QUARTERLY ESTIMATES OF CAPITAL STOCKS IN THE U.S. PRIVATE DOMESTIC ECONOMY, BY MAJOR INDUSTRY GROUPS*

BY JOHN W. KENDRICK

The George Washington University, Washington, D.C.

AND KYU SIK LEE

The Conference Board, New York

This paper describes a study designed to provide quarterly estimates of the real capital stock of the United States by sector and industry, which is being undertaken by the Conference Board. It surveys the history of wealth estimation in the United States, and goes on to describe work now in progress both in the Bureau of Economic Analysis and by private researchers. It then continues with a description of the methodology being used in the Conference Board study.

The estimation of wealth has lagged behind the development of national income and product estimates. Yet assets and stock-flow relations are being accorded an increasingly important role in economic theory. Estimates of tangible capital stocks by sectors and industries are, or would be, useful for analyses, and thus for predictions or projections, in several directions. (1) In current prices, the stock estimates, in conjunction with estimates of financial assets and liabilities, would permit development of complete balance sheets for sectors and thus the analysis of stock-flow relationships and portfolio composition. In the non-business sectors, the stock estimates would make possible imputations of property returns (not rentals) which, together with labor compensation, are necessary for estimates of income and product originating. In the business sector, the asset and equity estimates, by industry groups, would enable estimates of rates of return. (2) In constant prices, the real stock estimates for the business economy, by industry, are essential for statistically fitting production functions, estimating capital coefficients and total factor productivity, and thus analyzing the components of economic growth. (3) Stock estimates in both current and constant prices are essential ingredients for analysis of the interrelationships of factor prices, productivity, unit costs, and prices. These interrelationships are particularly germane to analysis of economic fluctuations, for which quarterly estimates are needed.

The purpose of this paper is to describe the major part of a study in which the authors are engaged, designed to provide quarterly estimates of the real capital stock of the United States by sector and industry. We are confining the paper to the private domestic business economy, by industry. The chief contributions of the broader Conference Board study[1] are (1) to assemble, and where necessary, to

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[1] The full report, containing estimates, is entitled "The Gross National Wealth of the United States, by Major Sector and Industry". It is available at The Conference Board, 845 Third Ave., New York, N.Y. 10022.

prepare annual estimates of gross and net national wealth in current and constant prices, in considerable industry detail (32 groups) not now available from government statistical agencies; (2) to extend the basic estimates through the most recent period feasible, on a current basis, until such time as comprehensive and detailed "official" estimates are instituted; and (3) to provide quarterly estimates, not elsewhere available, for the private domestic business economy by major industry segment since 1948, and since 1968 for the component industry groups, as a tool for cyclical analysis.

Background and Sources for the Study

This section provides some background on wealth estimation in the United States, with particular reference to the more recent studies into which our project is tied. For insofar as possible, in the business sector we have used annual or periodic estimates from other sources referred to below. We then interpolated and extrapolated on a quarterly basis by methods explained in the next section.

Historical Developments

Between 1850 and 1922 eight "censuses of wealth" were taken in the United States. They were based largely on assessed values of taxable real and personal property, the scope of the estimates was uncertain, and little detail could be shown by type of assets by industry in the early censuses. The later censuses, and some private studies in the 1930s,[2] supplemented the assessment data by book value data from selected industry censuses and other sources. But there were still problems with valuations, detail was limited, and the estimates suffered from the lack of an economic accounting framework to provide a meaningful structuring of the estimates.

Spurred by the development of national income and product accounts, wealth estimates received much more attention after World War II. First, there was Raymond Goldsmith's pathbreaking work, which popularized the perpetual inventory method, resulting in aggregate national wealth estimates, by major type, as part of national and sectoral balance sheets 1896–1949, in *A Study of Saving in the United States.* He subsequently improved and extended the national wealth estimates, but did not go beyond the sectoral allocations to industry divisions.[3]

At about the same time, various researchers at the National Bureau of Economic Research were preparing estimates of investment and capital for most of the major industries of the economy except for the services sector. The resulting series of monographs, which appeared between 1955 and 1961, was capped by Simon Kuznets' summary volume, *Capital in the American Economy.* Kuznets produced his own estimates of aggregate capital by the perpetual inventory method, using the net investment components of his GNP estimates. Comparing

[2] Especially Robert Doane, *The Anatomy of American Wealth* (New York: Harper, 1940); and National Industrial Conference Board, *Conference Board Studies in Enterprise and Social Progress* (New York, 1939).

