NBER WORKING PAPER SERIES

ON FUNCTIONS, QUALITY, AND TIMELINESS OF ECONOMIC INFORMATION

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Working Paper No. 608

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

December 1980

Research for this study was supported by a National Science Foundation Grant (522016) to the National Bureau. This paper is part of the NBER's research program in Economic Fluctuations. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

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ABSTRACT

The flow of production and use of economic information consists of the collection and processing of primary data, the reporting of the resulting measures, and the transformation of the latter into signals or messages that presumably aid knowledge or decision-making. Each stage contributes to the return and costs, quality and errors of the information. The processes involved on the micro and macro levels show important similarities and interactions.

The uncertainty about economic information increases with the probability of error in the underlying data and their processing and interpretation. Many errors cannot be promptly detected and eliminated but can be gradually reduced over time, as attested by the revisions in economic statistics.

This paper presents substantial evidence on the accuracy of provisional estimates of quarterly and monthly changes in eighteen important variables. Measures of several aspects of data quality and of average lags of data release and signal detection are provided for a collection of 110 widely used economic indicators. These materials help identify the location of the more serious measurement errors by variable and period, and they show that informational lags of five and more months are frequent.

The errors and lags of information may lead to apparently "systematic" but not readily detectable and removable errors in expectations. This is likely to happen, in particular, in times of great surprises and shocks when measurement of short-term changes in the economy is most difficult and current signals are often misread. Some illustrations are drawn from the events of 1970-75.

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I. Information and Measurement

Economic decisions confront more uncertainty as they grow in scope and reach further into the future. They are likely to do so increasingly in decentralized economies that expand and diversify.[1]

The economic incentives to reduce uncertainty and improve predictions and decisions give rise to the demand for large amounts of diverse information. This is not a new phenomenon, of course, but it is revealed more clearly than ever in the present era of great advances in informational technology, for now the demand is to a large extent visibly satisfied. The "knowledge industries" or "services of inquiring, communicating, deciding" account for a large and growing proportion of work performed by men and machines.[2] In the economic sphere alone, there is a bewildering array of types and sources of information. Yet there is also a logical sequence and division of labor in the production and use of information. An attempt to show this will be aided by a schematic presentation of the flow of these activities (Figure 1).

Data and Signals

In the first stage of the process, events are observed and recorded in the form of primary data. This function is performed for private purposes everywhere in the economy at least in some informal fashion. Much of the private information is the byproduct of routine activities but some is an end

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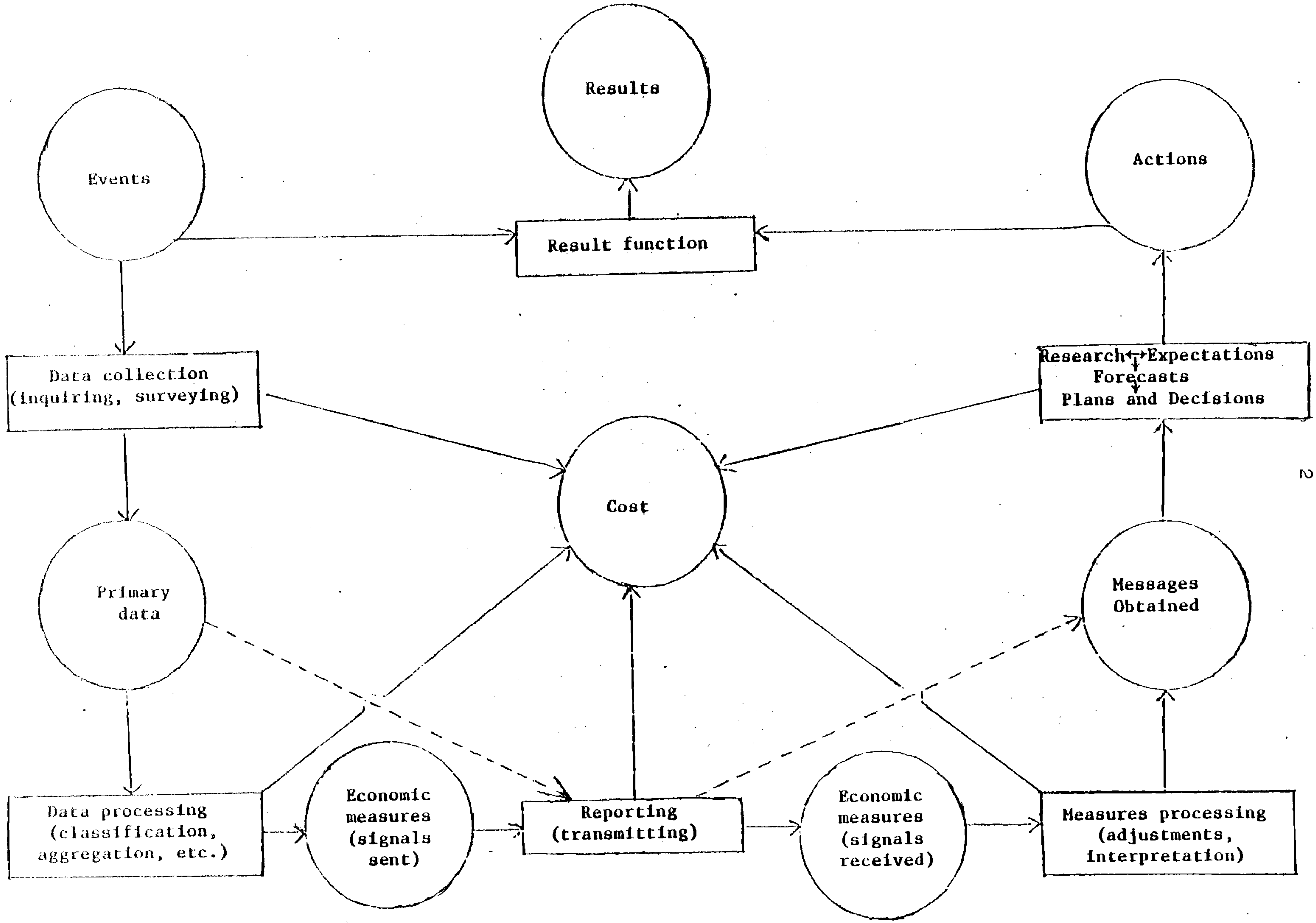
[1]Growth in the modern economy is motivated by the desire to accumulate human and physical resources (capital in the most general sense) and accomplished by actions that necessarily have long-term consequences. The decisions to choose these particular courses of action (strategies) must therefore be based on similarly long expectations, which are fallible. As the risk is high, so is the premium on any knowledge that might help the decision-maker.

[2]Machlup, 1962; Marschak, 1968.

Fig. 1. The Flow of Production and Use of Economic Information



NOTE: This scheme is adapted from Marschak (1968, p. 5) with changes arising from its being focused on the actual processes of collection, processing, reporting, and using economic information rather than on concepts of engineering communication and statistical decision theory (see text). Circles represent variables (generally random), boxes represent functions or transformations (generally stochastic, involving errors).

product of efforts to develop new and potentially profitable knowledge. The former may be confidential and the latter may be legally protected to enhance its expected value to the owner.[3] However, large amounts of microeconomic data result from transactions in open markets, and much of this information is publicly available. (In well-organized markets for standardized assets and commodities, prompt and general dissemination of the information is vital and constitutes a central part of the functioning of the market itself.)

If an additional piece of information costs more than the benefit from it is expected to be worth, then the representative economic agent will not incur the cost.[4] Indeed, procurement of <u>all</u> information bearing on a pending decision or problem is rarely economical, even where it is practicable: sampling is a pervasive feature of economic behavior. Hence, as a rule, information is incomplete, and at least those errors that are due to this fact are ubiquitous. It is analytically convenient to assume that probability sampling is the norm and the errors are random, but there is no compelling reason or evidence that in practice nonprobability sampling is unimportant and systematic errors are at all times negligible.

The primary data vary greatly in coverage and quality, depending on the knowledge and cooperation of respondents and compilers. In economic (and other social) matters, those who ignore the errors in the data do so at their

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[3]It is often difficult to appropriate valuable information, i.e., establish effective property rights to it. Unless the knowledge (say, of a new market prospect) is used, its value will not be realized; but the very use of the knowledge is apt to reveal at least some of it. The more information spreads, the more diluted are the individual gains from it (and the greater are the social gains).

