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Characteristics of the Revisions

The first estimates of GNP and its components in a given quarter are published one month following the close of the quarter. These are advance estimates prepared by the OBE for the Council of Economic Advisers for publication in *Economic Indicators* (*EI*) and in the *Economic Report of the President* (*ERP*). Revised but still provisional estimates are published one month later in the *Survey of Current Business* (*SCB*).[13] The provisional estimates are in turn revised in July of each of the following three years.

In addition to the three annual July revisions, the availability of new census data occasions a major benchmark revision. Such revisions have occurred in 1947, 1954, 1958, and more recently in 1965.

Incorporating new benchmarks into the estimates is a major undertaking and the opportunity is generally taken to supplement regularly used data with any new series that may have become available. For example, in the major revision of 1965, accuracy of the new 1958 benchmarks was increased by supplementing the census data with the improved data sources and estimating procedures used by the OBE to prepare the 1958 input-output table.[14] Changes in the 1958 benchmarks

[13] Provisional estimates have been published in *SCB* two months following the close of each quarter since the major revision of 1947. In 1950, the schedule was in effect moved up one month by publication of advance estimates in *EI*. In January 1963, the advance estimates were also published in *SCB* and they have been published there regularly since 1964.

[14] For example, in the report article on the 1965 major revisions ("The National Income and Product Accounts of the United States: Revised Estimates, 1929–64," *SCB*, August 1965), the OBE states (p. 7), "Construction of the input-output table required a complete accounting for all product flows—to industrial users of raw materials and semifinished products as well as to final markets. This provided a new and powerful cross-check, which improved the accuracy of the estimates of the level of GNP. In the prior bench mark revision, only sales to final markets

suggested by the input-output data led to a review and adjustment of the old 1947 and 1954 benchmarks and, as a consequence, a reworking of the income and product figures for the whole postwar period.

Major revisions have often involved definitional changes in addition to statistical revisions (that is, revisions which reduce statistical errors of measurement, given the particular concept, or definition, of GNP). The most important definitional changes were made in the major revision of 1947. Since then, the changes have been minor in the sense that none of the broad concepts underlying the accounts has been substantially altered.[15] The statistical revisions alone are relevant for appraising the accuracy of the early data, and it is generally possible to separate them from definitional changes.

There are then at least six estimates of the value of GNP for a given period. If A represents the true value of GNP, the advance estimates may be denoted by A_{00}. One month later, the provisional estimates (A_0) are published. The provisional estimates are in turn subject to three annual July revisions (A_1, A_2, and A_3, respectively), and, several years later, to one or more major benchmark revisions (A_n).

Resemblance to Extrapolation Errors

The provisional and benchmark revised estimates can be expressed as

$$A_0 = A + E_0 \text{ and } A_n = A + E_n,$$

the sum of the true value (A) and their respective measurement errors (E_0 and E_n). The cumulative revisions (ϵ) are defined as the difference between A_0 and A_n, which equals $E_0 - E_n$. Hopefully, the revisions measure the *reduction* in error in the provisional estimates though, strictly speaking, they measure merely the *change* in error from one set of estimates to another.

had been estimated, and no attempt made to ensure that—industry by industry—the implied sales of intermediate products to industrial users were consistent with information on purchases made by such users."

[15] There were some minor definitional changes in 1958 (e.g., cash grants to foreign countries were no longer added to federal government expenditures and deducted from exports of goods and services). Most notable of the changes in 1965 was in the treatment of interest paid by consumers; it is no longer considered part of total production, thereby lowering the estimates. See the report article on the 1965 revision "National Income and Product Accounts" *SCB*, August 1965, pp. 7–16, for an account of the definitional changes.

