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DATA REVISIONS AND SOME ECONOMETRIC AND POLICY CONSEQUENCES

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1. AN ANALYSIS OF REVISIONS TO SELECTED AUSTRALIAN ECONOMIC SERIES

Introduction

The foundation on which this paper rests is the sometimes overlooked fact that economic data is not measured with perfect accuracy. Consequently, we are interested in the extent of the existing inaccuracies and some of their consequences.[1]

It will not be claimed that this study will discuss the extent of measurement error in Australian economic data. In practice, this cannot be done; the best one can do is to illustrate the extent of revisions to selected Australian data. The conceptual difference between the size of measurement error and extent of revision is that the former relies heavily on the existence of "final" data which thereby provides a basis for measuring the extent of total "measurement error" (ie, the difference between the final and initial published figures). It is a fundamental tenet of this paper that, for practical purposes, final data does not exist. Even after the Commonwealth Bureau of Census and Statistics (hereafter referred to simply as "the Bureau") ceases to publish revisions for a particular quarter in the Quarterly Estimates of National Income and Expenditure (QE), the supposedly "final" figure may be revised in a future supplement to the QE - so unless there is a particular reason for assuming data is "final", "final data" will not be mentioned; rather, the emphasis will be on "latest" data. The concept of "latest" (as opposed to "final") gives scope for future revisions. It is assumed that the latest figure is "best" in that it is presumably nearer than the preceding revised figures to the (unknown) "true" figure.

At the outset, one should be aware that measurement error is not necessarily depicted in terms of frequency of revision. For example, a series not often revised may be relatively unreliable, with the lack of revision merely being a reflection of an inadequate supply of data. It must be remembered that a lack of revision is just that; it need not (and probably will not, as will be shown later) indicate a series of "firm", reliable figures.

On this "reliability" aspect, it is worth noting that the Australian National Accounts; National Income and Expenditure (ANA) and the QE, unlike the national accounts of the United Kingdom, contain

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[1] Any comments on data inaccuracies are not intended to denigrate the data collection work of the Commonwealth Bureau of Census and Statistics. It is recognised that inaccuracies are a fact of life;

no information about reliability gradings.[2] The U.K. national accounts data is classified into three reliability gradings, viz.

Grading	Margin of Error	Literal Grading
A	$<\|3\|\%$	good
B	$\|3-10\|\%$	fair
C	$>\|10\|\%$	poor

with approximately 90% confidence.

For Australian data, the Bureau's standard comment on reliability gradings is "It is not possible to put precise limits on the degree of revision likely to any particular series, nor to state degrees of reliability in a statistical sense."[3] It is this lack of specific reliability information in the Australian national accounts which could be a cause for concern, and it is one of the intentions of this paper to make some quantitative assessment of the extent of data revisions.

The Data

(i) Publication of Australian Quarterly Data

From the mass of currently published official data, it was decided to select several economic series which were widely known and used for general economic research purposes. Particularly, series which were used for econometric modelbuilding purposes were sought. Given these uses for the data, it seemed natural to concentrate on *quarterly* data, as most current empirical economic research is based on this type of data. Further, it was decided to analyse nonmonetary quarterly data.

The publication by the Bureau of the *QE* began with Bulletin No. 1 for the September quarter of 1960, ie, 1960(3). This contained quarterly data for the quarters from 1958(3). In general, the *QE* tables and definitions correspond to those of the annual *ANA*. *QE* have been published for every quarter since 1960(3). Additionally, several *Supplements* to various issues of the *QE* have been published. The *Supplements* generally contain a full history of quarterly data (ie, from about 1958(3)), as opposed to the normal *QE* which typically carry only figures for the current period and a limited number of immediately preceding periods. Up to and including *QE* Bulletin No. 43 for 1971(1), data for the current period and the preceding twelve quarters was carried in each Bulletin, except for the

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[2] See [13], pp. 39-42. (Numbers in square brackets refer to references listed at the conclusion of this paper.)

[3] [5], 1969-70, p.17. (But this is a standard comment which can be found, in approximately the same words, in any recent *ANA*.)

first twenty Bulletins where the number of preceding periods varied from eight to eleven after the full publication pattern was established. As from Bulletin No. 44, 1971(2), only the current period and the nine preceding quarters have been carried.

(ii) Data Selection

For analytical purposes, economists would generally concentrate on using constant price seasonally adjusted data. However, we analyse current price seasonally unadjusted data. There are two reasons for this: (a) a long history of constant price seasonally adjusted quarterly data which has been subjected to a number of revisions is simply not available in Australia and (b) more importantly, if constant price seasonally adjusted data was used there would be a serious difficulty in distinguishing between revisions caused purely by the availability and/or sufficiency of data collected and those "revisions" due to the conceptually artificial mathematical adjustments of deseasonalising and eliminating price effects. Rather than attempt the probably impossible task of separating the two effects in any given series, the problem is completely avoided by using current price seasonally unadjusted data, ie, data in its "purest" form.

A data sample period of 1958(3) to 1971(4) was selected. Consequently, data from QE published after 1971(4) was excluded from analysis. That is, we examined quarterly data published in QE Bulletin Nos. 1 to 46 inclusive.

(iii) Series Selected for Analysis

There were three basic motives underlying the selection of specific series. Given the range of quarterly data which exists, what was of primary interest were (a) some series which was widely known and used both for economic policy-making purposes and for econometric research. Such a series should be generally viewed as a summary statistic for general economic activity, (b) series which were of considerable econometric interest, especially with respect to modelbuilding and (c) a series which is relatively difficult to measure accurately and which would *a priori* be subject to large revisions. Such a series might thereby indicate something of an extreme in data revision.

Gross National Product (GNP) was the series chosen under (a) above. A complete Australian data series for quarterly GNP is available from the first QE.

For (b), personal income (YP), private investment expenditure (disaggregated, respectively, into private investment expenditure on dwellings, ID, and excluding dwellings, I) and personal consumption expenditure (disaggregated, respectively, into consumption expenditure on durables including motor vehicles, CD, and consumption expenditure on nondurables, CND) were chosen. Data for YP is available from 1958(3), but data for CD and CND, as currently defined, is only available as from

QE Bulletin No. 12 (1963(2)) (except for the Supplements which appeared later and carried the series back to 1958(3)). ID and I are also subject to this published data restriction.

Finally, the series "Change in the Value of Non-Farm Stocks" (ΔNFS) was selected as a series likely to be subject to extremes of revision. This might be expected as the series is notoriously difficult to measure accurately, is of a relatively small magnitude, and could possibly take both negative and positive quarterly values.

(iv) Comparability Over Time of Data Within Each Series

Basically, all revisions can be explained in terms of availability of data, changes in definition of a series, and changes in concept and terminology. However, it can be very difficult in practice to isolate the various effects, given only the published figures and some rather brief Bureau comments on the series concerned. Consequently, all changes in published figures due to changes in definition must be assumed indistinguishable from changes due to availability of data, unless it can be seen that a change in definition of a series alters the concept to such an extent that two or more genuinely distinct series are created. The series to be analysed do contain slight definitional changes, but the changes are considered to be such as not to cause serious conceptual breaks. Therefore, all data which has been used for a particular series is considered to be comparable over time.

General Methodology

To analyse the selected quarterly data, some appropriate quantitative measure of a "revision" was needed. In selecting such a measure, two basic issues arise: (a) in what direction is it desired to measure the revision - should one follow the chronological publication pattern, or instead base each calculated revision on a "final" figure, (b) should absolute or relative revisions be considered?

Consider firstly the orientation of the calculations. Some overseas studies (eg, Zellner [17] and Stekler [15]) base their revision calculation on a supposed "final" figure. They thus investigate the movements in revised estimates for a given period in terms of the "final" value for that period. However, this approach was considered unsuitable here, as it is felt that there should be as little emphasis as possible on any notion of "final" figures in the QE. Consequently, revisions here are based on a quarter-to-quarter calculation following the order of publication, ie, the difference between the latest published revised figure for any quarter and its immediate predecessor will be measured.

Should one measure absolute or relative revisions? When revisions to several distinct series are being considered, comparative absolute revisions will be inappropriate to the extent that the series considered have varying absolute magnitudes. This is the case here, hence a relative measure of revision was used.

The revision measure is defined as follows. For the series X (X = GNP, YP, ΔNFS, CND, CD, I, ID), if X_{ij} is the jth revised estimate of X for the ith quarter, then the actual quarter-to-quarter percentage revision is given by:

$$r_{ij} = 100\ (X_{ij} - X_{i,j-1})/X_{i,j-1}$$

where r_{ij} is the revision corresponding to the publication of X_{ij}. The range of i is from 1958(3) to 1971(4) and j = 0,1,2,...,14 (the upper bound on j is determined by the publication pattern of Australian quarterly data; figures are used which have been publicly revised a maximum of 14 times). If j=0, X_{ij} is interpreted as the first published figure for quarter i; it has thus been revised zero times.

