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Sources by column:

(1)(3) Calculated with price indexes and weights from American Appraisal Company [1967] and adjusted union wage rate index from Table A-1, column 3.

(2) Ratio of indexes shown in Table A-5 to this table, column 1.

(4) Ratio of indexes shown in Table A-5A to this table, column 3.

(5) Average of columns 2 and 4.

(6) Column 5 times input-cost index from Table A-1, column 6.

TABLE A-7

EXTENSIØN AND MØDIFICATIØN ØF DACY'S METHØD
(1965 = 1.00)

CØLUMN

(1) VALUE ØF CØNTRACT CØNSTRUCTIØN PUT IN P LACE (*MILLIØN)

(2) INDEX ØF VALUE ØF CØNTRACT CØNSTRUCTIØN PUT IN PLACE

(3) INDEX ØF MAN-HØURS IN CØNTRACT CØNSTRUCTIØN

(4) INDEX ØF NATIØNAL INCØME ØRIGINATING IN CØNTRACT CØNSTRUCTI

(5) EXTENDED DACY INDEX USING WAGE-BILL DATA

(6) 'INCØME-DACY' INDEX

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1919	6518	0.0900	0.5977	0.0706	0.4269	0.4033
1920	6830	0.0943	0.3890	0.0932	0.4736	0.5376
1921	6323	0.0873	0.4640	0.0700	0.4214	0.3838
1922	7873	0.1087	0.5431	0.0821	0.3826	0.3583
1923	9401	0.1298	0.5639	0.1177	0.4190	0.4343
1924	10408	0.1437	0.6059	0.1317	0.4128	0.4216
1925	11465	0.1583	0.6634	0.1396	0.4136	0.4077
1926	12117	0.1673	0.7123	0.1505	0.4277	0.4081
1927	12037	0.1662	0.7350	0.1451	0.4229	0.3837
1928	11697	0.1615	0.7296	0.1408	0.4320	0.3850
1929	10813	0.1493	0.6744	0.1353	0.4489	0.4043
1930	8648	0.1194	0.6221	0.1129	0.4557	0.3813
1931	6540	0.0903	0.5596	0.0783	0.4891	0.3256
1932	3788	0.0523	0.4568	0.0381	0.6136	0.2697
1933	3201	0.0442	0.3834	0.0278	0.7031	0.2697
1934	4041	0.0558	0.3896	0.0394	0.4835	0.3090
1935	4628	0.0639	0.4002	0.0473	0.4468	0.3124
1936	6801	0.0939	0.4630	0.0720	0.3929	0.3271
1937	7315	0.1010	0.4589	0.0742	0.4334	0.3519

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1938	7337	0.1013	0.4385	0.0707	0.4278	0.3278
1939	8553	0.1181	0.4845	0.0826	0.4123	0.3265
1940	9169	0.1266	0.5005	0.0913	0.4291	0.3392
1941	12646	0.1746	0.6285	0.1489	0.4380	0.3874
1942	15340	0.2118	0.7366	0.2291	0.4715	0.4743
1943	9966	0.1376	0.5620	0.1933	0.5089	0.6060
1944	6620	0.0914	0.4301	0.1463	0.5716	0.7444
1945	7445	0.1028	0.4441	0.1515	0.5532	0.6714
1946	15782	0.2179	0.6613	0.2293	0.5790	0.5346
1947	21526	0.2972	0.7778	0.2974	0.6932	0.6631
1948	27450	0.3790	0.8431	0.3746	0.7335	0.7263
1949	27921	0.3855	0.8077	0.3718	0.7178	0.7125
1950	34708	0.4792	0.8777	0.4201	0.7616	0.7147
1951	36490	0.5038	0.9349	0.4977	0.8216	0.8335
1952	38199	0.5274	0.9333	0.5367	0.8242	0.8413
1953	40242	0.5556	0.9181	0.5501	0.8413	0.8462
1954	42610	0.5883	0.8855	0.5497	0.8297	0.8232
1955	48108	0.6642	0.9044	0.5874	0.8511	0.8256
1956	49020	0.6768	0.9380	0.6539	0.8878	0.9073
1957	50382	0.6956	0.9201	0.6804	0.9126	0.9327
1958	51403	0.7097	0.8922	0.6703	0.9187	0.9132
1959	57118	0.7886	0.9198	0.7228	0.9396	0.9194
1960	55792	0.7703	0.9109	0.7346	0.9442	0.9351
1961	57487	0.7937	0.9023	0.7581	0.9397	0.9261
1962	61724	0.8522	0.9186	0.8060	0.9498	0.9435
1963	64419	0.8894	0.9379	0.8542	0.9722	0.9538
1964	67374	0.9302	0.9686	0.9326	0.9852	0.9898
1965	72430	1.0000	1.0000	1.0000	1.0000	1.0000

<u>Sources by column</u>:

(1) New construction by sector from U. S. Department of Commerce, Business and Defense Services Administration [1966a][1966b]. Maintenance and repair only available for total of all sectors, and was divided by sector annually in proportion to each sector's share of new construction in that year. Then the following constant percentages were multiplied by the sector new construction and maintenance-repair values to derive the contract portion:

(Continued on next page)

Sector	New Construction	Maintenance - Repair
Private:		
Residential nonfarm	93.2	59.4
Industrial	83.5	50.0*
Commercial	95.8	40.8
Other nonresidential	91.7	93.4
Farm	55.8	7.2
Public Utilities	56.2	.7
Petroleum and gas well drilling	80.0	.0*
Public:		
Nonresidential	91.7	32.4
Highways	87.5	9.3
Military-Naval	100.0*	85.7
Sewer and Water	89.2	3.7
Conservation and Development	92.9	19.1
Miscellaneous and Public Service Enterprises	91.1	6.0

Percentages from Dacy [1962], Table IV-1, p. 81, adopted by him from "BLS Report No. 2." The percentages marked by asterisks were omitted by Dacy and had to be guessed.

The final estimate shown in column 1 of Table A-7 is the sum of all sectoral estimates for the value of the contract share of new construction and maintenance-repair.

(2) Index of column 1, 1965 = 1.00.

(3) Man-hours = $E_t H_t + 1.145 (P_t - E_t) H_t$, where:

E_t = Number of Employees in Contract Construction.

1915-1962. U. S. Department of Commerce, Business and Defense Services Administration [1966a], pp. 66-67.

1963-1965. U. S. Department of Commerce, Bureau of the Census [1966], Table 314, p. 221, column 3.

H_t = Standard hours per week in the building trades.

1915-1961. U. S. Department of Labor, Bureau of Labor Statistics [1962], Table 10, p. 14.

(Continued on next page)

1962-1965. U. S. Department of Commerce, Bureau of the Census [1966], Table 344, p. 245, line 2.

P_t = Persons engaged in contract construction.

1919-28. $P_t = E_t(P_{1929}/E_{1929})$

1929-1965. U. S. Department of Commerce, Office of Business Economics [1966a], Table 6.6, pp. 110-13.

(4) 1919-1928. Kuznets [1941], Table 43.

1929-1965. U. S. Department of Commerce, Office of Business Economics [1966a], Table 1.12, pp. 18-21.

(5) See formula (17) in Section VIII of Chapter IV, where:

m' = Table A-1, column 5.
w' = Table A-1, column 3.
L' = Table A-7, column 3.
V' = Table A-7, column 2, as adjusted by (18) on p. 255.
b = 1965 share of employee compensation (EC_{1965}) to the sum of employee compensation and purchases of materials (mM_{1965}), where EC_{1965} is from U. S. Department of Commerce, Office of Business Economics [1966a], Table 6.1, pp. 90-93. mM_{1965} is the 1965 value of column 1 minus the 1965 value of national income originating, from the source of column 4.

(6) See formula (20) in Section VIII of Chapter IV, where the data are the same as in column 5, except that:

N' = Table A-7, column 4.
c = 1965 share of national income originating, from the source of column 4, in value, column 1.

TABLE A-8

FINAL ESTIMATES ØF PRICES, ØUTPUT, AND PRØDUCTIVITY IN CØNTRACT CØNSTRUCTIØN (1965 = 1.00)

CØLUMN

(1) 'CØMPØNENT-PRICE-HYBRID' FØR CØNSTRUCTIØN ('CPHC')

(2) FINAL PRICE ØF CØNSTRUCTIØN, AVERAGE ØF INCØME-DACY AND CPH

(3) INDEX ØF ØUTPUT IN CØNTRACT CØNSTRUCTIØN

(4) INDEX ØF ØUTPUT PER MAN-HØUR IN CØNTRACT CØNSTRUCTIØN

(5) GNP DEFLATØR

DATE	(1)	(2)	(3)	(4)	(5)
1919	0.0000	0.4034	0.2231	0.3732	0.0000
1920	0.0000	0.5378	0.1753	0.4507	0.0000
1921	0.0000	0.3838	0.2274	0.4902	0.0000
1922	0.4303	0.3943	0.2756	0.5075	0.0000
1923	0.4527	0.4435	0.2926	0.5189	0.0000
1924	0.4401	0.4308	0.3335	0.5504	0.0000
1925	0.4251	0.4164	0.3801	0.5730	0.0000
1926	0.4287	0.4184	0.3998	0.5613	0.0000
1927	0.4158	0.3997	0.4157	0.5656	0.0000
1928	0.3892	0.3871	0.4172	0.5718	0.0000
1929	0.3868	0.3955	0.3774	0.5596	0.4562
1930	0.3607	0.3710	0.3218	0.5173	0.4445
1931	0.3179	0.3217	0.2806	0.5014	0.4039
1932	0.2670	0.2683	0.1948	0.4266	0.3624
1933	0.2923	0.2810	0.1572	0.4102	0.3543
1934	0.3295	0.3192	0.1747	0.4485	0.3805
1935	0.3217	0.3170	0.2015	0.5035	0.3841
1936	0.3536	0.3403	0.2758	0.5958	0.3850
1937	0.3567	0.3543	0.2850	0.6211	0.4012
1938	0.3279	0.3278	0.3089	0.7045	0.3958

