RELIABILITY CRITERIA FOR NATIONAL ACCOUNTS

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The reliability of national accounts is determined by the adequacy of a great variety of data sources and estimating methods. This inquiry focuses on major conceptual and methodological problems, and while it does not solve the reliability problem, it provides a framework for reliability analysis and suggests criteria for the evaluation of results; it also assists the producers of national accounts in determining the major trade-offs between different areas of possible data improvement.

1. INTRODUCTION

The comprehensive nature of national accounts usually requires the preparation of estimates from inadequate data. Some of these estimates are based on simplifying assumptions, imputations, and various other approximations; other components may be supported more completely by underlying data. Objective measures often must be supplemented by subjective judgments. The combined use of data of varying quality makes the assessment of overall reliability difficult.

Moreover, concepts, definitions, and estimating methods of national accounts change over time and differ from country to country. Although the UN system of national accounts has now been generally adopted, a close examination of national practices reveals numerous departures from international standards. A detailed description of sources and methods will not necessarily permit most users to assess the reliability. They usually do not have the required specialized knowledge. Some users may be perturbed by the nature of certain oversimplifying assumptions while others may be impressed by the complexity of methodology, erroneously inferring a high degree of reliability.

For the benefit of users, subjective quality ratings could be assigned to various components of national income. In an early study, Kuznets made subjective assessments of maximum possible errors.[1] Similarly, a system of subjective reliability ratings was also developed by the U.K. Central Statistical Office for its national accounts.[2] Although they are based on subjective judgments of experts (in whose opinion the true estimates lie within the rating limits with 90 percent probability), the ratings are nevertheless useful as a guide to less informed users and as a quick reference for the experts. The U.S. Office of Statistical Standards, in collaboration with the UN Statistical Office, has appraised national accounts of 64 countries on the basis of the extent and quality of the available basic data and subjective judgments regarding the meaningfulness of the estimating procedures employed.[3]

*The views expressed in this paper are those of the author and not necessarily of any institution or organization.

[1] [16], chapter 12.
[2] [5], pp. 33 ff.
[3] [23], pp. 40–43.

In recent years, two objective approaches for testing some of the revealed errors in national accounts have been introduced. First, the discrepancies between preliminary estimates and final data have been tested by several statistical methods. The second set of studies investigated the statistical discrepancy (or residual error) between the independent estimates of GDP derived by production and expenditure approaches. These tests examine only a small proportion of errors which affect the reliability of national accounts.

The present inquiry explores the possibility of developing reliability criteria for national accounts and underlying basic statistics. It examines the errors that arise throughout the entire process of data generation and use—from the point of conceptual abstraction of economic and social processes, to the accuracy and consistency errors of basic statistics and national accounts, and to the application errors of ultimate users of national accounts. The methods of testing the accuracy of basic data are reviewed and their application to the national accounts is considered along with the consistency criterion. The possibility of aggregating the various errors is discussed in the light of available alternatives. Finally, the results of reliability tests are further evaluated in terms of errors and biases which arise in the process of conceptual abstraction and in the use of national accounts.

2. The Reliability Concept

Measuring the reliability of national accounts was considered an "insoluble task" three decades ago,[4] and the search for adequate reliability measures still continues. While the complex nature of national accounts and of the underlying basic statistics makes it almost impossible to come up with a unique reliability criterion, it appears possible to establish partial criteria suitable for measuring the main elements of reliability. These criteria are discussed below in general terms before the problems of errors and biases in basic data and national accounts are considered.

Two major criteria measure the reliability: accuracy and consistency. Neither one of them yields conclusive results. Accuracy is defined as the discrepancy between the observed and the "true" values. Since the latter must usually be approximated, the results of accuracy tests may themselves be subject to errors and biases. The consistency criterion measures the discrepancy between two or more observed values, all of which could depart considerably from the "true" value.

Accuracy and consistency tests supplement each other as measures of reliability. Given a consistent conceptual framework, corresponding "true" values should also be consistent. Application of consistency tests may detect accuracy errors or biases although compensating and offsetting accuracy errors may reduce or completely eliminate discrepancies between observed values. Consistency tests provide merely methods for detecting deficiencies in accuracy. Consistency cannot prove accuracy. While consistency tests are suitable for national accounts, accuracy tests can be more easily applied to the basic data. A direct application of consistency tests to basic data is sometimes difficult. The direct use of accuracy tests in national accounts is almost impossible.

[4][16], pp. 535.

3. The Reliability of Basic Data

a. Accuracy of Basic Statistics

The reliability of national accounts depends largely on the accuracy of basic data. Given adequate basic statistics, required adjustments to the concepts of national accounts would be relatively small. A properly functioning system of basic statistics could be expected to determine the accuracy if not also the consistency of data generated by surveys and administrative data reports.

Accuracy is measured by the mean square error (MSE) which includes all systematic (biases), sampling, and nonsampling errors between the observations and the "true" value of the population parameter. Although we do not know the "true" value, we can approximate it from the observed values by estimating random and systematic errors.

The determination of random errors requires independent measurements under duplicated or "replicated" conditions. This may be difficult because repeated inquiries are likely to reduce random measurement errors. For determination of systematic errors, however, repeated inquiries present fewer problems because it is necessary to reconcile inconsistencies by comparing the original with subsequent responses. Thus, for the measurement of errors in an original data generation process, we need two additional measurements—a replication for measuring random errors and a reconciliation for measuring systematic errors.

