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I

Errors in Estimates of GNP and Its Components

Gross national product estimates have been published on a current quarterly basis since 1947. They are built up from detailed component estimates. In the absence of a reporting system designed for GNP estimation, most of the data underlying the components are collected primarily for other purposes. The majority are government produced statistics and many are merely the by-product of administrative requirements. As a consequence, there is little opportunity for over-all quality control: The primary data differ in how up-to-date or frequently available they are and in how directly they measure components based on them.

The Office of Business Economics (OBE) of the Department of Commerce assembles the diverse and detailed information and from it constructs the national accounts estimates. The form of the accounts as we know them today was established in the major revision of 1947. At that time they were set more firmly into an accounting framework and separate estimates of both income and expenditures (product) accounts were constructed.

The statistical discrepancy is the item in the accounts which reconciles the income with the product estimates. Although the two estimates are not strictly independent inasmuch as some components of each rely on common data, they nevertheless provide the OBE with an important tool for controlling error. If a comparison reveals an unusually large discrepancy, it signals the presence of unusual error in one set of estimates or the other. An attempt is made to trace the source of error and eliminate it before the estimates are published.

Despite the usefulness of the discrepancy as a check on accuracy, measurement errors are of course present in the published statistics. The successive revisions of the estimates are designed to reduce these errors. To illustrate the types of error that the estimates may contain and the potential for reducing them, the section begins with a brief review of the data and methods used to construct GNP. Some of the sources of measurement error, the types of error that the revisions can be expected to eliminate, and some of the properties of these errors are then discussed.

Data and Methods Used in GNP Estimation

In the absence of a single body of comprehensive reports giving the income and expenditures accounts of consumer, producer, and government units, the national accounts estimates must be built up item-by-item from data obtained from a variety of sources.⁵ Though the specific estimating procedures are exceedingly detailed and complex, estimation of the value of the majority of goods and services produced by the private sector of the economy consists essentially of two steps: (1) deriving benchmark estimates from detailed and comprehensive data for years in which such data are available; and (2) interpolating the estimates between and extrapolating them beyond benchmark years by means of related, continuous series.

The benchmark estimates for commodities are derived by the complex and rather roundabout "commodity flow method." This method, first developed by Simon Kuznets,⁶ involves numerous estimating steps. First, the several thousand categories of commodities reported in the industrial censuses are classified as final or intermediate products, depending on the degree of processing and the use to which the goods are put. The final commodities are then allocated to either consumer or pro-

⁵ A new publication is due shortly; at present, the sources for detailed descriptions are *National Income, A Supplement to the Survey of Current Business*, U.S. Dept. of Commerce (OBE), Washington, D.C., 1954, and *U.S. Income and Output, A Supplement to the Survey of Current Business*, U.S. Dept. of Commerce (OBE), Washington, D.C., 1958. For a short account, see Richard and Nancy D. Ruggles, *National Income Accounts and Income Analysis*, second edition, New York, 1956, Chapter 8.

⁶ *Commodity Flow and Capital Formation*, New York, NBER, 1938.

ducers' durables categories. The estimates must next be raised from producers' prices to final user expenditure levels by adding transportation costs, trade markups, and taxes. Finally, adjustments are made for exports, imports, and inventory changes. This laborious procedure of tracing the flow of commodities through each stage of the economic process—from production to wholesale and retail distribution to final purchasers—was adopted primarily because there were very detailed and comprehensive data available at the production level (the Census of Manufactures), but by comparison a small amount of such data at the wholesale and retail levels.

The data used to interpolate and extrapolate the benchmark estimates, other estimation methods, and the data underlying other GNP components are briefly described below.

PERSONAL CONSUMPTION EXPENDITURES: COMMODITIES. The Census of Manufactures is the main body of the data underlying benchmark estimates of consumer expenditures on goods. The estimates derived from these data by the commodity flow method have accounted for somewhat over 80 percent of consumer goods. Estimates of expenditures for other consumer goods (automobiles, gasoline, oil, other fuel, and tobacco products) are obtained by multiplying estimated quantities purchased by the appropriate average retail prices (the retail valuation method). The values of relatively minor items (food and fuel produced and consumed on farms and standard clothing issued to military personnel) are imputed.