[4]This, of course, is merely tantamount to the hypothesis that the agent (individual or organization acting in the economy) is optimizing. The search theory provides a formal treatment of the marginal calculus involved in some information-gathering processes such as shopping and job-hunting (Stigler, 1961 and 1962; Alchian, 1969; Hirshleifer, 1973).

own peril.[5] Even where the data themselves are reported directly and with a high degree of accuracy, as is the case for prices of many individual commodities and assets, the information is usually incomplete in some respects (e.g., the quality aspects of the items are not well ascertained) and may not be available promply and frequently. The resulting problems are as much economic as statistical, and they may be difficult to identify, let alone resolve.[6]

The data relating to the immediate environment of the individual decision-maker, notably the changes in the observed relative prices, are essential and the first to command attention. In the familiar model of general economic equilibrium, such price signals would be sufficient for all decisions. Evidence on what information economic agents effectively demand and use leaves little doubt that this is not so in the real world. Recent theoretical writing offers attempts to explain why firms in a nonstationary decentralized economy with the capacity to produce the required flow of information should seek to reduce uncertainty by means of quantity signals as well as price signals.[7]

Economic Measures

The primary data may be reported directly, in which case they are themselves the messages or signals (see the broken lines in Figure 1). As a rule, however, the information transmitted consists of economic measures

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[5]In contrast, communication engineers are interested in efficient coding and transmission, not in the deficiencies, of the data. Hence, the theory of information which got its start in the telephone industry (Shannon, 1948) assumes that data = events.

[6]The statistical decision theory abstracts from communication problems and analyzes the optimal choice of "data-producing experiments" (e.g., sampling) and decision rules. It thus equates the messages received with the data. This restrictive assumption has had an important use in the microeconomic search theory. In terms of our flow scheme, the processing and communication stages (the bottom row in Figure 1) are omitted; further, it is assumed that the data are error free.

[7]See Arrow, 1973 and 1974.

into which the underlying data are transformed through various forms of processing. Here it is the measures that are demanded and supplied; the data are absorbed in the process as raw materials, and largely concealed.[8]

The measures are in large part macroeconomic in nature. There is much need for the analytical work that would clarify and incorporate the reasons for uses of such signals by economic agents. The facts of the matter are rather clear, however. There is evidently much demand for aggregate economic information by business, particularly large corporations. Macroforecasts are generated or purchased for use as inputs in sales forecasts, inventory and production management, capital investment decisions, etc.

Much aggregate information comes from private sources (e.g., industry data from trade associations), but a large part of public information on the economy is produced by the statistical agencies of the government. Macroeconomic information has some characteristics of a public good, is needed for policy purposes, and is presumably deemed to possess high social value.[9]

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[8]The operations may include classification, aggregation, and a menu of "massaging" techniques such as interpolation, extrapolation, splicing, smoothing, etc. They add up to processes that are in large part irreversible, i.e., it is impossible to work back from the given measures to the underlying data. This, again, is in contrast to the requirements of the mathematical communication theory (note 5), where encoding transforms data into signals in such a way that the data can be uniquely reconstructed from the code.

[9]Data on some major variables and developments (e.g., changes in real GNP, inflation, unemployment) are communicated by the media to an unlimited number of people at zero marginal cost of adding another consumer. The costs of production for such measures are high, the costs of transmission low. The pricing of published information is low (perhaps just to cover the distribution costs). Thus a tax subsidy is in effect provided for the public access to the information.

The procedures for the derivation of economic measures sometimes help to reduce the errors in the underlying data, but they also are a source of other errors. Relatively small errors in the aggregate often hide large compensating errors in the components, but such offsets do not necessarily occur and they should not be contrived; at times, the component errors are cumulative. The chances of serious procedural and aggregation errors probably tend to grow with the complexity of the measures, which frequently necessitates not only massive calculations but also numerous estimations and approximations.[10]

Even the simplest signals are expressed in symbols that must be "decoded," but economic measures, like the concepts to which they refer, are often far from simple, well-defined, and universally accepted. Also, user demands for data and measures change more or less continually, while the supplies respond with lags, that is, partially and unevenly over time.[11] For these reasons, users adjust and interpret the economic measures or signals received, according to their own purposes and preferred concepts (see Figure 1). Such further processing of the information is obviously important in quantitative economic research, and the same is presumably true of many practical business applications.

Uses and Results

The stock of useful information available to the user depreciates through obsolescence and is replenished by the flow of new data and measures; a net gain over time in that stock increases knowledge. It is normally in this context of relating the new to the old information with the aid of experience, models, or intuition that meaning is extracted from--or imparted

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[10]It would be easy but space-consuming to provide examples from such compilations as the national income and product accounts, the index of industrial production, the consumer price index, etc. For some related evidence, see Table 1 and text in part II below.

[11]See Kuznets, 1972, pp. 7-22.

to--the new "signals," thus converting them into "messages" obtained (to use the short labels of Figure 1). Users with different interests, beliefs, or knowledge may obtain different messages from the same signals.[12]

As increments to the working capital of economic information, the messages are inputs into the highly diversified productive processes of research, prediction, and public and private decision making. For example, incorporated in an internal analysis of the current business situation, they may influence formal forecasts of company economists and informal expectations of management, thereby helping to shape corporate plans and, eventually, decisions. The nexus is represented in simplified form by a "production function" transforming messages into action (see the upper right-hand box in Figure 1).[13]

The results achieved depend on the degree of control exercised by those who make the decisions and implement them through action, but as a rule also on events -- changes in the environment of the decision maker. Thus, actions and events can be viewed as joint inputs and the results as output, of this last function (shown in the top row of Figure 1). In principle, this is

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[12]To acknowledge this may be analytically inconvenient, but it is certainly an important fact which helps explain, a. o., the dispersion of individual readings of the current economic variables and of expectations of their future values. The crucial role of that dispersion with respect to the behavior of prices and wages is well known from recent developments in the debate on the Phillips curve and the theory of aggregate supply (see Friedman, 1968). Expectations are still often treated as if they were single-valued and universally shared, however.

[13]Even this description suffices to make it clear that economic information (in the form of messages obtained) is a codeterminant rather than a unique determinant of "real-world" actions. Interest in empirically verifiable uses of information, therefore, precludes adopting the simplification that is convenient for the purposes of the communication theory, where actions = messages and the results are good if messages = data, bad otherwise.

For another view of the relationship between information (predetermined variables), expectations, judgments, and plans, see Theil, 1965, pp. 18-22.

a deterministic function knowable precisely ex post, but in practice the knowledge of its form and arguments is typically fragmentary. In effect, then, the results of specific uses of economic information are generally uncertain and hard to assess. This is particularly the case when the round trip depicted in Figure 1 is time-consuming, for then changes in the environment may have occurred that were not correctly diagnosed and prognosed with the available information, so that the actions confront a new set of events, in the sense a changed "present." If the actions have longer consequences, the hazards are still greater because longer forecasts are required. Moreover, some of the consequences will then become events that via the flow of information will influence future expectations, decisions, and actions, so that a feedback loop would have to be considered (for simplicity, the feedback is not shown in Figure 1).

Data collection, processing, reporting, and uses all have costs that can be measured in terms of dollars spent on, or resources devoted to, these activities. Hence, each of the five functions representing the production and use of economic information contributes to the overall cost variable (Figure 1). But the direct costs are not the total costs involved: there are also the costs to the user caused by the errors in the information and by improper selection and application of the information. These costs cannot be assessed until the consequences of the actions taken with the aid of the information are revealed.[14]

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[14] In addition, the results, quite apart from the difficulty of their measurement, are strictly attributable only to the particular action and the events in question. But the observed action might have been produced by a different chain of information and decision functions. This would seem to preclude an unambiguous imputation of the indirect costs to the information function used.

Conclusions and Further Steps

As shown by the above account, the same schematic flow diagram can accommodate a remarkable variety of sources, types, and uses of economic information. While this is, of course, achieved largely by abstracting from the particular, it is worth noting that there is in fact a great deal of basic structural similarity as well as interaction between what might be called the macro and micro information "systems." The transformation of primary data into economic measures is necessary for both the quantitative study of the economy and the managerial decision making. What individuals and organizations in the economy are doing finds a representation in the micro data, and the information on the economy at large is built up from the microdata. But the availability of comprehensive information on changes in economic conditions (a rather recent phenomenon in historical terms) has now its own significant effects. Monitoring the flow of that information has become a regular part of the business scene and a matter of much intermittent public interest--it is no longer mainly an occupation or pastime of economists, as may have been the case years ago. The perceived changes in the major aggregates may affect individual and collective behavior in important ways. (Consider the potential impact of changes in the announced measures of inflation and unemployment, to mention the most prominent examples only.)

A discussion of what economic information is and how it is collected and processed leads directly to the consideration of errors in the data and measures. The analytical significance of the errors varies with their type and source. Revisions of economic time series shed some light on both their accuracy and their usefulness as sources of signals, to be judged by certain criteria of promptness and dependability. Apart from revisions, the reliability of the series depends on several attributes of reporting, coverage, and consistency while their signaling quality depends on how current and how "noisy" they are. These themes are developed in the second part of this paper, where the distributions of measures of some of the characteristics in question are presented and examined.