For the analysis to follow, it was desired to investigate how successful an estimate the first revision was of "total" revision. Bearing in mind the previously expressed distrust of any notion of "final" data or "total" revision, a concession had to be made in order that this test could be performed. In order to obtain some measure of "total" revision, figures which have been subjected to the maximum number of revisions (ie, 13 for CD and CND and 14 for all other series considered) in the normal course of QE publication (including Supplements) are regarded as final. (In relation to this specific test, the inverted commas around "final" and "total" will be hereafter omitted.) A measure of total percentage revision, r_{ti}, is:

$$r_{ti} = 100\ (X_{Li} - X_{oi})/X_{oi}$$

where r_{ti} refers to quarter i, X_{oi} is the first published figure and X_{Li} is the latest published figure for quarter i. The range of i is from 1958(3) to 1969(3) inclusive. With a data cut-off point of 1971(4), data for quarters up to and including 1969(3) will not be further revised in the normal course of QE publication, excluding Supplements.

Empirical Characteristics of Revisions

In this section, attention will firstly be given to the characteristics of the quarter-to-quarter percentage revisions per se. Following this, the first quarter-to-quarter revision will be examined in relation to the total revision.

(i) Distribution of Revisions by Sign

Before considering each individual series in turn, something should be said of the (sometimes frequent) appearance of zero quarter-to-quarter percentage revisions. Do these represent genuine "zero revisions" or, rather, "not revisions", in the sense that no new data was available for the QE publication corresponding to "no-change" actual figure? *Prima facie*, the appearance of a zero percentage revision would indicate a situation where there was new information available, but this new information merely confirmed that the previously published figure was "correct". If this viewpoint is adopted, then the zeros have an analytical significance in that a high incidence of zeros would indicate "reliable" published estimates. On the other hand, if the zero percentage change is merely an indication of lack of information, the zeros would have a different analytical significance; they would indicate the instances in which no revision has occurred. It was learned that the latter interpretation of the zero percentage change was usually correct. But while zero revisions may have little numerical significance, one can never in fact be sure that a particular zero revision has been interpreted correctly. For this reason, analytical tests here will usually accord some numerical significance to the zero revision; generally, results of tests will be given both for all revisions (ie, non-zero plus zero revisions) and for only non-zero revisions.

The distribution by sign of data revisions will now be considered for each series.

(a) GNP GNP data is available for 14 revisions. Typically, there was a high proportion of non-zero revisions in all 14 revision classes. The frequency of non-zero revisions never dropped below 63% for any revision class, with the overall proportion of individual non-zero revisions being 75% 420/556). There was no tendency for the proportion of non-zero revisions to differ as one moved from the earliest revision classes (eg, the first, second, third, etc.) to the later classes. The decomposition of non-zero revisions into those which were positive and negative showed that throughout all revision classes positive revisions predominated. Overall, nearly half (49% or 272/556) of all individual revisions were upward. The remaining GNP revisions were split almost equally between negative revisions (26%) and non-zero revisions (24%).[4]

The 45 total revisions for GNP accentuate the above results - 39 total revisions (87%) were positive and only 6 (13%) were negative, implying the effect of the positive quarter-to-quarter revisions certainly outweighs the effect of negative revisions. So GNP is most often revised upwards.

(b) YP As with GNP, the publication pattern of YP yielded 14 revision classes. For all revision classes, there is a consistently high proportion of non-zero quarter-to-quarter revisions - higher, in fact, than was evident for GNP. Of 556 individual revisions, 441 (80%) were non-zero.

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[4] The fact that proportions may not sum to unity in these and following results is a result of rounding proportions to two significant figures.

However, while the frequency of positive GNP revisions was twice that of negative revisions, for YP the difference is not so distinct. The overall figures for YP reveal an almost equal proportion of positive and negative revisions: 41% (226) of all revisions were positive and 39% (21[illegible] were negative.

While individual quarter-to-quarter revisions were almost equally positive and negative, the 45 total revisions for YP were overwhelmingly positive: there were 34 positive total revisions. Hence for YP positive quarter-to-quarter revisions tend to have a greater absolute magnitude than negative quarter-to-quarter revisions. Like GNP, YP is typically revised upwards - 76% of its total revisions are positive.

<u>(c) ΔNFS</u> It was expected that ΔNFS might well exhibit an atypical revision history. The validity of these <u>a priori</u> thoughts now begin to be confirmed. The most significant feature of the direction of ΔNFS revisions is that there is none; <u>zero</u> quarter-to-quarter revisions are very prevalent in all 14 revision classes. In fact, of the 556 quarter-to-quarter revisions, 314 (56%) are zero revisions. Looking at each individual revision class, it is difficult to determine any typical ratio of positive to negative quarter-to-quarter revisions. Of the non-zero revisions, 155 were positive and 37 were negative. However, the total revisions for ΔNFS were still predominantly positive (32/45).

It could be concluded from these figures that while ΔNFS might generally be revised upwards, there is much less certainty about the revision process than there is for either GNP or YP.

<u>(d) I</u> This is the first series analysed which exhibits something of a trend in the proportion of non-zero revisions as between revision classes. If the thirteenth and fourteenth revision classes are disregarded (these contain relatively few individual revisions) then the proportion of non-zero revisions clearly declines with the increase in revision class number. If a zero figure is interpreted as a "not revision" rather than a "zero revision", then the frequency of revision declines as the number of the revision class increases. Though relatively few in number, positive quarter-to-quarter revisions still predominate. Of 442 individual revisions, 36% (158) are positive compared with the 15% (65) which are negative. I is therefore like ΔNFS in having a relatively low <u>frequency of revision</u>. But when it is revised, I is usually revised upwards; 40 (89%) of its total revisions are positive.

<u>(e) ID</u> Not surprisingly, the distribution of quarter-to-quarter revisions to ID is similar to that of I. Again, zero revisions are the predominant feature of all revision classes (with the exception of the first revision). Overall, the frequency of revision is low at 67% (270/442). Although relatively few in number, there are approximately twice as many positive revisions as there are negative revisions. This is reflected in the figures for total revisions, where 23 (51%) are positive compared to 13 (29%) negative total revisions.

The most unusual feature of the distribution by sign of total revisions is the frequency (9, or 20%) of zero total revisions. These arise because of the practice of not revising ID figures for the early quarters of data publication.

While ID has a low frequency of revision, it is generally revised upwards.

(f) CND Through all revision classes, non-zero revisions are very evident. Of the total of 412 individual quarter-to-quarter revisions, 86% (354) are non-zero. Equally evident is the frequency of positive revisions; 63% (261) of all revisions are positive compared with only 23% (93) negative revisions.

When considering revisions in terms of revision classes it can be seen that the relative peaks for the proportion of non-zero and positive revisions respectively tend to coincide in the middle ranges of the revision classes (the fifth to the ninth class inclusive). This suggests that CND tends to be revised most often (in a positive sense) after about the fourth opportunity for revision, ie, about five to eight quarters after the initial figure is published.

The tendency for CND to be revised upwards could not be better illustrated by the total revision figures - all 45 are positive.

(g) CD There is a tendency for the proportion of non-zero revisions to increase after the seventh revision, suggesting that CD figures are most frequently revised at the earliest opportunity. The overall proportion of non-zero revisions is surprisingly low at 58% (239/412) - remember that the figure for CD was 86%. While CD may be revised less frequently than CND, the common tendency towards upward revision continues: there are four times more positive quarter-to-quarter revisions than negative revisions, and 41 (91%) of the total revisions are positive.

(h) Summary A clear qualitative tendency for upward revision is evident in all series. However, the path of the revisions is less certain for some series (eg, ΔNFS). It is significant (though not unexpected) that the census-based data (eg, ΔNFS, I and ID) are much less frequently revised than, say, CND, for which relatively more data is available.

(ii) Central Tendency and Dispersion of Revisions

(a) Theory The mean and standard deviation for revisions to each series should provide a simple measure of the central tendency and dispersion respectively of the revisions. While one is clearly interested in a mean revision, it is difficult to decide how the "mean revision" should actually be calculated: over all revisions, or just the non-zero revisions? It has already been argued the former may not in fact all be true revisions.

Another question is whether the mean revision should be calculated in an "actual" or "absolute" sense. The "actual mean" would make allowance for both positive and negative revisions - the revisions that actually occur - but if the positive and negative revisions are offsetting, then the mean revision could well be close to zero. Such a figure may be totally unrepresentative of a situation where a great deal of quarter-to-quarter revision has taken place. To counter offsetting revisions, the "absolute mean" could be calculated. Here, one would only consider the absolute magnitude of individual revisions. The absolute mean would thus give a more representative indication of central tendency in a situation where an approximately equal proportion of positive and negative revisions occur. (Note, for example, that such a situation occurs in the YP revisions.)

For each of these four possible measures of mean percentage revision, there would be a corresponding standard deviation, a measure of the dispersion of individual revisions about the mean.

As both revisions within revision class and for a series as a whole respectively are being considered, means and standard deviations should accordingly be calculated for each of these two groups.

It is difficult in practice to interpret the meaning of a zero revision. For this reason, means over all revisions (the "unadjusted mean") and non-zero revisions (the "adjusted mean") were calculated.

