DATA REVISIONS AND FORECASTING ACCURACY: AN ECONOMETRIC ANALYSIS BASED ON PRELIMINARY AND REVISED NATIONAL ACCOUNTING ESTIMATES*

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This paper entails an investigation of the effects of data revisions on forecasting accuracy, through use of preliminary and revised national accounting data compiled by the United Nations. A small model was estimated for each of fourteen countries and *ex post* "forecasts" generated for each country and each year of the period 1957–1964, using first preliminary and then revised data.

A prior analysis of the data revisions indicated a strong and widespread tendency for the preliminary estimates to understate both levels and year-to-year changes. This is consistent with the findings of other studies.

Two sets of forecasts obtained from the reduced form of the model were considered in relation to "actual" levels and changes, obtained from the revised data, and also in relation to each other. A strong downward bias was observed in the forecasts of levels based on preliminary data, and a weaker one in the forecasts of changes. The forecast discrepancies for different variables were found to be significantly correlated.

The results suggest that a tendency toward understatement in preliminary data may account in part for the general tendency toward understatement in forecasts noted in other studies.

Estimates of national accounting aggregates for a given year often pass through several stages of revision. The first published estimates may be based on data that are preliminary and quite incomplete. A second set of estimates may appear several months or a year later, based on more complete and reliable data. Perhaps a third set will be published after another year, and so on. Sometimes the process of revision will not be finished for many years, especially since "benchmark" data that are collected infrequently, such as those from a decennial census, may cause statistical agencies to revise estimates for periods extending back a decade or more.

Data revisions are of interest to the short-run economic forecaster from two points of view. First, by altering the statistical record of the past, they may affect his understanding or interpretation of how the economy has behaved in previous periods and hence his expectations as to how it will behave in the future. In the context of econometric analysis, this means that the estimated parameters of a model fitted to historical data may be subject to modification. Second, since short-run forecasting must be based on preliminary data for the most recent period or periods, errors in unrevised data imply errors in the forecaster's knowledge of the *current* position of the economy, and thereby affect his ability to predict its future position. Again in an econometric context, this means that even if somehow he could have a perfectly accurate model of the economy, he would still have to insert imperfect data into it in generating his forecasts.

*The authors wish to acknowledge gratefully the provision by the United Nations Statistical Office of some unpublished data used in this study and the excellent research assistance provided by Mrs. Christine Feaver.

The effects of using preliminary national accounting data to estimate the parameters of econometric models have been investigated empirically by Denton and Kuiper [5, 6], Holden [12], and Denton and Oksanen [7, 8, 9]. In the present paper, we investigate the effects of data revisions on forecasting accuracy from the second point of view. We do this by making use of preliminary and revised national accounting data compiled by the United Nations Statistical Office. A small econometric model is estimated for each of fourteen countries. *Ex post* "forecasts" are then generated for each country for each year of the period 1957–1964, first using preliminary data and then using final data. A comparison of the two sets of forecasts provides the basis for assessing the effects of the revisions.

I. The Model

The econometric model specified for purposes of this study is a simple one· It could hardly be otherwise, given that the analysis required the same basic model to be used for all countries, and given also the severe limitations on the length and availability of consistent time series that could be assembled for the fourteen countries involved.[1] The model includes a consumption equation, an investment equation, an import demand equation, and a national accounting identity. All variables are income or expenditure aggregates expressed in current monetary units of the particular countries.[2] The final form of the model, arrived at after considerable testing of alternative forms, is as follows:

$$c_t = \beta_{10} + \beta_{11}y_t + \beta_{12}c_{t-1} \tag{1}$$

$$i_t = \beta_{20} + \beta_{21}(y_t - y_{t-1}) + \beta_{22}i_{t-1} \tag{2}$$

$$m_t = \beta_{30} + \beta_{31}i_t + \beta_{32}(y_t - i_t) \tag{3}$$

$$y_t = c_t + i_t + z_t - m_t \tag{4}$$

The subscript t represents time (year). Definitions of the variables are

c—private consumption expenditure
i—gross domestic fixed capital formation
m—imports of goods and services
y—gross national product
z—all components of y other than c, i, and m.

Equation (1) relates consumption to total *GNP*, with allowance for lagged response. Equation (2) determines gross fixed investment by means of a crude accelerator relationship, again with allowance for lagged response. Equation (3) determines imports on the basis of the marginal import content of investment expenditure and all other types of expenditures combined. Equation (4) is the

[1]An attempt was made to include as many countries as possible in the analysis but lack of consistent time series reduced the number to fourteen. It should be noted that the analysis required that both preliminary and revised data be available on a consistent definitional basis for every year. For a number of countries, consistent series of revised data could be assembled, but not consistent series of preliminary data.

[2]The possibility of working with price-deflated aggregates was ruled out by the insufficient availability of suitable price data.

usual aggregate income-expenditure identity. Altogether, the model contains four current endogenous variables (c_t, i_t, m_t, y_t), three lagged endogenous variables (c_{t-1}, i_{t-1}, y_{t-1}), and one current exogenous variable (z_t).