II. Aspects of Quality and Timeliness

Errors and Revisions

Recent work in the theory of inflation, unemployment, and business cycles pays much attention to the effects on agents' expectations and behavior of imperfect information.[15] Its concern, however, is with imperfections arising from the incompleteness and lags in availability of the information and not with any more serious errors that are not completely removed in short order by a mere passage of time. Thus essentially correct economic data and measures are assumed to be generally available either contemporaneously, as for local information about prices, or with short single-period lags only, as for that macro information which is considered relevant such as the data on the money stock and perhaps on the price level. (Other aggregate information is typically not considered at all.)

In contrast to these premises, economic information in many important areas contains at any time large amounts of potential and probable errors. Observation of the flow of production and use of the information helps us understand why this is so. In data collection, sampling errors will, of course, always exist but they can be estimated, may be controlled, and present the least serious problem (would that more economic information were based on proper probability sampling!). Nonprobability sampling is very vulnerable to systematic errors of various kinds, as are the economic measures which

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[15] The literature is voluminous but a few survey articles and collections of essays may be cited: Laidler and Parkin, 1975; Gordon, 1976; Fischer, ed., 1980.

involve much data processing. Here it will often be difficult to isolate and assess the component errors: conceptual, procedural, and statistical.[16] To be sure, in the process many errors are prevented, while others are promptly detected and removed, but a great many errors are of the kind that can only be reduced partially and gradually.

The last statement is amply confirmed by the pervasiveness and persistence of revisions in economic statistics. For many variables, promptly and frequently available data, which are demanded for current purposes, can only take the form of preliminary figures subject to possibly large and repeated alterations by subsequent revisions. This applies to some important measures such as the monetary aggregates and GNP. The uncertainty about the preliminary estimates reduces their usefulness as timely signals insofar as they need to be confirmed by the revised figures. The larger, the less stable, and the more stretched out in time the revisions are, the less dependable are the data.

The discrepancies revealed by successive revisions of a time series represent for the most part errors resulting from large lags in the availability of primary data. Although other errors created by conceptual and procedural problems may well be more serious, they tend to be less identifiable. To use revisions for measuring and analyzing errors, it is necessary to assume that they cumulatively improve the statistics in question (which is, of course, what they are intended to do). Accordingly, the final figures are treated as correct

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[16] The conceptual component reflects (1) the limitations and shortcomings of the concepts underlying the measures and (2) the divergencies between the measures and the concepts. The procedural or analytical component includes the errors from data processing and massaging, aggregation, and computational approximations and truncations. The statistical component consists of errors due to the gaps and defects in the primary data and to the limitations of coverage. All these errors have a variety of sources and forms, which underscores the practical difficulties of their identification and correction. An appendix available upon request gives a more detailed tabular classification and characterization of errors in economic observations.

benchmarks against which to evaluate the data of any earlier vintage.[17] However, it is not unusual to find some revisions, in a chain of several, which increase rather than reduce the discrepancy between the prior and the final estimate.

For the national income and product accounts, the regularly published revisions extend over years: a set of figures is now released each month during the quarter following that to which the data refer, and each quarterly estimate is subject to three successive July (annual) revisions. In addition, there are benchmark revisions which incorporate new economic and demographic census information (there were six of them since 1947, the latest one in 1976). Here extrapolations of the last benchmark are replaced with interpolations between the last and the new benchmark. Some of these major revisions eliminated approximately up to 60 percent of the error in the initial estimates covering several past years.[18] Clearly, then, for these series (and any others subject to similar treatments), the "final" figures are in practice the latest available data, which are still, at least for some of the more recent periods covered, subject to further revisions.

It is the first few revisions that present most problems to active users of current economic information. The benchmark revisions matter a lot when they occur but they occur infrequently. The conceptual changes involved cause "breaks" or discontinuities in time series, which reduce the size of the samples (consistent segments of the series) that are available for the analysis.[19]

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[17] Even the "final" estimate may be incorrect, of course (for example, because of the errors in each batch of additional data that become available for the revisions or because of unresolved conceptual problems), but the extent to which this is so remains then usually unknown. But it is equally true that the absence of revisions does not prove the absence of errors.

[18] Cole, 1969, p. 49.

[19] The treatment of benchmark revisions is very difficult and will not be attempted here, but it must be noted that this amounts to an exclusion of an important category of data limitations which have been recognized as "errors" and acted upon by producers of economic information.

Errors in components may offset each other or be so small as to have little effect on the comprehensive aggregates, and in dealing with the latter this point is worth remembering. Some recent revisions in inventory investment and profits have been startlingly large.[20] Such cases will occur from time to time for special reasons; they are not preventable but rare. However, the quality of economic information is much more affected by basic and persistent problems for which no solution at acceptable costs may exist. For example, many firms keep inventory records only on a yearly basis, hence can only report guesses on their monthly or quarterly inventory changes. This imposes severe limitations on the best achievable estimates of total inventory changes (better information cannot be collected where it simply does not exist).

Measuring the Accuracy of Provisional Data

Table 1 presents summary measures for five revisions of quarterly percentage changes in nominal and real GNP and the implicit price deflator (IPD): the estimates released 15 days and 45 days after the end of the quarter (A_1 and A_2) and the three annual July estimates (A_3, A_4, and A_5). An "error" is defined as the difference $E_{it} = A_{1t} - A_{it}$, for i = 2, ..., 5 and any quarter t. The time periods are the longest uniform ones for which such comparisons can be made with strict consistency across all five vintages of the data (part I) or across the first three vintages (part II).

The mean errors $\overline{E_i}$ are predominantly negative, suggesting underestimation, but they are generally small (column 1). The successive revisions add to the dispersion of the discrepancies from the initial estimates: both

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[20] The July 1974 revision more than doubled the estimates of the change in business inventories for the five quarters 1973:1-1975:1, from an average \$7.5 billion to \$15.7 billion. On the problems of inventory estimation during that period of inflation-induced shifts from the FIFO to the LIFO system, see Zarnowitz and Moore, 1977, pp. 544-546. The July 1971 revision changed an increase of \$2.5 billion in corporate profits during 1969 to a decrease of \$3.4 billion. In this instance, unadjusted discrepancies between shareholder reports and tax return information probably bear most of the blame. See Young, 1974, pp. 2-4.

Footnotes to Table 1

[a]A_1 - advance (15 day) estimate released in the first month of quarter $t + 1$ for quarter t of year T.

A_2 - provisional (45 day) estimate released in the second month of quarter $t + 1$.

A_3 - first annual revision published in July of year $T + 1$.

A_4 - second annual revision published in July of year $T + 2$.

A_5 - third annual revision published in July of year $T + 3$.

All series are in form of quarterly percentage changes, after seasonal adjustments. The dates and numbers in parentheses indicate the periods covered and their duration in quarters.

[b]Column 1: $\bar{E}_i = \frac{1}{n} \sum_{t=1}^{n} E_{it}$; Column 2: $S_{Ei} = \sqrt{\frac{1}{n} \Sigma (E_{it} - \bar{E}_i)}$

Column 3: $\overline{|E_i|} = \frac{1}{n} \Sigma |E_{it}|$; Column 4: $U_i = \sqrt{\frac{1}{n} \Sigma E_{it}^2} \Big/ \sqrt{\frac{1}{n} \Sigma A_{it}^2}$;

Column 5: $MC = 100(\bar{E}_i^2/M_i)$; $M_i = \frac{1}{n} \Sigma E_{it}^2$;

Column 6: $SC = 100[(1 - b_i)^2 S_{A_i}^2 /M_i]$; Column 7: $RV = 100(S_u^2/M_i)$.

[c]Columns 8 and 9: a_i and b_i from equation (3); column 10:

$$F = \frac{(\Sigma E_{it}^2 - \Sigma u_{it}^2)/2}{\Sigma u_{it}^2/(n - 2)}$$

for testing H_0: $\alpha = 0$ and $\beta = 1$; Columns 11 and 12: $t(\alpha) = (a - \alpha)/S_a$ for testing H_0: $\alpha = 0$ and $t(\beta) = (b - \beta)/S_b$ for testing H_0: $\beta = 1$, both with $df = n - 2$. Column 13: $\bar{r}^2$ = squared coefficient of correlation between A_i and A_1, corrected for the degrees of freedom.

*Significant at the 1 percent level.

#Significant at the 5 percent level.

+Significant at the 10 percent level.

§Significant at the 25 percent level.

the standard deviations S_{Ei} and the absolute means of the errors $|E_i|$ tend to increase with i, the index of the time distance between the revisions (columns 2 and 3).

Most forecasts of the same variables, even those that look several quarters into the future, pass easily the minimal standard of relative accuracy represented by the naive model which extrapolates the last known value in the series of the rates of change that are being predicted. The estimates, although provisional and partly conjectural, look to the largely knowable past, and should generally do much better than the forecasts. Hence the inequality coefficient $U_i = \sqrt{\frac{1}{n}\sum_t^n E_{it}^2} \Big/ \sqrt{\frac{1}{n}\sum_t^n A_{it}^2}$ should be here typically a small fraction. Actually, most of the recorded U statistics are of the order of 0.1 - 0.2, but some exceed 0.3 and even 0.4 (column 4).[21] There is a tendency for U_i to increase with i.