There is a further situation in which a mean and corresponding standard deviation are relevant, viz., for the set of total revisions for each series. However, in the total revision case, no adjustment need be made for individual non-zero total revisions. If a zero total revision arises (and some do arise), it is generally because the first and latest published figures respectively coincide after a number of intervening offsetting revisions, not because the particular first published figure has remained entirely unrevised. (Total revisions for ID are an exception here; some zero figures do arise due to a total lack of revision.).

The particular measures calculated are now explicitly defined.

(b) Notation In general, for any series of n values Y_i, the mean of the Y_i, denoted by $\bar{Y}$, is defined by

$$\bar{Y} = \sum_i Y_i / n$$

Then the corresponding standard deviation of the Y_i's, denoted by S(Y), is given by:

$$S(Y) = [\sum_i (Y_i - \bar{Y})^2 / n]^{\frac{1}{2}}$$

$$= [\sum_i Y_i^2 / n - \bar{Y}^2]^{\frac{1}{2}}$$

For any calculated mean revision, the corresponding standard deviation is calculated using the above equation.

Specific means calculated are defined as follows:

Quarter-to-quarter percentage revisions

actual series mean	$\bar{R}=\sum_{i}\sum_{j} r_{ij}/n$
adjusted actual series mean	$\bar{R}'=\sum_{i}\sum_{j} r_{ij}/n'$
absolute series mean	$\bar{R}_a=\sum_{i}\sum_{j} \lvert r_{ij}\rvert/n$
adjusted absolute series mean	$\bar{R}'_a=\sum_{i}\sum_{j} \lvert r_{ij}\rvert/n'$
actual mean, jth revision class	$\bar{r}_j=\sum_{i} r_{ij}/n_i$
adjusted actual mean, jth revision class	$\bar{r}'_j=\sum_{i} r_{ij}/n'_i$
absolute mean, jth revision class	$\bar{r}_{ja}=\sum_{i} \lvert r_{ij}\rvert/n_i$
adjusted absolute mean, jth revision class	$\bar{r}'_{ja}=\sum_{i} \lvert r_{ij}\rvert/n'_i$

Total revisions

Actual mean	$\bar{R}_t=\sum_{i} r_{ti}/n_f$
Absolute mean	$\bar{R}_{ta}=\sum_{i} \lvert r_{ti}\rvert/n_f$

where

n is the total number of individual quarter-to-quarter revisions in each series

n_i is the number of individual quarter-to-quarter revisions in the jth revision class

' denotes the elimination of all zero revisions

$n_f = 45$ (ie, the number of quarters from 1958(3) to 1969(3))

$j = 1, 2, \ldots, 14$

$1958(3) \leq i < 1971(4)$

(c) Results

<u>GNP</u> $\bar{r}_j$ values are quite small -- all are less than 0.30. The level of the $\bar{r}_j$ remains relatively constant, showing no tendency to decline as the initial published figures are subjected to a larger number of revisions. As the frequency of revision of GNP is high (75%), $\bar{r}'_j$ are only slightly higher than the corresponding $\bar{r}_j$. Like the $\bar{r}_j$ and $\bar{r}'_j$, there is little tendency for the $s(\bar{r}_j)$ and $s(\bar{r}'_j)$ to decline through revision classes. The $\bar{r}_{ja}$ values tend to be anything up to twice as large as their corresponding $\bar{r}_j$. As there are almost twice as many positive revisions for GNP as there are negative revisions, this indicates that the absolute magnitude of the negative revisions is about the same as that of the positive revisions. Throughout the revision classes, there is no tendency for the variability of the $\bar{r}_{ja}$ (as evidenced in the $s(\bar{r}_{ja})$) to decline with increasing j.

The average quarter-to-quarter percentage revision values for GNP are quite low - well below 1%. Perhaps the best indicator here is $\bar{R}$, which has a value of only 0.25.

The average total revision to each first published GNP figure is clearly positive. The similarity of $\bar{R}_t$ (2.29) and $\bar{R}_{ta}$ (2.33), combined with the relatively low $S(\bar{R}_t)$ of 1.86, suggests that total percentage revisions to GNP are quite predictable. In general, after a series of generally positive quarter-to-quarter revisions, the first published GNP figure for a particular quarter will be revised upwards by about 2.3%.

<u>IP</u> The frequency of revision is high at 80%, hence the adjusted means will be 20% larger than the unadjusted mean.

There is no trend in the values of $\bar{r}_j$. The only unusual feature of the 14 $\bar{r}_j$ values is that two are negative - although only small in absolute magnitude. It is interesting to compare the corresponding values for $\bar{r}_j$ and $\bar{r}_{ja}$. Typically, $\bar{r}_{ja}$ is 1.5 to 4 times as large as $\bar{r}_j$, thereby indicating considerable fluctuation in the sign of the revisions within each revision class. This might be expected, as there is an almost equal number of positive and negative revisions in the overall YP series. However, the positive revisions clearly dominate the negative ones, as is evidenced by the generally positive $\bar{r}_j$ and the positive $\bar{R}$ value of 0.18.

The variability of the YP revisions relative to those of GNP is indicated by their respective $S(\bar{R})$ values. While the two series have very similar $\bar{R}$ values, the $S(\bar{R})$ values for YP and GNP are 1.41 and 0.54 respectively. Further, the respective $\bar{R}'_a$ values for YP and GNP are 0.71 and 0.39. Clearly then, YP revisions are much more variable than the revisions to GNP.

The average total revision, $\bar{R}_t$, for YP is clearly positive. While it is similar in magnitude to the corresponding GNP value, the $S(\bar{R}_t)$ value for YP is 4.51, an indication that caution would have to be exercised in making inferences about the magnitude of expected total revisions. However, initial YP figures could reasonably be expected to be revised upwards, although only after a great deal more offsetting revision than is evident for GNP.

ΔNFS This is by far the most troublesome series to analyse in terms of percentage revisions.

Complications arise in the calculations of mean revisions for this series; for example, two extremely large finite quarter-to-quarter revisions occur, viz. 1275.00% and 2300.00% in the revisions following the first published figure for 1968(4) and 1966(1) respectively. Clearly, any calculated mean or standard deviation which includes these two values will be meaningless as a measure representative of ΔNFS revisions. Consequently, these two values were ignored when calculating means and standard deviations for the ninth and first revision classes respectively. For the same reason, the total revision value of 1375.00% for 1968(4) was omitted when calculating $\bar{R}_t$ and $\bar{R}_{ta}$.

Even with the extreme values omitted, the ΔNFS revisions are highly atypical. As the frequency of revision is so low (44%), adjusted means are more representative of the size of revisions than unadjusted means. Note that the $\bar{R}'$ value of 8.14 has an associated $S(\bar{R}')$ of 47.82. The extreme variability is also evidenced in the difference between $\bar{R}'$ (8.14) and $\bar{R}'_a$ (23.45).

Total percentage revisions are both very large and highly variable ($\bar{R}_t$ = 45.47 and $S(\bar{R}_t)$ = 97.81). It is difficult to predict anything about the absolute magnitude of ΔNFS revisions; perhaps the most that can be said of them is that if small, predictable revisions are taken as an index of reliable data, the ΔNFS revisions would indicate this series is not reliably estimated.

<u>I</u> This is another series with a low frequency of revision (51%), hence emphasis will be placed upon the adjusted summary statistics.

No tendency for either $\bar{r}'_j$ or $\bar{r}'_{ja}$ to decrease with increasing revision class is evident, though the revisions do seem to become less variable within increasing revision classes. The range of revisions within classes decreased sharply after the fourth revision.

The $\bar{R}'$ value of 0.93 is relatively low, and the $\bar{R}'_a$ of 1.36 indicates that offsetting revisions are not very extensive within revision classes.

Analytical results indicate that total revisions to first published I figures are revised upwards by about 4.7% ($S(\bar{R}_t) = 4.07$). The very similar $\bar{R}_{ta}$ value of 4.91 ($S(\bar{R}_{ta}) = 3.83$) would increase one's confidence in making assertions about I revisions.

<u>ID</u> This series has the lowest frequency of revision (39%) of all series analysed. As usual, there is no tendency for either $\bar{r}'_j$ or $\bar{r}'_{ja}$ to decrease with increasing revision class. Except for the fourth revision, all $\bar{r}'_j$ are positive, suggesting upward revisions. Occasional large differences between $\bar{r}'_j$ and $\bar{r}'_{ja}$ within revision classes and the total values of $\bar{R}'$ (0.45) and $\bar{R}'_a$ (1.03) suggest extensive offsetting quarter-to-quarter revisions.

The ID $\bar{R}_{ta}$ of 1.73 is <u>prima facie</u> the lowest $\bar{R}_{ta}$ of any series. However, $\bar{R}_t$ is biased downwards as a result of the high incidence (20%) of zero total revisions. If $\bar{R}_{ta}$ is adjusted for zero revisions, its unadjusted value increases to 2.16 - a figure more of the expected order of magnitude. But while the $\bar{R}_{ta}$ is low, there is a fairly extensive variability in both the individual quarter-to-quarter revisions and the total revisions.