A simple error model is developed in the Appendix and used to illustrate some of the properties of the errors that would arise from the use of a related series to interpolate between two benchmark estimates; the errors that are introduced when the related series consists of preliminary data and is used to extrapolate the last benchmark; and the changes in errors when a new benchmark estimate is introduced. It is shown that the changes in errors (i.e., the revisions) would consist of two components: (1) the error in predicting the next benchmark estimate; and (2) the reduction in measurement error in the related series. The first component, the prediction error, would be a common element of the revision in each period and hence a source of positive serial correlation. It is next shown that if the prediction error were the most important component, then the revisions of the provisional estimates of the level would be larger than revisions of the estimates of the period-to-period change in A. Finally, if the benchmark predictions were extrapolations of the last known benchmark estimates, then the magnitude of the prediction error would be smaller, the smaller the variability and the greater the serial correlation in the series to be predicted.

If this error model provided an accurate description of the essential characteristics of the errors and revisions in the provisional estimates of GNP and its components,[16] then the revisions would be expected to have the following characteristics: First, if ϵ were primarily extrapolation error, the revisions would be larger, the greater the variability and the weaker the serial correlation in the benchmark period estimates. Moreover, revisions in the estimates of levels would be greater than revisions in the estimates of period-to-period changes; and finally, the revisions would be serially correlated.

Summary statistics of the revisions (ϵ) in the provisional estimates of quarterly levels and changes in GNP and its components are given in Table 1 (columns 2–4 and 7–9). The square root of some statistics (e.g., the standard deviation, rather than the variance) is used in order to keep them in the same units as GNP data (billions of dollars).

A comparison of the statistics for levels with the corresponding statistics for changes shows that the revisions in estimates of quarterly levels exceed those for changes for all except the two components estimated as residuals (change in business inventories and net exports).

[16] The model is clearly not applicable to the two components which are estimated as residuals (i.e., as the difference between two estimates): change in business inventories and net exports.

The table also shows the root mean square error ($\sqrt{M_X}$) of simple first order extrapolations (columns 5 and 10).[17] The statistic ($\sqrt{M_X}$) is computed as

$$\sqrt{M_X} = (1 - r^2)S^2(A_n), \tag{3}$$

where r denotes the coefficient of serial correlation in A_n, the 1965 statistically revised data. The statistic $\sqrt{M_X}$ provides a rough index of the difficulty in extrapolating each of the variables given in Table 1. If the revisions resembled extrapolation errors, there would be a close correspondence between the ranks of $\sqrt{M_X}$ and $\sqrt{M_\epsilon}$.

Although there is a strong relation between the rankings of $\sqrt{M_\epsilon}$ for revisions of quarterly change estimates, there is almost none for levels (the Spearman coefficients of rank correlation are .89 and .27, respectively). The main reason for this discrepancy is the relatively large bias (mean error) in the early data for levels. A fairly strong association results if we ignore the level bias and compare the rankings of S_ϵ and $\sqrt{M_X}$ (the rank correlation coefficient is .77). Errors in the early data thus tend to be largest in those series which show the greatest variability and weakest serial correlation and which would therefore be the most difficult to extrapolate accurately.

The mean errors are negative for most of the variables in Table 1, suggesting that the provisional estimates tend to underestimate quarterly levels and changes. The degree of underestimation of changes, however, is negligible. With only the two exceptions noted earlier, the standard deviation of the error in levels exceeds that in changes. This result could occur only if there were strong positive serial correlation in the level errors.

The evidence in Table 1 is thus consistent with the hypothesis that the errors eliminated by the revisions are primarily extrapolation errors and that these errors are serially correlated.

One implication of the positive serial correlation in ϵ is that forecasts, to the extent that they rely on the provisional data available at the time

[17] If the extrapolation (X) were based on a first order autoregression,

$$A_t = \beta_0 + \beta_1 A_{t-1} + u_t,$$

where u_t is not correlated with A, not serially correlated, and has a mean value of zero, then the mean square error of X would equal

$$M_X = \sigma^2(u) = (1 - \rho^2)\sigma^2(A)$$

where ρ denotes the first order coefficient of serial correlation in A.