In practice, all three data generation processes can be combined in a single operation by designing an appropriate sample for the measurement of errors. In addition to the original data collection process (which may be either a complete census, a sample survey, or an administrative data reporting system), random measurement errors may be determined on a sample basis in the same data collection process by incorporating equivalent items of information which respondents would be expected to provide without being aware of possible consistency checks. Having secured multiple measurements, the interviewer (or specially trained auditor or administrator) may proceed with the reconciliation to obtain the best possible estimate in order to determine systematic errors. In the case of large data collection operations, the determination of systematic errors may be carried out on a subsample basis by better trained and more experienced personnel, although the determination of random errors must be left to enumerators (or clerks in the case of administrative data) with the same qualifications as those who collect the original data. Therefore, it is possible for the original data collection process to include a random measurement, with follow-ups for the determination of the bias by more experienced interviewers (or administrators) who reconcile discrepancies.

The accuracy criterion must be distinguished from the concept of precision. While accuracy relates to the variance and the bias, precision is concerned only with the size of the variance, that is, with the estimated differences between the observed and the expected values. (This definition of precision is consistent with the spurious precision of an excessive number of significant digits shown for a figure of doubtful accuracy.) Thus, the accuracy criterion refers to the total variability between the unknown "true" value and the observations, while precision refers only to the unbiased portion of this variability.

The concept of the mean square error has been explored theoretically[5] and some attempts have already been made to estimate its major components for some surveys and censuses.[6] The application of the MSE concept to national accounts is beset with problems. Before considering them, it is helpful to review briefly the use of MSE and its components in basic statistics.

The accuracy of a mean derived from a random sample is measured by the MSE, which is defined as the expected value of the squared deviations in observations from the "true" mean. The MSE can be disaggregated into a total variance and the square of the bias. The total variance can be decomposed into a sampling variance, a response variance, and a covariance among response deviations within a replication trial.[7]

The response variance can be further disaggregated into simple response variance, which measures the contribution to the total variability for a given item in a sample, and into the correlated response variance which measures the contribution of the correlation between the responses of two items in a sample.

The MSE can also be disaggregated in several other ways. The response error can be further broken up to determine the bias, simple response variance, and correlated response variance attributable to differences in interviewers. Similarly, processing errors can be estimated independently for editing, coding, and card punching. Each of them can be decomposed into bias, sampling variance, simple (editing, coding, etc.) variance, and the correlated editing or coding variances which arise from differences among editors or coders within the same sample.[8]

Although the estimation of errors in basic statistics need not concern us here, it is nevertheless helpful to review these errors briefly and to indicate the practical methods for their measurement. The total observed variability in basic data cannot be taken as a measure of total error because some of the observed variability is due to the variance in the "true" values of the parent population. Moreover, the omissions and nonresponse due to the deficient coverage are only indirectly reflected in the observed values by affecting the sampling and some nonsampling errors.

b. Nonresponse and Omissions

These nonsampling errors usually tend to understate the basic data from which the national accounts are constructed. Statistical frames of sample surveys, census listings, and administrative data reports tend to be incomplete. Some establishments and persons escape the attention of government agencies; others fail to respond and provide the requested information. Thus, it has been estimated that the U.S. census of population has missed about five million people. Lists of establishments are also hardly ever complete although the direction of bias is less certain here because, in some countries, the lists contain nonoperating and even nonexistent establishments. In the experience of the World Bank, external debt data provided by creditor countries tend to exceed those reported by debtor

[5][12], pp. 51 ff.
[6][24].
[7][13], pp. 359–374.
[8][25], pp. 3 ff.

countries. Also, exports reported by the exporting countries tend to be larger than corresponding imports reported by the importing countries, and so forth.

Major surveys and censuses are usually followed by postenumeration quality checks and nonresponse sample surveys which determine the causes and the extent of nonresponse and omissions. Similar quality checks may be made for administrative data reports. The results of these statistical inquiries can be used for revising the data or at least for estimating the direction and the magnitude of biases. Some imputations of missing data can be made even in the absence of nonresponse surveys; for example, on the basis of incomplete information available or the reports for past years. However, in view of the limited resources of many statistical agencies, the nonresponse and omissions are often disregarded and the necessary corrections and imputations for them are not made.

The upward adjustment of basic data for nonresponse gives rise to additional errors of its own. Since the magnitude of bias cannot be estimated with great accuracy, the adjustment for bias may fall above or below the "true" value, giving rise to adjustment errors. These errors should be smaller than the bias; otherwise, the adjustments are not justified.

c. Response Errors

The reported data contain errors and usually also a downward bias. The respondents either lack adequate knowledge or are motivated to provide biased information. Poorly trained census enumerators and clerks preparing administrative reports may contribute to response variance by making erroneous assumptions and drawing wrong conclusions. Consistent interviewer attitudes may introduce interviewer biases. Establishment reports may contain errors and distortions of business accounting. Administrative data reports sometimes contain response biases and classification deficiencies because they are designed for administrative purposes and not necessarily for collecting statistical information. Response errors may extend even to data processing as in the case of coding errors resulting from inadequate descriptions of industrial or occupational characteristics. While it is impossible to measure accurately all these errors, their impact on the reliability of basic statistics can be estimated.

In principle, the measurement of response errors should be based on a sample of independent responses obtained under the same conditions from the same respondent. This is usually not possible because the respondent would remember his previous answers and would make the same statements if the responses are obtained at frequent intervals. If the time interval between successive responses is increased, changing conditions make it difficult to separate response errors from the actual changes. To obviate these difficulties, just two measurements on each of many respondents can be made and an average difference between the two measurements computed for all respondents. A further simplification can be introduced by incorporating equivalent questions which may permit derivations of the response variance, such as the questions on the various components of income, expenditure, and saving in personal expenditure surveys.