In general, while ID is not often revised, it is nevertheless generally revised upwards. An initial estimate for any quarter would on average be revised upwards by about 2.2%.

<u>CND</u> Due to the very high frequency of revision (86%) for CND, adjusted and unadjusted figures are very similar. All $\bar{r}_j$ are positive, although the magnitude of $\bar{r}_j$ does not decrease greatly until there is a sharp reduction in $\bar{r}_{11}$ and $\bar{r}_{12}$. But $\bar{r}_{13}$ increases to a value greater than any other $\bar{r}_j$. However, this latter figure is based on only six (all positive) quarter-to-quarter revisions.

The $\bar{R}'$ of 0.26 is quite low and very similar to the corresponding values for YP and GNP. However, of the three respective $\bar{R}'$, the $S(\bar{R}')$ for CND is clearly the lowest. The small difference between CND $\bar{R}'$ (0.26) and $\bar{R}'_a$ (0.33) indicates little offsetting revision; the effect of positive revisions is most pronounced.

CND's $\bar{R}_t$ (= $\bar{R}_{ta}$) of 1.88 with a low $S(\bar{R}_t)$ of 1.46 lends weight to the previous expectations and evidence that initial CND figures will be consistently revised upwards, both in a quarter-to-quarter and a total sense. This positive total revision will be less than 2%, and will result from frequent quarter-to-quarter revisions of about 0.2%.

<u>CD</u> <u>A priori</u>, CD might be expected to exhibit similar revision characteristics to those displayed by CND. While this was found to be so in a qualitative sense, both quarter-to-quarter and total CD revisions are quantitatively larger than revisions to CND.

Firstly, CD has a surprisingly low frequency of revision (58%). Hence any summary statistics calculated over all revisions will be biased downwards. Accordingly, adjusted means will be emphasised.

Of all the series considered, the $\bar{r}'_i$ for CD comes closest to exhibiting a general decrease for increasing revision class. In fact, they decline to a (just) negative $\bar{r}'_{12}$ and an even more negative $\bar{r}_{13}$.

Total revision figures clearly indicate that an initial CD figure for any quarter will be revised upwards to the extent of about 2.8%. This total revision will be obtained by relatively few quarter-to-quarter revisions; these latter revisions will however be larger than usual - generally around 0.6%.

If CD had to be classified with a similar series, this series would not be the typically expenditure-based CND. Rather, CD revisions most closely resemble those of the two investment series; in its overall characteristics, CD quantitatively lies between ID and I.

(iii) First Revision as an Indicator of Total Revision

It is a common practice for assertions to be made, on the basis of first published figures, about the general direction of economic activity. This practice provokes the question: how well does the first published figure or revision respectively indicate the final "actual" figure or the extent of subsequent "total" revision?

It is obviously possible, given the revision which has been shown to exist in all series, that the first published figure could often give a misleading impression in terms of the occurrence of cyclical turning points. In this respect, overseas studies contain conclusions urging caution or, at the extreme, expressing total scepticism when using first published figures or first revisions as an indication of "final" figures or "total" revision respectively. For example, Oskar Morgenstern [14] considers that United States data " ... should be viewed as casting serious doubts on the usefulness of national income figures for business cycle analysis."[5] Zellner [17] finds a high proportion of turning point

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[5] <u>op. cit.</u>, p. 268.

errors in some components of GNP but not in others, while Stekler [15] finds only a small number of turning point errors in provisional US[6] data. Rosanne Cole [4] presents the most extensive evidence on this issue and urges caution in the use of first published figures.

Two types of test are performed here. Firstly, the frequency of turning point (TP) errors in first published figures relative to final figures is examined. Secondly, the quantitative relation between the first revision and the total revision is computed by linear regression analysis.

(a) TP Analysis[7]. How well do initial figures indicate the occurrence of actual TP's as evidenced by the "final" (ie, latest available) figures? (Note here that actual figures, not revisions, are being considered.) To answer this question, the following table can be constructed:

		Latest Figures	
		TP	no TP
Initial Figures	TP	a	c
	no TP	b	d

This table gives four possible types of TP indication as between initial and final figures. Cases "b" and "c" (the off-diagonal places) represent failures; they could be called TP errors of the first kind and second kind respectively. This is analogous to the distinction made between Type I (incorrect rejection) and Type II (incorrect acceptance) errors. Perfect indication of actual TP's by initial data would require off-diagonal cells to be empty, ie, $b = c = 0$. One can therefore consider quantitative measures, k_1 and k_2, of the first and second kind of error respectively, where k_1 and k_2 are defined by:

$$k_1 = b/(a + b) \text{ and } k_2 = c/(a + c).$$

The k_i $(i = 1, 2)$ are required to be below, say, 5% for the initial data to have predicted well.

The analysis here concentrates on the quantity "a", as most economic time series increase monotonically, hence a real success is only achieved when a TP is correctly indicated.

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[6] See particularly pp. 73-80.

[7] This analysis follows the theory discussed by Theil [16].

TABLE 1.

ANALYSIS OF ALL REVISIONS TO EACH SERIES

	DISTRIBUTION BY SIGN			DISTRIBUTION BY QUARTER				$\bar{R}$	$\bar{R}'$	$\bar{R}_a$	$\bar{R}'_a$	$\bar{R}_t$	$\bar{R}_{ta}$
	(+)	(-)	ZERO	M (+)(-)	J (+)(-)	S (+)(-)	D (+)(-)	$S(\bar{R})$	$S(\bar{R}')$	$S(\bar{R}_a)$	$S(\bar{R}'_a)$	$S(\bar{R}_t)$	$S(\bar{R}_{ta})$
a	272 (0.49)	148 (0.26)	136 (0.24)	56 48 (0.25)	89 31 (0.29)	26 29 (0.13)	101 40 (0.34)	0.19 (0.54)	0.25 (0.61)	0.29 (0.49)	0.39 (0.52)	2.29 (1.86)	2.33 (1.80)
b	226 (0.41)	215 (0.39)	113 (0.21)	53 54 (0.24)	50 68 (0.27)	45 31 (0.17)	78 62 (0.32)	0.18 (1.41)	0.23 (1.58)	0.56 (1.31)	0.71 (1.43)	2.11 (4.51)	3.80 (3.22)
c	155 (0.28)	87 (0.16)	314 (0.56)	25 16 (0.17)	72 39 (0.46)	12 1 (0.05)	46 31 (0.32)	3.51 (31.68)	8.14 (47.82)	10.12 (30.23)	23.45 (42.47)	45.47 (97.81)	64.72 (86.82)
d	158 (0.36)	65 (0.15)	219 (0.50)	40 10 (0.22)	60 16 (0.34)	23 21 (0.20)	35 18 (0.24)	0.47 (1.30)	0.93 (1.71)	0.68 (1.20)	1.36 (1.39)	4.71 (4.07)	4.91 (3.83)
e	117 (0.27)	55 (0.12)	270 (0.61)	17 5 (0.13)	30 25 (0.32)	30 11 (0.24)	40 14 (0.31)	0.17 (0.85)	0.45 (1.32)	0.40 (0.77)	1.03 (0.94)	1.73 (2.99)	2.57 (2.32)
f	261 (0.63)	93 (0.23)	58 (0.14)	59 15 (0.21)	46 32 (0.22)	36 42 (0.22)	120 4 (0.35)	0.22 (0.48)	0.26 (0.51)	0.28 (0.45)	0.33 (0.46)	1.88 (1.46)	1.88 (1.46)
g	193 (0.47)	46 (0.11)	173 (0.42)	55 3 (0.24)	55 10 (0.27)	26 10 (0.15)	57 23 (0.33)	0.33 (0.71)	0.56 (0.86)	0.44 (0.65)	0.76 (0.70)	2.80 (2.20)	2.85 (2.12)

a - GNP
b - YP
c - ΔNFS
d - I

e - ID
f - CND
g - CD

For each series, corresponding initial and latest figures were compared for the 45 quarters from 1958(3) to 1969(3). As the values for the first and final quarters are indeterminate for purposes of TP analysis, there are 43 quarters effectively available for analysis.

The values of k_1 and k_2 for each of the seven series are presented in Table 2.

TABLE 2

TURNING POINT ANALYSIS

Series	k_1	k_2
GNP	.04	.04
YP	.23	.23
ΔNFS	.04	.21
I	.10	.10
ID	.27	.27
CND	.03	.06
CD	0	.08

The GNP and CND initial figures predicted TP's in the final figures very well. This tends to confirm prior indication that GNP and CND data is the most "reliable" of all series considered. CD also performed well. A high incidence in both types of error is found for both YP and ID initial figures, while initial I figures indicated TP's only moderately well. *A priori*, ΔNFS could have been expected to have the highest k_1 and k_2 coefficients. While the k_2 coefficient is in fact quite high at 0.23, k_1 (0.04) is surprisingly low, indicating initial ΔNFS figures rarely indicated "no TP" when there was an actual TP in the latest figures.