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)
1939	0.3269	0.3267	0.3614	0.7460	0.3895
1940	0.3368	0.3380	0.3745	0.7483	0.3958
1941	0.3932	0.3903	0.4473	0.7117	0.4256
1942	0.4923	0.4833	0.4382	0.5948	0.4779
1943	0.5379	0.5719	0.2405	0.4280	0.5121
1944	0.5344	0.6394	0.1429	0.3323	0.5247
1945	0.5170	0.5942	0.1729	0.3895	0.5383
1946	0.6013	0.5679	0.3836	0.5801	0.6014
1947	0.7503	0.7067	0.4205	0.5406	0.6726
1948	0.8420	0.7841	0.4833	0.5732	0.7177
1949	0.7972	0.7548	0.5106	0.6322	0.7132
1950	0.7719	0.7433	0.6446	0.7344	0.7231
1951	0.9162	0.8748	0.5758	0.6159	0.7718
1952	0.9379	0.8896	0.5928	0.6351	0.7889
1953	0.9208	0.8835	0.6288	0.6849	0.7962
1954	0.8869	0.8550	0.6880	0.7769	0.8079
1955	0.8849	0.8552	0.7765	0.8586	0.8196
1956	0.9806	0.9439	0.7169	0.7643	0.8476
1957	0.9987	0.9657	0.7202	0.7828	0.8791
1958	0.9293	0.9212	0.7703	0.8634	0.9017
1959	0.9031	0.9112	0.8653	0.9408	0.9161
1960	0.8898	0.9124	0.8441	0.9267	0.9314
1961	0.8839	0.9050	0.8770	0.9719	0.9431
1962	0.9220	0.9327	0.9136	0.9945	0.9540
1963	0.9606	0.9572	0.9291	0.9906	0.9666
1964	0.9586	0.9742	0.9547	0.9857	0.9819
1965	1.0000	1.0000	1.0000	1.0000	1.0000

Sources by column:

(1) .15 times Table A-4, column 1 plus .85 times A-6, column 6. Weight of .15 is the approximate share in 1965 of highways, conservation and development, and sewers and water, in the value of total contract construction, from the data underlying Table A-7, column 1.

(2) Average of Table A-7, column 6 and Table A-8, column 1.

(3) Table A-7, column 2, divided by Table A-8, column 2.

(4) Table A-8, column 3, divided by Table A-7, column 3.

(5) Economic Report of the President [1967], Table B-3, p. 216.

TABLE A-9

FINAL PRICE ØF STRUCTURES AND
F. W. DØDGE UNIT VALUE INDEXES
PER SQUARE FØØT ØF FLØØR AREA
(1965 = 1.00)

CØLUMN

(1) 'FINAL PRICE ØF STRUCTURES'

(2) DØDGE VALUE PER SQ FØØT FØR INDUSTRIAL CØNSTRUCTIØN

(3) DØDGE VALUE PER SQ FØØT FØR CØMMERCIAL BUILDINGS

(4) DØDGE VALUE PER SQ FØØT FØR PUB. + INST. BUILDINGS

(5) DØDGE VALUE PER SQ FØØT FØR RESIDENTIAL BUILDINGS

DATE	(1)	(2)	(3)	(4)	(5)
1865	0.3561	0.0000	0.0000	0.0000	0.0000
1866	0.3812	0.0000	0.0000	0.0000	0.0000
1867	0.3835	0.0000	0.0000	0.0000	0.0000
1868	0.3693	0.0000	0.0000	0.0000	0.0000
1869	0.3733	0.0000	0.0000	0.0000	0.0000
1870	0.3477	0.0000	0.0000	0.0000	0.0000
1871	0.3389	0.0000	0.0000	0.0000	0.0000
1872	0.3710	0.0000	0.0000	0.0000	0.0000
1873	0.3491	0.0000	0.0000	0.0000	0.0000
1874	0.2999	0.0000	0.0000	0.0000	0.0000
1875	0.2475	0.0000	0.0000	0.0000	0.0000
1876	0.2458	0.0000	0.0000	0.0000	0.0000
1877	0.2353	0.0000	0.0000	0.0000	0.0000
1878	0.2445	0.0000	0.0000	0.0000	0.0000
1879	0.2482	0.0000	0.0000	0.0000	0.0000
1880	0.2850	0.0000	0.0000	0.0000	0.0000
1881	0.3095	0.0000	0.0000	0.0000	0.0000
1882	0.3161	0.0000	0.0000	0.0000	0.0000
1883	0.3066	0.0000	0.0000	0.0000	0.0000

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DATE	(1)	(2)	(3)	(4)	(5)
1884	0.2787	0.0000	0.0000	0.0000	0.0000
1885	0.2668	0.0000	0.0000	0.0000	0.0000
1886	0.2731	0.0000	0.0000	0.0000	0.0000
1887	0.2901	0.0000	0.0000	0.0000	0.0000
1888	0.2854	0.0000	0.0000	0.0000	0.0000
1889	0.2535	0.0000	0.0000	0.0000	0.0000
1890	0.2569	0.0000	0.0000	0.0000	0.0000
1891	0.2368	0.0000	0.0000	0.0000	0.0000
1892	0.2315	0.0000	0.0000	0.0000	0.0000
1893	0.2281	0.0000	0.0000	0.0000	0.0000
1894	0.2122	0.0000	0.0000	0.0000	0.0000
1895	0.2030	0.0000	0.0000	0.0000	0.0000
1896	0.2015	0.0000	0.0000	0.0000	0.0000
1897	0.1980	0.0000	0.0000	0.0000	0.0000
1898	0.2032	0.0000	0.0000	0.0000	0.0000
1899	0.2391	0.0000	0.0000	0.0000	0.0000
1900	0.2387	0.0000	0.0000	0.0000	0.0000
1901	0.2289	0.0000	0.0000	0.0000	0.0000
1902	0.2380	0.0000	0.0000	0.0000	0.0000
1903	0.2414	0.0000	0.0000	0.0000	0.0000
1904	0.2166	0.0000	0.0000	0.0000	0.0000
1905	0.2256	0.0000	0.0000	0.0000	0.0000
1906	0.2481	0.0000	0.0000	0.0000	0.0000
1907	0.2565	0.0000	0.0000	0.0000	0.0000
1908	0.2278	0.0000	0.0000	0.0000	0.0000
1909	0.2310	0.0000	0.0000	0.0000	0.0000
1910	0.2347	0.0000	0.0000	0.0000	0.0000
1911	0.2256	0.0000	0.0000	0.0000	0.0000
1912	0.2281	0.0000	0.0000	0.0000	0.0000
1913	0.2224	0.0000	0.0000	0.0000	0.0000
1914	0.2078	0.0000	0.0000	0.0000	0.0000
1915	0.2205	0.0000	0.0000	0.0000	0.0000
1916	0.2851	0.0000	0.0000	0.0000	0.0000
1917	0.3420	0.0000	0.0000	0.0000	0.0000
1918	0.3563	0.0000	0.0000	0.0000	0.0000

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)
1919	0.3727	0.3134	0.2426	0.2954	0.2690
1920	0.5006	0.3134	0.3473	0.3357	0.3402
1921	0.3420	0.3182	0.3346	0.3614	0.2938
1922	0.3642	0.3134	0.3346	0.3633	0.2938
1923	0.4106	0.3375	0.3150	0.3761	0.3071
1924	0.4002	0.3432	0.3600	0.4174	0.3352
1925	0.3887	0.3471	0.3776	0.4192	0.3675
1926	0.3949	0.4406	0.4207	0.4376	0.3907
1927	0.3741	0.3645	0.4569	0.4440	0.3865
1928	0.3654	0.3876	0.3855	0.4192	0.3543
1929	0.3783	0.4194	0.3982	0.4220	0.3609
1930	0.3557	0.6509	0.4452	0.4100	0.3650
1931	0.3061	0.5130	0.4305	0.3633	0.3518
1932	0.2581	0.3683	0.3639	0.3238	0.3410
1933	0.2579	0.4879	0.3072	0.2917	0.3071
1934	0.2965	0.4840	0.3659	0.3302	0.3493
1935	0.2970	0.4050	0.3199	0.3027	0.3526
1936	0.3221	0.3645	0.3013	0.3073	0.3021
1937	0.3420	0.3818	0.3297	0.3284	0.3418
1938	0.3169	0.3567	0.3542	0.3504	0.3269
1939	0.3159	0.3085	0.3502	0.3412	0.3418
1940	0.3302	0.3432	0.3307	0.3247	0.3294
1941	0.3825	0.4628	0.3082	0.3321	0.3029
1942	0.4659	0.3741	0.2818	0.3440	0.2541
1943	0.5552	0.5564	0.3776	0.3688	0.2913
1944	0.6455	0.4030	0.4520	0.4036	0.3567
1945	0.5962	0.4676	0.3776	0.4311	0.4428
1946	0.5562	0.4050	0.4520	0.5183	0.4428
1947	0.7037	0.4995	0.5440	0.5596	0.4983
1948	0.7801	0.5593	0.6966	0.6651	0.5587
1949	0.7520	0.8293	0.7113	0.6926	0.5935
1950	0.7438	0.7714	0.6849	0.6917	0.6067
1951	0.8688	1.4030	0.8189	0.7752	0.6589
1952	0.8815	1.6972	0.8268	0.7770	0.7301
1953	0.8803	1.3982	0.8414	0.7981	0.7557

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DATE	(1)	(2)	(3)	(4)	(5)
1954	0.8558	0.8100	0.9148	0.8366	0.7350
1955	0.8604	1.2246	0.9373	0.8532	0.7557
1956	0.9456	0.9836	0.9686	0.8871	0.7963
1957	0.9640	0.9768	1.0078	0.9036	0.8071
1958	0.9160	0.9768	0.9902	0.9128	0.8278
1959	0.9111	0.9382	0.9295	0.9357	0.8377
1960	0.9164	0.9402	0.9990	0.9357	0.8692
1961	0.9061	0.9594	0.9735	0.9788	0.8857
1962	0.9329	0.9546	0.9735	0.9889	0.9180
1963	0.9575	0.9691	0.9686	0.9688	0.9693
1964	0.9758	0.9864	0.9872	0.9862	0.9867
1965	1.0000	1.0000	1.0000	1.0000	1.0000

Sources by column:

(1) 1865-1889. Implicit deflator for all structures, version 1, from U. S. Department of Commerce, Office of Business Economics [1966b], pp. 92-113, linked in 1890 to:

1890-1918. Table A-1, column 6 times $(1.0019)^t$ where t runs backwards beginning with t = 0 in 1965.