The large body of retail sales data are principally used to interpolate the benchmark estimates between and to extrapolate them beyond census years, though some use is also made of state sales tax, federal excise tax, and trade association data. Retail sales by type of store are prepared by the Bureau of the Census from sample surveys. The data underlying the quarterly estimates are essentially the same as those used for annual estimates. The major difference is that advance sample returns are used for the provisional quarterly estimates.

Some shortcomings in the procedure of using retail sales to move the benchmark estimates from one census period to the next were revealed in the major revision of 1958. This revision incorporated new benchmarks derived from the 1954 Census of Manufactures. Comparison of the extrapolations for 1954 with the new benchmarks showed that,

though the over-all totals agreed quite well, there were substantial differences among commodity groups. Tests based on the 1954 Census of Retail Trade indicated that the difficulty stemmed mainly from the use of retail sales data by type of store to estimate changes in consumer expenditures by commodity line.⁷

The practice of deriving secondary benchmarks from the Census Bureau's Annual Survey of Manufactures by an abbreviated commodity flow procedure was therefore instituted. These benchmarks, which are updated from year to year, are designed to help in spotting any biases that may be developing in the current extrapolations.

PERSONAL CONSUMPTION EXPENDITURES: SERVICES. No single body of comprehensive data such as that underlying the goods estimates is available for services. Estimates for the various categories of consumer services utilize a variety of heterogeneous sources. Estimates of the rental value of homes (nonfarm and farm) are benchmarked on the Census of Population and Housing and the Census of Agriculture. Expenditures for domestic service (cash payments and value of meals furnished) are based on wages paid. Outlays on household utilities are estimated from comprehensive annual reports of trade associations. Transportation expenditures are estimated from the annual report data of government agencies such as the Interstate Commerce Commission and the Federal Aviation Administration. Expenditures for professional services are benchmarked on sample information such as surveys of consumer expenditures, data from various professional associations and the Internal Revenue Service. Benchmark estimates for many other services such as auto and appliance maintenance and repairs, laundry, recreation, etc.

⁷ Another difficulty arose when the estimates based on the new 1954 benchmark were fitted into the national accounts. The revised aggregate expenditures estimates considerably exceeded the income estimates, creating a large, positive statistical discrepancy throughout the 1948-54 period. It was decided to allocate the discrepancy rather than publish the revised estimates as they stood with their obvious shortcomings. Upon thorough review, it was concluded that the error could be attributed to the consumption estimates and they were accordingly reduced. A major factor in the decision was the fact that there is no body of data for the consumption estimates that is comparable to the highly reliable wage and salary component of the income estimates. In effect, consumption expenditures were estimated as a residual: personal disposable income less personal saving. (For a detailed account of the problem and its resolution, see *U.S. Income and Output*, Chapter 8, pp. 74-76).

are derived from the Census of Business. Other source data include the Census of Religious Bodies and the Biennial Survey of Education.

Though fairly reliable and comprehensive annual data for services are available from various government agencies and private sources, data for the quarterly estimates are much less satisfactory. Series used to interpolate and extrapolate estimates of the various service components are usually indirect measures of the particular component. Some extrapolations rely on estimated quantities multiplied by the relevant component of the BLS Consumer Price Index; others use payroll or employment data.

NEW CONSTRUCTION. Monthly series on new construction activity are prepared by the Bureau of the Census. Prior to 1959, they were prepared jointly by the Bureau of Labor Statistics and the Business and Defense Administration. Estimates of the construction component of business fixed investment—except farm and public utility construction and oil and gas well drilling—are principally derived from the monthly reports on contract awards issued by the F. W. Dodge Corporation. Data on building permits and reports on contract awards appearing in trade journals were used for geographical areas not covered by the Dodge series. Though the geographical coverage was expanded to the western states in 1956, the Dodge series must still be adjusted for undercoverage. Public utility construction is estimated from direct reports of work done or paid for from federal regulatory agencies, private corporations, and trade associations.