The parameters of the model were estimated by two-stage least squares for each country for the period 1954–1964, using what we term "final data" for this period. These are revised data compiled for inclusion in the 1968 volume of the United Nations *Yearbook of National Accounts*. The term "final" is used by us to distinguish these revised data from the first estimates published each year by the U.N. The latter, which we term "preliminary data", are contained in the individual annual volumes of the *Yearbook*.[3]

The estimated equations for the fourteen countries are presented in Table 1. Obviously, no great claims can be made for the degree of realism with which the model represents the complexities of any particuar national economy. It is far too simple for that. However, given the purposes of the analysis and the restrictions on availability of data, the results in Table 1 appear generally satisfactory. The fits are rather good; the ratios of coefficient estimates to standard errors are respectable in the majority of cases; and, with only a few exceptions, the signs on the coefficients accord with *a priori* expectations.[4]

II. The Nature of the Data Revisions

Before turning attention to the effects of data revisions on forecasts we consider the data revisions themselves.[5] Table 2 provides summary information about the data revisions for all countries combined over the period 1957–1964.[6] The information relates to revisions of levels and revisions of year-to-year rates of change for each of the five variables appearing in the model (y, c, i, m, z). In analysing revisions of levels, we focus attention on r, the percentage difference between preliminary and final values. Letting x_t stand for any variable of interest

[3]All data for the period considered in this study were compiled according to the concepts and definitions set forth in United Nations [23]. More recently, the revised set of concepts and definitions described in United Nations [24] has been adopted, but this has no bearing on the present analysis.

[4]A few additional points may be noted: (1) Besides the two-stage least-squares estimates shown in Table 1, the equations were also estimated by ordinary least squares. $\bar{R}^2$ values computed for the *OLS* estimates were generally high—in excess of 0.95 in most cases and greater than 0.99 in many. (2) The residuals from the *OLS* equations gave no evidence of strong autocorrelation. (3) *A priori* expectations about the signs of the slope coefficients of the model were that they would be positive in every case. An examination of Table 1 reveals that these expectations were satisfied in all but 8 out of 84 cases. For further analysis of a similar model, see Denton and Oksanen [7, 8].

[5]A number of studies have been concerned with the revisions of national accounts data for particular countries. These studies include the following: *Canada*—Denton and Kuiper [5, 6], Denton and Oksanen [7, 8, 9], Goldberg, Adler, Randall and Sunga [11]; *Finland*—Niitamo [17]; *Germany (Federal Republic)*—Arndt [1], Rinne [18]; *United Kingdom*—Holden [12, 13], Stekler and Dalm [20]; *United States*—Cole [2, 3], DeJanosi [4], Jaszi [14], Nassimbene and Teeter [16], Stekler [19], Zellner [25]. In addition, Glejser and Dramais [10] have analysed revisions of *GNP* estimates for 42 countries.

[6]Final data were available for the 12-year period 1953–1964. Allowing for lags, this left 11 observations for use in estimating the model. However, preliminary data could not be assembled for the first few years on a basis comparable with later ones, and so the analysis of data revisions and the *ex post* forecasting experiments were restricted to the 8-year period 1957–1964.

TABLE 1

STRUCTURAL EQUATIONS ESTIMATED FROM "FINAL" DATA FOR 1954–1964 BY TWO-STAGE LEAST SQUARES

Country and Currency Unit	(1) Consumption Equation				(2) Investment Equation				(3) Import Equation			
	β_{10}	β_{11}	β_{12}	%$\bar{S}$	β_{20}	β_{21}	β_{22}	%$\bar{S}$	β_{30}	β_{31}	β_{32}	%$\bar{S}$
Austria	2.2	0.078	0.919	1.5	1.2	0.119	1.024	5.3	4.7	1.382	−0.149	4.9
—billion schillings	(1.2)	(0.5)	(3.1)		(0.5)	(1.2)	(19.5)		(0.2)	(0.8)	(0.2)	
Canada	22.3	0.279	0.596	0.5	601.6	0.514	0.848	4.7	455.4	0.437	0.122	3.2
—million dollars	(0.1)	(8.8)	(11.0)		(0.8)	(5.1)	(8.7)		(1.0)	(4.0)	(4.3)	
Denmark	1,630	0.457	0.270	1.2	−621.5	0.242	1.081	7.1	3,667	1.141	0.017	2.9
—million kroner	(1.9)	(5.1)	(1.5)		(1.2)	(2.1)	(11.5)		(2.5)	(3.0)	(0.1)	
France	10.7	0.363	0.408	1.4	−2.7	0.001	1.207	5.5	2.3	0.145	0.119	3.7
—billion francs	(1.6)	(2.2)	(1.3)		(0.9)	(0.0)	(20.6)		(0.7)	(1.1)	(2.4)	
Germany (Fed. Rep.)	8.9	0.488	0.110	0.7	−0.8	0.253	1.034	3.3	−23.2	−0.960	0.652	6.1
—billion DM	(6.5)	(10.1)	(1.2)		(0.4)	(2.6)	(26.8)		(1.7)	(1.5)	(2.4)	
Ireland	42.4	0.531	0.214	1.3	−2.1	0.338	0.976	7.2	−23.2	0.901	0.312	3.4
—million pounds	(1.4)	(4.1)	(0.9)		(0.1)	(2.0)	(4.5)		(1.3)	(4.3)	(5.0)	
Italy	874.7	0.557	0.078	1.6	360.1	0.159	0.953	5.6	−520.8	0.819	−0.010	4.8
—billion lire	(2.6)	(16.6)	(1.1)		(1.3)	(2.9)	(12.6)		(2.0)	(3.5)	(0.1)	
Japan	−15.2	0.180	0.771	1.4	−58.7	0.446	0.963	8.2	399.0	0.205	0.027	8.7
—billion yen	(0.1)	(2.9)	(5.2)		(0.2)	(2.6)	(11.6)		(1.4)	(1.8)	(0.4)	
Netherlands	119.2	0.423	0.294	1.8	394.5	0.444	0.889	4.3	1,886	1.714	0.025	2.4
—million guilders	(0.2)	(3.6)	(1.2)		(0.8)	(6.1)	(13.3)		(2.2)	(3.3)	(0.1)	
New Zealand	106.5	0.478	0.197	3.1	17.4	0.548	0.873	4.4	308.1	1.068	−0.138	5.1
—million dollars	(1.3)	(3.3)	(0.8)		(0.4)	(3.1)	(7.9)		(6.0)	(1.2)	(0.5)	
Norway	−309.9	0.188	0.740	1.1	214.7	−0.071	1.060	4.9	1,274	0.453	0.357	1.8
—million kroner	(0.7)	(1.9)	(3.7)		(0.3)	(0.4)	(10.6)		(3.2)	(2.7)	(5.4)	
Sweden	2,227	0.299	0.465	0.7	−868.6	−0.104	1.202	2.0	−4,218	−1.127	0.718	2.5
—million kroner	(1.6)	(2.9)	(2.1)		(2.1)	(0.7)	(15.8)		(2.5)	(2.9)	(5.1)	
United Kingdom	223.4	0.182	0.753	0.7	−233.9	0.065	1.121	5.9	4,132	2.126	−0.351	5.1
—million pounds	(0.5)	(0.8)	(1.9)		(0.6)	(0.8)	(13.4)		(2.4)	(2.0)	(1.2)	
United States	2.7	0.403	0.374	0.5	8.3	0.308	0.854	1.9	0.5	0.194	0.012	1.8
—billion dollars	(0.8)	(7.8)	(4.1)		(2.4)	(6.9)	(17.6)		(0.5)	(3.2)	(1.1)	