1919-1965. Equals (FPC-.15BPH)/.85, where FPC is Table A-8, column 1 (and is set equal to Table A-7, column 6 for 1919-21); BPH is from Table A-4, column 1, and the source of the weight of .15 is given in Table A-8, column 1.

(2) Lipsey and Preston [1966], Series A-18, pp. 17-18, divided by Series A-19, pp. 20-21. Resulting ratios were linked in 1925 and 1956 when Dodge coverage changed and converted then to 1965 = 1.00.

(3) Lipsey and Preston [1966], Series A-16, pp. 17-18, divided by Series A-17, pp. 20-21, same procedure as column 2.

(4) Lipsey and Preston [1966], Series A-20, pp. 17-18, divided by Series A-21, pp. 20-21, same procedure as column 2.

(5) Lipsey and Preston [1966], Series A-7, pp. 15-16, divided by Series A-8, pp. 20-21, same procedure as column 2.

APPENDIX B

SOURCES FOR NEW PRICE INDEX FOR BUILDING MATERIALS

TABLE B-1

SOURCES OF PRICE INDEXES BY CATEGORY, 1890-1961

Categories in this Study	Period	Index	Source	Source of Subclass Weights	Year to Which Weights Apply
1. Lumber and Wood	1890-1912	Oak, White, Quartered	BLS	BLS	1909
		Pine, Yellow, Siding	BLS	BLS	1909
	1913-1925	Lumber and Wood	BLS		
	1926-1962	Lumber and Wood	HS		
2. Paints, Glass	1890-1912	Lead, Carbonate of	BLS	BLS	1909
		Linseed Oil, Raw	BLS	BLS	1909
		Turpentine, Spirits of	BLS	BLS	1909
		Zinc, Oxide of	BLS	BLS	1909
	1913-1947	Paints & Paint Materials	BLS		
	1947-1958	Prepared Paint	BLS	BLS	1958
		Paint Materials	BLS	BLS	1958
	1958-1961	Paint Materials	BLS		
	1890-1912	Glass, Plate, Polished	BLS	BLS	1909
		Glass, Window, American	BLS	BLS	1909
	1913-1947	Window Glass (Type A)	BLS		
	1947-1958	Flat Glass	BLS		
	1958-1961	Window Glass	BLS		
		(Glass and paint combined)		SCB	1958
3. Petroleum	1890-1912	Petroleum, Crude	BLS	BLS	1909
		Petroleum, Refined, 150	BLS	BLS	1909
	1913-1958	Petroleum Products	BLS		
	1958-1961	Crude Petroleum	BLS		

4. Stone and Clay	1890-1912	Brick, Common, Red	BLS	BLS	1909
		Cement, Portland*	BLS	BLS	1909
	1913-1925	Brick	BLS	Census	1929
		Cement	BLS	Census	1929
	1926-1961	Nonmetallic Structural	HS		
5. Iron and Steel	1890-1912	Steel Billits, Bessemer	BLS		
	1913-1947	Structural Steel	BLS	Census	1929
		Reinforcing Steel	BLS	Census	1929
	1947-1958	Steel Mill Products	BLS		
	1958-1961	Finished Steel Products	BLS		
6. Nonferrous Metals	1890-1912	Copper Sheet, Hot Rolled	BLS	BLS	1909
		Lead Pipe	BLS	BLS	1909
	1913-1962	Nonferrous Metals	BLS		
7. Heating, plumbing	1890-1912	See Category 8 below			
	1913-1929	See Category 8 below			
	1929-1947	Plumbing and Heating	BLS		
	1947-1958	Plumbing	BLS	BLS	1958
		Heating	BLS	BLS	1958
	1958-1961	Finished Steel Products	BLS		
8. Other Fabricated Metal Products	1890-1912	Files, 8 inch mill	BLS	BLS	1909
		Hammers, Maydole	BLS	BLS	1909
		Locks, Common Mortise	BLS	BLS	1909
		Planes, Jack	BLS	BLS	1909
		Vises, Solid Box	BLS	BLS	1909
	1913-1929	Metal and Metal Products	BLS		
	1929-1947	Other Metal Products	BLS		
	1947-1958	Hardware	BLS		
	1958-1961	Finished Steel Products	BLS		
9. Electrical Machinery	1890-1962	Implicit Price Deflator for Electrical Mach.	OBE		

10. General Industrial Machinery	1890-1961	Implicit Price Deflator for General Industrial Machinery	OBE

Sources:

Census — U. S. Department of Commerce, Bureau of the Census [1933], Table XIII, p. 27.

SCB — Frumkin [1965], Table 2, p. 16.

BLS — Bureau of Labor Statistics, Wholesale Prices and Price Indexes, BLS Bulletins, various issues, of which the most important are:

1890-1912	1913 = 100	Bulletin	(1922)
1913-1928	1926 = 100	Bulletin 521	(1930)
1929-1947	1926 = 100	Bulletin 947	(1949)
1947-1958	1947-49 = 100	Bulletin 1257	(1959)

HS — Statistical History [1965].

OBE — U. S. Department of Commerce, Office of Business Economics [1966b].

Note:

*For 1890-1894 cement was not available and common lime was used instead, linked to cement in 1895.

TABLE B-2

SOURCES OF WEIGHTS FOR
MATERIALS PRICE INDEX, BY CATEGORY,
1929, 1947, and 1958

Classes in This Study	Classes in 1930 Census	Classes in 1958 Input-Output Study
1. Lumber and Wood	Lumber, rough and finished Millwork	20. Lumber and Wood
2. Paints, glass	Paints, varnishes, glass	30. Paints and allied 35. Glass
3. Petroleum	Bituminous paving, tar, asphalt, oil	31. Petroleum refining
4. Stone and clay	Sand, gravel, crushed stone, slag Brick Cut sone, granite, and marble Cement Plaster Pipe: tile, concrete	9. Stone and clay mining 36. Stone and clay products
5. Iron and Steel	Structural Steel Reinforced steel Pipe: cast iron, steel	37. Primary iron and steel
6. Nonferrous metals	(Not available--assumed the same proportion of iron and steel as in 1947)	38. Primary nonferrous metals
7. Heating, plumbing	Heating and ventilating Plumbing and gas-fitting	40. Heating, plumbing, and structural metal products

8. Other Fabricated Metal	Metal doors, windows, and trim Hardware Metal products, n.e.s.	41. Stampings, etc. 42. Other fabricated metal products
9. Electrical	Electrical appliances and supplies	53. Electrical industrial equipment 54. Household appliances 55. Electric lighting and wiring equipment
10. Other machinery	Elevators, dumb-waiters, and equipment Machinery	45. Construction, etc., machinery 46. Materials handling machinery 47. General industrial machinery 50. Machine Shop products 52. Service industry machinery

Sources:

1929. U. S. Department of Commerce, Bureau of the Census [1933] Table XIII, p. 27.

1947, 1958 Frumkin [1965], Tables 2 and 4, pp. 16, 20.

Notes: There is no miscellaneous category to avoid possible heterogeneity. Thus a number of products are not included in this distribution.

APPENDIX C

REAL INVESTMENT EXPENDITURES

TABLE C-1

PRIVATE EXPENDITURES ØN
STRUCTURES AND EQUIPMENT BY SECTØR,
UNREVISED DATA USED IN
Ø.B.E. 1966 CAPITAL GØØDS STUDY
(MILLIØNS ØF 1958 DØLLARS)

CØLUMN

(1) MANUFACTURING EQUIPMENT

(2) MANUFACTURING STRUCTURES

(3) NØNFARM NØNMANUFACTURING EQUIPMENT

(4) NØNFARM NØNMANUFACTURING STRUCTURES

(5) FARM EQUIPMENT

(6) FARM STRUCTURES

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1865	0	84	21	226	0	211
1866	0	123	32	364	0	205
1867	20	152	172	614	0	232
1868	23	206	180	651	0	242
1869	36	259	292	1010	0	265
1870	56	392	493	1604	0	326
1871	54	309	480	1518	0	380
1872	68	295	607	1841	0	361
1873	61	374	501	1550	0	476
1874	43	314	357	1062	0	664
1875	29	176	256	670	0	858
1876	107	184	315	744	0	829
1877	125	199	354	837	0	812
1878	166	206	452	1109	0	730
1879	189	215	524	974	0	551
1880	217	199	600	1372	0	433

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1881	378	451	1053	2857	124	355
1882	396	515	1154	2922	129	305
1883	321	518	940	2289	107	271
1884	303	579	885	2067	96	282
1885	250	494	744	1636	81	282
1886	283	460	740	1659	75	285
1887	447	547	1174	3075	116	326
1888	586	564	1269	2997	124	344
1889	635	953	1364	2829	126	392
1890	665	1337	1512	3495	134	613
1891	752	1442	1713	3340	135	645
1892	796	1473	1793	3401	128	626
1893	759	1464	1834	3536	126	624
1894	608	1417	1365	3164	109	577
1895	872	1643	1793	3026	120	585
1896	1057	2110	2173	3800	110	552
1897	603	2072	1687	4271	133	588
1898	702	1438	1762	3930	203	601
1899	897	1346	2288	4162	215	571
1900	1142	1266	2730	4598	208	570
1901	1104	1545	2864	4694	229	589
1902	1241	2284	3204	5947	319	591
1903	1451	2200	3740	6424	331	552
1904	1110	1594	3085	5887	261	558
1905	1362	1591	3710	5420	270	518
1906	1705	1930	4629	5774	340	499
1907	1678	2045	4949	6246	340	472
1908	1149	2040	2949	5715	290	485
1909	1349	2376	3181	6211	340	502
1910	1544	2506	3825	7431	359	494
1911	1302	2636	3337	7012	360	471
1912	1534	3083	4433	7063	507	509
1913	1685	2920	5091	6785	560	499
1914	1310	2097	3579	5287	566	505
1915	1312	1746	3181	4157	704	472