[3] See Raymond Goldsmith, *et al. A Study of Saving in the United States* (Princeton: Princeton University Press, 1955); and *The National Wealth of the United States in the Postwar Period* (New York: National Bureau of Economic Research, 1962).

his aggregates with the sum of the largely independent industry estimates (plus a rough approximation of the uncovered area), he found a fair degree of correspondence of long-term trends in fixed reproducible wealth, but significant divergences in decade-to-decade movements. It should be noted that the capital estimates for the commodity producing industries (agriculture, mining and manufacturing) had been obtained by the revaluation of asset data from Internal Revenue Service balance sheets or industry censuses. For the other industries the perpetual inventory method was used, as for the aggregate.

In *Productivity Trends in the United States* (1961), Kendrick adjusted and extended the Goldsmith estimates to provide total productive capital estimates for the U.S. by sector. He also drew upon and supplemented the NBER industry capital estimates to calculate capital-productivity and total factor productivity estimates for the private domestic business economy, by 33 industry groups. These estimates were later extended to 1969 and 1973 by the author, drawing on some of the subsequent work on capital, noted below.[4]

In 1963–64 Messrs. Goldsmith, Kendrick, and Creamer were instrumental in setting up, under a grant from the Ford Foundation, the Wealth Inventory Planning Study.[5] This group carefully reviewed all the existing data on wealth in the United States and recommended a program for developing more comprehensive benchmark data and continuing national wealth estimates by sector and industry, on a consistent basis, integrated with the national income and product accounts. The Economic Statistics Subcommittee, which held hearings and printed the group's report, in 1966 made positive recommendations to promote improved wealth data and estimates. Unfortunately, however, progress since then has been slow and spotty, particularly with regard to improvements in underlying investment and asset data.

Recent Developments and Sources for the Present Study

The most encouraging development has been the on-going work by the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce in preparing estimates of capital stocks in the U.S. private business economy and total residential capital.[6] Estimates of consumer durable stocks are near completion, and work has begun on public sector stocks. Net foreign asset data have been available for many years. Once land estimates have been added, BEA will have covered total tangible national wealth on a basis fully consistent with its national product estimates. The chief limitation of the BEA wealth project is that, within the private economy, industry breaks are limited to only three broad segments:

[4] See John W. Kendrick, *Postwar Productivity Trends in the United States, 1948–1969* (New York: National Bureau of Economic Research, 1973); also *The Formation and Stocks of Total Capital* (scheduled for publication by NBER in 1976).

[5] See *Measuring the Nation's Wealth* (Washington: Joint Economic Committee of Congress, 1964).

[6] Experimental work in capital stock estimates by BEA began in the 1950s, with occasional articles appearing on the subject during the 1960s in the *Survey of Current Business*. The most recent major publication is *Fixed Nonresidential Business Capital in the United States, 1925–1973* (Springfield, Virginia: National Technical Information Service, U.S. Dept. of Commerce, January 1974). See also "Stocks of Business Inventories in the United States, 1928–1971," *Survey of Current Business*, December 1972, and "New Estimates of Residential Capital in the United States, 1925–1973," *Survey of Current Business*, October 1974.

farming, manufacturing, and the nonfarm nonmanufacturing residual. We have used the BEA annual estimates for the major segments as a basis for quarterly estimates. But we had to go elsewhere for greater industry detail.

After the completion of the NBER monographs on capital in various industries, several investigators continued to work on an industry basis. Daniel Creamer, who had authored one of the NBER studies, continued to work on estimates of capital stocks in manufacturing industries at the 2- and 3-digit SIC levels at The Conference Board. In our work, we tie into his estimates at the 2-digit level through 1969.[7] For mining we have, ourselves, extended the NBER work, using the same basic sources and methods. In both mining and manufacturing chief reliance was placed for the annual estimates on revaluing asset book values.

For other industries outside the services sector, we tied into the estimates used by Kendrick in *Postwar Productivity Trends in the United States, 1948–1969.* These estimates, in turn, were extensions of the NBER series using estimates developed by Rayford Boddy and Michael Gort. Basically, Boddy and Gort developed industry fixed investment estimates from IRS balance sheet data, taking changes in year-end net assets and adding depreciation charges plus some other adjustments.[8] Gross investments were deflated, and converted to stock estimates by the perpetual inventory method.

In recent years, comprehensive industry capital estimates, in considerable industry detail, have been made by Jack Faucett Associates (JFA) on contract with U.S. Government agencies.[9] JFA has used much the same approach as Boddy and Gort. We have tied into the JFA capital estimates for the industries not covered in the Kendrick work: finance and insurance, real estate (nonresidential; for residential we rely on the BEA estimates), and services, exclusive of private nonprofit institutions.

An Appendix to the Conference Board report, available on request, gives a detailed description of the segmental and industry capital estimates used in the study.