Note: Figures in brackets are ratios of coefficients to standard errors. %$\bar{S}$ is standard error of estimate (adjusted for degrees of freedom) expressed as percent of mean value of variable being "explained".

in year t and attaching superscripts p and f to indicate preliminary and final figures, r is defined by $r_t = 100(x_t^p - x_t^f)/x_t^f$.

The table provides information about the mean values of r, the mean *absolute* values (mean $|r|$), and the numbers of times that r is negative, based on all 112 sets of observations (8 years for each of 14 countries). In addition, the number of countries in which r is negative in more than 4 of the 8 years is reported for each variable.

In analysing revision of year-to-year changes, attention is focused on the differences between the percentage changes represented by the preliminary figures and those represented by the final figures. Let $\dot{x}_t$ be the percentage change between years $t - 1$ and t. The measures of this change based on preliminary and final data are then given by $\dot{x}_t^p = 100(x_t^p - x_{t-1}^{rp})/x_{t-1}^{rp}$ and $\dot{x}_t^f = 100(x_t^f - x_{t-1}^f)/x_{t-1}^f$, where p and f stand for preliminary and final, as before, and rp stands for "revised preliminary". It is important to note that in calculating changes based on preliminary data one should not, in general, compare x_t^p and x_{t-1}^p, i.e., the first estimates for two consecutive years taken from different annual publications. By the time x_t^p is published, the estimate for $t - 1$ typically will have been revised, although very often the revision will be only partial and the estimate will be subject to further revision in subsequent years before becoming "final". Thus x_{t-1}^{rp} represents the "revised preliminary" figure for year $t - 1$ that is contained in the same publication as (and hence presumed to be consistent with) x_t^p.

Table 2 reports, for all 112 sets of observations combined, the mean values of $\dot{x}^p - \dot{x}^f$, the mean absolute values (mean$|\dot{x}^p - \dot{x}^f|$), the numbers of times

TABLE 2

SUMMARY OF DATA REVISIONS, ALL COUNTRIES COMBINED, 1957–1964: ANNUAL LEVELS AND YEAR-TO-YEAR CHANGES

Summary Measure	Number of Items Involved	Variable: y	c	i	m	z
Annual levels						
(1) Mean r (%)	112	−2.85	−2.63	−4.09	0.55	−0.47
(2) Mean $\lvert r\rvert$ (%)	112	2.94	3.24	4.44	1.63	2.23
(3) Number of times $r < 0$	112	103	89	96	48	68
(4) Number of countries in which $r < 0$ predominates	14	14	11.5	13	5.5	8.5
Year-to-year changes						
(5) Mean $(\dot{x}^p - \dot{x}^f)$ (%)	112	−0.55	−0.46	−0.98	0.03	−0.18
(6) Mean $\lvert\dot{x}^p - \dot{x}^f\rvert$ (%)	112	0.93	0.85	1.84	0.85	1.65
(7) Number of times $(\dot{x}^p - \dot{x}^f) < 0$	112	81	83	75	66	65
(8) Number of times $\lvert\dot{x}^p\rvert - \lvert\dot{x}^f\rvert < 0$	112	82	83	73	62	62
(9) Number of countries in which $(\dot{x}^p - \dot{x}^f) < 0$ predominates	14	13.5	12.5	11.5	10	10
(10) Number of countries in which $\lvert\dot{x}^p\rvert - \lvert\dot{x}^f\rvert < 0$ predominates	14	13.5	12.5	10.5	9.5	9.5

Note: Rows (1)–(3) and (5)–(8) are based on the 112 observations for all countries combined (14 countries, 8 years of data for each). Rows (4), (9) and (10) are based on the numbers of years out of the 8 in which the specified conditions hold in each country. A case in which a specified condition holds for exactly 4 years is counted as 0.5.