TABLE 1. Error Statistics for Provisional Estimates of Quarterly Levels and Changes in Gross National Product and Its Components, 1947 II–1961 IV[a]
(billion dollars)

		QUARTERLY LEVELS					QUARTERLY CHANGES				
		Average Level of Series	Mean Error	Standard Deviation of Error	Root Mean Square Error		Average Absolute Change	Mean Error	Standard Deviation of Error	Root Mean Square Error	
					Observed	Potential[b]				Observed	Potential[b]
Line	Variable	$\bar{A}_n$ (1)	$\bar{\epsilon}$ (2)	S_ϵ (3)	$\sqrt{M_\epsilon}$ (4)	$\sqrt{M_X}$ (5)	$\overline{\lvert\Delta A_n\rvert}$ (6)	$\bar{\epsilon}$ (7)	S_ϵ (8)	$\sqrt{M_\epsilon}$ (9)	$\sqrt{M_X}$ (10)
1	Gross National Product	382.7	−8.9	5.6	10.5	5.7	6.7	−0.6	3.2	3.2	5.3
2	Personal Consumption Expenditures	249.5	−4.4	3.3	5.5	3.0	3.7	−0.7	1.4	1.6	3.0
3	Durables	34.6	−2.6	1.8	3.2	1.9	1.4	−0.2	1.0	1.0	1.9
4	Nondurables	121.8	3.3	2.3	4.0	1.4	1.4	−0.2	1.0	1.0	1.3
5	Services	93.1	−5.1	1.4	5.3	0.4	1.6	−0.3	0.7	0.8	0.7
6	Gross Private Domestic Investment	58.6	−3.4	3.5	4.9	4.6	4.0	0.0	2.7	2.7	4.6
7	Producers' durables	23.0	2.2	3.2	3.9	1.1	0.9	0.3	0.9	0.9	1.1
8	New construction	32.9	−4.8	2.8	5.5	1.1	0.9	−0.1	0.7	0.7	0.9
9	Change in business inventories	2.7	−0.8	2.7	2.8	3.6	3.0	−0.2	3.1	3.1	3.9
10	Gov't. Expenditures on Goods and Services	70.9	2.1	2.2	3.0	2.2	2.0	−0.1	1.3	1.3	1.7
11	Federal Government	41.2	2.0	2.2	3.0	2.2	1.6	−0.1	1.1	1.1	1.6
12	State and local governments	29.7	0.1	0.7	0.7	0.4	0.7	−0.0	0.4	0.4	0.4
13	Net Exports	3.7	−2.6	1.6	3.1	1.1	1.1	−0.1	1.7	1.7	1.1

[a]Errors are computed as $\epsilon = A_0 - A_n$, where A_0 stands for the provisional estimates and A_n, for the 1965 statistically revised estimates. The data are in current dollars, seasonally adjusted, at annual rates.

Provisional estimates are from issues of the *Survey of Current Business* two months following the close of the quarter covered. For example, provisional estimates of GNP's level during the 1948 II and its change from the first quarter to the second quarter are from the August 1948 *SCB*.

The 1965 statistically revised estimates are taken from the August 1965 *Survey of Current Business*. The figures published are the result of both statistical and definitional revisions. The major definitional change was to exclude interest paid by consumers from the estimates (see the report article on the 1965 revision, "National Income and Product Accounts," *SCB*, August 1965, Tables 2 and 3). This item was added to the published figures (expenditures on consumer services, and hence to the aggregates, personal consumption expenditures and gross national product) to obtain estimates of the statistically revised data. This procedure does not entirely eliminate the definitional changes and the resulting series (A_n) therefore includes some minor definitional changes.

[b]The potential root mean square error, $\sqrt{M_X}$, is computed as

$$\sqrt{M_X} = \sqrt{(1 - r^2)\, S^2_{A_n}},$$

where r is the coefficient of serial correlation in A_n. See text and footnote 17.

they are made, would predict A_0 more accurately than the final data, A_n. To illustrate, let P_t denote a forecast, made in period $t - 1$, of the value of A in period t. P_t may be considered to consist partly of an extrapolative and partly of an "autonomous" component, as in

$$P_t = \alpha_1 A_{0t-1} + \alpha_2 A_{0t-2} + \cdots + u_t, \tag{3}$$

where α denotes the weights assigned to past values of the series, and u an autonomous component which summarizes all other information on which the forecast may draw.

