Volume Title: Annals of Economic and Social Measurement, Volume 2, number 3

Volume Author/Editor: NBER

Volume Publisher: NBER

Volume URL: http://www.nber.org/books/aesm73-3

Publication Date: July 1973

Chapter Title: Capital Expenditures and Capital Stocks

Chapter Author: Raford Boddy, Michael Gort

Chapter URL: http://www.nber.org/chapters/c9903

Chapter pages in book: (p. 245 - 261)

Annals of Economic and Social Measurement, 2/3, 1973

CAPITAL EXPENDITURES AND CAPITAL STOCKS*

BY RAFORD BODDY AND MICHAEL GORT

After examining some conceptual and technical problems in the estimation of industry capital expenditures and capital stocks, expenditures estimates are presented for thirty major industry sectors for 1921–63. We then compare alternative estimates of the growth of capital stocks for the sectors during 1947–63. The measurement of capital stocks is shown to depend upon a theory of production and numerous additional assumptions.

This paper has three components. First, it examines some conceptual and technical problems in the estimation of capital expenditures and capital stocks by industry. Second, it presents capital expenditures estimates for thirty major industry sectors for 1921–63 a body of data that should prove of interest because of its extensive historical coverage. These data were developed primarily in estimating capital stocks, but may prove useful in studies of investment demand as well.[1] Third, it briefly compares several alternative estimates (including our own) of the rate of growth of capital stocks in the 1947–63 period for the thirty industry sectors. This comparison illustrates a recurring theme of the paper, namely that capital stocks are midway between an observable phenomenon and a state of mind. One can touch and see the tangible assets, but to measure them in consistent units requires a theory of production and a host of assumptions.

In developing stock estimates, decisions made by data compilers which appear to be based on technical data characteristics, in fact often imply a specific theory of production. One must, therefore, keep in mind that other theories lead to other stock measures (and some theories imply there are no general or aggregate measures of capital at all). But the problem does not end with the choice among production theories. For each theory there is a range of possible estimates or assumptions about variables such as economic life, obsolescence rate, price changes, etc. that affect the measures of capital. Thus if one multiplies the number of theories by the number of empirical estimates consistent with each, the range of potential measures of capital becomes indeed wide. It, therefore, behoves the user of capital data to exercise much care in his choice of measures.

(A) MEASURES OF INVESTMENT EXPENDITURES

In the past, the scarcity of data on capital outlays has understandably led economists to ignore important questions of definition and scope in the measures they have used for analytical purposes. Since a choice among measures did not exist, there was little to be gained from discussing alternatives. As alternative

* Acknowledgements are due to Daniel Creamer for suggestions for improvements and to the Bureau of Economic Analysis of the U.S. Department of Commerce for assistance in the development of the basic data. The data were developed under auspices of the Interagency Study of Economic Growth but they are not "official series" and the authors take sole responsibility for them.

[1] The annual estimates of capital for each industry, the underlying investment series for 1921–63, and a detailed discussion of estimation techniques may be found in R. Boddy and M. Gort, *The Derivation of Investment Expenditures and Capital Stocks* (mimeographed).

measures are developed, however, the choice of a measure can be adapted more effectively to its contemplated uses, and the differences among the available statistical series are far from trivial.

An important aspect of the general problem of selecting an optimal measure is that the choice of a particular source of information frequently determines the definition and scope of the variables—a fact that should be given some weight when selecting a series for capital outlays. The choice of a measure must depend not only on the accuracy of the underlying data but on the relevance of the data for a given analytical use. The decision is complicated by the fact that greater accuracy and greater relevance may be conflicting criteria.

A fundamental issue in the choice of a measure of investment depends on whether one is interested in estimating variations in investment demand or, alternatively, changes in capital inputs. As we shall presently see, survey-based estimates are generally designed to generate measures that are best suited for examining the first question, while estimates based on accounting statements[2] (on which we relied for our estimates for the manufacturing sector) are better suited for the second.

From the standpoint of the contribution of investment to current demand, one needs a measure of the current flow of producer's goods. To the extent that progress payments for construction of plant and equipment are synchronous with work carried out, actual expenditures as reported in capital expenditure surveys should approximate the desired measure of investment. On the other hand, for the analysis of the relation of inputs to output, it is only when plant and equipment are fully installed that they contribute to production. In general, balance sheet values as reported to the Internal Revenue Service (a source of information used by us) represent installed capacity since uncompleted and non-operative investment projects cannot be depreciated for tax purposes. Hence, measures of investment derived from successive balance sheets based on tax returns yield a pattern of investment over time of greater relevance than survey data for the study of production relations. Lags between expenditures and final installation are at times considerable, and explain some sizeable differences in the pattern of investment over time shown by series derived from balance sheet data, such as ours for manufacturing industries, and investment series based on survey data, e.g. capital expenditures reported in the OBE-SEC surveys or in the Census Bureau's *Annual Survey Manufactures.*

Another and closely related issue is whether purchases of used property should be added and sales of used property subtracted from a measure of investment. Once again, from the standpoint of measuring inputs, used property is as relevant as the new—and, once again, the source of the data determines their scope.[3] For example, Census data on capital expenditures show an industry's purchases of either new or used property, but not the industry's sales of used property. The

[2] This involves taking the first difference between successive balance sheet values of net fixed assets and adding the annual depreciation charge.

[3] A general problem in measuring capital inputs with data on investment arises from the common use by one industry of capital goods purchased by other industries or by governments. This difficulty affects all the series and adjustments are hard to make because data on rental payments—a measure of the services of such inputs—are, at best, incomplete. A far more comprehensive set of rental payment estimates, integrated with capital stocks, will soon be published by Daniel Creamer.