(b) Regression of Total Revision on First Non-Zero Revision. A quantitative way in which one can express the relation between the total revision, r_t, and the first non-zero revision, r_1, is to estimate the linear regression equation:

$$r_t = a + br_1$$

where a and b are constant parameters. If r_1 was actually a highly accurate indicator of r_t, then, in a statistical sense, $\hat{a}$ should not be significantly different from zero and $\hat{b}$ should not be significantly different from unity for a specified confidence level. To the extent that $\hat{b}$ is significantly different from unity, a multiplicative bias exists in r_1; if $\hat{b}$ is greater than unity r_1 is biased downwards relative to r_t and conversely for $\hat{b}$ less than unity. Similarly, to the extent that $\hat{a}$ is significantly different from zero, then an additive bias exists in r_1. For $\hat{a}$ positive, r_1 is biased downwards relative to r_t and conversely for $\hat{a}$ negative. Empirical evidence considered thus far would suggest $\hat{a}$ would almost certainly be significantly greater than zero for all series. While $\hat{b}$ should certainly be positive, it is difficult *a priori* to generalise whether it will be greater than, equal to or less than unity.

The previously specified regression equation was estimated for each series, using a sample period of 1958(3) to 1969(3). The parameters of the estimated equation for each series are given in Table 3.

TABLE 3

REGRESSION OF TOTAL REVISION ON FIRST NON-ZERO REVISION

Series	$\hat{a}$	$\hat{b}$	R^2
GNP	1.9901* (0.2869)	0.9572 (0.3684)	0.1357
YP	2.1714* (0.6585)	0.9294 (0.4632)	0.0856
ΔNFS	20.1771* (18.0413)	0.9312 (0.0862)	0.7307
I	3.4091* (0.7655)	0.9198 (0.2411)	0.2822
ID	1.0807* (0.2615)	1.2703** (0.1055)	0.8239
CND	1.9840* (0.2359)	0.8303 (0.3347)	0.1496
CD	2.6360* (0.2534)	0.9991 (0.1488)	0.5702

Note:
(a) figures in parentheses are standard errors of estimated regression coefficients
(b) * denotes significantly different from zero at 5% level of significance
(c) ** denotes significantly different from unity at 5% level of significance.

As expected, all equations have a positive intercept which is significantly different from zero, thus implying that there is an additive bias in the first revision for any quarter; r_1 will actually be less than r_t. In all equations, the regression estimate of b is significantly different from zero, and for six of the seven series $\hat{b}$ is also not significantly different from unity. This indicates no multiplicative bias exists in the first revision for these series. However, the ID equation is unique in that its estimated b value is significantly different from unity; here, there is an indication that r_1 is biased multiplicatively downwards relative to r_t.

The R^2 values for each equation are of some interest. Those series which have an equation with a relatively high R^2 (ID and ΔNFS) have the lowest frequency of revision (0.39 and 0.44 respectively). Conversely, the three series with the lowest R^2 (YP, GNP and CND) have the three highest frequencies of revision (0.80, 0.75 and 0.86 respectively). Hence there is a clear inverse relation between frequency of revision and the explanatory worth of $(\hat{a} + \hat{b}r_1)$ as an indicator of r_t; for initial figures which will be subjected to relatively few non-zero quarter-to-quarter revisions, the expression $(\hat{a} + \hat{b}r_1)$ is a reasonable indicator of total revision. However, when any initial figure will be subjected to a relatively large number (say, 10 to 14) non-zero quarter-to-quarter revisions, $(\hat{a} + \hat{b}r_1)$ loses its ability to "explain" r_t.

CONCLUSIONS

The foregoing analysis has demonstrated the extent of data revisions for several economic aggregates. The analytical results can be used to formulate conclusions about data reliability.

Reliability of a series can be expressed in terms of several important characteristics. For a series to be considered "reliable" it should be characterised by revisions which are:

(a) frequent
(b) small in absolute magnitude, both in a quarter-to-quarter and in a total sense,
(c) in a consistent quarter-to-quarter direction (there should be a minimum of offsetting positive and negative quarter-to-quarter revisions),

and the first published figures should be good indicators of the direction of movement in the corresponding "final" figure.

On the basis of these criteria, the "reliability ranking" of series analysed here is:

1. CND
2. GNP
3. CD
4. YP
5. I
6. ID
7. ΔNFS

The first two series could be termed "very reliable"; they perform very well on all criteria and have an average total revision of less than 2.5%. CD, YP, I and ID could be termed "moderately reliable" in that while they perform well on some criteria they show poor results for other criteria. Particularly, YP is not revised in a very consistent manner (there is a high frequency of offsetting positive and negative quarter-to-quarter revisions) and CND has a low frequency of revision (only 58%).

As was initially hypothesised, ΔNFS is in a reliability class of its own - it has a "low reliability", as evidenced by its poor performance on all the reliability criteria.

With the benefit of hindsight, one can now see that the data sources of each respective series reveal a great deal about the series' eventual reliability grading. In general, the more a series is based on census data, the less frequently it will be revised, hence revisions that do occur will be relatively large in magnitude and often unpredictable in sign. Consequently, the series will be relatively unreliable. (The obvious illustration of these principles is ΔNFS.). Therefore, the use of census figures as a data source seems highly conductive to extrapolation error in data. It is notable here that the most reliable series examined (CND) is not census-based. Equally noteworthy is the fact that when census data is introduced into the sources of CD (which a priori could be expected to have a similar revision structure and reliability to CND) a decrease in reliability follows.

The general tendency towards underestimation in all series examined is consistent with overseas findings. For example, Cole [3] finds that for the US " ... the preliminary product (or expenditures) data have a negative bias: the preliminary estimates underestimate revised levels of GNP and most of its components."[8] Furthermore, Zellner [17] notes that provisional estimates of consumption on non durables tended to be high. Balacs [1] found that for UK data gross domestic product and consumption expenditure both tended to be revised upwards, although no such tendency existed for fixed capital investment; rather, this latter series tended to be unrevised (whether these were "zero revisions" or "not revisions" is not clear).

In general then, Australian data revisions are very much a function of data source. Qualitatively, data will be revised upwards, but the extent and pattern of these positive revisions varies as between different series. The results produced here for Australian data are in accord with results for overseas studies of national accounts figures. This is particularly so for the analysis of Australian GNP figures, where there is typically a consistent, relatively small, revision upwards in first published figures. This positive revision should be less than 3%.

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[8] op. cit., p.56.

2. DATA REVISIONS AND ECONOMETRIC STUDIES

Given the tendency for data to be revised by varying amounts, the selection of a data base for econometric studies is not a straightforward task. Denton and Kuiper [7], Denton and Oskanen [8], Holden [10], [11] and more recently Burns [18] have considered this subject, with differing conclusions as to its importance. This study considers the problem from the point of view of estimating, and using, a small quarterly model of the Australian economy.

The Model*

The basic model used in this study is a simple 15 equation model (9 behavioural equations and 6 identities) formulated within the Reserve Bank of Australia to help explain how one might use an econometric model for forecasting purposes.

The equations of the model are as follows:

GNP identity

$$GNP = CND + CD + I + ID + \Delta NFS - IM + G + X + \Delta FS + FE + SD$$

Personal Consumption Expenditure on Non-Durables

$$CNR = a_o + b_o YPD + c_o CND_{-1}$$

Personal Consumption Expenditure on Durables

$$CD = a_1 + b_1 YPD + c_1 KCD_{-1} + d_1 M_{-1} + e_1 RGS$$

Gross Private Fixed Capital Expenditure on Dwellings

$$ID = a_2 + b_2 YPD + c_2 KID_{-1} + d_2 M_{-1}$$

Gross Private Fixed Capital Expenditure Excluding Dwellings

$$I = a_3 + b_3 \Delta GNP_{-3} + c_3 \Delta GNP_{-4} + d_3 \Delta GNP_{-5} + e_3 KI_{-1}$$

Increase in the Value of Non-farm Stocks

$$\Delta NFS = a_4 + b_4 GNP + c_4 \Delta GNP + d_4 NFS_{-1}$$

Imports

$$IM = a_5 + b_5 GNP + c_5 IM_{-1} + d_5 dS$$

Personal Income

$$YP = a_6 + b_6 GNP$$

Personal Income Tax Payable

$$TPL = a_7 + b_7 YP + c_7 RPE$$

Personal Disposable Income Identity

$$YPD = YP - TPL$$

Demand for Money

$$M = a_8 + b_8 GNP + c_8 M_{-1} + d_8 RGS$$

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* We are indebted to Dr. W.E. Norton for providing this model.