The standard which is suitable for measuring variances cannot also be used for determining response biases. For measuring variances, the conditions of the

original response must be replicated as closely as possible to eliminate or minimize the effect of the response bias. Any attempt to reconcile the differences between two sources may reduce the response variance. It has been estimated that a reconciliation of responses by investigators may understate the simple response variance by as much as 40 percent.[9]

For random errors, the time elapsed between two measurements must be short enough to avoid a change in observed phenomena and yet sufficiently long for the respondent to have little recollection of his previous responses. The same kind of personnel, workload, questionnaires, and data processing should be used in the replication sample survey for determining random measurement errors as in the original data generation process. The creation of replication conditions is usually difficult and costly. Using random interpenetrating subsamples, however, most of these difficulties can be avoided.

For measuring the response bias, the most reliable rather than the most comparable measurement results are needed. In order to obtain the most reliable responses, superior personnel with more intensive training and longer experience may be employed. Instead of avoiding any references to the original response, interviewers (or administrators) investigating the bias may obtain more information by reconciling responses with direct observation, repeated questioning, consistency checks of related items, and responses obtained in previous reports. Alternative sources of information (employers, suppliers, tax records) may be checked to determine the reliability of results.

If a choice is to be made between the determination of simple response variance and the measurement of response bias, the latter should be given preference. The determination of the response bias goes a long way toward the measurement of the most reliable responses. The measurement of the simple response variance depends on several unrealistic assumptions, such as the replication of the same reporting conditions, and on complete independence of the successive responses. The absence of independence reduces the simple response variance. The obvious futility of subsequent attempts to replicate the original conditions should be recognized and the postenumeration survey should be directed toward obtaining the most reliable information which could be used as a standard for measuring the response bias.

d. Sampling Errors

In a properly designed probability sample survey, sampling errors can be controlled by sample size. For limited inquiries conducted in an effort to fill various minor data gaps in the national accounts, sampling errors may be relatively large and more difficult to estimate. Nevertheless, the reliability of sampling results can be determined without much difficulty.

e. Processing Errors

Correcting for nonresponse and response errors, checking of inconsistent reports and editing of incomplete and wrong answers, imputing missing items,

[9] [2], pp. 41–63 and [26], p. 1.

coding, punching of cards, and other handling of data by technicians and statistical clerks introduce further errors and biases. Inadequate training or a faulty design of checking procedures may result in systematic errors. A partial loss of some records and inappropriate coding of others may remain undetected and thus contribute to biases.

The use of statistical quality control methods and independent control groups may be helpful for determining processing errors. Thus, coding errors can be determined by assigning identical questionnaires to several equally qualified coders, matching the coded results, and analyzing the discrepancies. However, the sampling errors derived from the quality checks of, for example, editing and card punching may not be readily aggregated with each other or with the sampling errors of surveys. Although both of them—the response and the processing errors—contribute to the variability of data, the statistical universes are not independent and the sampling units may not be comparable.

4. Accuracy of National Accounts

a. Problem of the Accuracy Criterion

The accuracy criterion for testing the reliability of national accounts can be defined by the difference between the estimated and the "true" values which could have been derived with present knowledge and given estimating techniques of national accounts. The application of this accuracy criterion to national accounts encounters major difficulties, however.

Although in principle we can conceive an MSE composed of biases and variances, their measurement must largely be based on subjective judgments rather than on objective statistical methods. Even if it were possible to engage several equally qualified experts who could prepare independent estimates of national accounts, the difference between these estimates could not be readily used for estimating the error variance over all the different types of estimating procedures and adjustments. However, grouping the latter into more or less homogeneous strata (e.g., value added estimates by agricultural crops, value added by two-digit manufacturing industries) and applying standard national accounts estimating techniques to the same basic data, estimating variances could be computed for each stratum.

If it were possible to assume that the adjustment variances were due to random factors and the national accounts estimates had expected values which could be measured by error variances, the measurement of estimation biases would still remain insurmountable. In principle, it may be possible to obtain more accurate estimates by relaxing the independence condition and attempting a reconciliation between the various estimates prepared independently by the experts. In practice, however, the reconciled estimates would be accepted and their accuracy would remain untested. It may only be possible to use the latest estimates as the most accurate standard available for past periods. This approach is considered below.

b. Revisions as Standards of Accuracy

Disregarding preliminary estimates, it is possible to regress the final estimates of the past periods on the latest available final estimates for the same periods and use the resulting equation for estimating the accuracy of current national accounts. This procedure assumes that improvements in accuracy are made gradually over the years and past relationships can be used for estimating present and expected future relationships between the current national accounts and their "true" values, the latter being defined in relation to present knowledge and estimating techniques.

The major difficulty with this approach consists in the definition of accuracy and "true" value in relation to "present knowledge and estimating techniques." An additional difficulty arises when revisions for recent years are relatively smaller than those for earlier years. In this case, the latest estimates for the recent years may have to be excluded because the relatively small revisions would tend to overstate accuracy. This introduces a subjective element into the estimating procedure because there appears to be no objective method for distinguishing between major and minor revisions. Nevertheless, past revisions may be used as a guide for estimating the future revisions which may affect the present estimates. Using projected knowledge and the extent of likely revisions, we may use past revisions for determining "true" values which correspond to the current estimates of national accounts. This procedure is also not free from subjective judgments, however. Depending on how far we look into the future, we may have several standards for "superior" estimates and several approximations to the "true" values. Moreover, some revisions for early years may have been done as "quickies."

c. Adjustment and Judgment Errors

In the absence of objective methods, the accuracy of national accounts can be determined by estimating, mostly subjectively, the size of judgment and adjustment errors between the basic statistics and the estimates of national accounts. Adjustment of basic statistical data to the concepts and definitions of national accounts constitutes a major source of errors. Whether the adjustments add or subtract a certain amount, it is usually possible to determine the relative size of the adjustment in relation to the adjusted variable or in relation to national income. Thus, the allocation of new motor vehicles to business use may introduce a source of error in the estimate of capital formation. The maximum size of this error would not exceed the value of all new motor vehicles. This value, expressed as a percentage of total capital formation, represents the upper limit for this adjustment error.