OBE–SEC survey generally includes only new investment, but it is possible that some of the respondents to the survey include purchases of used property. Capital expenditures derived from successive balance sheets include used property but are, automatically, net of the sales of such property. Hence, in this respect, they are at least conceptually closest to the desired measure of capital inputs at the industry level.

The various estimates of capital expenditures can be usefully classified by (1) whether the records are those of the purchaser of the capital goods or the seller, (2) whether the information was elicited expressly to meet the needs of expenditure estimation or arose to meet other purposes such as taxation and (3) whether the estimates of expenditures are for the *companies* of an industry or for the *plants* classified in that industry.

The principal advantage of investment information derived from sellers' reports is that it permits annual breakdowns of equipment by type. Indeed, the so-called commodity flow estimates of investment as published for the United States[4] depend upon a detailed breakdown of manufacturing output by equipment class. The more detailed the information, the more reliable are the allocations between investment and consumption goods. Except for these commodity flow estimates, annual breakdowns of equipment expenditures are available for only a few industries, based on private surveys, and are limited to very broad categories of equipment types. Census survey data on investment in manufacturing contain only a distinction between plant and equipment.

While estimates of investment based on sellers' reports are rich in detail with respect to the types of capital goods sold, they at present contain almost no information about the identity of buyers. Consequently, they do not lend themselves to the estimation of capital expenditures by the investing (purchasing) industry. Breakdowns of capital outlays by industry, therefore, depend either upon direct survey data or upon accounting data from which investment flows can be derived.

The advantage of direct capital expenditure surveys rests in the opportunity to tailor the information collected to the needs of the survey. Thus there are fewer accounting problems to be resolved, though there are indications that the reports of some firms even in direct surveys may be affected by accounting revaluations.[5] The chief disadvantages of survey data are first that they are usually based on samples and are thus subject to sampling errors, second, effective control over the reports to the survey is often difficult[6] and, third, except for a few regulated industries, continuous series begin only in the late 1940's.

[4] Private business investment as reported in the national income estimates of the U.S. Department of Commerce is estimated in this way.

[5] For example, the discrepancy between the Interstate Commerce Commission survey of railroad capital expenditures (based on reports of all regulated railroads) for 1959, 1960, and 1961 and the OBE–SEC survey data approximates the revaluations that railroads made in those years because of mergers and consolidations.

[6] The difficulties of control are probably reflected in the occasional estimates of investment based on survey data that seem highly implausible. For example, Census estimates of investment show a median year-to-year change for food products in 1958–61 of less than one percent, for leather and leather products in 1958–62 of less than three percent, and for stone, clay, and glass products in 1959–62 of less than three percent. For the same periods, OBE–SEC estimates for food products showed a median year-to-year change of roughly eleven percent and for stone, clay, and glass products of roughly seventeen percent. OBE–SEC estimates were not available for leather products, but our estimates show a median year-to-year change for 1958–62 of twenty-two percent for that industry.

For analytical purposes, there are valid reasons for choosing both the company and the plant as the relevant unit of observation. Plants are generally more homogeneous than companies both with respect to products and technical processes. Consequently, the parameters of production relations are likely to be more stable when based on industry data derived from a classification of plants rather than of firms. On the other hand, companies are the basic decision units. For a study of investment decisions, the company is a more appropriate unit of observation to the extent that financial variables are relevant or to the extent there are inputs that are common to more than one plant. Indeed, certain equipment purchaes are not fully allocated to individual manufacturing plants. Examples of this would be purchases of motor vehicles, office furniture, business machines, aircraft, etc. The problem is complicated by the fact that Census investment data currently do not include the purchases of central administrative offices.

All these differences yield more than trivial variations in the measures themselves. For example, if we take the direction of change in the level of investment in manufacturing for each year in the 1949–63 period, we find that OBE-SEC series agree with the Census series only ten out of a possible fourteen times. While we did not examine quarterly data, differences for shorter intervals are likely to be even greater.

In Appendix Table A, we present historical dollar capital expenditures 1921–63 (for the specific SIC classification see Appendix Table B).

(B) Capital Stocks

As noted earlier, capital stock estimates vary considerably depending on the sources of information and estimating techniques used. Besides the choice of the underlying investment series, the key elements in our estimates of capital are breakdowns of investment according to equipment types and structures, price deflators, the economic lives of assets, and for measures of net stocks, "capital consumption." We first briefly examine the relation between theory and measures. Second, we indicate the sources of information used for deriving the above-noted key elements and how these elements were combined to generate the several classes of capital shown in our tables. In Section C, we present a comparison of our estimates with those of others.

While our measures extend the range of available capital measures, they represent only a small set of all those that could be generated by currently known theories and plausible assumptions about the facts. However, the data developed can be used to compute many measures of capital other than those generated by us. For the widest choice of measures based on our data one would use only the information on capital expenditures of Appendix Table A and introduce such other assumptions or estimates as seem appropriate.

The capital series we developed are all variants of the now familiar "perpetual inventory" capital stocks. These stock estimates, as indeed virtually all capital estimates currently in use, combine into aggregates (at least for industries) various categories of equipment as well as capital goods of different vintages. The formal theoretical conditions under which such aggregation is tenable are quite restrictive. The conditions under which the maximized value of aggregate output can be written as a function of labor and a homogeneous aggregate capital have been developed by Leontief[7] and by Fisher.[8] Where there are multiple types of capital goods and where these goods are of varying vintages, Fisher has shown that one of two conditions must be satisfied. Either all capital inputs but one must be variable —that is, allocable as is labor (with variable factor proportions) across the plants defined by the one remaining capital input—or, alternatively, that for each vintage, the aggregate capital must be composed of components among which the marginal rate of substitution is independent of the amount of labor employed.