Basic Methodology

Fixed Capital

Our method for estimating quarterly gross and net fixed capital stocks (structures and equipment) in constant and current prices is a short-cut version of the perpetual inventory method. It is made possible by the existence of annual or

[7]The estimates are still preliminary, and may be revised slightly before publication. For the basic approach, see his earlier work: Daniel Creamer, *Capital Expansion and Capacity in Postwar Manufacturing*, Studies in Business Economics No. 72 (New York: National Industrial Conference Board, 1961).

[8]See R. Boddy and M. Gort, "The Derivation of Investment Expenditure," and "The Derivation of Capital Stocks" (mimeographs); and "Obsolescence, Embodiment, and the Explanation of Productivity Change," *Southern Economic Journal*, April 1974.

[9]See Jack Faucett Associates, Inc. *Development of Capital Stock Series by Industry Sector* (Washington: Office of Emergency Preparedness, March 1973); also *Fixed Capital Stocks by Industry Sector*, 1947–70 (71), prepared for the Bureau of Labor Statistics (Chevy Chase, Md: Jack Faucett Associates, Inc., May 1975).

less frequent periodic stock estimates, together with quarterly gross fixed investment estimates in current and constant prices. The first step is to assemble the requisite stock and investment estimates for the various industry segments and groups, in terms of which our study has been conducted. The stock estimates were indicated in the previous sections, and are described fully in the Appendix.

The basic constraint on the degree of industry detail is the availability of quarterly investment estimates used to interpolate and extrapolate the annual investment series coordinate with, or used to derive, the outside stock estimates on which we relied. The chief source of the quarterly investment estimates is the BEA survey of expenditures for new plant and equipment. By using unpublished data from Conference Board surveys of capital outlays and appropriations, we were able to expand the BEA coverage of manufacturing to 20 industry groups. By using unpublished BEA data, we were able to cover 10 non-manufacturing industry groups, plus real estate and farming (not covered in the BEA survey). Price deflators were developed for the various industry investment estimates, since by the perpetual inventory approach one starts with real investment estimates at constant prices, and then reflates the stocks to current prices.

Given the periodic real gross and net stock estimates for the 32 industry groups and consistent annual and quarterly real investment series, the methodology may be summarized as follows. Implicit quarterly retirement and depreciation rates are computed for the years or longer time-intervals within which quarterly real stock estimates are to be interpolated. The rates are applied to the end-of-period real gross and net stock estimates, respectively, to estimate absolute real retirement and depreciation values. These are subtracted from real gross investment to obtain the changes in gross and net stocks on a quarterly basis. The changes are added to the real stocks at the end of the previous period to obtain the real stocks at the end of the first succeeding quarter. This procedure is repeated quarterly for the rest of the period (annual or other), and for succeeding periods up to the last benchmark stock estimate. Beyond this, the retirement and depreciation rates for the last period are used in conjunction with the real gross investment estimates to "unwind" the real gross and net stock estimates through the last quarter for which investment numbers are available.

In algebraic terms, our procedure may be expressed as follows, first with regard to net stocks. Note that all absolute variables are in real terms, and that the stocks relate to the ends of time periods, and the flows are the real values during the time periods.

$$NK_t = NK_{t-1} + GI_t - D_t \tag{1}$$

and

$$D_t = dNK_{t-1}, \tag{2}$$

where NK = net capital stock at the end of time period t, GI = gross investment during time period t, D = depreciation charges during t, and d = depreciation rate. Given the values of the initial net stock, gross investments, and the depreciation rate, we can generate the restock value in time t.

Similarly, for real gross stocks the expressions can be written as:

$$GK_t = GK_{t-1} + GI_t - R_t \tag{3}$$

and

$$R_t = rGK_{t-1}, \tag{4}$$

where GK = gross capital stock at the end of time t, R = retirement, and r = retirement rate. Gross stock in time t can also be computed given the initial stock, gross investments, and the retirement rate.

Substituting equation (2) into (1) gives

$$NK_t = GI_t + (1-d)NK_{t-1}. \tag{5}$$

Successively lagging this expression and substituting, we have

$$NK_t = \sum_{\tau=0}^{n-1} (1-d)^{\tau} GI_{t-\tau} + (1-d)^n NK_{t-n}, \tag{6}$$

where n = the length of time period considered, and n = 1, 2, . . . and τ = time lag. Given the observed values of the NK's and GI's, equation (6) becomes an nth degree polynomial with d as the unknown. In other words, for a time period n, if we know the value of the initial stock NK_{t-n}, the value of the terminal stock NK_t, and the value of gross investments for all intervening time periods, we can compute the value of the implied depreciation rate d by solving the nth degree polynomial. We can easily obtain the value of d by a computer, using an iteration procedure.[10] As long as the stock data are consistent with the corresponding investment data we can find a unique value of the implied depreciation rate for a period n. Similarly, the retirement rate can be computed by solving the following expression:

$$GK_t = \sum_{\tau=0}^{n-1} (1-r)^{\tau} GI_{t-\tau} + (1-r)^n GK_{t-n}. \tag{7}$$

Our methodology implies that, for a given length of time, data on the initial and terminal stocks and gross investment are all that are required for the estimation of stocks of the intervening time points.