This exaggerated error estimate can be reduced by disaggregation to a more tolerable level. To the extent that no subjective judgments enter into the disaggregation, the percentage of the adjustment to the adjusted aggregate of national accounts would measure objectively the maximum adjustment error for the component. Computed as a percentage of total national income, the relative adjustment errors could be made comparable.

Subjective judgments may further reduce considerably the size of adjustment errors although the use of judgments would result in subjective adjustment errors. The latter could be somewhat improved by taking an average of several adjustments based on subjective judgments of independent estimators—a method used by Kuznets for determining the total reliability of national accounts.[10]

Inasmuch as some adjustment errors may offset each other, adjustment errors could not be aggregated meaningfully and it would be necessary to classify them by type (objective and subjective) and by size (major and minor). Adjustment errors which arise in the disaggregation and disappear in the subsequent aggregation could be shown for components but not for the totals. A count of the adjustment errors could be supplemented with their average relative size.

Apart from determining the limits of adjustment errors, judgment errors arise from the use of inappropriate estimating techniques. Assuming present knowledge of data and estimating techniques, judgment errors would either remain undetected or if discovered, could in most cases be corrected. Sometimes corrections are not possible. Some judgment errors may be discovered too late to be corrected; others may be recognized in time, but the alternative correct procedure may be rejected for a variety of reasons (e.g., excessive cost).

Judgment errors can be estimated by considering the effect of alternative judgments on the national accounts components. While adjustment errors relate to errors of commission, judgment errors include both—errors of commission and of omission. Adjustment errors are more akin to statistical variances in the sense that the adjustment is made to the point where the bias is eliminated and a certain range of uncertainty surrounds the estimate. The judgment error, on the other hand, is likely to involve a bias if unnecessary adjustments are made or necessary adjustments are erroneously omitted.

A direct estimation of judgment and adjustment errors by determining the size of alternative estimates has several advantages. Thus, there is no need for independent estimates by several experts. The same national accounts expert can consider the alternative estimates and determine the size of possible errors. Moreover, errors can be determined without reference to earlier years. The main disadvantage of this procedure is the subjective evaluation by a national accounts expert.

5. Consistency Criteria

Being constructed from a variety of different sources, national accounts usually show inconsistencies, at least at the early stages of their compilation. External inconsistencies can be observed between the estimates of national accounts, basic data, and other derived data systems. Internal inconsistencies may arise as a result of double-entry accounting for the same period of time (e.g., a statistical discrepancy between total value added by production and total final demand expenditure), between related aggregates of national accounts over time

[10][16], chapter 12.

(inconsistent growth rates), or both simultaneously. Internal and external inconsistencies may originate either in data inaccuracies or they may sometimes arise independently of basic data accuracy, as a consequence of estimating methods.

The inaccuracies of basic data usually prevent the compilers of national accounts from achieving consistency. Being unable to determine the inaccuracies in the basic data, they can either show explicitly the statistical discrepancy (or residual error) in the national accounts or try to allocate it to the least accurate (and if possible the largest) components. The ideal situation of accurate basic data and of consistent national accounts can hardly ever be achieved.

Inconsistencies are not an indication of the total error by which the reliability can be determined. Nevertheless, large inconsistencies in national accounts provide an indication of their unreliability. Small inconsistencies, on the other hand, do not necessarily indicate greater reliability. Thus, consistency provides only a negative and an imperfect test of reliability for the national accounts. This is particularly true of international comparisons which attempt to deduce the reliability of national accounts from the similarities in their relative structure.

Analyzing some 100 countries over twenty years (1950–70), the World Bank has recently derived expected values for major macro-economic variables and social indicators. These values result from regressions which use GNP per head, population, foreign capital inflow, and time as independent variables. Dependent variables include, among others, five major expenditure components as percentages of GDP and value added by industrial origin. Being grouped by two categories of countries (with either more or less than 15 million population in 1960), the expected values and the corresponding standard errors of estimate provide a basis for rough consistency checks for major structural relationships of national accounts. If as a result of such a consistency test the observed value falls outside the limits set by the corresponding standard error, its consistency and accuracy can be investigated further by country economists and national accounts experts.

The statistical discrepancy between the expenditure and production approaches has been studied repeatedly in several countries in order to shed more light on the reliability of national accounts. The periodic revisions of preliminary estimates have also been investigated in an attempt to measure the usefulness of preliminary estimates for forecasting purposes. In both instances, most findings indicated that the errors were statistically and analytically insignificant. These findings, however, are not conclusive with respect to the total reliability of national accounts.

a. External Consistency

The relevant basic statistics and other derived data systems (e.g., balance of payments, government accounts, input–output tables) should be consistent with national accounts to the extent that they measure the same economic activity. However, the related data need not be identical because of the differences in definitions which give rise to spurious external inconsistencies. Adjusting the data to comparable definitions—if a reconciliation is possible—reveals the extent of the real external inconsistency.

The external consistency of national accounts can be tested on a component-by-component basis. For data from which the national accounts have been derived, the external consistency is determined by the existing adjustments. Consistency with other related data can be established by making the necessary adjustments. These adjustments are often quite complex and may themselves be subject to a considerable margin of error. Thus, exports and imports in national accounts may not be directly comparable to those shown in the balance of payments. The former often relate to the movement of goods and services across international borders while in the latter, exports and imports may relate to payments. In an attempt to reconcile the two data systems, the United Nations and the International Monetary Fund have adopted the change-of-ownership criterion. In practice, however, it is not always possible to ascertain the value of goods at the time of the transfer of their legal title between residents and nonresidents of a country. The new SNA (1968) incorporates an adjustment item for this purpose in the external account, but hardly any country has been able to make appropriate estimates.