The restrictiveness of the above conditions is reflected in the fact that they preclude fixity of factor proportions *ex post*. That is, they preclude the plausible assumption that often the combinations in which various types of capital goods are used in a given production process cannot be varied after a plant has been built. Nevertheless, even though the formal conditions for aggregation are not met, capital stocks such as those we developed may still be useful for a variety of rough approximations. For example, they may permit a rough scaling of the impact of investment streams on the relation of aggregate labor input to aggregate output.[9]

(i) *Depreciation, Obsolescence, and Economic Lives*

Table 3 shows estimates of growth in capital in both gross and net form. A gross stock in the context of production relations implies that the productivity of capital goods remains unchanged until their retirement. This presumption is reasonable as an approximation only if obsolescence is negligible and if maintenance expenditures are sufficient to offset the effects of the physical deterioration of capital goods on output.

In some instances, economists have introduced measures of net stock in an analytical framework in which technical change is assumed to be "disembodied" —that is, independent of improvements in new as compared with old capital goods and, hence, independent of new investment. This procedure is tenable only if depreciation measures physical deterioration in capital goods as contrasted with obsolescence. On this assumption, however, estimates of net stocks cannot be based on generally used depreciation rates which, in turn, derive from estimates of the economic life of capital goods. As Table 1 shows, the economic life of most classes of equipment does not exceed fourteen years. If depreciation is computed on the basis of the double declining balance method, Table 1 implies a depreciation rate for most types of capital goods of more than fourteen percent a year, and on a straight line basis, a depreciation rate of seven to ten percent a year. Such rates of decline in the economic value of capital goods cannot be attributed plausibly to physical decay especially since maintenance outlays tend to offset the effects of deterioration. Accordingly, it is reasonable to assume that most depreciation implied by estimated economic lives results from obsolescence. Thus, the use of such depreciation rates is inconsistent within the framework of a model that specifies technical advance as being of the disembodied type.

[7] W. Leontief, "Introduction to a Theory of the Internal Structure of Functional Relationships," *Econometrica*, 1947.

[8] F. Fisher, "Embodied Technical Change and the Existence of an Aggregate Capital Stock," *Review of Economic Studies*, 1966.

[9] J. K. Whitaker, "Vintage Capital Models and Econometric Production Functions," *Review of Economic Studies*, 1966.

TABLE 1

MEDIAN ECONOMIC LIVES FOR EQUIPMENT AND STRUCTURES[1]

Capital Goods	Years of Life
Cars and Trucks	5.5
Industrial Machinery	16
Other Transportation Equipment	8
Furniture and Fixtures	13
Office Machinery	10
Construction and Mining Machinery	17
Aircraft	7
Ships and Boats	22
Railroad Equipment	26
Instruments	6
All Other Equipment (excluding electric and gas utilities)	11
Structures	32.5
Electric and gas transmission plant and equipment	34
Electric distribution plant and equipment	32
Electric production plant and equipment	37
All other electric and gas utility plant and equipment	30

[1] Median for all industries using the relevant plant and equipment.
Source: Developed from data in R. Boddy and M. Gort, *The Derivation of Investment Expenditures and Capital Stocks* (mimeographed).

A frequent objection to economic lives drawn from tax data is that there is an incentive for the taxpayer to underestimate economic life. Efforts, however, to underestimate economic life are constrained by Internal Revenue Service rules which seek (apart from explicitly intended acceleration) to approximate in the allowed economic lives actual practice. That lives used for tax purposes do not generally underestimate seriously actual practice is reflected in the fact that economic lives on the basis of which depreciation is computed for financial reports to stockholders do not deviate much from those used for tax purposes. The managerial incentive in reports to stockholders is usually to show favorable profits with the result that one might expect a bias in such reports opposite to that associated with tax data. The Internal Revenue Service does not require depreciation used for tax purposes to be the same as that employed in corporate reports to stockholders. Notwithstanding these facts, F.T.C.–S.E.C. data[10] for manufacturing corporations, based on a sample survey but with depreciation reporting probably similar to that made to stockholders, show that depreciation charges were 11.6 percent of net plant and equipment in 1956, 11.1 percent in 1960, and 12.0 percent in 1963. This is roughly midway between the ratios we computed on the assumption of straight line and double declining balance depreciation (Table 1).

To be sure, economic lives estimated for tax purposes are only rough guesses or approximations of actual experience. This is reflected partly in the changes in estimates of economic life that occur over time. Generally, it appears there has been a gradual shift to shorter estimates and this, in turn, is reflected in the changes in the Treasury guidelines over time. In our computation of capital, we have

[10] U.S.F.T.C. and S.E.C., *Quarterly Financial Report*, Table 8 for first quarter reports for 1964 and 1961, and Table 7 for fourth quarter report for 1956.

assumed that these changes reflect primarily changes in the estimates rather than a gradual shortening of economic life itself. This is a conservative assumption and others, as we indicate later, believe that there has been an actual reduction in economic life.