$\dot{x}^p - \dot{x}^f$ is negative and the numbers of times $|\dot{x}^p| - |\dot{x}^f|$ is negative. It reports also, for each variable, the number of countries for which $\dot{x}^p - \dot{x}^f$ is negative more than half the time, and similarly for $|\dot{x}^p| - |\dot{x}^f|$.

Considering first the revisions of levels, we note the very strong tendency for the preliminary estimates of y, c, and i to lie below the final figures. The mean values of r are negative for all three variables and the preliminary figures for individual years were revised upward in the great majority of instances. In the case of y, r is negative no less than 103 out of 112 times. Clearly there is a pronounced and widespread tendency for the levels of *GNP*, consumption, and investment to be understated by the preliminary national accounts estimates.

There is also some tendency for the preliminary estimates of z to be too low, although this tendency seems to be much weaker than in the case of y, c, or i. In the case of m, the tendency is in the opposite direction, but again it appears to be comparatively weak. Inasmuch as m enters as a *deduction* in the calculation of y, the tendency toward overstatement of m would serve to reinforce the tendency toward understatement of c, i, and z, and thereby augment the tendency toward understatement of y.

In terms of the mean values of either r or $|r|$, i is the series subject to the greatest amount of revision. This is probably not surprising. In light of the short-run volatility of investment, one might well expect that this variable would be the most difficult one for statistical agencies to estimate accurately on the basis of preliminary or incomplete information.

The pattern is similar, in broad outline, for revisions of year-to-year change. The preliminary estimates of change tend to be too low for y, c, and i and, in lesser degree, for z. This is reflected in the mean values of $\dot{x}^p - \dot{x}^f$. It is reflected also in the predominance of negative signs in the counts of individual cases and individual countries. As before, understatement of change in c, i, and z is consistent with understatement of y.

Underestimation of change may take the form of underestimation in an algebraic sense. Alternatively, it may represent a tendency for estimates of change to be too small in *absolute* value, i.e., to be biased toward zero rather than simply biased downward. Of course, the distinction is relevant only when a particular time series does not continually increase (or decrease). The differences in the results reported in Table 2 based on comparisons of algebraic changes (rows (7) and (9)) and those based on absolute changes (rows (8) and (10)) are slight and provide insufficient evidence to support a conclusion in favour of one type of underestimation rather than the other.

As in the case of levels, the mean absolute size of revisions of change is greatest for i. Again, this is probably not surprising. Unlike the levels case, however, the revisions of change in z are also comparatively large, as evidenced by row (6) of Table 2.

Table 3 displays, for revisions of the y series only, some summary results for individual countries. These results confirm that the tendency toward underestimation in the preliminary national accounts data is widespread, with regard to both levels and changes. The mean value of r is negative for every one of the 14 countries. Levels were understated more than half the time in every country and changes were understated more than half the time in all but one country.

TABLE 3

SELECTED SUMMARY MEASURES FOR REVISIONS OF GROSS NATIONAL PRODUCT DATA (y), INDIVIDUAL COUNTRIES, 1957–1964: ANNUAL LEVELS AND YEAR-TO-YEAR CHANGES

	Annual Levels			Year-to-Year Changes		
Country	Mean r (%)	Mean $\|r\|$ (%)	Number of Times $r < 0$ (out of 8)	Mean $(\dot{x}^p - \dot{x}^f)$ (%)	Mean $\|\dot{x}^p - \dot{x}^f\|$ (%)	Number of Times $\dot{x}^p - \dot{x}^f < 0$ (out of 8)
Austria	−4.00	4.00	8	−0.38	0.93	6
Canada	−1.03	1.03	8	−0.42	0.44	7
Denmark	−0.45	0.63	6	−0.33	0.72	5
France	−4.04	4.04	8	−1.56	1.59	7
Germany (Fed. Rep.)	−2.29	2.33	7	−0.99	1.06	5
Ireland	−1.10	1.12	7	−0.46	0.82	5
Italy	−7.20	7.20	8	−0.52	0.63	6
Japan	−8.19	8.19	8	−0.36	2.62	5
Netherlands	−0.91	1.44	6	−0.56	0.98	6
New Zealand	−0.18	0.74	5	−0.08	0.69	4
Norway	−1.44	1.44	8	−0.39	0.62	6
Sweden	−5.31	5.31	8	−0.44	0.49	5
United Kingdom	−2.01	2.01	8	−0.84	0.84	8
United States	−1.70	1.70	8	−0.37	0.53	6

A further characteristic of interest is the extent to which revisions for different variables are correlated. For each country, the matrix of correlations for all pairs of variables was computed. Table 4 presents, for each pair, counts of the numbers of countries in which revisions were positively correlated. On the

TABLE 4

SUMMARY OF CORRELATIONS AMONG DATA REVISIONS FOR DIFFERENT SERIES, ALL COUNTRIES COMBINED, 1957–1964: ANNUAL LEVELS AND YEAR-TO-YEAR CHANGES

	Number of Countries (out of 14) in which Coefficient of Correlation between Data Revisions is Positive	
Variables Involved	Annual Levels	Year-to-Year Changes
y and c	12**	12**
y and i	11*	14***
y and m	6	4
y and z	12**	11*
c and i	5	7
c and m	8	8
c and z	6	2**
i and m	6	6
i and z	8	7
m and z	9	8

Note: * indicates significance at 10% level, ** at 5% level, and *** at 1% level, based on two-tail test with binomial probabilities.

hypothesis that the relationships are essentially random and that the probabilities of getting positive or negative correlation coefficients from the data are identical, one can use the binomial distribution with equal probabilities to test for significance. The results of the test, as indicated by asterisks in Table 4, suggest significant positive correlation between the revisions of y and c, y and i, and y and z, both for revisions of level and revisions of change. This is consistent with the observed tendency for the preliminary estimates to be too low for each of these four variables. In addition, significant negative correlation is indicated between the revisions of change for c and z. The reason for this latter result is not clear.