Capital Stock Identities

$$KCD = KCD_{-1} + CD$$

$$KID = KID_{-1} + ID$$

$$KI = KI_{-1} + I$$

$$NFS = NFS_{-1} + \Delta NFS$$

The model's notation is explained as follows (an asterisk denotes an endogenous variable):

CD*	personal consumption expenditure on household durables and purchases of motor vehicles, $M.
CND*	personal consumption expenditure excluding CD, $M.
dS	dummy variable for UK dock strike; +1 in 1967(4), -1 in 1968(1), 0 elsewhere.
FE	current expenditure by financial enterprises, $M.
ΔFS	increase in the value of farm stocks, $M.
G	current and fixed capital expenditure by public authorities and public enterprises, $M.
GNP*	gross national product, $M.
I*	gross private fixed capital expenditure excluding ID, $M.
ID*	gross private fixed capital expenditure on dwellings, $M.
IM*	imports of goods and services, $M.
KCD*	capital stock for CD, $M.
KID*	capital stock for ID, $M.
KI*	capital stock for I, $M.
M*	volume of money, $M.
ΔNFS*	increase in the value of non-farm stocks, $M.
NFS*	capital stock for ΔNFS, $M.
RGS	theoretical yield on rebateable (where relevant) government securities with two years to maturity, %.
RPE	index of effective tax rates on personal income, defined as the ratio of TPL to YP less cash benefits to persons from public authorities, %.
SD	statistical discrepancy, $M.
TPL*	income tax payable plus estate and gift duties, $M.
X	export of goods and services, $M.
YP*	personal income, $M.
YPD*	personal disposable income, $M.

This model was originally estimated using seasonally adjusted data, which was inappropriate for this study. Thus each behavioural relationship was re-estimated introducing seasonal dummy variables (both additive and multiplicative). This led to the re-specifying of the equations for CND, ID, ΔNFS, IM and YP. The model finally adopted has the following behavioural relationships:

$$
\begin{aligned}
CND &= a_1 + b_{11}YPD + b_{12}CND_{-1} + b_{13}S_1 + b_{14}S_3 \\
CD &= a_2 + b_{21}YPD + b_{22}KCD_{-1} + b_{23}M_{-1} + b_{24}RGS \\
ID &= a_3 + b_{31}YPD + b_{32}KID_{-1} + b_{33}M_{-1} + b_{34}S_1 + b_{35}S_2 + b_{36}S_3 \\
I &= a_4 + b_{41}\Delta GNP_{-3} + b_{42}\Delta GNP_{-4} + b_{43}\Delta GNP_{-5} + b_{44}KI_{-1} \\
\Delta NFS &= a_5 + b_{51}GNP + b_{52}\Delta GNP + b_{53}NFS_{-1} + b_{54}S_2NFS_{-1} + b_{55}S_3NFS_{-1} \\
IM &= a_6 + b_{61}GNP + b_{62}IM_{-1} + b_{63}dS + b_{64}S_1 + b_{65}S_2 + b_{63}S_3 \\
YP &= a_7 + b_{71}GNP + b_{72}S_1 + b_{73}S_3 \\
TPL &= a_8 + b_{81}YP + b_{82}RPE \\
M &= a_9 + b_{91}GNP + b_{92}M_{-1} + b_{93}RGS
\end{aligned}
$$

$S1, S2, S_3$ - Seasonal dummy variables

S_2NFS_{-1}, S_3NFS_{-1} - Multiplicative seasonal dummy variables.

The Data Base

All data used was obtained either from the *QE* (and *Supplements* thereto) or the monthly *Statistical Bulletin* of the Reserve Bank of Australia. The capital stock variables were defined to be equal to zero in 1958(2) and subsequent values derived from their recursive definitions. The actual sample period for all estimation was 1958(3) - 1970(2) and forecast tests were for the nine quarters 1970(3) - 1972(3). [Data collection for this part of the study was carried out in the early part of 1973 and the figures used are not exactly the same as those in the previous analysis. This section includes slightly more recent data.]

To study the effect of revisions three different data sets were used, and the model estimated by both OLS and 2SLS. The three data sets correspond closely to those of Burns [18].

(i) Initial data

This is the set of data of first-released values of each variable. This data has undergone no revisions.

(ii) Latest data

The figures used in this set may be considered to be "final" and subject to no further revision. This statement would be strictly true if the only source of National Income data were the *QE* (the series from the Statistical Bulletin, M and RGS, are not revised). Only the preceding nine quarters and the current quarter are published in each Bulletin and thus data could be thought of as final after nine revisions (c.f. Burns [18]). However the existence of *Supplements* to the *QE* alters this picture slightly, with revisions occurring for an almost indefinite period, corresponding to the release of a new Supplement. In this case the set of latest data was derived where possible from the Supplement to QE Bulletin No. 46, otherwise the most recent issue of the QE.

(iii) Mixed data

This is the data set that would be most commonly used by an econometrician when estimating a model. For this exercise it was the data available on the release of QE Bulletin No. 39, 1970(1). Data for the most recent quarter has undergone no revision, for the previous quarter one revision and so on up to nine revisions when the data becomes "final" (or subject to revision on the issue of a Supplement). Mixed data is what would be regarded as the current data if a model were to be estimated for a sample period which included the most recently released information. The essential characteristic of this data set is that the observations have NOT undergone a constant number of revisions, but revisions ranging from zero to (effectively) nine.

Results of Estimation

(i) The Model itself.

It should be stated from the outset that no claims are made about the adequacy of the model being used to fully reflect the structural behaviour of the Australian economy. There are other quarterly models, currently developed, which perform more reliably. However the resources available for this work, both in terms of time and finance, dictated that the model be small and already developed. The model being used satisfied both criteria, and for this we are indebted to the Reserve Bank of Australia. No attempt was made to try to improve on poor equations such as that for ΔNFS, as the bounds to such improvements are limitless and resources limited.

However any imperfections of this model should not greatly alter the relevance of the results. No alternative model is perfectly specified, and all studies in this area must be considered in relationship to the particular model as specified. The analysis of estimates are made only for this model, and care must be taken not to draw too broad a set of conclusions at this stage.

(ii) The Results - Coefficient Revision

The estimated relationships are presented in Tables 4 a and b, with R^2 F statistic, and the Durbin Watson statistic also being presented for the OLS estimates. The important comparisons to be made are between coefficients estimated by the same method of estimation, but from different data sets. To facilitate such comparisons it seems reasonable to take the coefficients estimated from the latest data set as the base, for such estimates are based on the most accurate data available.

TABLE 4a.

OLS ESTIMATES FOR THE THREE DATA SETS

	a_i	b_{i1}	b_{i2}	b_{i3}	b_{i4}	b_{i5}	b_{i6}	R^2	F	D.W.
1 $CND = a_1 + b_{11}YPD + b_{12}CND_{-1} + b_{13}S_1 + b_{14}S_3$										
I	65.91 (1.59)*	0.180 (6.85)	0.793 (21.95)	-275.09 (-12.76)	-123.53 (-7.30)			0.99[illegible]	2670	(i) 2.37
M	79.77 (2.23)	0.198 (7.56)	0.766 (21.61)	-270.59 (-13.27)	-110.08 (-7.11)			0.997	3620	(i) 2.66
L	70.86 (2.10)	0.201 (8.17)	0.765 (23.13)	-264.97 (-13.88)	-109.52 (-7.51)			0.997	4151	(i) 2.57
2 $CD = a_2 + b_{21}YPD + b_{22}KCD_{-1} + b_{23}M_{-1} + b_{24}RGS$										
I	-76.36 (-3.73)	0.104 (9.67)	-0.011 (-1.77)	0.022 (1.74)	-3.516 (-0.53)*			0.949	194	(+) 1.02
M	5.46 (0.26)*	0.116 (10.35)	-0.006 (-0.94)*	0.011 (0.81)*	-11.090 (-1.66)*			0.954	215	(+) 0.84
L	-4.52 (-0.22)*	0.118 (10.37)	-0.007 (-0.99)*	0.011 (0.84)*	-10.503 (-1.56)*			0.953	214	(+) 0.85
3 $ID = a_3 + b_{31}YPD + b_{32}KID_{-1} + b_{33}M_{-1} + b_{34}S_1 + b_{35}S_2 + b_{36}S_3$										
I	-127.18 (-7.66)	0.055 (2.13)	-0.007 (-0.50)*	0.016 (1.10)*	24.387 (1.33)*	27.779 (1.57)*	31.610 (2.12)	0.951	128	(+) 0.39
M	-327.94 (-26.24)	0.078 (3.36)	-0.033 (-3.37)	0.041 (3.98)	31.865 (2.04)	37.734 (2.56)	49.291 (3.74)	0.975	248	(+) 0.57
L	-328.72 (-26.32)	0.081 (3.36)	-0.033 (-3.32)	0.039 (3.84)	33.614 (2.07)	40.177 (2.62)	50.899 (3.72)	0.974	251	(+) 0.60
4 $I = a_4 + b_{41}\Delta GNP_{-3} + b_{42}\Delta GNP_{-4} + b_{43}\Delta GNP_{-5} + b_{44}KI_{-1}$										
I	320.16 (7.41)	-0.042 (-2.69)	0.037 (2.69)	-0.061 (-3.86)	0.022 (27.73)			0.951	204	(+) 0.55
M	340.26 (8.61)	-0.032 (-2.49)	0.043 (3.63)	-0.053 (-4.08)	0.023 (27.74)			0.959	245	(o) 1.86
L	339.17 (8.60)	-0.033 (-2.50)	0.044 (3.74)	-0.052 (-3.98)	0.023 (28.07)			0.960	250	(o) 1.77