Estimates of economic lives do not yield unique measures of depreciation since the latter depend also upon the way in which the original cost of an asset is allocated over its life. Moreover, the importance of various asset classes as components of the capital stock varies greatly. However, Table 2 shows that for most industries the annual depreciation, whether computed on a straight line or on a double declining balance basis, is a substantial fraction of the net stock of capital. These computations are based on estimated economic life and are not the depreciation rates derived from actual corporate accounts. Thus the implied

TABLE 2

RATIOS OF ANNUAL DEPRECIATION CHARGES TO THE NET CAPITAL STOCK, 1950 AND 1960

Industry	Ratio 1[1]		Ratio 2[2]	
	1950	1960	1950	1960
Food Products	0.080	0.090	0.110	0.118
Tobacco	0.085	0.089	0.111	0.121
Textiles	0.074	0.084	0.108	0.114
Apparel	0.097	0.117	0.136	0.149
Furniture	0.094	0.093	0.121	0.124
Paper	0.072	0.075	0.102	0.103
Printing and Publishing	0.082	0.091	0.114	0.119
Chemicals	0.091	0.104	0.127	0.137
Rubber	0.099	0.100	0.131	0.135
Leather	0.092	0.104	0.130	0.139
Stone, clay and glass	0.080	0.080	0.106	0.111
Primary metals	0.070	0.068	0.095	0.092
Fabricated metal products	0.081	0.084	0.110	0.113
Machinery (except electrical)	0.095	0.106	0.131	0.141
Electrical machinery	0.086	0.092	0.121	0.122
Motor Vehicles and parts	0.090	0.104	0.127	0.136
Aircraft and parts	0.139	0.117	0.169	0.161
Other transportation equipment	0.086	0.098	0.108	0.116
Petroleum	0.095	0.105	0.135	0.138
Mining	0.085	0.095	0.122	0.131
Railroads	0.065	0.076	0.081	0.098
Water transportation	0.124	0.111	0.165	0.147
Air transportation	0.268	0.209	0.336	0.316
Electric utilities	0.053	0.047	N.A.	0.065
Gas utilities	0.046	0.043	0.064	0.068
Telephone	0.071	0.070	0.099	0.097
Broadcasting	0.135	0.133	0.203	0.183
Contract construction	0.177	0.189	0.258	0.261
Wholesale trade	0.115	0.124	0.167	0.163
Retail trade	0.099	0.108	0.144	0.144

N.A. not available.

[1] Both net stock and depreciation computed on the assumption of straight line depreciation.

[2] Both net stock and depreciation computed on the assumption of double declining balance depreciation.

Source: Net stock and depreciation based on estimated lives as shown in R. Boddy and M. Gort, *The Derivation of Investment Expenditures and Capital Stocks* (mimeographed).

obsolescence rate is assumed to be constant for each equipment class within each industry.

In our data, a separate economic life was estimated for structures and for the various equipment types, for each industry. All equipment of a specified type, industry, and vintage, was assumed to be retired at the same time. However, since investment in each industry was divided into a number of components with different lives, the assumed retirement of an industry's total investment of a given vintage was spread over a considerable span of years.

The procedure used is perhaps inferior conceptually to assuming a distribution of retirements for each class of equipment within each industry. It is, however, clearly preferable to alternative estimates made by some scholars in which a normal distribution of retirements is assumed for investment expenditures aggregated across all equipment types. This is because capital outlays tend to be heavily concentrated in a few equipment classes and the average lives of the various equipment types differ greatly. Hence the distribution of retirements over time for equipment of a given vintage cannot approximate a normal distribution.

(C) Comparisons of Growth Rates for Measures of Capital

Table 3 presents growth rates of capital stocks computed in several ways as well as comparisons, wherever possible, of these estimates with those developed by Creamer[11] and Hickman,[12] the only other capital series with comprehensive industry detail published for the United States. An interesting feature of the estimates is that for most industries the annual growth rates of gross stocks did not differ greatly from those of net stocks. Our estimates of net stocks, however, reveal fairly consistently a higher growth rate than the comparable estimates of both Creamer and Hickman.

There are several reasons for the differences in the estimates. Creamer's measure of capital are deflated book values of net fixed capital as reported in the Internal Revenue Service, *Statistics of Income*. Thus the growth rates are reduced relative to those of our estimates by the fact that depreciation practices implicit in reported book values changed somewhat over time towards shorter economic lives. Moreover, Creamer uses a complex method of price deflation which depends upon estimates of economic life. The assumed life for all structures in his computations is fifty years as compared to our average of roughly thirty-three years. As a result, he assumes that the stock of 1947 is composed of much older capital than is implicit in our computations. This in turn increases his deflator generating a capital stock for 1947 significantly larger than ours—hence the slower growth rate after 1947.

Hickman's estimates, though of the perpetual inventory type, also reflect assumed changes in the economic life of assets over time. Hickman depreciates all assets purchased before 1946 at a lower rate than all assets purchased after 1946. This assumption of two depreciation rates reduces the growth rate of his estimates

[11] Daniel Creamer, *Capital and Output Trends in Manufacturing Industries, 1880–1948*, Occasional Paper 41, National Bureau of Economic Research, New York, 1954.

[12] Bert G. Hickman, *Growth and Stability of the Postwar Economy*, Brookings Institution, Washington, D.C., 1960.

TABLE 3

ANNUAL GROWTH RATES FOR ALTERNATIVE MEASURES OF CAPITAL, 1947–63 (IN PERCENT)