The analysis of external consistency can be facilitated by computing ratios and regressions between national accounts and related time series. The International Monetary Fund has computed various ratios from the data stored in its data fund, including the ratios of GNP and GDP to the money supply, its components, and quasi-money as well as ratios relating national income to GDP and GNP. The World Bank has also computed numerous ratios from its data bank, testing the external consistency of national accounts with related series.

In the preparation of country program papers (CPP) by the World Bank, national accounts are compared with other social and economic indicators for consistency. Some of the apparent external inconsistencies are spurious, however. Thus, a major West African country has recently reported factor payments in national accounts which differed considerably from those shown in the balance of payments. Trying to reconcile this inconsistency, a national accounts expert found that net factor payments of an international airline located in this country accounted for the inconsistency. In the national accounts, only a part of the factor payments was included (in proportion to domestic operations), whereas according to IMF instructions, the airline was considered a resident company and its total factor payments appeared in the balance of payments.

Another example of testing external consistency may be mentioned with respect to small West African countries, where public investment shown in national accounts is closely related (70 to 90 percent) to foreign aid. Foreign aid commitments, however, are less closely related than the disbursements, and the latter being often dispersed among numerous paying agencies are difficult to determine. Thus, it is clear that the preparation of comparable estimates for consistency checks may encounter major problems in some countries.

Having determined the magnitude of the real external inconsistency, the error may either be eliminated or shown separately as a measure of inconsistency. If the external statistical discrepancy is retained, it can either be shown in relative terms, as a percentage of the relevant national accounts components, or in absolute terms, to be aggregated with errors of other components.

b. Internal Consistency

Internal consistency of national accounts has been studied in many countries and analyzed with nonparametric tests, particularly in the United States, United Kingdom, and Canada. These studies focused either on the statistical discrepancy (residual error) in GDP or on the revisions of preliminary estimates in relation to the subsequently published final estimates of national accounts. The results of these studies are reviewed here summarily for their usefulness in determining the criteria for testing the reliability of national accounts.

Statistical discrepancy.—The statistical discrepancy in GDP (or GNP) derived by two or more alternative approaches (production, expenditure, and income) has been analyzed for normality (Kolmogorov–Smirnov chi-square test), trend (Mann–Kendall test), cyclical fluctuations (Wallis–Moore test), and autocorrelation (Hart–Von Neuman test).[11] With a few exceptions, these tests showed normality, absence of trend and of cyclical fluctuations, and some autocorrelation, particularly for intercensal years. Given these findings, the statistical discrepancy could probably be considered a random disturbance which affects the precision of GDP (GNP) without biasing it significantly. Some of the residual variables, however, such as gross domestic saving, would be more sensitive to changes in the statistical discrepancy, particularly if the latter contained trends and cyclical fluctuations.

Moreover, the regression of the statistical discrepancy on various GDP components has revealed a few significant relationships and even some systematic errors. In the United States, the discrepancy showed in the 1950s a significant relationship with exports, government purchases of goods and services, and inventory valuation adjustment.[12] Similar regressions of the residual error on various components of the U.K. national accounts have also revealed significant relationships. The residual error was found to be negatively related to gross trading profits of companies and to gross trading surplus of public corporations.[13]

Such findings are helpful in tracing possible errors through the system of national accounts. For example, inasmuch as the compensation of government employees enters on both sides of the U.S. national accounts, it is not a part of the statistical discrepancy. Therefore, the high correlation of the statistical discrepancy and government purchases of goods and services must have been induced by the other components of the latter series. Thus, although the data on government purchases of goods and services are probably among the most reliable components of the U.S. national accounts, the analysis of the statistical discrepancy casts some doubt on their reliability.

Regressions and nonparametric tests are useful in tracing internal consistency errors to possible accuracy errors in the components of national accounts. However, apart from this limited significance, they reveal little about the accuracy and the overall reliability of national accounts.

Revisions.—Periodic revisions of preliminary estimates have been investigated to determine their reliability and usefulness, particularly for short-term

[11] [1], [7], [10], and [17].
[12] [1], pp. 1224–1228.
[13] [17], p. 199.

forecasting. Several studies have analyzed the errors in the level, amount, and direction of change of preliminary in relation to the corresponding final estimates.[14]

In many instances, the level of preliminary estimates has been found to be understated,[15] the turning points shown by the final results have sometimes been missed by the preliminary estimates,[16] and some errors have revealed seasonal and cyclical variations.[17] The downward bias of certain preliminary estimates has been reflected in business forecasts which also often tend to be understated.[18] Nevertheless, preliminary estimates have generally been found useful for short-term forecasting.[19]

The observed U.K. revisions of preliminary estimates have been found smaller than the official (90 percent probability) ratings.[20] This result could be expected *a priori* inasmuch as the official reliability ratings relate to final estimates rather than to the discrepancies between the preliminary and the final figures. These discrepancies give only a limited picture of the overall reliability of the final data.

Large revisions of preliminary estimates tend to affect components with large errors remaining in the final estimates. In the U.S. national accounts, disposable income and nondurable consumption have been systematically underestimated while the more cyclical components such as the consumption of durables and private domestic investment have been overestimated.[21]

In the U.K. national accounts, the largest percentage revisions in quarterly levels have been found for stocks, work-in-progress, imports, exports, and subsidies. The quarterly changes for these components (inclusive of taxes on expenditure) have also been found to have large percentage errors. The largest absolute errors have affected quarterly changes in GDP and consumer expenditure.[22] These findings are consistent with the relatively poor quarterly data, particularly for the above components of national accounts.