...Continued

TABLE 4a - Continued:

	a_i	b_{i1}	b_{i2}	b_{i3}	b_{i4}	b_{i5}	b_{i6}	R^2	F	D.W.
5 $\Delta NFS = a_5 + b_{51}GNP + b_{52}\Delta GNP + b_{53}NFS_{-1} + b_{54}S_2NFS_{-1} + b_{55}S_3NFS_{-1}$										
I										(+)
	-328.78	0.118	-0.091	-0.222	0.047	0.118		0.515	8.69	1.17
	(-6.13)	(3.33)	(-3.81)	(-3.14)	(2.52)	(6.00)			9	
M										(i)
	-277.13	0.106	-0.079	-0.122	0.018	0.074		0.499	8.18	1.33
	(-4.45)	(2.99)	(-3.21)	(-2.63)	(1.39)*	(5.51)				
L										(i)
	-299.82	0.113	-0.082	-0.129	0.021	0.075		0.503	8.29	1.36
	(-4.75)	(3.09)	(-3.25)	(-2.71)	(1.59)*	(5.49)				
6 $IM = 9_6 + b_{61}GNP + b_{62}IM_{-1} + b_{63}dS + b_{64}S_1 + b_{65}S_2 + b_{66}S_3$										
I										(i)
	-18.30	0.062	0.592	-85.367	67.065	97.657	77.542	0.958	153	1.78
	(-0.40)*	(3.53)	(5.09)	(-2.50)	(3.08)	(4.34)	(3.54)			
M										(i)
	-37.91	0.054	0.675	-63.401	53.693	74.829	60.245	0.974	247	1.35
	(-0.99)*	(3.32)	(6.73)	(-2.23)	(2.78)	(3.80)	(3.27)			
L										(i)
	-41.91	0.056	0.665	-62.280	54.616	78.539	61.331	0.974	245	1.37
	(-1.08)*	(3.46)	(6.64)	(-2.18)	(2.82)	(4.00)	(3.31)			
7 $YP = 9_7 + b_{71}GNP + b_{72}S_1 + b_{73}S_3$										
I										(o)
	153.40	0.738	48.370	-118.95				0.992	1806	2.20
	(1.61)*	(73.07)	(1.43)*	(-3.43)						
M										(+)
	257.28	0.725	-110.78	-167.75				0.997	4445	1.23
	(4.34)	(113.69)	(-5.25)	(-7.75)						
L										(i)
	194.01	0.738	-92.78	-156.73				0.998	7809	1.35
	(4.28)	(150.86)	(-5.75)	(-9.48)						
8 $TPL = a_8 + b_{81}YP + b_{82}RPE$										
I										(+)
	-299.56	0.133	18.60					0.995	4163	1.16
	(-24.26)	(34.43)	(7.59)							
M										(+)
	-334.14	0.133	21.63					0.994	3585	0.75
	(-25.20)	(18.30)	(4.35)							
L										(+)
	-315.41	0.138	18.27					0.990	2151	0.66
	(-17.71)	(14.25)	(3.19)							

...Continued

TABLE 4a - Continued:

	a_i	b_{i1}	b_{i2}	b_{i3}	b_{i4}	b_{i5}	b_{i6}	R^2	F	D.W.
9	$M = a_9 + b_{91}GNP + b_{92}M_{-1} + b_{93}RGS$									
I	678.11	0.360	0.846	-154.54				0.998	9147	(0) 2.05
	(6.32)	(9.76)	(41.49)	(-4.55)						
M	593.83	0.368	0.844	-145.80				0.999	9542	(0) 2.21
	(5.65)	(9.99)	(41.85)	(-4.39)						
L	590.05	0.369	0.844	-146.06				0.998	9248	(0) 2.23
	(5.53)	(9.77)	(40.94)	(-4.33)						

Figures in brackets for the results of the Durbin Watson test.

+ = Accept hypothesis of positive serial correlative at 5% significance level

- = Accept hypothesis of negative serial correlative at 5% significance level

O = Accept hypothesis of no serial correlative at 5% significance level

i = inconclusive region.

TABLE 4b.

2SLS ESTIMATED FOR THE THREE DATA SETS

	a_i	b_{i1}	b_{i2}	b_{i3}	b_{i4}	b_{i5}	b_{i6}
1 $CND = a_1 + b_{11}YPD + b_{12}CND_{-1} + b_{13}S_1 + b_{14}S_3$							
I	63.80 (2.36)	0.189 (7.04)	0.782 (21.21)	-269.81 (-12.37)	-120.94 (-7.11)		
M	60.50 (3.44)	0.194 (7.34)	0.770 (21.51)	-272.66 (-13.28)	-111.17 (-7.16)		
L	72.21 (3.26)	0.196 (7.81)	0.772 (23.00)	-268.32 (-13.91)	-111.29 (-7.59)		
2 $CD = a_2 + b_{21}YPD + b_{22}KCD_{-1} + b_{23}M_{-1} + b_{24}RGS$							
I	-78.77 (-0.99)*	0.105 (9.63)	-0.011 (-1.79)	0.022 (1.74)	-3.550 (-0.52)*		
M	9.17 (0.11)*	0.115 (10.16)	-0.006 (-0.89)*	0.010 (0.80)*	-11.036 (-1.65)*		
L	-0.41 (-0.00)*	0.116 (10.13)	-0.006 (-0.94)*	0.011 (0.83)*	-10.452 (-1.55)*		
3 $ID = a_3 + b_{31}YPD + b_{32}KID_{-1} + b_{33}M_{-1} + b_{34}S_1 + b_{35}S_2 + b_{36}S_3$							
I	-119.18 (-1.14)*	0.051 (1.71)	-0.006 (-0.44)*	0.017 (1.14)*	21.472 (1.04)*	24.965 (1.26)*	29.321 (1.77)
M	-322.19 (-4.09)	0.075 (3.01)	-0.033 (-3.26)	0.041 (3.99)	30.066 (1.80)	36.052 (2.29)	47.806 (3.40)
L	-327.43 (-4.02)	0.080 (2.94)	-0.033 (-3.21)	0.040 (3.82)	33.20 (1.83)	39.79 (2.33)	50.56 (3.32)
4 $I = a_4 + b_{41}\Delta GNP_{-3} + 6_{42}\Delta GNP_{-4} + b_{43}\Delta GNP_{-5} + b_{44}KI_{-1}$							
I	320.16 (7.41)	-0.042 (-2.69)	0.037 (2.69)	-0.061 (-3.86)	0.022 (27.73)		
M	340.26 (8.61)	-0.032 (-2.49)	0.043 (3.63)	-0.053 (-4.08)	0.023 (27.74)		
L	339.17 (8.60)	-0.033 (-2.50)	0.044 (3.74)	-0.052 (-3.98)	0.023 (28.07)		

...Continued

TABLE 4b - Continued:

	a_i	b_{i1}	b_{i2}	b_{i3}	b_{i4}	b_{i5}	b_{i6}
5 $\Delta NFS = a_5 + b_{51}GNP + b_{52}\Delta GNP + b_{53}NFS_{-1} + b_{54}S_2NFS_{-1} + b_{55}S_3NFS_{-1}$							
I	-299.02	0.108	-0.085	-0.203	0.044	0.114	
	(-2.76)	(3.01)	(-3.56)	(-2.83)	(2.33)	(5.84)	
M	-246.45	0.096	-0.074	-0.109	0.016	0.073	
	(-2.25)	(2.66)	(-2.98)	(-2.31)	(1.21)*	(5.40)	
L	-254.98	0.098	-0.075	-0.110	0.018	0.073	
	(-2.23)	(2.60)	(-2.91)	(-2.25)	(1.36)*	(5.32)	
6 $IM = a_6 + b_{61}GNP + b_{62}IM_{-1} + b_{63}dS + b_{64}S_1 + b_{65}S_2 + b_{63}S_3$							
I	-18.17	0.061	0.597	-85.308	66.709	97.195	77.153
	(-0.60)*	(3.48)	(5.10)	(-2.50)	(3.07)	(4.31)	(3.52)
M	-36.09	0.051	0.692	-63.071	51.921	72.800	58.728
	(-1.39)*	(3.10)	(6.81)	(-2.22)	(2.68)	(3.67)	(3.18)
L	-39.47	0.052	0.688	-61.88	52.26	75.89	59.29
	(-1.51)*	(3.17)	(6.75)	(-2.16)	(2.68)	(3.84)	(3.18)
7 $YP = a_7 + b_{71}GNP + b_{72}S_1 + b_{73}S_3$							
I	153.61	0.738	48.355	-118.96			
	(2.84)	(73.03)	(1.43)*	(-3.43)			
M	255.04	0.726	-110.61	-167.66			
	(7.36)	(113.66)	(-5.24)	(-7.75)			
L	191.75	0.739	-92.01	-156.64			
	(7.22)	(150.76)	(-5.74)	(-9.47)			
8 $TPL = a_8 + b_{81}YP + b_{82}RPE$							
I	-298.66	0.134	18.428				
	(-16.72)	(34.31)	(7.49)				
M	-337.20	0.132	22.148				
	(-10.37)	(17.99)	(4.40)				
L	-318.10	0.137	18.79				
	(-9.38)	(13.99)	(3.25)				

...Continued

TABLE 4b – Continued:

	a_i	b_{i1}	b_{i2}	b_{i3}	b_{i4}	b_{i5}	b_{i6}
9 $M = a_9 + b_{91}GNP + b_{92}M_{-1} + b_{93}RGS$							
I	578.91 (5.03)	0.363 (9.60)	0.845 (41.28)	-154.54 (-4.55)			
M	593.94 (4.51)	0.371 (9.99)	0.840 (41.41)	-145.72 (-4.38)			
L	590.19 (4.41)	0.376 (9.82)	0.842 (40.32)	-145.91 (-4.32)			

I = Initial Data
M = Mixed Data
L = Latest Data

Figures in brackets are t values.