Industry	Gross Stock 1947–63	Net Stock[1] 1947–63	Net Stock[1] 1953–60	Net Stock[2] 1947–60	Creamer Est.[3] Net Stock 1953–60	Hickman Est.[2] Net Stock 1947–60
Food Products	2.85	2.45	2.05	1.95	−0.09	0.14
Tobacco	3.36	3.93	5.68	3.26	5.10	N.A.
Textiles	3.17	1.63	−1.41	1.58	−4.88	−0.17
Apparel	2.93	2.02	1.50	0.74	−1.43	N.A.
Furniture	1.95	2.69	3.40	2.67	2.25	N.A.
Paper	5.34	5.95	6.56	6.34	4.25	4.98
Printing and Publishing	3.40	3.88	3.62	3.55	3.31	N.A.
Chemicals	4.64	4.59	3.88	4.62	2.83	2.14
Rubber	4.19	3.93	5.17	2.62	3.12	1.37
Leather	2.86	2.67	1.60	1.81	−1.02	N.A.
Stone, clay and glass	4.90	6.05	7.95	6.56	6.93	2.02
Primary metals	3.83	3.81	3.52	4.57	3.00	5.00
Fabricated metal products	5.17	5.85	5.07	6.12	2.10	N.A.
Machinery (except electrical)	4.36	3.76	3.76	3.79	1.74	3.52
Electrical Machinery	5.29	4.79	3.14	4.24	0.42	3.55
Motor Vehicles and parts	5.49	4.50	4.21	5.10	2.26	4.21
Aircraft and parts	8.88	7.58	1.00	8.43	N.A.	N.A.
Other transportation equipment	−0.47	−1.42	−2.91	−3.17	2.48	N.A.
Petroleum	5.34	4.64	3.76	5.15	N.A.	4.81
Mining	6.63	6.12	7.60	7.40	N.A.	N.A.
Railroads	−1.35	−1.79	−2.26	−1.23	N.A.	−1.00
Water transportation	1.23	1.70	3.36	1.53	N.A.	N.A.
Air transportation	10.58	8.20	18.08	9.60	N.A.	N.A.
Electric utilities	3.79	5.22	4.76	N.A.	N.A.	6.39
Gas utilities	6.20	7.69	6.20	8.85	N.A.	N.A.
Telephone	5.50	6.29	6.41	6.56	N.A.	N.A.
Broadcasting	8.56	9.15	9.77	10.53	N.A.	N.A.
Contract construction	9.85	9.25	8.93	8.75	N.A.	N.A.
Wholesale trade	7.30	6.85	6.29	7.05	N.A.	N.A.
Retail trade	5.35	5.62	5.02	5.29	N.A.	N.A.

[1] Computed with straight line depreciation.
[2] Computed with double declining balance depreciation.
[3] Computed mainly on the basis of straight line depreciation.
N.A. not available.
Source: Based on data in R. Boddy and M. Gort, *The Derivation of Investment Expenditures and Capital Stocks* (mimeographed).

relative to ours. Further, his data for the underlying investment streams show a smaller rise in the 1947–60 period than the rise reflected in the investment series developed by us and shown in Appendix Table A.

An especially awkward corner in the construction of capital stocks is deflation of capital expenditures for changes in prices. For the deflation of equipment we used various producer's durables price indexes. For structures we used a construction cost index. This structures price index is clearly inadequate. It fails to reflect productivity changes in the construction industry. Recently new indexes have become available and may be used for future capital series by industry. However, there is no generally accepted set of adjustments now. And until there is a major intellectual breakthrough on the whole question of capital productivity or the quality of capital (the dual of the price index) agreement is not likely to be forthcoming. However, given a new set of price indexes, approximate adjustments can be made directly to the growth rates of our capital series.

(D) Capital Stock Formulas

All our capital stock measures were summations of the various components (structures and equipment types) of annual investment streams.[13] In any summation, the number of successive investment expenditures for each investment component or asset class can be determined by the economic life of the asset class. Three types of capital measures were developed: gross stocks, net stocks with "declining balance" depreciation and net stocks with "straight line" estimates of depreciation. The differences among the measures arise from the differences in weights that are given to investment expenditures of various vintages.

The total capital for an industry is the sum of the stocks of the various asset classes. That is,

(i) $$K(t) = K_j(t)$$

where $K(t)$ = the total stock of the I'th industry at time t and $K_j(t)$ = the stock for asset class j in that industry at time t.

For both gross and net stocks we have the general formula:

(ii) $$K_j(t) = \sum_{v=t-\theta_j+1}^{t} \omega_j(t-v)I_j(v)$$

θ = the economic life of the j'th asset class and v = the vintage of the investment expenditure for the asset.

For gross stocks, the weight $\omega(t-v)$ is unity, there being no depreciation for assets not as yet retired. For net stocks with straight line depreciation the weights are:

(iii) $$\omega_j(t-v) = 1 - \frac{1}{2\theta_j} - \frac{t-v}{\theta_j}$$

since, as is customary, only half a year's depreciation is taken for the most recent investment expenditure.

For net stocks with double declining balance depreciation, and once again taking half a year's depreciation for the most recent investment, the weights are given by the formula:

(iv) $$\omega_j(t-v) = \left(1 - \frac{1}{\theta_j}\right)\left(1 - \frac{2}{\theta_j}\right)^{t-v}$$

[13] While the investment series we derived were for aggregate expenditures not broken down by equipment type, an investment expenditure matrix was applied to these series. The matrix is shown in R. Boddy and M. Gort, "The Substitution of Capital for Capital," *Review of Economics and Statistics*, May, 1971.

However, a somewhat arbitrary procedure, but one consistent with current practice in computing depreciation for tax purposes, was used. There is a point at which straight line depreciation of the remaining balance (after double declining balance depreciation has been deducted) over the remaining years of economic life leads to a higher depreciation charge than generated by the double declining balance method. At that point, the depreciation method shifts to a straight line basis and the asset, accordingly, is given a finite life. This procedure leads only to relatively small differences in the level and changes over time in net stocks compared to the level and movement of a series with an unmodified double declining balance depreciation.