Consider the sample regression equations:

$$(1)\quad A_{it} = a_i + b_i A_{1t} + u_{it}$$

and, correspondingly, the decomposition of the mean square error

$$(2)\quad M_i = \frac{1}{n}\sum E_{it}^2 = \bar{E}_i^2 + (1 - b_i)^2 S_{A1}^2 + S_{ui}^2 ,$$

where the three terms on the right-hand side may be labeled the mean, slope,

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[21] The U's for the percentage changes in IPD, 1959-61 and 1959-63, seem disturbingly high, but it should be noted that these were years of very low inflation rates (so even small E's could be fairly large relative to the A's).

and residual variance components (MC, SC, and RV, respectively).[22] Given M_i, the smaller both MC and SC, the better. As shown in columns 5-7, MC is mostly less than 10 percent and throughout less than 20 percent of M_i, but SC is large in several cases, particularly for IPD.

Ideally, the estimates should be unbiased and efficient. In terms of the standard regression model

$$(3) \quad A_{it} = \alpha_i + \beta_i A_{1t} + \varepsilon_{it} ,$$

with the usual assumptions, $\mathcal{E}(\varepsilon_{it}) = 0$ and $\mathcal{E}(\varepsilon_{it}^2) = \sigma_i^2$ (where $\mathcal{E}$ denotes expected value), this means that $\alpha_i = 0$ and $\beta_i = 1$, so that $\mathcal{E}(A_i) = \mathcal{E}(A_1)$ and ε_{it} and A_{1t} are uncorrelated.[23] While the parameters of (3) are unobservable, estimates from the sample regression (1) permit statistical tests of the joint null hypothesis that $\alpha = 0$ and $\beta = 1$. More often than not such tests reject the hypothesis, as shown by the frequency of the F-ratios that are significant at the 1, 5, 10, and 25 percent levels (column 10). Separate t-tests indicate that this is attributable partly to a number of a_i coefficients being significantly different from zero (columns 8 and 11), but in larger measure to the significant deviations from unity of more than half of the b_i coefficients (columns 9 and 12).

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[22]Here S_{A1}^2 and S_u^2 are variances of A_{1t} and u_{it}. Since $M_i = \bar{E}_i^2 + S_{Ei}^2$, and $\bar{E}_i^2$ is very small, the root mean quare errors $\sqrt{M_i}$ (which serve as the numerators in U_i) are only marginally higher than the corresponding values of S_{Ei} and are not shown separately in Table 1. On the inequality coefficient and the mean square error decompositions, see Theil, 1966, Chapter 2.

[23]If the model is appropriate, the estimates would in this case be optimal, with $E_{it} = \varepsilon_{it}$; that is, the observed discrepancies due to the revisions would be purely random errors with constant variance.

The correlations between the estimates A_1 and A_i decrease as i increases, but are generally high (column 13). However, the revisions in IPD during the early 1960s and some of those in nominal and real GNP during the late 1970s show rather conspicuously low $\bar{r}^2$ coefficients.[24]

The periods covered in Table 1 are discontinuous and relatively short because of the breaks due to benchmark revisions; if the data could be pooled across these periods, the number of degrees of freedom (df) would be increased and the relative precision of the estimated parameters improved. Pooled regressions were found to yield seemingly good results (generally lower F- and t-ratios in our tests of $\alpha = 0$, $\beta = 1$), but the Chow tests[25] rejected in several cases the hypothesis that the coefficients are stable for the pre- and post-benchmark periods. Close inspection of scatter diagrams also indicates the presence of some significant interperiod differences in the regression intercepts and slopes, thus advising against pooling.

There is little evidence of autocorrelation among the residuals from the regressions of A_i on A_1. The revisions rarely altered the signs of the changes in any of the three variables: the highest observed frequency of "directional misses" is eight percent.[26]

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[24] It should be noted that where the correlations are very high, and the regression statistics are associated with very small standard errors, even small deviations of a_i from zero and of b_i from unity can be found significant by our tests. It is also possible for the results to appear very good for a particular sample of observations simply because the revisions of the given series happened to be unusually small or sporadic in the period in question.

[25] Chow, 1960.

[26] Perhaps the results would be worse if the coverage included periods of sharp cyclical reversals such as the recession and recovery of 1973-75. It is suggestive that the record of revisions is better for 1975:4-1978:4, a time of continuing expansion, than for the two earlier episodes, each of which contained a mild recession. But it is also possible that a learning process occurred whereby the estimation techniques and data gradually improved.

TABLE 2 (continued)

Estimates Compared $(A_1 - A_i)$[a]	Summary Statistics for Errors[b]: Mean Error $\bar{E}$ (1)	Stand. Deviation S_E (2)	Mean Absol. Error $\overline{\lvert E \rvert}$ (3)	Inequality Coefficient U (4)	Components of Mean Square Error (percent): MC (5)	SC (6)	RV (7)	Regressions and Test Statistics[c]: Estimates of the Intercept a (8)	Slope b (9)	F Ratio for $\alpha=0$ $\beta=1$ (10)	t-Tests for $\alpha=0$ (11)	$\beta=1$ (12)	Adjusted Squared Correlation $\bar{r}^2$ (13)	Estimates Compared $(A_1 - A_i)$
41. Employees on Nonagricultural Payrolls, Millions (C)														
$A_1 - A_2$	.01	.07	.06	.22	1.6	0.3	98.1	-.00	.98	.38	-.11	-.35	.84	$A_1 - A_2$
$A_1 - A_3$	-.01	.09	.07	.26	0.8	0.0	99.2	.01	.996	.16	.33	-.04	.78	$A_1 - A_3$
47. Industrial Production, Index: 1967 = 100 (C)														
$A_1 - A_2$	-.02	.18	.14	.25	0.8	4.0	95.2	.03	.94	.98	1.10	-1.27	.92	$A_1 - A_2$
$A_1 - A_3$	-.01	.23	.19	.33	0.3	5.8	93.9	.04	.91	1.28	1.05	-1.55§	.87	$A_1 - A_3$
51. Personal Income Less Transfer Payments, 1972 Dollars (C)														
$A_1 - A_2$	-.04	.25	.19	.42	2.4	1.8	95.8	.05	.94	.86	1.22	-.87	.80	$A_1 - A_2$
$A_1 - A_3$	-.12	.25	.22	.44	18.6	2.6	78.7	.13	.92	5.26*	3.24*	-1.14	.80	$A_1 - A_3$
57. Manufacturing and Trade Sales, 1972 Dollars (C)														
$A_1 - A_2$	-.16	.31	.28	.19	20.0	14.8	65.1	.14	1.08	10.18*	2.95*	2.94*	.97	$A_1 - A_2$
$A_1 - A_3$	-.14	.33	.30	.20	16.5	14.2	69.3	.12	1.08	8.40*	2.55#	2.79*	.97	$A_1 - A_3$
62. Labor Costs per Unit of Output, Manufacturing, Index: 1967 = 100 (Lg)														
$A_1 - A_2$	-.06	.34	.25	.44	2.9	0.0	97.1	.06	.99	.58	.89	-.12	.68	$A_1 - A_2$
$A_1 - A_3$	-.14	.38	.31	.45	11.9	3.1	85.0	.08	1.14	3.43#	.97	1.19	.70	$A_1 - A_3$
70. Manufacturing and Trade Inventories, 1972 Dollars (Lg)														
$A_1 - A_2$	-.04	.13	.11	.29	8.1	0.0	91.9	.04	.99	1.68§	1.44§	-.08	.86	$A_1 - A_2$
$A_1 - A_3$	-.02	.12	.11	.28	2.0	2.6	95.4	.04	.94	.92	1.35§	-1.02	.86	$A_1 - A_3$
72. Commercial and Industrial Loans Outstanding, Million Dollars (Lg)														
$A_1 - A_2$	-.19	.43	.34	.31	17.1	2.3	80.6	.23	.94	4.82#	3.08*	-1.08	.88	$A_1 - A_2$
$A_1 - A_3$	-.20	.42	.32	.30	18.5	0.5	81.0	.22	.97	4.70#	2.91*	-.51	.89	$A_1 - A_3$

TABLE 2
Accuracy Statistics for Revisions in Monthly Changes of Fifteen Selected Cyclical Indicators, 1975-80