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1916	1991	1976	4739	5113	831	588
1917	2435	2013	5691	4513	1010	723
1918	2359	1940	5889	3308	950	656
1919	2082	2264	4948	3576	1184	762
1920	2330	3106	5603	4370	1151	551
1921	1464	2469	4203	4284	572	316
1922	1813	2355	5167	5701	714	370
1923	2425	2471	7351	6756	1101	414
1924	2123	2083	6659	7507	991	386
1925	2485	2337	7069	8513	1156	392
1926	2671	3303	7858	9249	1271	369
1927	2439	3218	6802	9581	1203	451
1928	2592	3702	7050	8912	1333	412
1929	2816	4443	8291	9092	1462	373
1930	2144	2701	6522	8898	1246	207
1931	1228	1261	4219	6156	784	116
1932	943	451	2404	3899	461	65
1933	1017	1146	2841	2104	401	87
1934	1242	1090	3509	2442	805	104
1935	1678	889	4755	2929	1074	210
1936	2300	1438	6559	3750	1465	253
1937	2614	2137	7568	4663	1568	294
1938	1796	1122	5101	4221	1164	252
1939	2114	1375	6031	4232	1273	286
1940	2766	1992	7998	4542	1360	221
1941	3121	2932	9149	4834	1923	286
1942	2202	1097	4554	3204	1143	262
1943	2107	413	4225	2138	845	318
1944	2617	594	5459	2879	1555	312
1945	3813	1910	8564	3494	1714	287
1946	5424	5517	10633	5849	1682	1089
1947	7276	3973	14448	6632	2882	1036
1948	6940	3274	15139	8067	3604	983
1949	5432	2494	13349	8489	3793	926
1950	5522	2169	15521	9615	3763	911

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1951	6847	3162	15112	10026	3558	880
1952	6854	3016	14732	9808	3011	877
1953	6922	3002	15476	11054	3364	838
1954	7190	2916	14349	11464	2918	809
1955	6994	3154	17733	12342	2970	747
1956	8592	3717	17743	13965	2508	792
1957	8582	3882	17952	13610	2580	749
1958	6424	3281	15610	12567	2994	737
1959	6290	2431	18681	13097	2907	698
1960	7143	2777	20041	13988	2445	673
1961	6887	2686	18483	14056	2699	663
1962	7518	2623	21356	14648	2849	657
1963	8214	2677	22508	14725	3126	634
1964	9935	2793	25013	15444	3321	623
1965	11312	3138	28333	16254	3506	608

Sources by Column:

(1)(3) (5) U. S. Department of Commerce, Office of Business Economics [1966b], pp. 60-81.

Notes:

1865-1889. These totals include only certain long-lived types of equipment and should not be used for purposes in which a figure for all equipment is desired.

1890-1901. The OBE figures for these years omit Office and Store Machines and Miscellaneous. Estimates of these categories have been added in by assuming that they were the same proportion of total 1890-1901 expenditures as they were in 1902.

(2)(4) (6) U. S. Department of Commerce, Office of Business Economics [1966b], pp. 110-120.

TABLE C-2

PRIVATE EXPENDITURES ØN
STRUCTURES AND EQUIPMENT BY SECTØR,
AFTER ADJUSTMENT FØR REVISIØNS
MADE IN CHAPTERS TWØ AND FØUR
(MILLIØNS ØF 1958 DØLLARS)

CØLUMN

(1) MANUFACTURING EQUIPMENT

(2) MANUFACTURING STRUCTURES

(3) NØNFARM NØNMANUFACTURING EQUIPMENT

(4) NØNFARM NØNMANUFACTURING STRUCTURES

(5) FARM EQUIPMENT

(6) FARM STRUCTURES

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1865	0	38	21	167	0	133
1866	0	48	32	271	0	132
1867	20	59	172	446	0	140
1868	23	81	180	483	0	151
1869	24	98	305	738	0	159
1870	39	139	511	1256	0	192
1871	37	113	499	1181	0	216
1872	46	103	632	1382	0	217
1873	42	139	522	1248	0	254
1874	29	128	371	949	0	314
1875	19	81	268	666	0	396
1876	74	81	349	715	0	383
1877	87	85	388	778	0	377
1878	115	82	500	959	0	340
1879	102	81	606	778	0	313
1880	115	70	699	1060	0	234

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1881	203	156	1225	2163	124	183
1882	210	185	1337	2213	129	165
1883	173	191	1080	1780	107	149
1884	160	210	1024	1659	96	154
1885	132	18[illegible]	855	1314	81	161
1886	151	184	863	1308	75	164
1887	237	202	1378	2323	116	170
1888	327	205	1520	2272	124	186
1889	340	390	1645	2265	126	242
1890	553	524	1628	2870	134	385
1891	627	603	1837	2533	135	429
1892	651	621	1938	2504	128	407
1893	600	626	1995	2586	126	409
1894	426	634	1555	2300	109	392
1895	688	780	1970	2229	120	415
1896	850	995	2363	2827	110	390
1897	427	962	1903	3196	133	420
1898	517	662	1957	2952	203	432
1899	768	570	2425	3091	215	367
1900	963	571	2919	3603	208	387
1901	882	724	3078	3773	229	408
1902	1009	1100	3421	4730	319	404
1903	1328	1085	3852	5270	331	387
1904	933	896	3252	5362	261	427
1905	1216	905	3846	5002	270	393
1906	1453	1055	4859	5198	340	376
1907	1423	1078	5186	5553	340	360
1908	859	1170	3205	5376	290	394
1909	1135	1308	3377	5892	340	408
1910	1348	1303	4005	7247	359	425
1911	1031	1551	3597	6951	360	426
1912	1392	1835	4564	7035	507	453
1913	1536	1750	5224	7133	560	465
1914	1248	1353	3636	5801	566	498
1915	1406	1121	3092	4233	704	432

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DATE	(1)	(2)	(3)	(4)	(5)	(6)
1916	2200	1169	4551	4568	831	472
1917	2779	1205	5385	4210	1010	591
1918	2460	1272	5642	3462	881	629
1919	1835	1671	4946	3915	1078	835
1920	2178	2177	5413	4214	1076	477
1921	1143	1888	4185	5166	561	297
1922	1719	1607	4944	5933	665	334
1923	2253	1675	6907	6672	989	343
1924	1853	1441	6454	7418	916	331
1925	2325	1666	6594	8646	1056	351
1926	2480	2307	7240	9572	1170	324
1927	2274	2338	6407	10024	1147	418
1928	2477	2757	6560	9721	1246	381
1929	2795	3171	7533	9942	1312	341
1930	2031	1892	6353	9286	1193	187
1931	1064	891	4377	6463	772	104
1932	725	330	2669	4166	487	60
1933	937	838	3067	2745	420	74
1934	1140	797	3686	2706	836	95
1935	1693	650	4834	3266	1066	197
1936	2375	1032	6449	3876	1458	218
1937	2699	1807	7331	5187	1548	246
1938	1548	907	5396	4806	1170	228
1939	2114	1232	6021	4964	1268	243
1940	2755	1808	7780	5226	1430	166
1941	3091	2533	8707	5108	1933	210
1942	2202	892	4250	2929	1428	196
1943	2107	303	4039	1745	1025	237
1944	2617	367	5248	2127	1749	225
1945	3813	1355	8531	3011	1743	236
1946	5402	4971	10409	6447	1678	1110
1947	7237	3428	14058	6370	2877	1002
1948	6916	2838	14891	7714	3612	939
1949	5317	2223	12262	8340	3636	912
1950	5417	1983	14407	9289	3504	922

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1951	6787	2758	14596	8863	3514	845
1952	6836	2691	14309	8707	3089	907
1953	6874	2708	14919	10285	3294	818
1954	7190	2653	14266	11311	2998	790
1955	6994	2868	17642	12159	3057	745
1956	8592	3361	17697	13261	2553	755
1957	8582	3694	17944	13434	2587	725
1958	6424	3281	15506	14083	3098	737
1959	6290	2490	18581	14672	3004	744
1960	7143	2821	19994	15404	2490	714
1961	6887	2786	18483	16117	2699	718
1962	7518	2681	21356	16477	2849	683
1963	8214	2836	22501	16477	3132	647
1964	9935	3353	25001	17110	3332	622
1965	11312	4659	28187	18878	3640	600

<u>Sources by Column</u>:

(1)(3) (5) Table C-1, columns 1, 3, and 5, plus Table 6, p. 96a, columns 2, 5, and 9, the latter deflated by the OBE implicit deflator for equipment.

(2)(4) (6) Data in historical dollars from U. S. Department of Commerce, Office of Business Economics [1966b], pp. 92-102, plus Table 7, p. 96b, columns 2 and 5, all deflated by Table A-9, column 1.