American University
State University of New York at Buffalo, and
National Bureau of Economic Research

received: November 24, 1972
revised: April 29, 1973

APPENDIX TABLE A

GROSS CAPITAL EXPENDITURES BY INDUSTRY, 1921–63
(millions of dollars) Historial Prices

Year	Food Products	Tobacco	Textiles	Apparel	Furniture	Paper
1921	308.2	2.0	175.3	8.2	19.8	62.4
1922	138.5	3.8	104.0	7.3	17.6	56.6
1923	268.2	6.2	201.2	11.2	26.9	86.9
1924	69.4	6.8	74.0	9.6	23.2	75.7
1925	178.1	4.1	79.4	11.9	28.8	94.4
1926	110.2	4.9	30.6	16.4	39.7	131.3
1927	142.0	6.3	61.5	17.2	41.6	104.6
1928	146.6	13.6	40.3	14.1	34.3	166.1
1929	124.8	10.6	19.2	19.9	48.6	203.5
1930	284.3	11.8	22.9	18.1	44.7	94.8
1931	148.4	5.8	3.4	9.9	16.7	12.8
1932	111.6	5.3	27.6	8.7	14.8	68.3
1933	172.2	0.7	43.4	8.0	17.5	19.0
1934	138.4	1.0	27.5	7.8	20.7	45.4
1935	131.6	5.1	58.5	16.2	25.1	68.0
1936	262.4	4.8	115.5	15.2	63.8	85.2
1937	336.7	13.5	97.5	10.1	17.8	140.3
1938	274.7	5.3	31.5	10.8	30.0	78.0
1939	216.3	10.7	60.4	5.5	34.0	77.1
1940	360.5	8.6	74.4	36.5	45.6	122.7
1941	252.1	4.8	111.8	50.8	6.3	125.0
1942	234.9	2.8	85.5	33.8	18.6	109.7
1943	131.1	4.8	23.9	6.3	7.0	34.7
1944	161.2	1.3	44.9	12.2	29.7	40.8
1945	376.2	5.9	120.5	36.0	54.8	123.5
1946	898.3	17.3	338.0	128.6	61.4	307.1
1947	1048.5	27.0	497.3	122.0	77.8	467.9
1948	1006.0	22.9	579.8	99.4	85.0	495.2
1949	719.0	18.2	407.1	68.6	53.5	347.3
1950	967.3	11.0	376.4	82.4	92.3	374.6
1951	891.7	16.8	487.1	83.1	90.7	624.6
1952	633.9	11.4	269.3	76.4	93.0	456.1
1953	422.3	11.2	300.2	53.6	73.1	490.6
1954	859.3	24.3	223.4	92.9	100.5	681.1
1955	937.6	22.3	514.2	111.9	143.3	738.6
1956	869.8	34.7	374.5	77.8	110.5	1027.6
1957	1100.9	41.6	141.5	53.1	115.6	1107.6
1958	1194.6	41.7	116.6	126.5	132.8	755.6
1959	1476.9	57.8	257.3	128.8	195.9	680.0
1960	1096.8	36.7	379.4	99.3	145.6	1088.2
1961	1556.2	45.6	195.8	138.5	111.2	805.7
1962	1515.9	59.2	339.3	207.0	144.2	908.6
1963	1558.8	69.8	505.6	127.0	238.0	961.1

APPENDIX TABLE A (continued)

GROSS CAPITAL EXPENDITURES BY INDUSTRY, 1921–63

(millions of dollars) Historical Prices

Year	Printing and Publishing	Chemicals	Rubber	Leather	Stone, Clay and Glass	Primary Metals
1921	52.8	14.2	9.6	6.5	55.1	182.6
1922	47.9	111.3	9.3	5.9	50.4	100.5
1923	73.5	108.7	9.0	9.0	78.0	203.8
1924	64.0	148.5	10.4	7.9	68.6	265.3
1925	79.7	171.7	14.1	9.8	86.2	248.1
1926	110.9	143.2	14.3	13.6	120.8	297.1
1927	98.8	142.9	20.7	14.3	130.6	315.3
1928	99.6	142.6	28.1	9.0	179.2	216.6
1929	150.7	437.6	42.3	26.0	67.8	241.7
1930	129.9	372.0	27.8	9.4	153.7	475.8
1931	36.0	897.5	14.3	6.1	55.1	308.0
1932	54.6	242.3	2.6	5.4	48.6	98.4
1933	37.1	242.0	6.0	6.1	40.5	30.3
1934	61.1	133.4	14.8	3.6	31.6	104.3
1935	35.6	88.3	17.3	10.1	17.2	280.9
1936	64.3	212.3	5.7	7.8	55.0	219.2
1937	64.4	216.9	30.7	1.5	95.6	204.5
1938	43.6	81.5	19.0	5.1	44.3	148.1
1939	45.2	198.3	54.5	4.9	60.7	138.6
1940	94.0	268.4	77.2	20.1	70.2	146.3
1941	39.0	278.3	44.5	18.9	66.7	529.5
1942	60.1	223.9	66.1	15.2	67.8	321.1
1943	82.1	159.5	42.5	4.8	21.3	1339.8
1944	13.9	143.0	105.3	10.9	22.1	291.8
1945	59.0	402.5	70.7	22.4	78.5	346.5
1946	147.9	714.7	101.0	51.6	240.0	523.2
1947	389.7	862.1	132.2	59.9	360.4	976.8
1948	326.3	869.5	82.9	77.9	247.2	1096.4
1949	280.9	872.4	61.6	41.4	159.3	740.2
1950	250.0	557.9	83.8	22.8	257.0	715.7
1951	229.3	1100.1	133.4	39.7	411.3	1392.5
1952	211.1	1339.8	132.2	38.4	294.2	2166.2
1953	196.6	1104.7	86.6	30.7	456.9	1645.4
1954	208.9	977.9	135.3	34.7	437.0	1188.2
1955	352.1	1486.8	198.8	49.5	623.4	1289.6
1956	394.9	1503.3	173.1	65.6	836.4	1706.3
1957	403.7	1915.9	245.7	55.7	886.4	2832.9
1958	405.4	1548.3	237.9	39.5	634.5	1879.9
1959	437.2	1554.8	231.0	68.5	711.7	1087.0
1960	583.3	1757.3	297.5	83.6	846.4	2244.7
1961	435.2	1685.3	283.1	73.4	675.5	1604.9
1962	647.8	2176.1	391.1	83.5	743.6	1485.1
1963	687.9	2077.4	373.7	101.6	967.9	1422.2