III. Forecasting Experiments with the Model

The model was used to generate two sets of annual *ex post* "forecasts" for each country for the period 1957–64, one set based on final data and the other on preliminary data. For this purpose, the estimated structural equations were converted into reduced form. In each of the four reduced-form equations, the set of predetermined variables appearing on the right side is the same, namely, c_{t-1}, i_{t-1}, y_{t-1}, and z_t.

A question that arises in all *ex post* forecasting experiments is how much information to assume on the part of the hypothetical forecaster. Ignoring delays in the availability of data, one can assume knowledge of the values of all lagged variables, but there remains the question of what to assume about current exogenous variables—in our case z_t. With regard to forecasts based on final data, a reasonable assumption for our purposes is that the final values of all predetermined variables are known, including z_t. With regard to forecasts based on preliminary data, one can also assume knowledge of the preliminary values of the lagged variables[7] but the choice of an assumption about z_t is less straightforward. One might be tempted to assume that the preliminary value of z_t was known, but this would be inconsistent with the assumption about the lagged variables. The preliminary (i.e. first) estimate of z_t would come from a later publication than the preliminary estimates of c_{t-1}, i_{t-1}, and y_{t-1}, and in general would not be consistent with them; by the time the preliminary estimate of z_t was published, there would probably be available partially revised estimates of the latter variables.

Another way of looking at this problem is to note that z is a component of y (*via* equation (4)) and that if the forecaster actually knew the preliminary value of z_t it would have to be assumed that he also had available a partially revised estimate of z_{t-1}. But if he had an improved estimate of z_{t-1}, he could use this to obtain an improved estimate of y_{t-1}. Hence it would be inconsistent to assume that he would have only preliminary estimates of both z_t and y_{t-1}.

[7]At this point it may be noted that there exists the possibility that a forecaster who is aware that preliminary estimates are subject to bias would attempt to correct his data. Alternatively, he might think of estimating reduced-form equations wherein *final* data were used for all of the current endogenous variables and *preliminary* data for all of the predetermined variables, so that the forecasting equations would effect the bias correction automatically. It might well be reasonable to adopt one of these procedures, although we think it highly unlikely that in practice they have been used to any extent. In any event, we ignore such possibilities for present purposes.

Our solution to this problem is to adjust the preliminary value of z_t to make it consistent with the preliminary value of z_{t-1}. We assume that the forecaster who is using preliminary data knows the preliminary value of z_{t-1} and the preliminary estimate of the *change* in z between the years $t-1$ and t, but not the preliminary value of z_t itself. Hence his estimate of z_t is $z_t^* = z_{t-1}^p + (z_t^p - z_{t-1}^{rp})$.[8]

Ignoring stochastic terms, the reduced form of the model can be written as

$$(5) \qquad Y_t = \Pi_0 + \Pi_1 Y_{t-1} + \Pi_2 z_t$$

where $Y = [c\ i\ m\ y]'$ is a column vector of endogenous variables, Π_0 is a 4-element column vector of constant terms, Π_1 is a 4×4 matrix of coefficients of lagged endogenous variables, and Π_2 is a 4-element column vector of coefficients of the single exogenous variable z. The adaptation of this equation for forecasting year-t levels with final data is straightforward. The forecasting equation may be written as

$$(6) \qquad F(Y_t)^f = \Pi_0 + \Pi_1 Y_{t-1}^f + \Pi_2 z_t^f$$

where F is used to indicate forecast, so that $F(Y_t)^f$ stands for a forecast of the vector of endogenous variables in year t based on final data. The adaptation for forecasting year-t levels with preliminary data results in

$$(7) \qquad F(Y_t)^p = \Pi_0 + \Pi_1 Y_{t-1}^p + \Pi_2 z_t^*.$$

In addition to forecasts of levels, *ex post* forecasts of changes were also generated from preliminary and final data. For this purpose, the reduced form system is differenced to obtain

$$(8) \qquad Y_t - Y_{t-1} = \Pi_1(Y_{t-1} - Y_{t-2}) + \Pi_2(z_t - z_{t-1})$$

The adaptations required for forecasting with final and preliminary data are then

$$(9) \qquad F(Y_t - Y_{t-1})^f = \Pi_1(Y_{t-1}^f - Y_{t-2}^f) + \Pi_2(z_t^f - z_{t-1}^f)$$

$$(10) \qquad F(Y_t - Y_{t-1})^p = \Pi_1(Y_{t-1}^p - Y_{t-2}^{rp}) + \Pi_2(z_t^p - z_{t-1}^{rp}).$$

IV. Analysis of Forecast Results

The reduced-form equations defined above yield forecasts of y, c, i, and m in the currency units of the individual countries. In order to make comparisons possible among countries and to permit the calculation of averages over all countries, the errors of forecast and related measures are expressed in percentage form. As the "standard of truth" in computing errors, we use the final national accounts estimates. That is to say, we compare both the forecasts based on final