The 1950 benchmarks for nonfarm residential construction were developed from the 1950 BLS Survey of Consumer Expenditures and the Federal Reserve Board's Survey of Consumer Finances for 1951. Benchmark estimates are interpolated and extrapolated by series on building permits.

A difficulty in using the data on contract awards and building permits is that they must be adjusted to a work-put-in-place basis. This adjustment requires estimating (1) the varying time lags between the award of the contract and the start of work and (2) the variation in the rate of work progress after the start. Though the timing adjustments reduce the reliability of the annual estimates, the effects are even more serious for the quarterly estimates.

Comparisons of the housing statistics with information from the 1956

National Housing Inventory and the 1960 Census have revealed substantial underestimation of the number of dwelling units built in the postwar period. These findings led to large revisions in the estimates of residential construction activity by the Census Bureau after it assumed responsibility for compiling these series. The revised estimates were incorporated into the national accounts in the major revision of 1965.

PRODUCERS' DURABLE EQUIPMENT. Benchmark estimates of expenditures on producers' durable equipment are built up from the Census of Manufactures by the commodity flow method. Business passenger cars are the only sizeable component for which this method is not followed. Commodity flow estimates of producers' durables for other years are derived from the Census Bureau's Annual Survey of Manufactures, which was initiated in 1950.

The quarterly estimates are derived largely by interpolation and extrapolation of the annual estimates by an adjusted series based on the OBE-SEC Plant and Equipment Survey.⁸ Since the quarterly figures on actual plant and equipment expenditures are not available in time for the provisional estimates, these estimates are based largely on the series of anticipated outlays.

CHANGE IN BUSINESS INVENTORIES. Tax return data compiled by the Internal Revenue Service and published in *Statistics of Income* are the basic source of information on business inventories. Returns for the corporate sector are available on an annual basis, but with a considerable publication lag.⁹ Data for the noncorporate sector are available periodically from IRS and Census Bureau tabulations.

The reported data on business inventories require substantial adjustment to bring them to the national income concept of the change in inventories. Estimates are made, on an industry basis, of the portions of

⁸ These data are collected in regular quarterly and annual surveys. They cover the whole of the private economy except for agriculture, professional practitioners, nonprofit institutions and finance, insurance, and real estate. The survey data are not directly incorporated into GNP because separate data are lacking for the noncovered sectors. Moreover, the survey does not provide a regular and comprehensive breakdown of expenditures into the separate categories of plant and equipment.

⁹ Prior to 1958, the lag was about two and a half years. It was reduced by one year in 1958, when *Business Indicators*, a series of reports by IRS, was initiated. They contain advance information derived from samples of the data published later in complete form in *Statistics of Income*.

inventories that are reported on a LIFO and a nonLIFO basis. The nonLIFO inventories are then deflated by the relevant price components of the BLS wholesale price index and the change in the deflated beginning and year-end inventories is computed. This change is converted to current dollars to obtain the current value of the change in the volume of inventories. The adjustment procedure differs for inventories reported on a LIFO basis. Increases in LIFO inventories require no adjustment; decreases, however, require a conversion to current prices. Farm inventories are calculated by the Department of Agriculture according to the national income accounting concept.

Quarterly movements in the book value of inventories for manufacturing and trade are based on monthly sample data. Data for other components of nonfarm inventories are derived from the SEC quarterly reports on "working capital of United States corporations." These reports, however, are not available in time to be included in the provisional estimates. Farm inventories data are available only on an annual basis; quarterly estimates are obtained by fitting a smooth curve through the annual data.

NET EXPORTS OF GOODS AND SERVICES. These estimates are part of the regularly issued balance of payments reports. However, because of lags in source reporting, publication of the quarterly reports is not synchronized with GNP publication. The provisional estimates are therefore based on incomplete data.

GOVERNMENT PURCHASES OF GOODS AND SERVICES: FEDERAL. The basic sources of data are the annual Budget of the United States Government, the Daily Statement of the United States Treasury, and the Monthly Statement of Receipts and Expenditures of the United States Government. Some of the information used to convert these basic data to a national income accounting basis, however, is not available on a quarterly basis, or is not available in time for the provisional estimates.