Any errors in past values of the series would thus be transmitted to the forecast and become a component of its error. This is seen by using the relation $A_0 = A_n + \epsilon$ to express P_t as

$$P_t = P_t' + \Sigma\alpha_j\epsilon_{t-j}, \text{ where } P_t' = \alpha_1 A_{n_{t-1}} + \alpha_2 A_{n_{t-2}} + \cdots + u_t. \tag{3'}$$

The forecast error can be computed as

$$E_{P_t} = P_t - A_{n_t} = (P_t' + \Sigma\alpha_j\epsilon_{t-j}) - A_{n_t}, \tag{4}$$

or as

$$E_{P_t}^{\circ} = P_t - A_{o_t} = (P_t' + \Sigma\alpha_j\epsilon_{t-j}) - A_{n_t} - \epsilon_t = E_{P_t} - \epsilon_t. \tag{5}$$

The variance of E_p° equals

$$\sigma^2(E_P^{\circ}) = \sigma^2(E_P) + \sigma^2(\epsilon) - 2r_{\epsilon E_P}\,\sigma(E_P)\,\sigma(\epsilon). \tag{6}$$

If the early data errors, ϵ, were merely random errors of measurement then ϵ would be unrelated to E_P (i.e., $r_{\epsilon E_P} = 0$ because ϵ would not be serially correlated) and the variance of E_P° would exceed the variance of E_P. That is, the errors in forecasts measured as deviations from the provisional estimates would generally exceed the errors in forecasts measured from the revised estimates.

Table 2 shows statistics for the two measures of error in forecasts of annual levels of GNP and its major components. The forecasts are averages from Zarnowitz' sample of several hundred forecasts which were collected for the NBER short-term forecasting study.[18] They were issued during the fourth quarter of the base year and refer to the level of the variables during the coming year.

[18] For a description of the forecasts, see Victor Zarnowitz, *An Appraisal of Short-Term Economic Forecasts,* New York, NBER Occasional Paper 104, 1967, Chapter 1.

TABLE 2. Selected Error Statistics for Average Business Forecasts of Annual Levels of GNP and its Major Components: Comparison of Errors Computed with Provisional and Revised Estimates of Actual Values, 1953–62[a]
(billion dollars)

Line	Variable Forecast	Description of Error Measures[b]	Mean Error (1)	Standard Deviation of Error (2)	Mean Absolute Error (3)	Root Mean Square Error (4)
1	Gross National Product	E°	−5.4	9.3	9.0	10.3
2		E	−16.2	9.6	16.2	18.6
3	Personal Consumption Expenditures	E°	−1.8	4.3	3.5	4.5
4		E	−7.5	4.5	7.5	8.6
5	Gross Private Domestic Investment	E°	−1.4	5.3	4.7	5.2
6		E	−5.6	5.4	6.1	7.6
7	Gov't. Expenditures on Goods and Services	E°	0.7	1.8	1.7	1.9
8		E	1.6	2.8	2.4	3.1
9	Net Exports	E°	−0.3	1.6	1.2	1.5
10		E	−2.1	1.9	2.5	2.8

[a]Forecasts are from Zarnowitz' sample of short-term forecasts. See text and footnote 18.

[b]$E^\circ = P - A_0$ and $E = P - A_n$, where P stands for forecast, A_0 for the provisional estimates, and A_n for the 1965 statistically revised estimates (see Table 1, note a for sources of data).

The forecasts and estimates refer to year T. P is published in the fourth quarter of year $T - 1$; A_0, in February of year $T + 1$.

Without exception, the error statistics based on E_P exceed those based on E_P°. The fact that S_E consistently exceeds S_{E° means that there is a strong positive correlation between ϵ and E_P. This correlation could be attributed to the forecasts' reliance on provisional data and the serial correlation of the errors in these data.