[8]This is not a perfect solution. One could go on to argue that knowledge of the preliminary estimate of $z_t - z_{t-1}$ would imply the availability of an improved estimate of $z_{t-1} - z_{t-2}$. But the latter could then be used to obtain an improved estimate of $y_{t-1} - y_{t-2}$. Given his best available estimate of y_{t-2}, the forecaster could then derive an improved estimate of y_{t-1}. The argument can also be extended to assumptions about second differences of z, third differences, and so on. However, the assumption that we have made seems satisfactory for our purposes.

data and those based on preliminary data with the final national accounts values for the forecast year.[9]

The two sets of forecasts may both be compared with final national accounts estimates. They may also be compared with each other, and from one point of view this is a more meaningful comparison. The forecasts based on final data are obtained by inserting final national accounts estimates of predetermined values into the reduced-form equations of a model that has itself been fitted to final data. Thus both the estimated forecasting equations and the estimates of the predetermined variables may be regarded as the best available. The forecasts based on these equations and estimates may then be regarded as the best that can be made with the given model. From this point of view, it is meaningful to judge the forecasts based on preliminary data by how far they differ from those based on final data. This comparison is valid even though the forecasts based on preliminary data will, by chance, turn out sometimes to be closer to the "truth", i.e., to the final national accounts figures; the forecasts based on final data are still the "best" forecasts that can be made.

With these considerations in mind, we introduce the terms *forecast error* and *forecast discrepancy*. By *forecast error*, we mean the difference between a forecast and the corresponding final national accounts estimate. By *forecast discrepancy* we mean the difference between a forecast based on preliminary data and one based on final data. Specifically, we define the percentage forecast errors for the two sets of levels as $e_t^f = 100[F(x_t)^f - x_t^f]/x_t^f$ and $e_t^p = 100[F(x_t)^p - x_t^f]/x_t^f$. The percentage forecast discrepancy for forecasts of levels is defined as $d_t = 100[F(x_t)^p - F(x_t)^f]/F(x_t)^f$.

With regard to year-to-year changes, we define the forecasts based on preliminary and final data by $\hat{x}_t^f = 100[F(x_t)^f - x_{t-1}^f]/x_{t-1}^f$ and $\hat{x}_t^p = 100[F(x_t)^p - x_{t-1}^p]/x_{t-1}^p$. The forecast errors are then defined with reference to $\dot{x}_t^f = 100(x_t^f - x_{t-1}^f)/x_{t-1}^f$, the "actual" percentage change computed from final data. Thus, the percentage forecast errors are $\hat{x}_t^f - \dot{x}_t^f$ and $\hat{x}_t^p - \dot{x}_t^f$; the percentage forecast discrepancy is $\hat{x}_t^p - \hat{x}_t^f$.

Summary measures of forecast errors and discrepancies are presented in Table 5 for all countries combined for each of the four endogenous variables, while Table 6 provides some limited summary information for individual countries for forecasts of *GNP* only. Correlations between forecast discrepancies for different variables are summarized in Table 7.

It is quite clear that the forecasts of levels based on preliminary data are consistently biased downward. The mean values of e^p reported in row (1) of Table 5 are negative and substantial for every variable, whereas the mean values

[9]It might be thought that forecasts based on preliminary data should be compared with the preliminary national accounts estimates of the variables being forecast, rather than with the final ones. Certainly, when the preliminary national accounts data are published it is these against which annual forecasts made a year or so earlier would be judged. Indeed, a shrewd and unscrupulous forecaster might be inclined to try deliberately to forecast the preliminary estimates rather than the final ones! He might well believe that his reputation for accuracy would be based largely on comparisons with the preliminary estimates and that by the time the final ones were published there would be little interest in short-run forcasts made several years earlier and little incentive to reassess them. Nevertheless, the final national accounts data do represent the best estimates of the true values and hence are the most appropriate ones for judging both sets of forecasts.

TABLE 5

SUMMARY OF "FORECASTS", ALL COUNTRIES COMBINED, 1957–1964: ANNUAL LEVELS AND YEAR-TO-YEAR CHANGES

Summary Measure	Number of Items Involved	Variable y	c	i	m
Annual Levels					
(1) Mean e^p (%)	112	−1.90	−1.90	−3.14	−1.56
(2) Mean e^f (%)	112	0.02	0.14	0.04	0.12
(3) Mean $\|e^p\|$ (%)	112	2.97	3.00	5.84	4.77
(4) Mean $\|e^f\|$ (%)	112	1.45	1.52	3.90	3.89
(5) Mean d (%)	112	−1.92	−2.04	−3.18	−1.67
(6) Mean $\|d\|$ (%)	112	2.77	2.55	4.33	2.82
(7) Number of times $d < 0$	112	87	86	88	73
(8) Number of countries in which $d < 0$ predominates	14	11.5	12.5	12	9
Year-to-Year Changes					
(9) Mean $(\hat{x}^p - \dot{x}^f)$ (%)	112	−0.21	−0.24	−0.68	−0.78
(10) Mean $(\hat{x}^f - \dot{x}^f)$ (%)	112	−0.02	0.01	−0.29	−0.19
(11) Mean $\|\hat{x}^p - \dot{x}^f\|$ (%)	112	2.27	2.08	6.39	6.22
(12) Mean $\|\hat{x}^f - \dot{x}^f\|$ (%)	112	2.04	2.07	6.18	6.06
(13) Mean $(\hat{x}^p - \hat{x}^f)$ (%)	112	−0.19	−0.25	−0.39	−0.59
(14) Mean $\|\hat{x}^p - \hat{x}^f\|$ (%)	112	1.26	0.83	2.78	1.87
(15) Number of times $(\hat{x}^p - \hat{x}^f) < 0$	112	66	76	69	71
(16) Number of times $\|\hat{x}^p\| - \|\hat{x}^f\| < 0$	112	66	77	70	72
(17) Number of countries in which $(\hat{x}^p - \hat{x}^f) < 0$ predominates	14	9.5	11	9.5	10
(18) Number of countries in which $\|\hat{x}^p\| - \|\hat{x}^f\| < 0$ predominates	14	9.5	11.5	10.5	11.5