TABLE C-3

REVISED PRIVATE EXPENDITURES ØN STRUCTURES AND EQUIPMENT BY SECTØR PLUS NET ADDITIØNS ØF GØVERNMENT-FINANCED CAPITAL IN PRIVATE ØPERATIØN (MILLIØNS ØF 1958 DØLLARS)

CØLUMN

(1) MANUFACTURING EQUIPMENT

(2) MANUFACTURING STRUCTURES

(3) NØNFARM NØNMANUFACTURING EQUIPMENT

(4) NØNFARM NØNMANUFACTURING STRUCTURES

(5) FARM EQUIPMENT

(6) FARM STRUCTURES

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1865	0	38	21	167	0	133
1866	0	48	32	271	0	132
1867	20	59	172	446	0	140
1868	23	81	180	483	0	151
1869	24	98	305	738	0	159
1870	39	139	511	1256	0	192
1871	37	113	499	1181	0	216
1872	46	103	632	1382	0	217
1873	42	139	522	1248	0	254
1874	29	128	371	949	0	314
1875	19	81	268	666	0	396
1876	74	81	349	715	0	383
1877	87	85	388	778	0	377
1878	115	82	500	959	0	340
1879	102	81	606	778	0	313
1880	115	70	699	1060	0	234

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DATE	(1)	(2)	(3)	(4)	(5)	(6)
1881	203	156	1225	2163	124	183
1882	210	185	1337	2213	129	165
1883	173	191	1080	1780	107	149
1884	160	210	1024	1659	96	154
1885	132	188	855	1314	81	161
1886	151	184	863	1308	75	164
1887	237	202	1378	2323	116	170
1888	327	205	1520	2272	124	186
1889	340	390	1645	2265	126	242
1890	553	524	1628	2870	134	385
1891	627	603	1837	2533	135	429
1892	651	621	1938	2504	128	407
1893	600	626	1995	2586	126	409
1894	426	634	1555	2300	109	392
1895	688	780	1970	2229	120	415
1896	850	995	2363	2827	110	390
1897	427	962	1903	3196	133	420
1898	517	662	1957	2952	203	432
1899	768	570	2425	3091	215	367
1900	963	571	2919	3603	208	387
1901	882	724	3078	3773	229	408
1902	1009	1100	3421	4730	319	404
1903	1328	1085	3852	5270	331	387
1904	933	896	3252	5362	261	427
1905	1216	905	3846	5002	270	393
1906	1453	1055	4859	5198	340	376
1907	1423	1078	5186	5553	340	360
1908	859	1170	3205	5376	290	394
1909	1135	1308	3377	5892	340	408
1910	1348	1303	4005	7247	359	425
1911	1031	1551	3597	6951	360	426
1912	1392	1835	4564	7035	507	453
1913	1536	1750	5224	7133	560	465
1914	1248	1353	3636	5801	566	498
1915	1406	1121	3092	4233	704	432

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1916	2200	1169	4551	4568	831	472
1917	3317	1336	5385	4210	1010	591
1918	2884	1398	5642	3462	881	629
1919	1835	1671	4946	3915	1078	835
1920	2178	2177	5413	4214	1076	477
1921	1143	1888	4185	5166	561	297
1922	1719	1607	4944	5933	665	334
1923	2253	1675	6907	6672	989	343
1924	1853	1441	6454	7418	916	331
1925	2325	1666	6594	8646	1056	351
1926	2480	2307	7240	9572	1170	324
1927	2274	2338	6407	10024	1147	418
1928	2477	2757	6560	9721	1246	381
1929	2795	3171	7533	9942	1312	341
1930	2031	1892	6353	9286	1193	187
1931	1064	891	4377	6463	772	104
1932	725	330	2669	4166	487	60
1933	937	838	3067	2745	420	74
1934	1140	797	3686	2706	836	95
1935	1693	650	4834	3266	1066	197
1936	2375	1032	6449	3876	1458	218
1937	2699	1807	7331	5187	1548	246
1938	1548	907	5396	4806	1170	228
1939	2114	1232	6021	4964	1268	243
1940	2969	2108	7780	5226	1430	166
1941	4654	5222	8707	5108	1933	210
1942	7201	6804	4252	2931	1428	196
1943	6754	3002	4073	1770	1025	237
1944	4767	1877	5343	2183	1749	225
1945	5086	2192	8856	3051	1759	236
1946	4915	3899	11449	6470	1764	1110
1947	6705	2914	14784	6384	2952	1002
1948	6759	2614	15150	7740	3628	939
1949	5369	2121	12283	8369	3639	912
1950	5553	1949	14469	9323	3504	922

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1951	7265	2776	14659	8895	3514	845
1952	8291	2888	14421	8775	3089	907
1953	8578	3091	15020	10348	3294	818
1954	8544	3276	14327	11345	2998	790
1955	7927	3222	17699	12195	3057	745
1956	9034	3526	17714	13264	2553	755
1957	8875	3751	17973	13445	2587	725
1958	6726	3321	15595	14125	3098	737
1959	6423	2490	18671	14740	3004	744
1960	7299	2821	20090	15459	2490	714
1961	7067	2786	18617	16190	2699	718
1962	8040	2681	21475	16563	2849	683
1963	8550	2836	22641	16582	3132	647
1964	9941	3353	25175	17251	3332	622
1965	11333	4659	28323	18977	3640	600

Sources by Column:

(All figures from Tables 25 and 26 were deflated by Table A-9, column 1, and were reduced to take account of private purchases of capital goods from the government already included by Wasson in the OBE investment estimates for 1946-49 and 1955.)

(1) Table C-2, column 1, plus deflated value of Table 25, p. 168, columns 1 through 4.

(2) Table C-2, column 2, plus deflated value of Table 26, p. 171, columns 1 through 3.

(3) Table C-2, column 3, plus deflated value of Table 25, p. 168, columns 6 through 8,

(4) Table C-2, column 4, plus deflated value of Table 26, p. 171, column 5.

(5) Table C-2, column 5, plus deflated value of Table 25, p. 168, column 10.

(6) Table C-2, column 6.

APPENDIX D

REAL CAPITAL STOCKS

TABLE D-1

CØMPØNENTS ØF REVISIØNS IN GRØSS STØCK ØF MANUFACTURING EQUIPMENT (MILLIØNS ØF 1958 DØLLARS)

CØLUMN

(1) CØNSTRUCTED WITH UNREVISED Ø. B. E. DATA

(2) EFFECT ØF CHAPTER TWØ REVISIØNS

(3) EFFECT ØF CHAPTER THREE REVISIØNS

(4) AFTER ADJUSTMENT FØR ALL REVISIØNS

DATE	(1)	(2)	(3)	(4)
1910	19574	-3340	0	16233
1911	20268	-3430	0	16837
1912	20930	-3387	0	17542
1913	21558	-3329	0	18228
1914	22265	-3215	0	19049
1915	22875	-2937	0	19937
1916	23969	-2599	0	21369
1917	25262	-2076	537	23723
1918	26517	-1753	962	25725
1919	27358	-1768	962	26551
1920	28237	-1797	962	27401
1921	28591	-1940	962	27612
1922	29042	-1888	962	28115
1923	29762	-1808	962	28915
1924	30207	-1823	962	29345
1925	31543	-1693	962	30811
1926	32865	-1670	962	32156
1927	33760	-1638	962	33083
1928	35050	-1482	962	34530
1929	36332	-1361	962	35932
1930	36791	-1326	962	36426
1931	36709	-1427	962	36243

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)
1932	36340	-1739	962	35562
1933	35366	-2028	962	34299
1934	34173	-2475	424	32121
1935	33492	-2561	0	30930
1936	33710	-2238	0	31471
1937	33994	-2001	0	31992
1938	34326	-1928	0	32397
1939	34627	-1835	0	32791
1940	34968	-1675	214	33507
1941	35966	-1435	1778	36308
1942	35683	-1275	6778	41185
1943	35119	-1085	11425	45458
1944	35297	-921	13575	47951
1945	36518	-806	14848	50560
1946	39126	-807	8557	46875
1947	44258	-733	7931	51455
1948	49970	-593	7687	57063
1949	54459	-489	7656	61625
1950	58964	-514	7748	66197
1951	64569	-472	8126	72222
1952	69745	-505	9407	78646
1953	74367	-629	10942	84680
1954	78943	-714	11854	90083
1955	84141	-467	12365	96039
1956	90619	-467	12687	102839
1957	96435	-456	12766	108744
1958	99738	-426	12213	111524
1959	103826	-426	9760	113159
1960	108862	-426	7627	116062
1961	113132	-426	6839	119544
1962	116837	-426	6793	123203
1963	119627	-405	7558	126780
1964	122286	-366	8148	130068
1965	126658	-343	8314	134629

(Continued on next page)

TABLE D-1 (con'd)

Each annual entry is the sum of elements in an investment stream for the current year and the previous 16 years, where the sources of the investment data are:

(1) Table C-1, column 1.

(2) Table 6, p. 96a, column 2, deflated by OBE implicit deflator.

(3) Table 25, p. 168, columns 1 through 5. Columns 3 through 5 include estimates of retirements and thus were not dropped from the capital stock after 17 years.

(4) The sum of columns 1 through 3.