APPENDIX TABLE A (continued)

GROSS CAPITAL EXPENDITURES BY INDUSTRY, 1921–63

(millions of dollars) Historical Prices

Year	Fabricated Metals	Machinery except Electrical	Electrical Machinery	Motor Vehicles and parts	Aircraft and parts	Other trans-portation equipment	Petroleum
1921	39.6	52.1	16.6	3.7	5.8	18.7	249.8
1922	35.7	47.2	15.0	6.1	5.2	17.0	252.4
1923	55.3	73.3	23.3	31.9	8.2	26.4	394.1
1924	48.2	64.2	20.4	26.6	7.2	23.1	277.0
1925	60.7	81.2	25.8	50.0	9.0	29.2	363.0
1926	84.7	113.8	36.1	101.1	12.7	40.9	535.3
1927	89.7	120.8	38.3	86.8	13.5	43.4	557.7
1928	74.7	101.1	32.1	93.0	11.3	36.3	477.9
1929	106.6	145.0	45.9	85.6	16.2	52.1	689.2
1930	97.8	133.0	42.1	21.3	14.9	47.8	588.8
1931	43.1	43.0	6.3	11.2	4.6	27.2	316.8
1932	38.2	37.8	9.1	11.4	4.1	10.8	288.6
1933	10.8	31.9	10.1	13.0	3.4	9.1	204.7
1934	59.8	59.3	14.2	36.1	6.4	17.0	351.6
1935	80.9	56.8	18.9	39.3	4.4	39.3	311.7
1936	116.8	110.7	37.0	85.0	21.6	39.6	432.1
1937	75.4	151.3	65.0	119.0	8.1	12.7	723.8
1938	72.8	84.7	32.2	36.8	7.4	24.4	459.3
1939	23.9	128.7	31.9	56.3	18.5	75.9	205.2
1940	75.7	179.9	55.6	98.3	73.1	45.0	488.9
1941	68.1	289.8	98.5	116.1	90.8	36.7	451.2
1942	57.2	255.2	76.7	61.3	46.9	41.1	411.0
1943	61.6	128.0	52.5	40.7	156.7	66.2	638.8
1944	20.9	129.9	73.2	71.3	42.5	93.5	716.3
1945	87.0	262.3	100.6	179.2	148.0	89.2	929.0
1946	212.2	749.6	296.1	351.4	20.9	215.0	1121.2
1947	197.4	661.9	299.3	364.5	19.3	54.9	1704.8
1948	341.2	627.0	231.8	312.2	34.2	109.3	2524.0
1949	213.8	443.0	161.7	142.4	29.9	52.9	1773.4
1950	286.0	514.0	189.1	300.2	88.7	38.3	1375.1
1951	459.3	758.6	313.9	567.8	363.8	40.6	2508.3
1952	274.9	664.9	409.9	636.2	689.0	93.8	2361.8
1953	380.2	831.6	402.6	418.8	569.8	56.5	2379.8
1954	359.9	771.4	181.6	699.6	261.2	90.2	2712.1
1955	425.1	924.4	382.5	540.1	332.0	72.6	3004.9
1956	540.7	1174.9	497.4	1199.5	406.7	79.1	3817.5
1957	738.2	1106.3	384.7	653.7	418.0	75.7	3468.6
1958	296.4	1000.2	321.9	375.7	236.3	80.3	2965.1
1959	577.7	1117.2	432.1	372.5	235.9	67.5	2896.8
1960	657.5	1066.9	583.6	584.7	281.3	75.8	2807.4
1961	771.1	1021.2	620.6	384.2	175.3	117.4	3205.0
1962	852.8	1226.2	434.7	536.7	234.1	194.0	3353.3
1963	507.8	1204.1	797.7	760.2	568.2	164.2	3407.2

APPENDIX TABLE A (continued)