In the U.S. national accounts, the application of the Von Neuman test indicated highly significant autocorrelation of the errors. The Mann–Kendall test for trend in the amplitude of errors revealed a significant negative trend for some components. Finally, the Friedman rank test (to determine randomness in the size of errors among quarters) has shown that the first quarter errors tend to be significantly larger for consumer expenditure on services.[23]

The usefulness of the above criteria for analyzing the reliability of preliminary estimates is again largely limited to their relationship with the final figures. The magnitude of the revisions is by no means a sound criterion for determining the total reliability. Although the presence of large revisions has some bearing on

[14][4], [6], [8], [9], [11], [15], [21], [22], [28], and [29].
[15][4], p. 336; [8], p. 206; [9], p. 446; [21], p. 475; [22], p. 206; and [29], pp. 57–61.
[16][21], pp. 471f.
[17][29], pp. 60–65.
[18][8], p. 206; [21], pp. 542f.
[19][8], p. 203; [29], pp. 60–65.
[20][15], p. 137.
[21][21], p. 475f.
[22][15], p. 136.
[23][29], pp. 59f.

the total reliability, the lack of revisions is not necessarily an indication of reliability. Keeping preliminary estimates in the final revisions may be justified because better data are not available at the later date.

On the other hand, in the experience of some developing countries, the estimating procedures of national accounts are sometimes so inadequate that these countries are not even making any revisions when better data become available. Thus, agricultural production in the subsistence sector is often estimated on the basis of population growth. Subsequent revisions in population estimates may not even be reflected in the revision of national accounts.

c. Independent Inconsistencies

Inconsistencies in national accounts may also arise quite independently of the inaccuracies in basic data. Such independent inconsistencies are primarily the result of the index number problem which arises in the explicit or implicit use of weights, deflators, and linking procedures. It is well known that in view of the negative correlation between quantities and prices (apart from perfectly inelastic supply or demand or both, smaller quantities are consumed at higher prices and vice versa), the relatively faster growing components of quantity indexes with base-year weights (Laspeyres index) impart an upward bias while those with given-year weights (Paasche index) show a downward bias. For the same reasons, the use of smaller quantities as base-year weights for the relatively faster growing components introduces a downward bias in price indexes. The index number problem cannot be solved by improving the accuracy of basic data.

For the national accounts at current prices, the index number problem does not arise because the implicit weights are not kept constant over time. At constant prices, however, national accounts contain index number biases. These biases tend to be larger, the longer the weights are kept constant and the larger the relative differences are in the growth of various sectors.

Although a perfect solution to the index number problem has not been found, the "true" values could be approximated either by using Fisher's ideal index (geometric average of the Laspeyres' and Paasche's indexes) or a chain index. However, the latter two indexes require weights at frequent intervals (annual). In the absence of current weights, it is sometimes possible to take weights from the middle of the period. If growth is very rapid in the first half of the period, the weights originating in the middle of the period may be adequate if subsequent changes are small. However, if growth is at a fairly constant rate or is at a slower pace in the first half of the period, the ideal weights must be taken from a more recent year to allow for the relatively greater importance of fast growing sectors. Although the ideal weights may not be readily available in practice, it is possible to determine them in principle by comparing the size of the biases preceding and following the year from which the ideal weights were taken. Equalizing the downward bias of the earlier years with the upward bias of the later years, the "ideal" weights could be determined. The unbiased estimate of the index could then be used as a standard of accuracy for measuring the biases in national accounts at constant prices. Similar unbiased indexes could also be constructed for price deflators.

The index number problem arises also in external data. These must similarly be analyzed and adjusted to comparable ideal weights before an external consistency test with national accounts is attempted. (This is only one of several other adjustments which may be needed to allow for differences in concepts and definitions.)

The various linking procedures of time series introduce further inconsistencies which are independent of data accuracy. No matter how accurate the data, the linking of components at constant prices of one year with those of another usually leads to inconsistencies with respect to the totals linked directly. More generally, the application of different estimating techniques usually results in new estimates with different internal and external consistency problems.

6. Problems of Error Aggregation

a. Types of Errors

The application of partial reliability criteria to basic data and national accounts may reveal several types of errors. Producers of basic statistics may estimate accuracy errors, including biases and sampling and nonsampling errors. Compilers of national accounts may estimate adjustment, judgment, and consistency errors. A tolerable level of these errors can be determined by comparing them to other errors which arise in the application of national accounts.

Given hundreds of statistical series from which national accounts are compiled, some meaningful method of error aggregation should be found for determining overall reliability. The difficulties in determining the relative importance of various errors and the problems of their aggregation are still largely unresolved. The following examination of selected problems indicates the extent of these difficulties and makes a few tentative suggestions toward their solution.

b. Aggregation Conditions

Independence of errors and comparable units of measurement are needed for a successful aggregation of errors. Following the aggregation of national accounts, a meaningful aggregation of their errors should be comprehensive in coverage, free from duplications, and easy to express in comparable units.

Ideally, all types of errors should be aggregated for the same components of national accounts and each type of error should be given for the total of all components. Inasmuch as national accounts are compiled in terms of value, the corresponding errors could also be expressed accordingly, except perhaps for errors derived in abstract units.

The well-known overlapping of errors presents a more difficult problem. Errors tend either to compensate or to reinforce each other, as may be the case with some variances and biases. In the absence of independence, their aggregation tends to overstate the total error. When Kuznets added individually determined errors in his assessment of the total reliability of national income, he divided the total error in half, partly to account for the offsetting errors.[24]

[24] [16], pp. 527–528.

Most of the accuracy errors originate in the disaggregation of the mean square error of basic data. To this extent, the aggregation of these errors should not present any difficulty. Adjustment and judgment errors, however, may introduce duplications. If the extent of these duplications cannot be directly ascertained from the data, the relative size of the offsetting errors may provide some clue to the solution of the problem. In the absence of independence, a significantly smaller variance may be disregarded. Inconsistency errors which are independent of accuracy errors could be aggregated with accuracy errors although a complete elimination of the inconsistency bias would be preferable.