TABLE D-2

COMPONENTS OF REVISIONS IN GROSS STOCK
OF MANUFACTURING STRUCTURES
(MILLIONS OF 1958 DOLLARS)

COLUMN

(1) CONSTRUCTED WITH UNREVISED O. B. E. DATA

(2) EFFECT OF CHAPTER TWO REVISIONS

(3) EFFECT OF CHAPTER THREE REVISIONS

(4) EFFECT OF CHAPTER FOUR REVISIONS

(5) AFTER ADJUSTMENT FOR ALL REVISIONS

DATE	(1)	(2)	(3)	(4)	(5)
1910	44671	-2881	80	-20723	21145
1911	46998	-3068	80	-21426	22582
1912	49786	-3387	80	-22164	24314
1913	52332	-3665	80	-22820	25925
1914	54115	-3823	80	-23220	27150
1915	55685	-3957	80	-23616	28190
1916	57477	-4081	80	-24197	29278
1917	59291	-4238	80	-24734	30398
1918	61025	-4404	80	-25112	31588
1919	63074	-4624	80	-25351	33178
1920	65981	-4909	80	-25866	35285
1921	67999	-5151	80	-25911	37016
1922	69839	-5338	78	-26141	38436
1923	71792	-5535	76	-26414	39918
1924	73296	-5695	74	-26526	41147
1925	75139	-5878	72	-26708	42623
1926	77982	-6161	70	-27145	44744
1927	80653	-6436	68	-27405	46879
1928	83791	-6766	66	-27661	49429
1929	87281	-7127	64	-28008	52208

(CONTINUED ON NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)
1930	88645	-7304	62	-27827	53575
1931	88464	-7345	60	-27316	53861
1932	87442	-7319	58	-26611	53568
1933	87124	-7352	56	-26049	53778
1934	86797	-7381	54	-25530	53938
1935	86043	-7377	52	-24910	53807
1936	85371	-7385	50	-24193	53841
1937	85436	-7290	48	-23507	54685
1938	85120	-7335	46	-22902	54928
1939	85149	-7258	44	-22346	55587
1940	85875	-7181	374	-21912	57155
1941	87262	-7061	3311	-21610	61901
1942	86075	-6915	9748	-20777	68130
1943	84288	-6771	12945	-19916	70546
1944	83288	-6652	14996	-19563	72068
1945	83607	-6531	16033	-19554	73554
1946	87194	-6390	13878	-19366	75315
1947	89122	-6244	13290	-19090	77077
1948	90356	-6079	13030	-18821	78485
1949	90474	-5904	12913	-18199	79283
1950	90137	-5690	12873	-17396	79923
1951	90663	-5487	12891	-16918	81148
1952	90596	-5153	13112	-16328	82225
1953	90678	-4857	13536	-15749	83607
1954	91497	-4681	14222	-15444	85593
1955	92905	-4535	14610	-15251	87728
1956	94646	-4400	14790	-14935	90100
1957	96515	-4232	14851	-14484	92650
1958	97856	-4054	14892	-13993	94699
1959	98023	-3823	14890	-13572	95516
1960	97694	-3529	14888	-12894	96158
1961	97911	-3266	14886	-12475	97054
1962	98179	-3052	14886	-11883	98129
1963	98385	-2729	14886	-11251	99290
1964	99095	-2068	14886	-10710	101201

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)
1965	99896	-450	14886	-10136	104194

<u>Sources by column</u>:

Each annual entry is the sum of elements in an investment stream for the current year and the previous 39 years, where the sources of the investment data are:

(1) Table C-1, column 2.

(2) Table 7, p. 96b, column 2, deflated by Table A-9, column 1.

(3) Table 26, p. 171, columns 1 through 4; columns 2 through 4 include estimates of retirements and thus were not dropped from the capital stock after 40 years in the perpetual inventory calculation.

(4) Data in historical dollars from U. S. Department of Commerce, OBE [1966b], pp. 92-102, deflated by Table A-9, column 1, minus Table C-1, column 2.

(5) The sum of columns 1 through 4.

TABLE D-3

COMPONENTS OF REVISIONS IN GROSS STOCK
OF NONMANUFACTURING EQUIPMENT
(MILLIONS OF 1958 DOLLARS)

COLUMN

(1) CONSTRUCTED WITH UNREVISED O. B. E. DATA

(2) EFFECT OF CHAPTER TWO REVISIONS

(3) EFFECT OF CHAPTER THREE REVISIONS

(4) AFTER ADJUSTMENT FOR ALL REVISIONS

DATE	(1)	(2)	(3)	(4)
1910	45995	2472	0	48467
1911	47701	2537	0	50238
1912	50034	2531	0	52565
1913	52624	2475	0	55099
1914	53644	2319	0	55963
1915	54055	2012	0	56067
1916	55545	1712	0	57257
1917	58821	1238	0	60059
1918	61660	787	0	62447
1919	62823	449	0	63272
1920	64269	-52	0	64216
1921	65735	-336	0	65398
1922	67928	-804	0	67123
1923	71995	-1539	0	70455
1924	75742	-2078	0	73663
1925	78830	-2783	0	76046
1926	82037	-3635	0	78401
1927	85453	-4142	0	81310
1928	89705	-4562	0	85142
1929	93535	-5176	0	88358
1930	94461	-5017	0	89443
1931	93003	-4613	0	88389

(CONTINUED ON NEXT PAGE)

DATE	(1)	(2)	(3)	(4)
1932	90206	-4270	0	85935
1933	86744	-3722	0	83021
1934	85864	-3421	0	82442
1935	85370	-3027	0	82342
1936	84772	-2599	0	82172
1937	86046	-2595	0	83450
1938	83909	-1732	0	82176
1939	81893	-980	0	80912
1940	83203	-679	0	82523
1941	86441	-609	0	85831
1942	83386	102	0	83491
1943	81533	246	36	81815
1944	83523	40	131	83695
1945	90323	-222	474	90575
1946	98332	-669	1585	99248
1947	110585	-1221	2373	111736
1948	123409	-1545	2635	124499
1949	132719	-2675	2647	132691
1950	143075	-3880	2696	141890
1951	154721	-4746	2739	152714
1952	165290	-5365	2831	162756
1953	175287	-5955	2917	172249
1954	181850	-5710	2964	179104
1955	196285	-5438	2993	193840
1956	210629	-5249	2910	208290
1957	222820	-5033	2849	220636
1958	229256	-5009	2645	226892
1959	236418	-4630	1699	233487
1960	240693	-3983	1061	237771
1961	243178	-3693	953	240438
1962	251023	-2684	1074	249413
1963	257772	-1502	1206	257476
1964	268076	-1067	1380	268388
1965	282213	-744	1515	282983

(Continued on next page)

Sources by column:

Each annual entry is the sum of elements in an investment stream for the current year and the previous 12 years in the case of nonfarm nonmanufacturing equipment and 9 years in the case of farm equipment, where the sources of the investment data are:

(1) Table C-1, column 3 and 5.

(2) Table 6, p. 96a, columns 5 and 9 deflated by appropriate OBE implicit deflators.

(3) Table 25, p. 168, columns 6 through 10. Columns 8 and 9 include estimates of retirements and thus were not dropped from the capital stock after 13 years.

(4) The sum of columns 1 through 3.

TABLE D-4

CØMPØNENTS ØF REVISIØNS IN GRØSS STØCK ØF NØNMANUFACTURING STRUCTURES (MILLIØNS ØF 1958 DØLLARS)

CØLUMN

(1) CØNSTRUCTED WITH UNREVISED Ø. B. E. DATA

(2) EFFECT ØF CHAPTER TWØ REVISIØNS

(3) EFFECT ØF CHAPTER THREE REVISIØNS

(4) EFFECT ØF CHAPTER FØUR REVISIØNS

(5) AFTER ADJUSTMENT FØR ALL REVISIØNS

DATE	(1)	(2)	(3)	(4)	(5)
1910	150527	15529	36	-45864	120228
1911	157135	16540	36	-46903	126807
1912	163731	17707	36	-48033	133440
1913	169936	18861	36	-48723	140109
1914	174354	19690	36	-48789	145290
1915	177683	20220	36	-48954	148984
1916	181632	20766	36	-49685	152748
1917	183650	21129	36	-49644	155170
1918	184216	21314	36	-48771	156794
1919	185601	21671	36	-47858	159450
1920	187597	22166	36	-47713	162086
1921	189732	22950	36	-46867	165851
1922	193332	23951	35	-46886	170432
1923	196697	24910	34	-46859	174782
1924	201042	25848	33	-46978	179945
1925	206685	27015	32	-47291	186441
1926	212453	28488	31	-47687	193284
1927	218840	29819	30	-47662	201027
1928	224492	31161	29	-47207	208475
1929	230139	32595	28	-46745	216016

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DATE	(1)	(2)	(3)	(4)	(5)
1930	235798	33453	27	-46250	223027
1931	238759	33573	26	-45156	227202
1932	238597	33283	25	-43476	228429
1933	236173	33151	24	-41482	227866
1934	234397	33153	23	-40101	227472
1935	232761	33117	22	-38441	227458
1936	231521	33222	21	-37244	227519
1937	231158	33402	20	-35808	228771
1938	229060	33237	19	-33650	228666
1939	226577	33214	18	-31599	228209
1940	224868	33314	17	-30375	227823
1941	224016	33432	16	-29715	227748
1942	221120	32963	17	-28844	225256
1943	216729	32225	45	-27718	221281
1944	213634	31509	121	-27298	217966
1945	210634	30883	170	-26704	214983
1946	209552	31216	195	-26053	214910
1947	209617	31168	210	-26052	214943
1948	211052	31060	239	-26148	216203
1949	213124	30963	271	-26431	217927
1950	217845	30838	308	-27011	221980
1951	224095	30925	343	-28249	227114
1952	229195	30731	418	-28469	231875
1953	236089	30807	486	-28938	238444
1954	244552	31171	523	-29534	246712
1955	253571	31148	562	-29967	255314
1956	263487	31122	564	-30480	264693
1957	273053	30942	576	-31327	273244
1958	280157	31296	621	-30364	281710
1959	286691	31266	692	-28621	290028
1960	293373	30928	749	-26696	298353
1961	298991	30486	824	-24155	306147
1962	304324	29591	916	-21596	313235
1963	309446	28860	1032	-19517	319822
1964	315839	27925	1183	-17799	327149

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)
1965	323058	27722	1291	-15754	336317

Sources by column:

(Each annual entry is the sum of elements in an investment stream for the current year and the previous 35 years for nonfarm nonmanufacturing structures and 44 years for farm structures, where the sources of the investment data are:

(1) Table C-1, columns 4 and 6.

(2) Table 7, p. 96b, column 5 deflated by Table A-9, column 1.

(3) Table 26, p. 171, column 5.

(4) Data in historical dollars from U. S. Department of Commerce, OBE [1966b], pp. 92-102, deflated by Table A-9, column 1; minus Table C-1, column 2.

(5) The sum of columns 1 through 4.