Cyclical Characteristics

Table 3 provides further evidence that the variability of errors in the provisional estimates of quarterly levels is not merely random. The error in an estimate of GNP level for a given quarter depends on that period's position in the business cycle. Provisional estimates tend to underestimate most during periods of expansion and underestimate less, or over-

TABLE 3. Mean Errors in Provisional Estimates of Quarterly Levels of GNP and Its Components Classified According to Cyclical Characteristics of Quarter Covered, 1947 II–1961 IV[a]
(billion dollars)

Variable	MEAN ERROR OF ESTIMATES DURING: Expansion: First Year	Expansion: Remainder	Contraction
Gross National Product	−5.5	−3.9	−2.5
Personal Consumption Expenditures	−2.9	−3.1	−2.3
Durables	−1.4	−1.9	−1.0
Nondurables	.1	1.7	.5
Services	−1.7	−3.0	−1.8
Gross Private Domestic Investment	−2.1	−.5	.4
Producers' durable equipment	.5	2.1	1.6
New construction	−.4	−2.0	−.6
Change in business inventories	−2.2	−.6	−.2
Gov't. Expenditures on Goods and Services	−.2	−.1	−.1
Federal government	.2	.2	.2
State and local governments	−.4	−.2	−.1
Net Exports of Goods and Services	−.3	−.2	−.5

NOTE: Details may not add to total because of rounding.

[a]Revisions after approximately three years (third July Revisions). Errors are computed as $A_0 - A_3$.

estimate, during periods of contraction. There is some suggestion that the initial figures underestimate more during the first year than in later periods of expansion.

The main source of underestimation is the personal consumption expenditures component. The cyclical differences are due mainly to errors in gross private domestic investment (especially in the inventories component), although there is also a slight tendency for the early consumption data to underestimate levels more during periods of business cycle expansion than during periods of contraction.

Overestimation, Underestimation, and Direction of Change Errors

Had the revisions merely changed the level of the estimates, they would have little or no systematic effect on the changes. Instead, as is shown in Table 4, the initial estimates of quarterly change in GNP tend to underestimate increases and overestimate decreases (lines 2 and 3).

TABLE 4. Types of Error in Provisional Estimates of Quarterly Change in Gross National Product and Its Components, 1947 II–1961 IV

Line	Type of Change in Revised Estimates (ΔA_n)	Total[b] (1)	Type of Error in Provisional Estimates (ΔA_0)[a] Underestimate[c] (2)	Overestimate[d] (3)	Directional Error[e] (4)
			GROSS NATIONAL PRODUCT		
1	All observations	57	23	27	7
2	Increases	47	23	19	5
3	Decreases	10	0	8	2
			PERSONAL CONSUMPTION EXPENDITURES		
4	All observations	56	34	19	3
5	Increases	49	31	15	3
6	Decreases	7	3	4	0
			CONSUMER DURABLES		
7	All observations	54	16	31	7
8	Increases	33	13	14	6
9	Decreases	21	3	17	1
			CONSUMER NONDURABLES		
10	All observations	54	24	26	4
11	Increases	45	24	19	2
12	Decreases	9	0	7	2
			CONSUMER SERVICES		
13	All observations	55	41	13	1
14	Increases	54	41	13	0
15	Decreases	1	0	0	1
			GROSS PRIVATE DOMESTIC INVESTMENT		
16	All observations	58	26	24	8
17	Increases	37	17	15	5
18	Decreases	21	9	9	3
			PRODUCERS' DURABLE EQUIPMENT		
19	All observations	49	20	20	9
20	Increases	30	12	15	3
21	Decreases	19	8	5	6
			NEW CONSTRUCTION		
22	All observations	51	28	17	6
23	Increases	33	20	9	4
24	Decreases	18	8	8	2

TABLE 4. (concluded)

Line	Type of Change in Revised Estimates (ΔA_n)	Total[b] (1)	Type of Error in Provisional Estimates (ΔA_0)[a] Under-estimate[c] (2)	Over-estimate[d] (3)	Directional Error[e] (4)
		CHANGE IN BUSINESS INVENTORIES			
25	All observations	57	18	27	12
26	Increases	30	10	13	7
27	Decreases	27	8	14	5
		GOV'T. EXPENDITURES ON GOODS AND SERVICES			
28	All observations	57	26	23	8
29	Increases	45	23	18	4
30	Decreases	12	3	5	4
		FEDERAL GOVERNMENT			
31	All observations	58	19	29	10
32	Increases	37	12	18	7
33	Decreases	21	7	11	3
		STATE AND LOCAL GOVERNMENTS			
34	All observations	52	25	23	4
35	Increases	51	25	23	3
36	Decreases	1	0	0	1
		NET EXPORTS			
37	All observations	56	26	22	8
38	Increases	30	10	15	5
39	Decreases	26	16	7	3

[a]See TABLE 1 note a and TABLE 7 note b for a description of the changes used.