Considering the relative importance of the various errors, accuracy errors in basic statistics may be expected to account for a large proportion of all errors. The aggregation of accuracy errors with adjustment and judgment errors of national accounts would go a long way toward measuring the overall reliability. However, even if the data were independent, it is not always meaningful to aggregate objective standard errors and systematic errors of basic statistics with largely subjective adjustment and judgment errors of national accounts. In the absence of a satisfactory method for such an aggregation, accuracy errors of basic statistics may be shown separately for the various components of national accounts, along with the size of adjustment and judgment errors. The use of multiple criteria is further discussed below, following a more detailed consideration of aggregation problems of biases and sampling and nonsampling errors.

c. Elimination of Bias

If the direction and the extent of a bias is known, the basic data can be usually adjusted to eliminate it. Given a bias which is estimated with a certain margin of error, the elimination of this bias may lead to a nonsampling error or uncertainty. Finally, if the direction of a bias is known and its extent cannot be estimated, there appears to be no way of aggregating it either with the biased data or with other errors.

A bias direction could be aggregated, however, with other bias directions of the same sign. The number of upward and downward biases may be just as helpful for appraising the national accounts as the total count of stock advances and declines on the New York Stock Exchange. The number of biases could be specified for each series and stated as a percentage of all biases in the same direction. Upward and downward biases (their number and the value of series which they affect) could also be related to the total number and value of the basic data series which are used in the compilation of national accounts.

d. Aggregation of Sampling Errors

For independent sampling variances (e.g., agriculture and industry), sampling errors could be aggregated and shown along with corresponding estimates based on these samples. In the absence of independence, the addition of sampling errors becomes less meaningful. While sampling errors of nonresponse surveys (separate surveys of nonrespondents) are sufficiently independent and can be aggregated with those of the main survey, sampling errors of response surveys (separate surveys for measuring response errors) cannot be aggregated with those

of the main survey—just as the basic data of response surveys are not directly additive with those of the main survey.

If the quality control of data processing is also based on sampling methods, the resulting sampling errors cannot be aggregated directly with sampling errors of the main subject-matter survey, although it may be possible to estimate the additional variability generated by processing errors which would permit an adjustment of subject-matter errors. However, standard errors derived from processed data already reflect response, processing, and other nonsampling errors. Therefore, there is no need to consider them separately for aggregation purposes.

e. Nonsampling Errors

Strictly speaking, all statistical estimates are subject to some nonsampling errors or uncertainty. It would be almost impossible to consider all the uncertainties about the reliability of each particular series. However, there are many known nonsampling errors whose size can be determined either objectively by replication and reconciliation methods or subjectively by expert judgment. In the compilation of national accounts, these are mostly errors remaining in the estimates after all the adjustments have been made. They may be the result of either bias elimination, the use of crude adjustment methods, imputations, or other estimating techniques which are known to be crude and inaccurate. Quantifiable nonsampling errors either could be grouped by size or, in case of independence, could be aggregated in terms of value and shown for the various components of national accounts.

f. Multiple Reliability Criteria

With our present knowledge and the state of the arts, multiple criteria for determining the overall reliability of national accounts appear to be almost a necessity. The use of multiple criteria may be more meaningful and helpful than a questionable aggregation of errors. The number of upward and downward biases, the size of sampling errors, and a frequency distribution of nonsampling errors may be just as helpful for determining the reliability of national accounts as the data on temperature, humidity, wind velocity, precipitation, and cloudiness for describing weather conditions. The presentation of objective and subjective reliability measures could be supplemented by subjective judgments with reliability ratings. Such summary appraisals would be helpful as a guide and as a quick reference for general users. Technical experts could examine the information on biases and errors, while still greater scrutiny of the reliability may require a complete review of estimating methods, procedures, and basic data. Such a complex problem as the determination and measurement of the reliability of national accounts could probably never be reduced to and solved with a single indicator.

7. Evaluation of Reliability

The absolute results of accuracy and consistency tests are useful in themselves and they may be meaningfully interpreted in relation to the absolute values

of national accounts and their components. Further evaluation is possible in relation to the various errors and biases which arise in the selection of appropriate data concepts (abstraction) and in the various uses of national accounts (application).

Abstraction and application errors provide a means for comparing the estimated reliability with the required reliability of national accounts. This comparison makes it possible to avoid waste of resources either in developing excessive reliability or in applying refined analytical methods to inadequate data. It provides a means for balancing the reliability of national accounts with the reliability of other data and of econometric methods. The more sensitive the analysis to data levels and fluctuations, the greater the reliability that may be required. While measuring the absolute reliability of national accounts, it may be sufficient to consider the statistical and methodological errors; their relative importance can be evaluated in relation to other errors which arise in the original conceptualization of data and in the final use of national accounts.

Abstraction can be defined in this context as a deliberate selection of certain characteristics from all relevant characteristics which measure economic and social processes meaningfully. The reduction to income and expenditure concepts simplifies complex economic processes which could be described and measured in numerous other ways. Any set of data is an abstraction—we can usually enrich our knowledge by including additional characteristics in a set of data. In designing national accounts, we also abstract from economic activity by defining certain concepts. While statistical errors (sampling and nonsampling) affect averages and totals of selected indicators, abstraction renders the original configuration of social and economic phenomena in a simplified form. The process may involve the loss of secondary characteristics. A complicated economic process may be stated in terms of its volume of output and prices, which is further aggregated and included as value with other processes. Although the value may be determined or expressed meaningfully, the other characteristics of economic activity are lost in the process of simplification and aggregation.