The accuracy of the quarterly stock estimates obtained using this method depends upon the stability of the depreciation and retirement rates implied by the benchmark stock and investment estimates (taking these as given) during the periods being interpolated and extrapolated. Since the depreciation and retirement rates for structures and equipment (or for both together) reflect the rates on the component types of structures and equipment, in effect we are assuming that the stock components change only slowly in relative importance and/or that changes tend to be offsetting. This seems a reasonable assumption for broad industry groups for periods of a year, or even several years. The annual detailed perpetual inventory estimates confirm that the implied aggregate depreciation and retirement rates change only slowly. The implied annual rates derived from revalued asset data are much more erratic due to occasional (rather than smooth) revaluations and capital adjustments in the book value data. This is why we use rates based on census year data spanning 4 or 5 years for interpolations and extrapolations of capital stocks in manufacturing and mining for which asset data

[10]A computer program for this procedure by K. S. Lee is available at The Conference Board.

are used. It is clear, however, that the extrapolated quarterly stock estimates should be revised periodically as new benchmark stock estimates, and possibly revised investment estimates, result in more accurate depreciation and retirement rates. At this point, former extrapolations now become interpolations.

The revaluations of the real stock estimates should, ideally, be based on interpolations of the implicit deflators for the stocks, using relative weights of the stock components, not the investment components, since the composition of investment and stocks for an industry would be identical only by coincidence. In practice, however, the implicit investment deflators are used for interpolation and extrapolation of the stock deflators. This procedure is subject to more possible error in the case of extrapolation, since there would be no correction for the effect of differences in composition until a new set of benchmark stock estimates became available.

Finally, it will be noted that the sums of the fixed capital estimates for the component industry groups within manufacturing and non-farm non-manufacturing segments do not exactly equal the BEA aggregates, since they are based on different sources. Because the BEA estimates are carefully prepared and are fully consistent with the income and product flows, we use these in analysis of the segments, and in aggregating to the business economy totals (and on up to national wealth, in our full study). However, we do not force the estimates for the industry components within the manufacturing segments to equal the BEA aggregates. Rather, we use the industry capital estimates as they stand in computing capital coefficients, capital/labor ratios, and the industry composition of the segment aggregates. The ratios of the industry aggregates to the BEA estimates for the manufacturing segment are quite stable, but they decline somewhat for the non-manufacturing segment. Obviously, a desirable major project for the future will be to try to reconcile the two sets of estimates, and to derive estimates for the industry components and the aggregates on a consistent basis.

Inventories and Land

With respect to business inventory stocks, the year-end estimates are those published by BEA for farming, manufacturing, trade, and other, based on census and sample survey data. For these broad segments, interpolation and extrapolation of real stocks was carried out simply by accumulating the quarterly real net inventory changes (components of GNP) from the latest year-end estimate. Revaluations involved not only the current dollar value of the real change, but also the estimated appreciation of the preexisting stocks during successive quarters. The stock estimates for manufacturing and the "other" segments were allocated among the component industry groups by book value data as described in the Appendix.

Annual estimates of the value of farm real estate are published by the U.S. Department of Agriculture[11] based on census and survey data. The value of farmland represents the total less the value of structures. The current value

[11]Economic Research Service, U.S. Department of Agriculture, "Farm Real Estate Market Developments," annual issues and supplements.

estimates were deflated by an index of the average value per acre, from the same source. Both the current and constant dollar estimates were linearly interpolated and extrapolated quarterly, since the constant-dollar series showed very little change from year to year, and quarterly price data do not exist. The value of mineral lands was likewise based on census data and deflated, as explained in the detailed notes.

The annual land estimates for manufacturing and component industries were taken from Daniel Creamer, and those for nonfarm non-manufacturing were estimated from the IRS corporate income tax returns by Creamer's method. The constant dollar land estimates were obtained by applying the base-period (1958) ratios to fixed capital to the quarterly real stock estimates. The current dollar series were, in effect, interpolated and extrapolated quarterly by the current dollar stock estimates. It is generally agreed that the non-farm land estimates are the weakest of the several components of tangible capital, since there is only fragmentary data on the areas and prices of non-farm site land in various categories.