Notes: Rows (1)–(7) and (9)–(16) are based on the 112 observations for all countries combined (14 countries, 8 years of forecasts for each). Rows (8), (17), and (18) are based on the numbers of years out of the 8 in which the specified conditions hold in each country. A case in which a specified condition holds for exactly 4 years is counted as 0.5.

of e^f in row (2) are close to zero. The mean values of d are negative in every case (row (5)); the majority of all values are negative (row (7)), as are the majority of values for most individual countries (row (8)).

Row (6) of Table 5 indicates average discrepancies for forecasts of levels, ignoring signs, of about 2.8 percent for y, 2.6 percent for c, 4.3 percent for i, and 2.8 percent for m. These discrepancies in absolute values reflect, of course, the bias in the forecasts based on preliminary data, as well as other differences. A comparison of the algebraic means of d in row (5) with the means of the absolute values in row (6) suggests that bias accounts for the largest part, but not all, of the absolute discrepancies. In the case of y, for example, one may note that the mean difference between the forecasts was 1.9 percent when signs are taken into account but 2.8 percent when signs are ignored.

Turning to the forecasts of year-to-year changes, the evidence suggests again that the use of preliminary data tends to result in understatement. However, the tendency is much less pronounced than in the case of levels. For each of the four variables, the mean forecast discrepancy $(\hat{x}^p - \hat{x}^f)$ is negative for all

TABLE 6

SELECTED SUMMARY MEASURES FOR "FORECASTS" OF GROSS NATIONAL PRODUCT (y), INDIVIDUAL COUNTRIES, 1957–1964: ANNUAL LEVELS AND YEAR-TO-YEAR CHANGES

Country	Annual levels: Mean d (%)	Annual levels: Mean $\|d\|$ (%)	Annual levels: Number of times $d<0$ (out of 8)	Year-to-year changes: Mean $(\hat{x}^p - \hat{x}^f)$ (%)	Year-to-year changes: Mean $\|\hat{x}^p - \hat{x}^f\|$ (%)	Year-to-year changes: Number of times $\hat{x}^p - \hat{x}^f < 0$ (out of 8)
Austria	−2.75	3.95	5	0.11	0.66	4
Canada	−1.74	1.74	8	−0.29	0.75	5
Denmark	−0.94	1.35	6	−0.19	1.00	4
France	−5.09	5.09	8	−1.72	1.91	7
Germany (Fed. Rep.)	2.02	2.07	1	0.72	1.27	3
Ireland	1.03	1.86	3	0.34	1.44	3
Italy	−1.36	3.16	4	0.69	0.86	1
Japan	−4.43	5.17	7	0.32	4.78	5
Netherlands	−0.40	0.95	6	−0.24	0.87	5
New Zealand	−1.79	2.05	7	−0.29	1.11	5
Norway	−1.43	1.43	8	−0.27	0.52	4
Sweden	−4.44	4.44	8	−0.48	0.76	6
United Kingdom	−3.43	3.43	8	−0.88	0.88	8
United States	−2.12	2.12	8	−0.44	0.92	6

TABLE 7

SUMMARY OF CORRELATIONS AMONG FORECAST DISCREPANCIES FOR DIFFERENT SERIES, ALL COUNTRIES COMBINED, 1957–1964: ANNUAL LEVELS AND YEAR-TO-YEAR CHANGES

Variables Involved	Number of Countries (out of 14) in which Coefficient of Correlation between Forecast Discrepancies is Positive: Annual levels	Year-to-year changes
y and c	13**	14**
y and i	13**	14**
y and m	12**	12**
c and i	10*	14**
c and m	10*	12**
i and m	12**	13**

Note: * indicates significance at 10% level, ** at 1% level, based on one-tail test with binomial probabilities.

countries combined (Table 5, row (13)), and this is true also of the majority of individual countries (row (17)). Ignoring signs, the mean forecast discrepancies range from 0.8 percent for c to 2.8 percent for i, implying that the differences between forecasts based on preliminary and final data are by no means negligible in relation to actual year-to-year percentage changes. However, the conclusion that final data yield much better forecasts is unwarranted: a comparison of rows (11) and (12) of Table 5 reveals that when signs are ignored, the mean percentage errors for the two sets of forecasts are quite similar (2.3 compared with 2.0 percent for y, 2.1 and 2.1 for c, 6.4 and 6.2 for i, and 6.2 and 6.1 for m).