Estimates Compared $(A_1 - A_i)$[a]	Summary Statistics for Errors[b]: Mean Error $\bar{E}$	Stand. Deviation S_E	Mean Absol. Error $\lvert\bar{E}\rvert$	Inequality Coefficient U	Components of Mean Square Error (percent): MC	SC	RV	Regressions and Test Statistics[c]: Estimates of the Intercept a	Slope b	F Ratio for α=0 β=1	t-Tests for α=0	β=1	Adjusted Squared Correlation $\bar{r}^2$	Estimates Compared $(A_1 - A_i)$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	
8. New Orders for Consumer Goods and Materials, 1972 Dollars (L)														
$A_1 - A_2$	-.39	1.34	1.13	.44	8.0	21.1	70.9	.44	.82	11.70*	2.84*	-4.12*	.85	$A_1 - A_2$
$A_1 - A_3$	-.44	1.44	1.20	.48	8.6	22.5	68.9	.49	.80	12.86*	2.99*	-4.31*	.83	$A_1 - A_3$
12. Net Business Formation, Index: 1967 = 100 (L)														
$A_1 - A_2$	.06	1.25	.83	.81	0.2	27.0	72.8	.18	.60	10.45*	1.20	-4.56*	.45	$A_1 - A_2$
$A_1 - A_3$	.08	1.41	1.03	.94	0.3	33.1	66.6	.22	.50	14.04*	1.34§	-5.28*	.32	$A_1 - A_3$
20. Contracts and Orders for Plant and Equipment, 1972 Dollars (L)														
$A_1 - A_2$	-1.61	3.17	2.47	.39	20.9	0.5	78.5	1.61	.97	5.33*	3.21*	-.52	.88	$A_1 - A_2$
$A_1 - A_3$	-1.26	2.73	2.25	.33	17.8	0.4	81.7	1.25	.98	4.36#	2.90*	-.46	.90	$A_1 - A_3$
29. New Building Permits, Private Housing Units, Index: 1967 = 100 (L)														
$A_1 - A_2$	.20	1.33	.68	.15	2.3	6.2	91.5	-.15	.96	2.65+	-.90	-1.96+	.98	$A_1 - A_2$
$A_1 - A_3$	.26	1.60	.87	.18	2.7	4.7	92.5	-.21	.96	2.30§	-1.04	-1.71+	.97	$A_1 - A_3$
36. Net Change in Inventories on Hand and on Order, 1972 Dollars (L)														
$A_1 - A_2$	-.21	1.39	.89	.40	2.4	2.9	94.7	.18	.93	1.08	.82	-1.09	.85	$A_1 - A_2$
$A_1 - A_3$	-.04	1.29	.75	.37	0.1	5.5	94.4	-.00	.91	1.17	-.01	-1.51§	.86	$A_1 - A_3$
92. Change in Sensitive Prices of Crude Materials (L)														
$A_1 - A_2$	.00	.06	.01	.12	0.2	0.2	99.6	-.00	.99	.11	-.27	-.34	.98	$A_1 - A_2$
$A_1 - A_3$	-.00	.08	.04	.18	0.1	0.7	99.2	.00	.98	.23	.28	-.65	.96	$A_1 - A_3$
104. Change in Liquid Assets, Percent (L)														
$A_1 - A_2$	-.01	.04	.03	.54	3.3	14.3	82.4	.00	.81	6.09*	.81	3.14*	.76	$A_1 - A_2$
$A_1 - A_3$	-.01	.06	.04	.75	5.9	23.4	70.7	.01	.68	11.84*	1.20	-4.35*	.59	$A_1 - A_3$
106. Money Supply (M2) in 1972 Dollars (L)														
$A_1 - A_2$	-.00	.05	.02	.11	0.1	22.2	77.7	-.00	.95	5.60*	-.31	-3.34*	.99	$A_1 - A_2$
$A_1 - A_3$	-.01	.07	.03	.15	2.5	21.0	76.5	.01	.94	5.97*	.58	-3.27*	.98	$A_1 - A_3$

The estimates for 1975-78 look considerably better than those for the earlier periods. On the whole, the estimates for nominal GNP appear to be more reliable than the estimates for real GNP and, particularly, those for IPD. This is consistent with the argument made above with respect to economic measures generally, viz., that the costs of greater complexity is higher probability of error. (The adjustments of national income and product accounts for the effects of inflation are inevitably both intricate and approximate in nature.)

Many monthly time series which are widely used as important cyclical indicators are subject to revisions that are comparable in relative size to the revisions in the quarterly GNP accounts but much less diffused over time. The preliminary figures for the previous month are followed by three or four revisions in as many successive months, but the first two changes in the data generally account for a very high proportion of the total revision. There are also some indicators that are never revised and others that undergo only occasional, often minor revisions. Table 2, which uses the same type of accuracy statistics and the same format as Table 1, is limited to the first two changes in those components of the indexes of leading, coincident, and lagging indicators which have been frequently revised in the recent years.[27]

[27] There are no revisions of any kind in such indicators as the stock price index, vendor performance (percent of companies reporting slower deliveries), and the average prime rate charged by banks. The revisions in labor market series--average workweek and layoff rate in manufacturing, average duration of unemployment--are sporadic or seasonal and not very significant. The changes covered in Table 2, like those in Table 1, stem from a variety of sources: additional information as more primary data become available, coverage of more reporting units or places, once-a-year overhaul of seasonal factors, etc. The statistics cover only the periods for which the presently used composite indexes of the indicators are available, that is, 58-59 months in 1975-80 for the leading series and 40-42 months in 1976-80 for the coincident and lagging series. For information on the definitions, sources, and methods of derivation of the series covered in Table 2, see the series descriptions in U. S. Department of Commerce, Bureau of Economic Analysis, 1977.

FOOTNOTES TABLE 2

[a]A_1 - preliminary estimate published in U. S. Department of Commerce, Bureau of Economic Analysis, Business Conditions Digest (BCD) in month t+1 for month t.
A_2 - first revised estimate published in BCD in month t+2 for month t.
A_3 - second revised estimate published in BCD in month t+3 for month t.

The numbers preceeding the titles of the series are the identifying numbers from BCD. The components of the Index of Leading Indicators are labeled L, the components of the Index of Coincident Indicators C, and the components of the Index of Lagging Indicators Lg.

[b]See note b in Table 1.

[c]See note c in Table 1.

*Significant at the 1 percent level.

#Significant at the 5 percent level.

+Significant at the 10 percent level.

§Significant at the 25 percent level.

Quantitatively, several results noted before are reaffirmed in Table 2: the mean errors are mostly negative; the standard deviations and mean absolute errors tend to be larger as the distance between the estimates (i) increases; and the U coefficients are reasonably low and the $\bar{r}^2$ coefficients high, with a few notable exceptions (columns 1-4, 13). But the decomposition and, particularly, the test statistics (columns 5-12) differentiate strongly between the series, showing that the revisions caused large and apparently systematic changes in some indicators, small and random changes in others. The poorest results (in terms of low correlations and high F and t statistics) are obtained for the index of net business formation, a series based on indirect and, in its early versions, quite incomplete estimates. Significant F- ratios likewise characterize the revisions in real new orders and sales, plant and equipment commitments, residential building permits, change in liquid assets, real money supply (M2), and commercial and industrial loans outstanding. In most of these cases, the t-ratios for either $\alpha = 0$ or $\beta = 1$ or both are also high.

Directional errors due to revisions are very frequent for some of the monthly indicators (32% for net business formation, 18% for change in liquid assets, 12% for industrial production and inventories), rare for others (less than 5% for building permits, change in sensitive prices, real money supply, labor costs). The average for the series covered is 11 percent.

Measurement errors probably account for a fair proportion of the short irregular variations which are frequent and relatively large in many monthly indicators.[28] But large and troublesome revisions affect some series that are not very noisy (here again net business formation provides a good example).

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[28]For some evidence, see Shiskin, 1973. Of course, much of the volatility is genuine, particularly in the highly sensitive leading series (the coincident and, even more so, the lagging indicators tend to be smoother).

Statistical Adequacy

Revisions tell us something about the errors in provisional data and the uncertainty surrounding economic information, but much more is needed to assess how well a given series measures the economic variable or process in question. Studies of cyclical indicators[29] attempted to answer that question by evaluating the "statistical adequacy" of the series, consisting of a number of attributes such as the quality of the reporting system, coverage of process and time unit, availability of estimates of sampling and reporting errors, frequency of revisions, length of series, and comparability over time. Each of these aspects was assessed, and a weighted combination of the resulting scores was computed for each of the series on the 0-to-100 scale. For example, direct reporting would score higher than indirect estimation; full enumeration and probability sampling higher than nonprobability sampling; data referring to a full month or quarter higher than data referring to one day per week or one week per month; and longer series with few or no breaks higher than short and more discontinuous series.[30]

As shown in Table 3, the statistical adequacy scores for 110 time series average 70 and are rather heavily concentrated in the 60-79 range (21% are higher, 16% lower). These series have been selected as useful cyclical indicators with wide coverage.[31] It is plausible that the scores for a random sample of economic time series would be lower.