The need for a more diversified description of economic activity has been partly met by alternative concepts of national accounts. The new system of national accounts (SNA), and particularly input–output matrices, provides a less aggregated and more diversified picture of economic activity. The basic concept of GNP has recently been supplemented by a new concept of NNW (net national welfare). These concepts may be further extended to more comprehensive measures of economic activity. The differences between them partly represent elements of economic activity, and they fall short of measuring abstraction.

There appears to be no adequate method for measuring the simplification introduced by conceptual abstraction. If all the relevant characteristics of observed phenomena could be identified and quantified in comparable units, the relationship of abstracted to total relevant characteristics would indicate the degree of abstraction. While abstraction is necessary for effectively analyzing complex phenomena, it is very difficult in practice to determine the degree of simplification which is introduced by various indicators in measuring the economic and social characteristics.

Application errors provide another basis for determining what level of reliability would be acceptable to major users of national accounts. In this context, application errors comprise all errors which arise in the use of national accounts. They include certain relevance errors for each particular purpose, the reliability of analytical methods, and the errors of other data to which the national accounts are related or with which they are combined in various econometric models. There is hardly any economic theory or econometric model which would not involve some approximation and sometimes very substantial errors, particularly in projections, optimization, and the interpretation of results.

When econometric relationships based on past experiences become invalid, it is often the theories rather than the statistics that are at fault.[25] Projections are based on the assumption that the forces which operated in the past will either continue to operate in the same manner or change in a certain way; some forces will cease while new forces may be expected to appear. This can only be anticipated with a substantial margin of error and uncertainty. Crop failures, new technological discoveries, and a host of other uncertainties contribute to errors in projections. Even the projection of trends depends on the choice of a mathematical function and the relevant time period.

Policy objectives of most countries usually envisage deviations from past allocations of resources as reflected in the national accounts. Most economic policies attempt to improve the allocation of some resources among alternative uses. This optimization process is subject to many errors and uncertainties. While econometric models produce optimum solutions under certain assumptions and constraints, there are usually many alternative models possible with a great variety of different outcomes. These differences constitute errors which may be far in excess of those present in the national accounts.

Even a crude estimate of application errors would be useful for determining an acceptable level of reliability required for national accounts. We could then consider the question whether or not five percent errors in the national accounts provide estimates of sufficient reliability. If the analytical methods and other data show errors of ten percent or higher, then a five-percent accuracy error in national accounts may be tolerable and there may be no need to reduce it. If the reliability is grossly inadequate in relation to the uses of national accounts, additional resources may be allocated for improving the national accounts and the basic statistics from which they are derived. In practice, it would usually be sufficient to consider the needs of only a few major users and, even then, only to the extent that their maximum application errors are smaller than those estimated for the national accounts. The final evaluation of trade-offs between the cost of improvements in the reliability of national accounts and the benefits derived by these users could be based on conventional analytical methods.

8. Summary and Conclusions

In the absence of a meaningful single criterion, the absolute and relative reliability of national accounts can be determined by several partial criteria at

[25] [3], p. 648.

various stages of data generation and use. Three partial criteria are considered, two of which—accuracy and consistency—are of special importance to the producers of these statistics. The third criterion—simplification arising in abstraction of basic data and errors in application of national accounts—provides a standard for comparing the existing with the required reliability of national accounts.

The accuracy of basic data can be measured, in principle, by the mean square error which comprises variance and the square of the bias. For the determination of measurement errors in basic statistics, special estimating procedures are required. The variances of measurement errors are determined by "replication" methods—a duplication of the original data collection process without reference to the original measurement. The bias is determined by a deliberate reconciliation of discrepancies at all stages of data collection and processing.

Applying the same estimating technique to the national accounts encounters major difficulties in estimating variances and biases. Although in principle it may be possible to conceive a mean square error which would comprise variances and the square of the bias in the various components of national accounts, their estimation must be based on subjective judgments rather than on objective statistical methods. Estimation of biases in national accounts is particularly difficult if the national accounts use the best available estimates and if there is no better data against which they can be tested. Regressing the final estimates of the past periods on the latest available final estimates for the same periods gives an indication of the possible accuracy of the latest final estimates, although this technique has its own serious limitations. Largely subjective adjustment and judgment errors can also be considered in place of variances and biases.

Consistency criteria provide a negative test of reliability inasmuch as consistent data may be quite inaccurate. Thus, consistency tests facilitate but do not replace the analysis of accuracy. The external consistency test determines the relationship of national accounts with basic data and other derived data systems. Studies of internal consistency have shown that the statistical discrepancy in GDP could be considered a random disturbance despite a number of exceptions uncovered by nonparametric tests. Revisions of preliminary estimates have also been tested for consistency and randomness of errors. Large revisions tend to concentrate on weak estimates, although this test is not foolproof inasmuch as some of the weakest preliminary estimates may not be revised for lack of better data.

Inconsistencies independent of inaccuracies in basic data may arise in national accounts as a result of the index number problem and the linking of components. These inconsistencies can be measured by unbiased indexes whenever it is possible to construct them.

The aggregation of various errors encounters major difficulties. Addition of absolute errors is possible if they are all in comparable units and the condition of independence is met. Otherwise, the various errors may be classified by size and counted by type. Partial criteria and different types of errors may remain to some extent disaggregated, reflecting the complexities in measuring the reliability.

The reliability of national accounts can finally be evaluated in terms of abstraction and application errors. Abstraction measures the loss of relevant

details in basic statistics by rendering economic phenomena in a simplified form. Application errors comprise all errors which arise in the use of national accounts—the relevance errors, the errors in data to which they are related, and the errors of analytical methods. A comparison of accuracy and consistency errors to those of abstraction and application provides a basis for determining the trade-offs in the improvement of national accounts.

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