As discussed in Section II, a tendency toward understatement of change may take the form of a tendency toward either algebraic understatement (downward bias) or absolute understatement (bias toward zero). This is true of forecasts as well as preliminary estimates, although again the distinction is meaningful only if not all of the actual year-to-year changes have the same sign. In an attempt to see whether the bias is more likely to be of one kind or the other, we compare rows (15) and (16) and rows (17) and (18) of Table 5. Rows (15) and (17) are based on discrepancies with signs taken into account and rows (16) and (18) are based on discrepancies between the absolute values of the forecasts of percentage change. To the extent that the forecasts with preliminary data are biased toward zero rather than merely downward, one would expect the condition $|\hat{x}^p| - |\hat{x}^f| < 0$ to hold more frequently than the condition $\hat{x}^p - \hat{x}^f < 0$. However, as the table shows, the two sets of results are quite similar and the evidence therefore is insufficient to permit a conclusion in this regard.

The summary results for *GNP* forecasts reported in Table 6 for individual countries tell the same general story as the all-country results in Table 5. With the exception of two countries, forecasts of levels based on preliminary data tend to be lower than those based on final data. In the case of percentage changes, this is true of 9 of the 14 countries. As one might expect, there is considerable variation from country to country, but in most, if not all, countries, the discrepancies between the two sets of forecasts are large enough to be regarded as non-negligible, both for levels and for changes.

It is of interest to consider also the degree to which discrepancies in forecasts of different variables are correlated with each other. Table 7 reports, for each pair of endogenous variables, the number of countries in which the coefficient of correlation between forecast discrepancies was positive. On the hypothesis that the discrepancies are independently distributed, one would expect positive and negative correlation coefficients to occur with equal frequency, aside from small-sample random variation. As the table indicates, a one-tail test based on equal binomial probabilities rejects the hypothesis of zero correlation at the 1 percent significance level in every case for forecasts of percentage changes. For forecasts of levels, the hypothesis is rejected at the 10 percent level in every case and at the 1 percent level in all but two cases. Clearly, the forecast discrepancies for different variables are strongly and positively associated. Of course, this is hardly surprising, given that the same predetermined variables enter into each of the reduced-form forecasting equations.

V. Summary and Conclusions

This paper has been concerned with the effects of data revisions on forecasting accuracy, with regard to forecasts of both annual levels and year-to-year changes. The data used in the study are national accounts statistics for fourteen countries, as compiled by the United Nations Statistical Office. An econometric model was estimated for each country. Because of severe data limitations and for other reasons, this model is necessarily very small. Nevertheless, measures of goodness-of-fit, signs and significance levels of estimated coefficients, and other criteria suggest that it is adequate for the purposes of the analysis.

Before analysing forecast results, the data revisions themselves were examined. For *GNP*, consumption, and investment, there was found to be a strong and widespread tendency for the preliminary (i.e., first) national accounts estimates to understate both levels and year-to-year changes, a result that is consistent with the findings in other studies.[10] The distinction between straightforward downward bias and bias toward zero was noted with reference to the estimates of change, but the evidence did not permit a conclusion to be drawn as to whether the tendency toward understatement in these estimates represented one type of bias or the other. In the case of imports, there appeared to be a tendency for preliminary estimates to overstate levels, but it was noted that this would tend to reinforce the downward bias in the *GNP* estimates. Of the five variables considered, investment was the one for which the data revisions were greatest, on average. Coefficients of correlation between revisions of the different series indicated significant positive associations between the *GNP* revisions and the revisions of each of the major components of *GNP* except imports (which enter as a deduction).

The model was put into reduced form and used to generate *ex post* "forecasts", for each country, for each year of the period 1957–64. Two sets of forecasts were generated, one based on preliminary data and the other on revised data. Care was taken in specifying the information assumed to be available to the hypothetical forecaster about the values of predetermined variables.

The two sets of forecasts were considered in relation to actual levels and changes (as indicated by the "final" national accounts statistics) and in relation to each other. A very strong downward bias was observed in the forecasts of levels based on preliminary data, and a weaker one in the forecasts of changes. Thus, the tendency toward understatement in the preliminary national accounts data was found to be transmitted to forecasts based on these data. As before, it was not possible to tell whether understatement, this time in the forecasts of changes, represented downward bias or bias toward zero. Somewhat surprisingly, while revised data yielded, on average, better forecasts, the improvement in accuracy was rather small for forecasts of changes; the mean absolute errors were only slightly different for the two sets of change forecasts. Coefficients of correlation were computed for the discrepancies between the two sets of forecasts, and the application of a binomial test indicated a significant positive association between the forecast discrepancies for every pair of endogenous variables. This latter result, which held for forecasts of both levels and changes, is of course a reflection of errors in the data entering the reduced-form forecasting equations, inasmuch as each of these equations involves the same set of predetermined variables.

The results of this study suggest that a tendency toward understatement in preliminary estimates may account in part for the general tendency toward

[10]See, for example, Cole [2, 3] and Denton and Kuiper [5, 6].

understatement in forecasts noted by others.[11] But it may be that the preliminary estimates themselves should be viewed as somewhat in the nature of forecasts and therefore that they may be affected by the same influences that cause pure forecasts to be biased. Finally, while econometric forecasts have been the subject of analysis in this paper, it may be conjectured that the observed tendency toward understatement would be found also in forecasts based on noneconometric methods. One would expect forecasts of the latter kind also to be influenced by biases in the data that forecasters rely on for information about the most recent position and performance of the economy.

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[11] A general tendency for forecasts to be too low, both for levels and changes, has been noted elsewhere. In particular, see Theil [21, 22] and Mincer and Zarnowitz [15]. In econometric *ex post* forecasting experiments with Canadian data, Denton and Kuiper [5, 6] found that forecasts based on preliminary national accounts estimates tended to understate year-to-year changes.

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