Gross Capital Expenditures by Industry, 1921–63

(millions of dollars) Historical Prices

Year	Mining	Railroads	Water Trans-portation	Air Trans-portation	Electric Utilities	Gas Utilities	Telephone
1921	58.7	591.0	305.6	N.A.	271.0	95.9	213.0
1922	91.9	518.0	143.6	N.A.	383.8	112.7	245.5
1923	113.6	1103.0	115.8	N.A.	693.4	182.4	298.2
1924	84.3	972.0	89.2	N.A.	791.6	190.0	359.8
1925	91.8	791.0	89.2	1.2	736.6	172.0	355.7
1926	122.2	887.0	122.9	2.6	669.5	180.1	371.6
1927	106.6	804.0	91.4	6.5	683.1	176.6	353.6
1928	115.4	727.0	90.3	16.4	649.9	167.9	404.8
1929	139.7	860.0	109.8	26.7	699.4	199.9	556.8
1930	85.0	834.0	133.8	17.7	769.0	190.0	548.9
1931	26.0	349.0	98.3	14.7	469.4	111.0	337.0
1932	19.0	166.0	21.2	3.8	233.6	84.0	177.5
1933	21.0	112.0	25.8	4.4	128.7	44.0	98.0
1934	33.4	180.0	26.1	7.7	140.0	53.0	112.7
1935	31.2	171.0	11.1	8.6	187.1	60.0	130.8
1936	196.0	328.0	70.9	17.6	291.9	90.0	180.8
1937	193.2	565.0	58.9	10.0	454.1	97.0	261.8
1938	52.2	273.0	151.7	2.8	395.1	79.0	236.7
1939	59.7	267.0	70.9	16.9	345.3	74.0	250.0
1940	284.4	462.0	71.6	36.4	481.4	116.0	310.0
1941	349.1	566.0	61.0	24.6	578.9	140.0	450.0
1942	72.4	684.0	53.3	4.8	445.1	111.0	370.0
1943	69.5	483.0	16.4	3.6	249.7	75.0	165.0
1944	92.9	581.0	0.0	14.8	206.5	162.0	185.0
1945	129.4	569.0	66.7	76.5	342.6	160.4	275.0
1946	212.6	581.0	153.8	199.3	628.5	309.6	730.0
1947	544.2	873.0	340.0	154.2	1211.5	758.0	1260.0
1948	776.4	1322.0	212.3	101.9	1786.1	770.0	1551.0
1949	401.8	1357.0	157.5	97.2	2137.4	959.0	1150.0
1950	702.8	1129.0	14.6	72.1	2000.8	1198.0	945.0
1951	723.8	1487.0	219.5	140.9	2082.7	1462.0	1164.8
1952	495.5	1416.0	107.7	145.9	2536.6	1067.0	1672.8
1953	289.4	1327.1	132.3	233.2	2806.9	1350.0	1564.9
1954	1187.1	911.5	154.7	269.4	2766.9	1055.0	1607.2
1955	1208.2	990.1	189.0	205.4	2653.7	1345.0	1819.4
1956	809.4	1336.8	184.7	402.5	2840.2	1552.0	2499.8
1957	1256.7	1562.9	211.9	558.7	3590.7	1772.0	3115.6
1958	937.3	853.3	349.0	496.3	3673.6	1618.0	2610.4
1959	1633.0	1140.7	332.9	874.0	3301.8	1728.0	2682.1
1960	991.9	1740.4	418.4	895.0	3251.1	1845.0	3105.1
1961	1134.4	1121.2	208.9	802.0	3158.0	1662.0	3100.1
1962	884.2	869.2	357.1	636.7	3032.0	1673.0	3449.6
1963	854.6	1114.5	268.0	557.2	3196.0	1558.0	3648.4

APPENDIX TABLE A (continued)

GROSS CAPITAL EXPENDITURES BY INDUSTRY, 1921–63

(millions of dollars) Historical Prices

Year	Broadcasting	Contract Construction	Wholesale Trade	Retail Trade
1921	6.4	8.6	6.0	20.1
1922	6.4	9.7	22.5	75.6
1923	9.7	71.5	24.9	83.9
1924	10.8	92.4	31.2	105.2
1925	11.9	113.4	56.5	190.2
1926	13.0	146.7	40.3	135.9
1927	14.0	156.3	58.2	196.2
1928	15.1	79.1	104.5	352.1
1929	16.2	181.5	120.7	406.5
1930	17.3	120.5	52.3	176.1
1931	7.5	80.3	67.5	161.4
1932	4.6	27.8	29.9	74.6
1933	7.5	13.5	18.7	36.5
1934	4.5	31.5	29.0	79.8
1935	3.9	57.2	30.5	85.2
1936	4.5	50.9	45.6	143.7
1937	4.5	46.4	65.9	137.4
1938	4.9	40.3	40.3	104.0
1939	4.9	37.0	22.5	348.0
1940	10.4	38.3	93.9	225.8
1941	7.8	52.1	113.7	266.0
1942	8.4	39.0	83.4	144.7
1943	0.6	33.0	54.4	33.9
1944	7.4	13.3	72.9	87.2
1945	14.7	56.9	85.4	172.1
1946	22.6	215.2	457.6	835.4
1947	47.8	276.4	498.6	1200.2
1948	60.8	286.6	600.7	1140.9
1949	41.3	229.5	479.4	975.0
1950	32.0	312.0	681.2	1067.7
1951	52.3	387.1	711.8	989.3
1952	50.6	379.1	460.4	784.1
1953	54.3	261.4	345.5	833.7
1954	83.7	382.8	632.5	883.8
1955	88.1	570.3	947.6	1500.9
1956	88.6	583.7	1045.6	1699.0
1957	142.6	767.7	905.4	1513.6
1958	101.9	593.6	895.5	1456.9
1959	95.4	920.1	881.7	1909.1
1960	156.3	847.8	1043.2	1888.7
1961	83.6	879.5	772.9	2025.2
1962	105.1	1153.1	1330.6	2119.6
1963	224.2	1218.9	1202.7	2444.5

Source: Described in R. Boddy and M. Gort, *The Derivation of Investment Expenditures and Capital Stocks* (mimeographed).

APPENDIX TABLE B

INDUSTRY SECTORS AND SIC CODES[1]

Industry Sector	SIC Code
Manufacturing	
Food products	20
Tobacco	21
Textiles	22
Apparel	23
Furniture	25
Paper	26
Printing and publishing	27
Chemicals	28
Rubber	30
Leather	31
Stone, clay and glass	32
Primary metals	33
Fabricated metal products	34
Machinery except electrical	35
Electrical machinery	36
Motor vehicles and parts	371
Aircraft and parts	372
Other transportation equipment	373, 374
Non-manufacturing	
Petroleum	29, 13
Mining	10, 11, 12, 14
Railroads	4, 011
Water transportation	44
Air transportation	45
Electric utilities	4, 911
Gas utilities	492
Telephone	481
Broadcasting	77
Contract construction	15–17
Wholesale trade	50, 51
Retail trade	52–59

[1] For Manufacturing, the codes are based on the 1945 SIC. For Non-manufacturing they are based on the 1949 SIC. Except for wholesale and retail trade and construction, the data in all tables encompass both the corporate and non-corporate sectors. For the above three industries, they encompass only the corporate sector.