[b]Maximum number of observations is 59. Cases in which the quarterly change, ΔA_n, is zero and in which $\Delta A_0 = \Delta A_n$ are excluded.

[c]Provisional estimate is less than revised estimate ($\Delta A_0 < \Delta A_n$).

[d]Provisional estimate exceeds revised estimate ($\Delta A_0 > \Delta A_n$).

[e]Sign $\Delta A_0 \neq$ sign ΔA_n.

Failure to distinguish between increases and decreases gives a considerably different impression of the error characteristics. It would appear there is a slight tendency to overestimate when all changes in GNP are considered (line 1). However, this is due mainly to overestimation of the relatively few decreases that occurred (compare lines 1, 2, and 3).

Most of the underestimation of increases in the aggregate comes from

underestimating increases in consumption expenditures, particularly services, while decreases in consumer goods, business inventories, and federal government expenditures are initially overstated. In fact, the early figures on inventories and federal government expenditures tend to overstate both increases and decreases.

One could expect that the systematic errors in the early GNP statistics would be transferred to forecasts, which may consist partly of extrapolations of these data.[19] In fact, Zarnowitz, in his evaluation of forecasting accuracy, does find errors of a somewhat similar nature.[20] The forecasts in his sample tend to underestimate levels, particularly of GNP and personal consumption expenditures. Furthermore, the magnitude of error in forecasts, just as in the early GNP data, varies according to the stage of the business cycle. The forecasts underestimate GNP levels most during the first year of expansion. GNP levels during the remaining periods of expansion are underestimated by a lesser amount and they tend to be slightly overestimated during periods of contraction.

While forecasts of annual change tend to overestimate as often as underestimate changes in gross private domestic investment (both increases and decreases), increases in GNP and consumption are underestimated. There was no indication of bias, however, in forecasts of decreases in GNP.

Directional errors were much more frequent for series that have a more nearly equal distribution of increases and decreases than for series that show a great preponderance of increases (Table 4). For example, this type of error accounted for only 5 per cent of the errors in total consumption expenditures as compared with 14 per cent for gross private domestic investment, or 2 per cent for consumer services as compared with 21 per cent for business inventory change.

In contrast to the relatively few directional errors in the provisional data (12.2 per cent), Zarnowitz finds that forecasts show a very poor record in predicting the direction of the next quarter's GNP movement. This type of error ranged from 23 to 44 per cent in three of the fore-

[19] A detailed analysis of the effects of data errors on forecasting accuracy is given in R. Cole, "Data Errors and Forecasting Accuracy," in Jacob Mincer, ed., *Economic Forecasts and Expectations: Analyses of Forecasting Behavior and Performance*, New York, NBER, 1969, pp. 47–82.

[20] Zarnowitz, *An Appraisal of Short-Term Economic Forecasts*, Tables 3, 7, and 11.

cast sets that he examined.[21] In addition, he found that major turning points are often missed while false turns are occasionally predicted. Most frequently missed by the forecasts were the declines in GNP.

In summary, we can conclude that: (1) the revisions of the provisional estimates can be considered primarily a measure of extrapolation errors and (2) these errors are by no means random. There are systematic differences between the first and revised estimates of quarter-to-quarter change in GNP and many of its components, as well as between the estimates of quarterly levels. The provisional estimates underestimate GNP levels most during the early periods (the first year) of business cycle expansion, somewhat less throughout later periods of expansion, and still less during periods of contraction. Moreover, these characteristics of errors in the early GNP data are similar to those Zarnowitz found in his sample of forecasts.

[21] *Ibid.*, Table 13.