For some groups of economic variables, notably employment, commodity and stock prices, and interest rates, the quality of the data, according to these scores, is relatively high. For other groups, such as job vacancies

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[29]Moore and Shiskin, 1967; Zarnowitz and Boschan, 1975a and 1975b.

[30]For detail on the scoring rules and results, see the references in note 29.

[31]They are included in the "Cyclical Indicators" section of Business Conditions Digest (BCD), a monthly report by U. S. Department of Commerce, Bureau of Economic Analysis.

Table 8

Cross-Classification of 110 U.S. Indicators by Economic Process and Total Score for Statistical Adequacy

Class of Scores for Statistical Adequacy \ Economic Process	I. Employment and Unemployment	II. Production and Income	III. Consumption, Trade, Orders and Deliveries	IV. Fixed Capital Investment	V. Inventories and Inventory Investment	VI. Prices, Costs, and Profits	VII. Money and Credit	No. of Series	Per-cent
80 - 90	Marginal employment adjustments (4); Comprehensive employment (3); Compr. unemployment (1)			Business investment expenditures (1); Business investment commitments (1)		Sensitive commodity price (1); Stock price (1)	Interest rates (5); Money (3); Credit flows (2); Debt outstanding (1)		
Number of series:	8			2		2	11	23	20.9
70 - 79	Marg. employment adjustments (2); Compr. empl. (2); Compr. unemployment (4)	Compr. output and income (1); Industrial production (1)	New and unfilled orders & deliveries (5); Consumption and trade (3)	Bus. investment expenditures (3); Residential construction (2)	Inventory investment (1); Inventories on hand & on order (1)	Comm. price (1); Profits & cash flows (8)	Money (2); Velocity (1); Bank reserves (2) Interest rates (2)		
Number of series:	8	2	8	5	2	9	7	41	37.3
60 - 69		Compr. output & income (3); Industrial production (3)	Consumption and and trade (4)	Formation of bus. enterprises (2); Bus. investment commitments (4); Bus. investmt. expenditures (1)	Inventory investment (1); Inventories on hand, etc. (2)	Profits (1); Unit labor costs (2); Labor share (1)	Credit difficulties (1) Interest rates (1); Debt outstanding (1); Velocity (1)		
Number of series:		6	4	7	3	4	4	28	25.5
50 - 59		Capacity utilization (1)	Orders and deliveries (1)	Bus. investmt. commitments (2); Bus. investmt. expend. (1); Residential construction (1)	Inventory investment (2); Inventories on hand, etc. (2)	Unit labor costs (1)	Credit flows (2); Credit difficulties (1) Debt outstanding (1)		
Number of series:		1	1	4	4	1	4	15	13.6
40 - 49	Job vacancies (2)	Capacity utilization (1)							
Number of series:	2	1						3	2.7
Total	18	10	13	18	9	16	26	110	100.0
Mean Score	74	64	71	67	63	70	74	70	

Note: For detail on the identification and classification of the series covered, see U. S. Department of Commerce, Bureau of Economic Analysis, Business Conditions Digest, Part I, "Cyclical Indicators." All indicators whose length is at least 25 years are included. The titles in the cells identify subgroups of the given economic process, and the number of series in each such group is given in parentheses following the title.

and capacity utilization, the scores are low. However, there is considerable dispersion of the scores in each of the seven broad "economic process" categories distinguished in the table, and the averages for these categories do not differ much.

Currency and Smoothness

How frequently are the data compiled? How promptly do they become available? The answer to these two questions determine how well a series scores on "currency." The advantage of daily and weekly figures is that they help to make early estimates for the current month and can be smoothed with a minimum loss of timeliness. Monthly series are released at the earliest in the next month, quarterly series in the next quarter.

Table 4 (in its top headings and two bottom lines) shows the distribution of the 110 U. S. indicators according to their currency aspects. For 48 of these series data become first available two months or more after (the midpoint of) the period to which they refer. Another 48 series are released with lags of about one month, and 14 are collected at least weekly. On the 0-to-100 scale, the average score for currency is 61 for all 110 indicators, 76 for the 81 series with monthly or shorter unit periods.

Even if a series is available promptly in its final form, its month-to-month movement may be so obscured by either seasonal change or irregular variation (noise) as to shed little light on the longer, cyclical movements and trends that are of primary interest for current business analysis and forecasting. Most economic indicators today are reported in seasonally adjusted form (indeed, unadjusted data are not readily available for some of them), but the noise element is large in many series, small in others. Hence it is useful to have standardized measures of relative smoothness aid the interpretation of current changes in the indicators.

Table 4

Cross-Classification of 110 U. S. Indicators
by Measures of Currency and Smoothness

Currency[a] / Smoothness[b]	Periodicity: Frequency of Data Collection					Number of Series, Total	Percent
	Weekly	Monthly	Monthly	Monthly	Quarterly		
	Availability: Lag of Data Release						
	Same month or next month	Next month	Two months later	Three months later	Next Quarter		
	SCORE						
	100	80	54	27	20		
	Number of Series						
MCD = 1 $\overline{I}/\overline{C} < .34$ Score = 100	4	18	8		4	34	30.9
MCD = 2 $.34 \le \overline{I}/\overline{C} \le .66$ Score = 80	4	13	3	1	13	34	30.9
MCD = 3 $.67 \le \overline{I}/\overline{C} \le 1.00$ Score = 60	3	12	1	1	11	28	25.5
MCD = 4 $1.01 \le \overline{I}/\overline{C} \le 1.33$ Score = 40		4	2		1	7	6.4
MCD = 6 Score = 0	3	1	1	2		7	6.4
Total	14	48	15	4	29	110	
Percent	12.7	43.6	13.6	3.6	26.4		100.0

[a] Periodicity scores: Weekly series, 47; monthly, 27; quarterly, 0.

Availability scores: lag of one month or less behind the period to which the monthly data refer, 53; lag of two months, 27; lag of three months or more, 0; for quarterly series with data available any time during the quarter following that to which the data refer, 20.

Periodicity contributes 47% and availability 53% to the total currency score which can assume the values 100, 80, 54, 27, 20, or zero.

[b] MCD (months for cyclical dominance) is the shortest span in months over which $\overline{C} > \overline{I}$, where $\overline{C}$ is the average monthly change, without regard to sign, in the cyclical component, and $\overline{I}$ is the corresponding measure for the irregular component, of the given monthly series. The smoothness score for the monthly series is computed from the formula $[6 - MCD] \times 100$. For quarterly series, the score is based on $\overline{I}/\overline{C}$, the ratio of the average quarterly changes, without regard to sign, in the irregular and cyclical components of the given quarterly series.

Two such measures, routinely computed in the Census X-11 program of time series decomposition and seasonal adjustment, are provided for all cyclical indicators published in BCD. One is the ratio $\bar{I}_i/\bar{C}_i$, which compares irregular to the trend-cycle component of the given series, the average changes in the two being measured over i unit periods.[32] As the span i is increased, say from 1 to 6 months, the C component builds up while the I component remains about the same, so the ratio generally declines. For the shortest span of one month, only the smoothest of the indicators have $\bar{I}/\bar{C} < 1$ and for some volatile ones the ratio exceed 2 or 3. For the quarterly series, however, the values of $\bar{I}_i/\bar{C}_i$ (i = 1 quarter) are almost always less than one.

The second measure, derived from the first, is called MCD ("months for cyclical dominance") and is the shortest span i, in months, for which the irregular movement in the series is on the average smaller than the cyclical movement, that is, $\bar{I}_i/\bar{C}_i < 1$. The smoother a series, the smaller is its MCD.[33]

For monthly series, smoothness is measured, inversely, by the MCD estimate; for quarterly series, the size of the ratio $\bar{I}/\bar{C}$ computed over one-quarter intervals is used. Table 4 (in its last columns) shows how the indicators

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[32] Most series are assumed to be products, but some are assumed to be sums, of C, S, and I--the trend-cycle, seasonal, and irregular components. In the multiplicative case, the seasonally adjusted series CI is divided by the estimate of C (a flexible weighted moving average of CI) to obtain the random component I. $\bar{C}_i$ and $\bar{I}_i$ are average percentage (in the additive case, absolute) changes in the component series C and I, respectively, computed without regard to sign over the span i. For a detailed description of the method, see Shiskin, 1957 and 1973, and Shiskin, Young, and Musgrave, 1965.

[33] For example, for the monthly aggregates of industrial production, employment, inventories, and money supply, MCD = 1. The more irregular series on employee hours, unemployment, and retail sales have MCD = 2. Measures of average workweek, layoff rate, new orders and contracts, housing starts are much more volatile yet and their MCD's are 3 or 4 months. Finally, some monthly first-difference series--changes in inventories, in bank loans to business, in money stocks--have MCD values as high as 6.

are distributed according to these statistics. There are 30 monthly series with MCD = 1, 21 with MCD = 2, and 30 with MCD $\geq$ 3 (the corresponding sample proportions are 37%, 26%, and 37%). Including the quarterly series, the comparable numbers are 34, 34, and 42 (31%, 31%, and 38%, respectively). The average score for smoothness is about 73 on the 0-to-100 scale.