APPENDIX E

OUTPUT AND CAPITAL-OUTPUT RATIOS

TABLE E-1

GRØSS PRIVATE DØMESTIC ØUTPUT,
TØTAL ECØNØMY AND BY SECTØR
(MILLIØNS ØF 1958 DØLLARS)

CØLUMN

(1) MANUFACTURING

(2) NØNMANUFACTURING

(3) PRIVATE DØMESTIC ECØNØMY

DATE	(1)	(2)	(3)
1910	23220	81218	104439
1911	21984	85826	107811
1912	26412	86492	112904
1913	27699	89715	117415
1914	26309	81515	107825
1915	30840	79880	110720
1916	36658	90020	126678
1917	36349	85316	121666
1918	35937	90912	126849
1919	31406	100599	132005
1920	33980	99211	133192
1921	27545	102576	130121
1922	35062	102750	137812
1923	39592	117161	156754
1924	37790	123713	161504
1925	42167	123013	165180
1926	44381	131912	176293
1927	44844	132960	177804
1928	46389	133382	179771
1929	51486	139413	190899
1930	44072	126027	170099
1931	37070	118729	155799
1932	27699	103300	130999
1933	32333	95166	127499

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)
1934	35577	102722	138299
1935	42630	109769	152399
1936	49838	123261	173099
1937	53185	131114	184299
1938	41652	130947	172599
1939	52773	135926	188699
1940	61062	144537	205599
1941	81296	155303	236599
1942	101530	155769	257299
1943	122588	150211	272799
1944	119705	167194	286899
1945	101170	181329	282499
1946	82686	192413	275099
1947	91799	189600	281399
1948	96299	198700	294999
1949	90899	203200	294099
1950	105499	218700	324199
1951	116199	228400	344599
1952	118699	234500	353199
1953	128599	242500	371099
1954	119499	246700	366199
1955	133599	263600	397199
1956	134099	270700	404799
1957	134599	275900	410499
1958	123699	281500	405199
1959	138899	294500	433399
1960	140899	303100	443999
1961	140399	311900	452299
1962	154599	328300	482899
1963	162399	340800	503199
1964	173599	357200	530799
1965	188700	374800	563500

(Continued on Next page)

Sources by column:

(1) 1910-1946. Kendrick [1961a], Table D-II, pp. 465-6, in index form (1929 = 100), linked in 1947 to values in 1958 dollars from:

1947-1965. Gottsegen [1967], Table 2, p. 23.

(2) Column 3 minus column 1.

(3) 1910-1928. Kendrick [1961a], Table A-XXII, pp. 334-35, in index form (1929 = 100), linked in 1929 to values in 1958 dollars from

1929-1965. *Economic Report of the President* [1967], Table B-8, p. 223, column 2.

TABLE E-2

REVISED AND UNREVISED CAPITAL-ØUTPUT RATIØS IN MANUFACTURING (1958 PRICES)

CØLUMN

(1) UNREVISED STRUCTURES AND EQUIPMENT

(2) REVISED STRUCTURES AND EQUIPMENT

(3) UNREVISED EQUIPMENT

(4) REVISED EQUIPMENT

(5) UNREVISED STRUCTURES

(6) REVISED STRUCTURES

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1910	2.7667	1.6097	0.8429	0.6990	1.9237	0.9106
1911	3.0596	1.7931	0.9219	0.7658	2.1377	1.0272
1912	2.6773	1.5847	0.7924	0.6641	1.8849	0.9205
1913	2.6675	1.5940	0.7782	0.6580	1.8892	0.9359
1914	2.9031	1.7560	0.8462	0.7240	2.0568	1.0319
1915	2.5473	1.5605	0.7417	0.6464	1.8055	0.9140
1916	2.2217	1.3816	0.6538	0.5829	1.5679	0.7986
1917	2.3261	1.4889	0.6949	0.6526	1.6311	0.8362
1918	2.4359	1.5948	0.7378	0.7158	1.6980	0.8789
1919	2.8793	1.9018	0.8710	0.8454	2.0083	1.0564
1920	2.7726	1.8447	0.8309	0.8063	1.9417	1.0383
1921	3.5066	2.3462	1.0379	1.0024	2.4686	1.3438
1922	2.8201	1.8981	0.8283	0.8018	1.9918	1.0962
1923	2.5649	1.7385	0.7517	0.7303	1.8132	1.0082
1924	2.7388	1.8653	0.7993	0.7765	1.9395	1.0888
1925	2.5299	1.7415	0.7480	0.7307	1.7819	1.0108
1926	2.4976	1.7327	0.7405	0.7245	1.7570	1.0081
1927	2.5513	1.7831	0.7528	0.7377	1.7985	1.0453

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1928	2.5618	1.8098	0.7555	0.7443	1.8062	1.0655
1929	2.4008	1.7119	0.7056	0.6979	1.6952	1.0140
1930	2.8461	2.0421	0.8347	0.8265	2.0113	1.2156
1931	3.3766	2.4306	0.9902	0.9776	2.3863	1.4529
1932	4.4687	3.2177	1.3119	1.2838	3.1567	1.9339
1933	3.7883	2.7240	1.0937	1.0608	2.6945	1.6632
1934	3.4002	2.4190	0.9605	0.9028	2.4396	1.5161
1935	2.8039	1.9877	0.7856	0.7255	2.0183	1.2621
1936	2.3893	1.7117	0.6763	0.6314	1.7129	1.0803
1937	2.2455	1.6297	0.6391	0.6015	1.6063	1.0282
1938	2.8676	2.0965	0.8241	0.7777	2.0435	1.3187
1939	2.2696	1.6746	0.6561	0.6213	1.6134	1.0533
1940	1.9789	1.4847	0.5726	0.5487	1.4063	0.9360
1941	1.5157	1.2080	0.4424	0.4466	1.0733	0.7614
1942	1.1992	1.0766	0.3514	0.4056	0.8477	0.6710
1943	0.9740	0.9462	0.2864	0.3708	0.6875	0.5754
1944	0.9906	1.0026	0.2948	0.4005	0.6957	0.6020
1945	1.1873	1.2267	0.3609	0.4997	0.8263	0.7270
1946	1.5276	1.4777	0.4731	0.5669	1.0545	0.9108
1947	1.4529	1.4001	0.4821	0.5605	0.9708	0.8396
1948	1.4571	1.4075	0.5188	0.5925	0.9382	0.8150
1949	1.5944	1.5501	0.5991	0.6779	0.9953	0.8722
1950	1.4132	1.3850	0.5589	0.6274	0.8543	0.7575
1951	1.3359	1.3198	0.5556	0.6215	0.7802	0.6983
1952	1.3508	1.3552	0.5875	0.6625	0.7632	0.6927
1953	1.2833	1.3086	0.5782	0.6584	0.7051	0.6501
1954	1.4262	1.4701	0.6606	0.7538	0.7656	0.7162
1955	1.3251	1.3755	0.6297	0.7188	0.6953	0.6566
1956	1.3815	1.4387	0.6757	0.7668	0.7057	0.6718
1957	1.4335	1.4962	0.7164	0.8079	0.7170	0.6883
1958	1.5973	1.6671	0.8062	0.9015	0.7910	0.7655
1959	1.4531	1.5023	0.7474	0.8146	0.7057	0.6876
1960	1.4659	1.5061	0.7726	0.8237	0.6933	0.6824
1961	1.5031	1.5427	0.8057	0.8514	0.6973	0.6912
1962	1.3907	1.4316	0.7557	0.7969	0.6350	0.6347

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1963	1.3424	1.3920	0.7366	0.7806	0.6058	0.6113
1964	1.2752	1.3321	0.7044	0.7492	0.5708	0.5829
1965	1.2006	1.2656	0.6712	0.7134	0.5293	0.5521

Sources by column:

The following are divided by Table E-1, column 1:

(1) Table D-1, column 1 plus Table D-2, column 1.

(2) Table D-1, column 4, plus Table D-2, column 5.

(3) Table D-1, column 1.

(4) Table D-1, column 4.

(5) Table D-2, column 1.

(6) Table D-2, column 5.

TABLE E-3

REVISED AND UNREVISED
CAPITAL-ØUTPUT RATIØS IN NØNMANUFACTURING
(1958 PRICES)

ƆLUMN

1) UNREVISED STRUCTURES AND EQUIPMENT

2) REVISED STRUCTURES AND EQUIPMENT

3) UNREVISED EQUIPMENT

4) REVISED EQUIPMENT

5) UNREVISED STRUCTURES

6) REVISED STRUCTURES

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1910	2.4196	2.0770	0.5663	0.5967	1.8533	1.4803
1911	2.3866	2.0628	0.5557	0.5853	1.8308	1.4774
1912	2.4714	2.1505	0.5784	0.6077	1.8930	1.5428
1913	2.4807	2.1758	0.5865	0.6141	1.8941	1.5617
1914	2.7969	2.4689	0.6580	0.6865	2.1389	1.7823
1915	2.9010	2.5669	0.6767	0.7018	2.2243	1.8651
1916	2.6347	2.3328	0.6170	0.6360	2.0176	1.6968
1917	2.8420	2.5227	0.6894	0.7039	2.1525	1.8187
1918	2.7045	2.4115	0.6782	0.6868	2.0263	1.7246
1919	2.4694	2.2139	0.6244	0.6289	1.8449	1.5850
1920	2.5386	2.2810	0.6477	0.6472	1.8908	1.6337
1921	2.4904	2.2544	0.6408	0.6375	1.8496	1.6168
1922	2.5426	2.3119	0.6610	0.6532	1.8815	1.6587
1923	2.2933	2.0931	0.6144	0.6013	1.6788	1.4918
1924	2.2372	2.0499	0.6122	0.5954	1.6250	1.4545
1925	2.3210	2.1338	0.6408	0.6181	1.6801	1.5156
1926	2.2324	2.0595	0.6219	0.5943	1.6105	1.4652
1927	2.2885	2.1234	0.6426	0.6115	1.6459	1.5119