GOVERNMENT PURCHASES OF GOODS AND SERVICES: STATE AND LOCAL. The major source of information is the summary statistics on state and local finances which are collected by the Bureau of the Census. These are essentially budgetary data and they require numerous adjustments to fit them into the framework of the national accounts.

The data underlying the quarterly estimates are reported payroll and

construction outlays. Other categories of purchases are estimated on the basis of their past relationship to payrolls.

Types of Errors and Potential of the Revisions

Though the preceding sketch would hardly enable one to replicate the estimates, it is sufficient to illustrate that they are highly manufactured products. The resulting measurement error is therefore a conglomerate of errors whose magnitude is exceedingly difficult to determine.¹⁰

By way of contrast, it would be a fairly easy matter to assess the errors if GNP estimates were generated by a probability sampling process. For example, it would then be possible to attach confidence intervals to the estimates. Moreover, if the revisions represented a successive enlargement of a sample drawn from the same universe, there would be strong grounds for supposing that they improve accuracy.

Sampling error, however, is a fairly unimportant source of measurement errors in GNP. The major errors arise from the many gaps in the primary data. As we have seen, the comprehensive data underlying many GNP components are available only at infrequent intervals and long after the fact. These data are used to construct benchmark estimates. To provide continuous, up-to-date, quarterly series, the movements of related series are used to interpolate between the benchmarks and to extrapolate beyond them. There are then four major sources of error in the provisional estimates: (1) errors in the benchmark estimates; (2) measurement errors in the related series; (3) errors arising from an inexact or misspecified relationship between the two variables; and (4) errors arising from extrapolations of past benchmark values.¹¹

¹⁰ The only estimates of error that have been made are those by Simon Kuznets and they refer to his estimates of national income (*National Income and Its Composition, 1919-1938*, Volume II, New York, NBER, 1944). Under no illusion about the reliability of his error estimates, he states flatly that the task is an impossible one. ("Were we able to ascertain the sign and size of error for any given estimate, we could, of course, correct for this error and there would be no need to retain it," p. 535.) His error estimates were expert opinions, expressed in quantitative form.

¹¹ For a general discussion of the defects of widely used methods of interpolation and the advantages of a method which takes account of the correlation between the movements of the two series, see Milton Friedman, "The Interpolation of Time Series by Related Series," *Journal of the American Statistical Association*, December 1962, and reprinted as NBER Technical Paper 16.

The provisional estimates are revised as additional data become available. Minor revisions are made as a result of revisions in the related series. For example, the preliminary figures on retail sales are advance returns from sample surveys, and they are revised on the basis of more complete returns. Similarly, anticipated outlays on plant and equipment are replaced with realized outlays.

The availability of new Census data (Manufactures, Population and Housing, etc.) permits the construction of new benchmarks. Incorporation of the new benchmarks into the estimates constitutes a major revision: extrapolations of the last benchmark are replaced with interpolations between the last and the new benchmark.

The revisions could therefore be expected to improve the accuracy of GNP estimates in two ways: the minor revisions would be expected to reduce the component of error attributable to measurement errors in the related series; major revisions would eliminate the error due to extrapolating the last known benchmark.¹²

¹² It is often contended that the mere fact that GNP estimates are revised offers no guarantee that the revised estimates are more accurate than the initial figures. It is shown in Appendix I, however, that the errors in the provisional estimates would be expected to exceed the errors in the revised estimates provided that (1) the error in extrapolating the last benchmark exceeds the measurement errors in the new benchmark estimate; and (2) revisions of the related series reduce measurement errors in these series. Errors in the last benchmark estimate would be a component of the extrapolation error. Thus, in the absence of any evidence that the accuracy of the benchmark estimates and data for the related series have deteriorated over time, it seems reasonable to conclude that extrapolations of the last benchmarks are less accurate than interpolations between the last and new benchmarks and hence to reject the contention that the revised estimates are no more (let alone *less*) accurate than the provisional estimates.