Table 4 also shows the cross-classification of the 110 series by currency and smoothness, and (viewed as an ordered contingency table) it suggests no tendency for the two ordinal scales to agree or disagree with each other systematically. Indeed, the coefficient of rank association computed from these data is G = .07, and the probability of the true value of G being different from zero seems extremely low.[34]

Across the series, then, our measures of the data release lag (currency) and the signal detection lag (smoothness) are uncorrelated. By adding these lags for each series, one can obtain a rough estimate of the total lag involved in extracting the information from the data.

Lags of Information

Table 5 shows that the so calculated lags vary from 2 to 9 months for the monthly indicators and from 4 to 7 months for the quarterly indicators. Of the 110 series, 41 (37%) have lags of 5 or more months, and this group accounts for about half of the series on investment, inventories, prices, costs, profits, money, and credit.[35]

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[34]The observed frequencies of agreements and inversions are f_a = 1,717 and f_i = 1,493, respectively, and $G = (f_a - f_i)/(f_a + f_i)$. With 110 observations and ties present, G is approximately normally distributed, and so is its numerator $S = f_a - f_i$, whose standard error is easier to calculate. After a continuity correction, the ratio of $\hat{S}$ to its standard error is 200.6/350.6 = .63. See Goodman and Kruskal, 1954 and 1963.

[35]These are scores in economic-process groups IV-VII (see Table 3). The series on employment, production, income, consumption and trade (groups I-III) have generally shorter lags (only 15 percent have lags exceeding 4 months).

TABLE 5

Estimated Information (Data Release and Signal Detection) Lags for 110 U. S. Indicators

Information Lag[a] (months)	Number of Series with Given Lags: Weekly or Monthly	Quarterly	All	All Series, Percent
(1)	(2)	(3)	(4)	(5)
2	22	0	22	20.0
3	25	0	25	22.7
4	18	4	22	20.0
5	6	13	19	17.3
6	3	11	14	12.7
7	4	1	5	4.6
8	1	0	1	0.9
9	2	0	2	1.8
Total	81	29	110	100.0
Average Lag (Months)	3.6	5.3	4.1	

[a]Sum of the data release lag (1 to 3 months) and signal detection lag (1 to 6 months). The information lags of 2 to 4 months consist of data release lags of 1-2 months and signal detection lags of 1-3 months; the longer information lags include also data release lags of 3 months and signal detection lags of 4 t0 6 months.

Source: Table 4.

In some cases, the availability of weekly (or still more frequent) data could shorten the effective information lags below the estimates in the table. The same could in principle be accomplished more generally by skillful data analysis and forecasting which would somehow succeed in correcting deficient and anticipating tardy information. In practice, however, not much can be expected from either factor.[36]

It is important to note that the measures of signal detection lags in Table 5 are derived from "final" observations rather than current, frequently preliminary estimates. The latter are typically "noisier" than the former because they contain larger measurement errors which are yet to be reduced by future revisions. In terms of the statistics underlying our lag estimates, the $\overline{I}/\overline{C}$ ratios are higher and the smoothing (MCD) periods are longer for preliminary than for final data. The task of distinguishing signal from noise (the persistent from the transitory component) would take more time on the current basis than the historical measures indicate. On this account, the lags in Table 5 are probably underestimated by 1 to 3 months for most of the series that are subject to significant revisions and perhaps by an average of one or 1½ months for all the series covered.[37]

In sum, the effective information lag includes not only the time required for incremental data to be produced and transmitted but also the time required for the signals in these data to be detected by the user. Some important

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[36]Few series are compiled daily or weekly, and most changes over such short periods consist largely of noise. Smoothing techniques can help in signal detection but generally at a loss in timeliness (e.g., centered moving averages do not reach to the most recent months). Business analysts and forecasters believe that their work is hindered by informational lags, irregularities, and errors, and this common view is consistent with available evidence.

[37]This is a rough estimate based on some rather fragmentary past studies. Thus according to Shiskin 1973, p. 14, eighteen monthly U. S. indicators 1965-69 had MCD measures averaging 2.4 in historical data and 3.8 in current data, a difference of 1.4 months. All but one of the 13 non-zero differences varied from 1 to 3 months.

information, notably prices of financial assets traded in organized auction markets, is prompt, generally accurate, and subject to continual, efficient processing. Most economic information, however, is much less current and reliable. Published time series, in particular, tend to lag well behind their reference periods and contain unknown measurement errors only partially and gradually reduced by revisions; their longer movements are overlaid and blurred by various types of short, eratic variations. The information lag exceeds the unit period and varies over a few or several months for any monthly or quarterly series in a sizable collection of widely used indicators.

The signal detection lags presumably can and should be assessed by different methods, but the reported results seem generally plausible.[38] Forecasters have long applied various smoothing techniques to estimate and then project the more persistent movements in noisy variables, and economists have proceeded similarly in testing hypotheses about "permanent" components of, say, income, output, sales, and prices. Some indirect but consistent evidence is also provided by the observed lags in recognition of turning points.[39]

[38]The NBER methods used in the studies of cyclical indicators are simple and applicable to large volumes of data at relatively low costs. Although subjected to serious criticism, their substantive results remain generally valid. Modern time series analysis offers an attractive program of research here, which would involve stochastic modeling of the indicators and careful statistical inference. When used on a large scale, however, this approach would be costly, with high (sometimes perhaps excessive) data requirements and rather uncertain returns. (For some work along these lines, see Granger and Hatanaka, 1964, chapter 12; Hymans, 1973; Sargent and Sims, 1977.)

[39]Fels and Hinshaw, 1968; Zarnowitz, 1967 and 1972; Moore, 1969.

III. Some Generalizations and Implications

Macro and Micro Information

The preceding discussion of the availability and accuracy of economic information included empirical applications to aggregate time series but this merely reflects the limitations of the evidence on hand. It is by no means only the aggregates but also microdata, eg., on sales and inventories, that are often of uncertain quality, incomplete, or tardy. This applies especially to real measures of income, output, expenditures, and relative prices and wages.

It is true, of course, that economic agents do have large amounts of direct knowledge of many local variables such as the nominal prices they charge and pay, and that the decisions they make depend largely on the data and predictions for such microvariables. But here, too, signal extraction problems exist, and the predictive value of the information under uncertainty turns out to be limited. The few studies in this area suggest that the errors in microforecasts of new orders, sales, inventories, and business fixed investment tend to be large, exceeding on the average, in relative terms, the errors in corresponding macroforecasts (which generally refer to smoother time series that may for this reason be easier to predict).[40]

The assumption of incomplete information plays a large role in contemporary theoretical discussions of how changes in nominal variables--the stock of money and its growth rate and the price level--can affect real variables--output, employement, and unemployment. Efforts to reconcile such effects with microeconomic precepts of optimizing behavior have led first to the "natural

[40] Hirsch and Lovell, 1961; Zarnowitz, 1973, pp. 62-68, 366-67, 433-38.

rate" hypothesis of long-run neutrality of money and then to new market-clearing equilibrium models of aggregate supply and business cycles. These models raise many problems that must remain outside the scope of this paper; our concern here is only with their informational aspects which include transitory confusion of nominal with real wage changes or of absolute with relative price changes (and always, consequently, of nominal with real disturbances).[41] An employer knows the prices of the items he sells but a worker does not know as well and as promptly the prices of all the items he will buy. Or the suppliers generally (individuals, firms) alter their output when the price level varies, mistaking the change in the nominal price of the output for a change in the relative price.

Consistent with earlier discussion, specific prices are indeed much better known than the overall price level and nominal incomes than real incomes. However, some of the hypotheses involve a contrast between ample information on the local level and limited information on the aggregate level. They are unconvincing on this point, since macroeconomic data are not in short supply currently. But the criticism of incomplete information models is still seriously in error to the extent that it ignores the uncertainties and lags of information which, there are good reasons to believe, are important on both the macro and the micro levels.[42]

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[41] Friedman, 1968; Lucas, 1972 and 1975.

[42] Thus it is difficult to agree with Hall, 1980, p. 23: "A large amount of information about prices, wages, employment, unemployment, and other aggregate variables is available virtually instantaneously and essentially for free." Certainly, there is a great flow of data but it is neither instantaneous nor costless to get usable information out of it.

Information, Expectations, and Behavior

The pervasiveness of business fluctuations implies that a great many economic times series are highly autocorrelated: "good news" prevail heavily in certain phases, "bad news" in others. The cumulation of the former (latter) fosters optimistic (pessimistic) expectations, which are characteristic and supportive of economic expansions and contractions, respectively.