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1928	2.3556	2.2013	0.6725	0.6383	1.6830	1.5629
1929	2.3216	2.1832	0.6709	0.6337	1.6507	1.5494
1930	2.6205	2.4793	0.7495	0.7097	1.8710	1.7696
1931	2.7942	2.6580	0.7833	0.7444	2.0109	1.9136
1932	3.1829	3.0432	0.8732	0.8318	2.3097	2.2113
1933	3.3931	3.2667	0.9114	0.8723	2.4816	2.3943
1934	3.1177	3.0169	0.8358	0.8025	2.2818	2.2144
1935	2.8981	2.8222	0.7777	0.7501	2.1204	2.0721
1936	2.5660	2.5124	0.6877	0.6666	1.8782	1.8458
1937	2.4192	2.3812	0.6562	0.6364	1.7630	1.7448
1938	2.3900	2.3737	0.6407	0.6275	1.7492	1.7462
1939	2.2693	2.2741	0.6024	0.5952	1.6669	1.6789
1940	2.1314	2.1471	0.5756	0.5709	2.2818	1.5762
1941	1.9990	2.0191	0.5565	0.5526	1.5557	1.4664
1942	1.9548	1.9820	0.5353	0.5359	1.4424	1.4460
1943	1.9856	2.0178	0.5427	0.5446	1.4195	1.4731
1944	1.7773	1.8042	0.4995	0.5005	1.4428	1.3036
1945	1.6597	1.6850	0.4981	0.4995	1.2777	1.1855
1946	1.6001	1.6327	0.5110	0.5158	1.1616	1.1169
1947	1.6888	1.7229	0.5832	0.5893	1.0890	1.1336
1948	1.6832	1.7146	0.6210	0.6265	1.1055	1.0880
1949	1.7019	1.7254	0.6531	0.6530	1.0621	1.0724
1950	1.6502	1.6637	0.6542	0.6487	1.0488	1.0150
1951	1.6585	1.6629	0.6774	0.6686	0.9960	0.9943
1952	1.6822	1.6828	0.7048	0.6940	0.9811	0.9888
1953	1.6963	1.6935	0.7228	0.7103	0.9773	0.9832
1954	1.7284	1.7260	0.7371	0.7259	0.9735	1.0000
1955	1.7065	1.7039	0.7446	0.7353	0.9912	0.9685
1956	1.7514	1.7472	0.7780	0.7694	0.9619	0.9778
1957	1.7972	1.7900	0.8076	0.7996	0.9733	0.9903
1958	1.8096	1.8067	0.8144	0.8060	0.9896	1.0007
1959	1.7762	1.7776	0.8027	0.7928	0.9952	0.9848
1960	1.7620	1.7688	0.7941	0.7844	0.8619	0.9843
1961	1.7382	1.7524	0.7796	0.7708	0.9679	0.9815
1962	1.6915	1.7138	0.7646	0.7597	0.9586	0.9541

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1963	1.6643	1.6939	0.7563	0.7555	0.9269	0.9384
1964	1.6347	1.6672	0.7504	0.7513	0.9079	0.9158
1965	1.6149	1.6523	0.7529	0.7550	0.8842	0.8973

Sources by column:

The following are divided by Table E-1, column 2.

(1) Table D-3, column 1, plus Table D-4, column 1.

(2) Table D-3, column 4 plus Table D-4, column 5.

(3) Table D-3, column 1.

(4) Table D-3, column 4.

(5) Table D-4, column 1.

(6) Table D-4, column 5.

TABLE E-4

REVISED AND UNREVISED CAPITAL-ØUTPUT RATIØS, PRIVATE DØMESTIC ECØNØMY (1958 PRICES)

CØLUMN

(1) UNREVISED STRUCTURES AND EQUIPMENT

(2) REVISED STRUCTURES AND EQUIPMENT

(3) UNREVISED EQUIPMENT

(4) REVISED EQUIPMENT

(5) UNREVISED STRUCTURES

(6) REVISED STRUCTURES

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1910	2.4968	1.9731	0.6278	0.6195	1.8690	1.3536
1911	2.5238	2.0078	0.6304	0.6221	1.8934	1.3856
1912	2.5196	2.0181	0.6285	0.6209	1.8911	1.3972
1913	2.5248	2.0386	0.6317	0.6245	1.8930	1.4140
1914	2.8228	2.2949	0.7040	0.6956	2.1188	1.5992
1915	2.8025	2.2866	0.6948	0.6864	2.1077	1.6002
1916	2.5152	2.0576	0.6276	0.6206	1.8875	1.4369
1917	2.6878	2.2138	0.6910	0.6886	1.9967	1.5252
1918	2.6284	2.1801	0.6951	0.6951	1.9333	1.4850
1919	2.5669	2.1396	0.6831	0.6804	1.8838	1.4592
1920	2.5983	2.1697	0.6945	0.6878	1.9038	1.4818
1921	2.7055	2.2738	0.7249	0.7147	1.9806	1.5590
1922	2.6132	2.2066	0.7036	0.6910	1.9096	1.5156
1923	2.3619	2.0035	0.6491	0.6339	1.7128	1.3696
1924	2.3546	2.0067	0.6560	0.6378	1.6986	1.3689
1925	2.3743	2.0336	0.6681	0.6469	1.7061	1.3867
1926	2.2992	1.9773	0.6517	0.6271	1.6474	1.3501
1927	2.3548	2.0376	0.6704	0.6433	1.6843	1.3942

(CØNTINUED ØN NEXT PAGE)

DATE	(1)	(2)	(3)	(4)	(5)	(6)
1928	2.4088	2.1003	0.6939	0.6656	1.7148	1.4346
1929	2.3430	2.0561	0.6802	0.6510	1.6627	1.4050
1930	2.6789	2.3661	0.7716	0.7399	1.9073	1.6261
1931	2.9328	2.6039	0.8325	0.7999	2.1002	1.8040
1932	3.4548	3.0801	0.9660	0.9274	2.4888	2.1526
1933	3.4933	3.1291	0.9577	0.9201	2.5356	2.2089
1934	3.1903	2.8631	0.8679	0.8283	2.3224	2.0347
1935	2.8718	2.5888	0.7799	0.7432	2.0918	1.8455
1936	2.5151	2.2819	0.6844	0.6565	1.8306	1.6254
1937	2.3691	2.1644	0.6513	0.6263	1.7178	1.5380
1938	2.5053	2.3068	0.6850	0.6638	1.8202	1.6430
1939	2.2694	2.1065	0.6174	0.6025	1.6519	1.5039
1940	2.0861	1.9504	0.5747	0.5643	1.5113	1.3860
1941	1.8329	1.7404	0.5173	0.5162	1.3156	1.2242
1942	1.6566	1.6248	0.4627	0.4845	1.1939	1.1402
1943	1.5310	1.5363	0.4276	0.4665	1.1034	1.0697
1944	1.4490	1.4697	0.4141	0.4588	1.0349	1.0109
1945	1.4905	1.5209	0.4489	0.4995	1.0415	1.0213
1946	1.5783	1.5861	0.4996	0.5311	1.0786	1.0549
1947	1.6118	1.6176	0.5502	0.5799	1.0616	1.0377
1948	1.6094	1.6144	0.5877	0.6154	1.0217	0.9989
1949	1.6687	1.6712	0.6364	0.6607	1.0322	1.0105
1950	1.5731	1.5730	0.6231	0.6418	0.9499	0.9312
1951	1.5497	1.5473	0.6363	0.6527	0.9134	0.8945
1952	1.5708	1.5727	0.6654	0.6834	0.9054	0.8893
1953	1.5532	1.5601	0.6727	0.6923	0.8805	0.8678
1954	1.6298	1.6425	0.7121	0.7350	0.9176	0.9074
1955	1.5783	1.5934	0.7060	0.7298	0.8722	0.8636
1956	1.6289	1.6450	0.7441	0.7686	0.8847	0.8764
1957	1.6780	1.6937	0.7777	0.8023	0.9002	0.8913
1958	1.7448	1.7641	0.8119	0.8351	0.9329	0.9289
1959	1.6727	1.6894	0.7850	0.7998	0.8876	0.8895
1960	1.6680	1.6854	0.7872	0.7969	0.8807	0.8885
1961	1.6652	1.6873	0.7877	0.7958	0.8775	0.8914
1962	1.5952	1.6234	0.7617	0.7716	0.8335	0.8518

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DATE	(1)	(2)	(3)	(4)	(5)	(6)
1963	1.5604	1.5965	0.7499	0.7636	0.8104	0.8328
1964	1.5171	1.5576	0.7354	0.7506	0.7817	0.8069
1965	1.4761	1.5228	0.7255	0.7411	0.7505	0.7817

Sources by column:

The following are divided by Table E-1, column 3.

(1) Sum of column 1, Tables D-1 through D-4.

(2) Sum of column 4, Tables D-1 and D-3, and column 5, Tables D-2 and D-4.

(3) Sum of Column 1, Tables D-1 and D-3.

(4) Sum of Column 4, Tables D-1 and D-3.

(5) Sum of column 1, Tables D-2 and D-4.

(6) Sum of Column 5, Tables D-2 and D-4.

BIOGRAPHICAL NOTE

Name: Robert James Gordon

Born: September 3, 1940 in Boston, Massachusetts

Married: Julie Peyton on June 22, 1963

Attended: Harvard University, 1958-62

- B. A. magna cum laude in Economics
- Phi Beta Kappa
- Detur Prize
- Allan Young Prize

Corpus Christi College, Oxford University, 1962-64

- B. A. in Philosophy, Politics, and Economics
- First Class Honours
- George Webb Medley Senior Prize
- Marshall Fellowship
- Awarded Fulbright Fellowship

Massachusetts Institute of Technology, 1964-67

- Ph. D. in Economics to be awarded September 1967
- National Science Foundation Fellowship
- Ford Foundation Fellowship
- Awarded Harvard Prize Fellowship