None of this seems problematic but some business cycle theories postulate the presence of aggregative errors of excessive optimism and pessimism and attribute a major independent role to them. Prospective profits are being overestimated and such errors spread and grow until discovered in the markets for the "overproduced" commodities and replaced for a time by similarly infectious and partly self-validating underpredictions. In classical writings, access to more and better information on industry fortunes would help reduce the individual forecast errors and their cumulation.[43] For Keynes, information mattered little, since the expectations on the future yield from investment can draw only on knowledge that is "usually very slight and often negligible."[44]

Contemporary literature recognizes that economic behavior is governed by perceptions and expectations, but the latter are no longer treated as autonomous but rather as endogenous, that is, conditioned on the relevant

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[43]Consider Marshall, 1923, pp. 260-261: "Better and more widely diffused knowledge is a remedy for that excessive confidence which causes a violent expansion of credit and rise in prices, as it is also a remedy for that excessive distrust which follows." Or Pigou on "psychological causes of industrial fluctuations" which "consist in the tone of mind of persons whose action controls industry, emerging in errors of undue optimism or undue pessimism in their business forecasts" (1927, p. 66). The range of these errors depends on "the measure in which relevant information is accessible to the makers of forecasts" (ibid., p. 69).

[44]Keynes, 1936, p. 149. Hence "the basis for such expectations is very precarious. Being based on shifting and unreliable evidence, they are subject to sudden and violent changes (ibid., p. 315).

information and models available to the agents. The errors of expectations, then, are likewise conditioned: those that are inconsistent with the data and relationships in current use will be detected and corrected before long. By this reasoning, systematic errors are unlikely to persist and models that seem to imply the contrary are suspect.[45]

Indeed, carried to its logical conclusion, this approach postulates that expectations are "rational" in the sense of agreeing with the predictions from the proper models of economic behavior. A model is not free to assume arbitrary rules of expectation formation that are inconsistent with itself. This restriction is clearly desirable in principle, but it is too general to be of much help in practice: it all depends on what the "available and relevant" information and models actually are. Unless that is known or ascertained, there may be no hypothesis here which is objectively testable against the data but merely an assumption which rules out the data which are found to disagree with it. The danger then is that of a vague circularity if neither the model nor the data inspire much confidence. Alternatively, there is the risk that the hypothesis is excessively strong as the model used to test the "rationality" of the expectations may be improperly specified--after all, there is much uncertainty about model selection in economics.

Finally, the consequences of incomplete or deficient information may be mistaken for departures from the rational expectations model. Errors that seem "systematic" in retrospect are often difficult to identify and correct

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[45] The "psychological" hypotheses of the preceding paragraph fall in this category, which helps explain why they are in general out of favor now. However, with limited information and knowledge, it is by no means obvious what errors will be eliminated in practice (see text below). Incidentally, macroeconomic forecast evaluations provide no evidence of overoptimism and overpessimism: the most common errors are those of underestimation of expansions and inflation and missed downturns.

on a current basis for lack of sufficiently long and consistent series of observations. The reasons include changes in the structure of the measured phenomena as well as changes in concepts, sources, availability, and quality of the information. Even where the errors are detected and eliminated, this will seldom be done without some more or less costly and time-demanding process, and in the meantime the committed errors will have had some effects on expectations and behavior.

Striking illustrations of apparently inconsistent and (at least to the contemporaries) confusing changes in important economic intelligence are provided by the history of the turbulent first half of the 1970s. The original GNP data for 1973 greatly underestimated the slowdown of growth that was taking place at the time.[46] Later, extraordinary divergencies appeared between real GNP (which declined between 1973:4 and 1975:1) and industrial production and nonfarm employment (which declined only after June and September 1974, respectively). Accounting measures grossly overstated corporate profits and understated inventories. Business investment in constant dollars stayed strong more than a year after stock prices fell and returns turned negative, and long after real consumer outlays on housing and durable and nondurable goods declined decisively. Business analysts and forecasters generally failed to recognize (let alone anticipate) the onset and deepening of the recession. Economic policies were predominantly restrictive until late in 1974. Meanwhile the expected inflation rates lagged well behind the rapidly rising actual rates, according to all available surveys of

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[46]The annual growth of real GNP in the two middle quarters of 1973 averaged 2.9% according to the data published in January 1974, 1.4% according to the data available two years later. For evidence on the developments discussed below, see Zarnowitz and Moore, 1977.

anticipations and forecasts.[47] Thus many observers and decision makers, in both the public and private sector, seem to have been misled by the strength of the nominal aggregates and the temporarily conflicting signals from the real aggregates. The apparent conflicts and distortions of the data are now understood to derive from combined effects of particular events and persistent difficulties of measurement.[48]

In more stable times, when the shocks to the economy are less concentrated, frequent, and severe, expectations should prove to be generally more accurate, and they are. (For example, economic forecast errors are found to be on the average much smaller for periods of maintained expansion then in the vicinity of business cycle turning points.) However, informational delays alone would produce errors of foresight, even in the absence of any particular difficulties due to unpredictable disturbances, incorrect data, etc. In general, the longer the effective lags that are involved, the more inaccurate are the short-term expectations likely to be. Assuming a lag of, say, k time units, predictions for periods shorter than k may well be biased or show autocorrelated errors even if they are formed rationally, that is, optimally given the available information.[49]

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[47] Later, in 1975-76, when inflation rates fell, expectations lagged again (on the upgrade, the result of such lags is underestimation; on the downgrade, overestimation).

[48] The price and wage controls and decontrols between April 1971 and early 1974 must be mentioned first among the special events, followed closely by the collapse of the fixed exchange rate system and the energy crisis. They aggravated the problems of measuring inflation and adjusting the nominal aggregates for price changes. Other difficulties were associated with the use of shipments, man-hours, and electric power as proxies for physical production, and with growth of part-time employment, particularly in the expanding service sector.

[49] In theory, a sequence of k-step ahead forecasts should be a moving average process of order $k - 1$, so that optimal predictions with the span k have errors with autocorrelations of order k and higher equal to zero (see Box and Pierce, 1970). If the reaction to new information is delayed (say, because of contractual rigidities), then this may impede the learning process and work in a way parallel to an information lag.

Summary

Economic data are subject to a variety of errors (from inadequate sampling, concealment, falsification, poorly trained collectors, etc). There is also much uncertainty about economic measures, which tends to increase with the amount and complexity of the processing performed on the underlying data as well as with the distance between the user and the processor. Many errors in economic information cannot be promptly detected and removed but can only be reduced partially and gradually, as confirmed by the pervasiveness and persistence of data revisions.

This paper presents detailed evidence on the accuracy of provisional data on quarterly changes in three GNP series and monthly changes in fifteen important business cycle indicators. The statistics consist of summary measures of absolute and relative accuracy, regressions of revised on preliminary data, and tests of bias and inefficiency. The results vary in interesting ways for different variables and subperiods. For example, the estimates for nominal GNP compare favorably with those for real GNP and, even more so, those for the implicit price deflator. This presumably reflects the difficulty of measuring inflation and adjusting the current-dollar aggregates for the effects of price changes. The data for 1975-78 appear to be considerably better than those for the earlier periods covered, whether because the latter contained recessions or because the estimation techniques and materials improved.

The statistical quality of economic time series has a number of aspects which can be assessed such as the characteristics of the reporting system, coverage, length, consistency, sampling errors, etc. On the scale of 0 to 100, the statistical adequacy scores for 110 regularly published series selected

for their usefulness as cyclical indicators average 70; the series for a random sample of macroeconomic data would probably be lower.

For the same collection of series, measures of the data release lag (currency) and the signal detection lag (smoothness) have been compiled and found to be uncorrelated with each other. The sum of the two lags provides a rough estimate of the total lag involved in extracting signals from the "final" data for the given indicator. These estimates vary from 2 to 9 months for the monthly series and from 4 to 7 months for the quarterly series. Many important indicators have lags of 5 or more months. Additional lags of 1 to 3 months should be added for those series that are subject to significant revisions.

It is not only the aggregates but also microdata (e.g., on sales, inventories, profits) that present signal detection problems and are often inaccurate, incomplete, or tardy. Economic agents know best the local variables relating to their own activities, but businessmen increasingly monitor and have important uses for macroinformation as well. The alleged sharp contrast between ample information on the local level and limited information on the aggregate level has been greatly overdrawn.

Informational lags and biased measurement may lead to systematic errors in expectations and hence decisions. If they concern variables of general importance, such errors are apt to be broadly diffused. It takes some time before they are discovered, and the corrective reactions which then follow would often be sharp and similarly widespread. None of this is necessarily inconsistent with the optimal utilization of the available information (rational expectations).

In times of surprising events and strong shocks, measurement of short-term changes in the economy is particularly difficult and current signals are often misinterpreted, as happened repeatedly in the past decade.

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