* = Coefficient not significally different from 0 at 5% (one-tail) level.

The summary statistics, R^2, F, and D.W., generally reflect the idea that most change occurs in the initial - latest comparison, rather than the mixed - latest pairs. In fact very little significant change is observed in these summary statistics by moving from mixed data to latest data. (This is not surprising when one considers that of the 47 observations in the sample period, the first 34 mixed and latest observations are identical.) In terms of the significant difference of coefficients from zero, similar conclusions would appear to hold true - the alteration from initial to latest causes more variation than that from mixed to latest. In most cases this reflects a movement from an insignificant to a significant difference, though the changes in equation 2 (CD) are in the opposite direction (The 2SLS estimates provide almost exactly the same evidence.) There is virtually no evidence of changes in sign of the coefficients. For both OLS and 2SLS, equation 2 exhibits the only change in sign for constant terms. In the case of the OLS estimates, the initial data yields a significantly negative estimate, while the other two data sets have a positive coefficient (mixed) and a negative coefficient (latest) but both are insignificantly different from zero. In the case of the 2SLS estimates they are all insignificantly different from zero, so the change in sign is of little importance. The one case of a coefficient of one of the variables changing in sign is in that coefficient attached to S_1 in equation 7 (YP). There both methods of estimation show the initial coefficient as positive but not significantly different from zero, whilst the mixed and latest coefficients are negative and significant.

However such comparisons as these are of limited importance. Of more significance is the magnitude and direction of change (error) in the estimates of the parameters. Is there consistent overestimation or underestimation of the coefficients, and does the size of this error vary substantially between the data sets? Tables 5, 6, 7, 8, 9, and 10 help us to answer these questions.

The basis for comparison in each case is the appropriate set of latest data coefficients. For the purpose of this analysis we may think of these latest figures as being the correct values of the perameters, and we shall measure all errors from them. If the latest coefficient is positive an "underestimate" (positive percentage change) occurs when the initial/mixed estimate is strictly less than the latest value. If the latest coefficient is negative an "overestimate" (negative percentage change) occurs when the estimate is strictly less than the latest value (ie, - 270 is an overestimate of -100). It is on this basis that the Tables are compiled, using the formula

$$\text{Percentage change} = \frac{\text{latest estimate} - \text{initial/mixed estimate}}{\text{latest estimate}} \times 100.0$$

Because of their different economic (and mathematical) significance the constant terms are considered separately from the coefficients of the variables.

(It should be noted that in this analysis no attempt is made to differentiate between estimates which are significantly different from zero, and those that are not significantly different from zero. Only the numerical values themselves are taken into account. If such statistical significance were to be considered then maybe it should be by deleting all variables whose coefficients are not significantly different from zero and then re-estimating the newly specified equations. This does not seem warranted, nor sensible in terms of the economic significance of the variables.)

From the first two columns of results presented in Tables 5 and 6 it would appear that the initial data underestimates the constant more often than it overestimates it, whilst for the mixed data the trend is reversed. The means support this case when the extreme percentage values associated with a_2 (due to a small denominator) are removed from the calculations. We get an average underestimate of about 16% for the initial data, and overestimate of about 4% for the mixed data. (Figures in brackets are for the adjusted means and standard deviations.) The standard deviations of the percentage revisions suggest that the greater variations in the estimates occur between the initial and latest data, rather than between the mixed and latest.

In considering the coefficients of the variables, a different picture emerges. The initial data would seem to overestimate - approximately 2% to 3% on the average - with a reasonably high degree of variability. The mixed data seems to underestimate - approximately 0.5% on the average - with a much smaller degree of variability.

Again these conclusions are mostly supported if we take as the "true" parameter values, not the latest data estimates for the particular estimation method, but the 2SLS estimates using latest data. This can be justified on the grounds that these results embody the most accurate data and the better (though some would dispute this) estimation procedure. Table 7 summarizes these percentage revisions, and it can be seen they are consistent with the revisions where the estimation technique is kept the same. The only variations are:-

(a) the mixed data more significantly overestimates the constants, with 78% of the changes being overestimates (compared with 56% for the initial data) and a mean revision of about 7% compared with about 4½%.

(b) the revisions to coefficients are more pronounced for both initial and mixed data sets, but the mixed data change is now one of overestimation, not underestimation. Percentages of revisions by sign show little variation except that the mixed data in this case shows a marginal leaning to overestimation (51% of the revisions) compared with the two previous comparisons (35% for OLS and 32% for 2SLS). Average revisions are again greatest for the initial-latest comparisons and slightly larger than for Tables 5 and 6 but now the mixed data

TABLE 5.*

Summary of percentage revisions to coefficients due to differing data sets – OLS Estimates

	%+ve	%-ve	Max.	Min.	Mean	Std. Deviation
Initial to Latest – Constant terms	66.7	33.3	+61.3088 – 1589.1	+5.0259 -9.6608	-161.95 (16.454)	505.21 (26.523)
Mixed to Latest – Constant terms	44.4	55.6	+ 220.76 – 32.607	+0.2380 -0.3225	20.672 (-4.3398)	71.722 (12.525)
Initial to Latest – b coefficients	45.9	54.1	+ 152.13 – 127.69	+0.0894 -0.2987	-1.9576	48.363
Mixed to Latest – b coefficients	64.9	35.1	+ 9.7889 – 19.398	+0.1758 -0.0071	0.5966	5.7691

TABLE 6.*

Summary of percentage revisions to coefficients due to differing data sets – 2SLS Estimates

	%+ve	%-ve	Max.	Min.	Mean	Std. Deviation
Initial to Latest – Constant terms	66.7	33.3	+63.6006 – 19283	+5.6034 -15.033	-2128.3 (16.064)	6065.3 (27.428)
Mixed to Latest – Constant terms	44.4	55.6	+ 2357.3 – 33.004	+1.5995 -0.3226	257.70 (-4.7436)	742.40 (12.064)
Initial to Latest – b coefficients	48.6	51.4	+ 152.21 – 146.02	+0.1557 -0.5189	-3.2919	51.578
Mixed to Latest – b coefficients	67.6	32.4	+ 13.133 – 19.436	+0.1114 -0.1928	0.4298	6.2256

TABLE 7.*

Summary of percentage revisions to coefficients due to differing data sets and different estimation methods

	%+ve	%-ve	Max.	Min.	Mean	Std. Deviation
Initial (OLS) to Latest (2SLS) – Constants	66.7	33.3	+61.1561 – 18689	+5.6035 -14.897	-2064.3 (13.891)	5878.0 (28.888)
Mixed (OLS) to Latest (2SLS) – Constants	22.2	77.8	+ 1443.3 – 34.171	+3.9446 -0.1557	154.20 (-6.9394)	455.90 (11.2298)
Initial (OLS) to Latest (2SLS) – b coefficients	48.6	51.4	+ 152.23 – 164.05	+0.1502 -0.7022	-5.5312	53.389
Mixed (OLS) to Latest (2SLS) – b coefficients	48.6	51.4	+ 5.1753 – 19.614	+0.0259 -0.4094	-1.[illegible]	5.4669

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* Figures in brackets allow for the exclusion of constant a_2

TABLE 11.*

Summary of percentage revisions to coefficients due to differing methods of estimation

	%+ve	%-ve	Max.	Min.±c	Mean	Std. Deviation
Initial data - Constants (	33.3	55.6	+3.0648	+0.1174	-1.9588	3.8084
			-9.9548	-0.3016	(-2.5868)	(3.5733)
Mixed data - Constants (	44.4	44.4	+40.488	+0.0186	2.464[illegible]	14.0263
			-12.448	-0.8772	(-2.2891)	(4.2435)
Latest data - Constants (	33.3	55.6	+1.8680	+0.0228	-115.00	317.3183
			-1012.4	-0.3947	(-2.8278)	(6.015)
Initial data - b coefficients (	29.7	59.5	+4.6935	+0.0011	-2.2551	4.4433
			-13.5771	-0.0054		
Mixed data - b coefficients (	21.6	67.6	+2.8883	+0.0606	-2.1787	4.4617
			-20.436	-0.0510		
Latest data - b coefficients (	21.6	67.6	+2.7884	+0.0609	-2.4700	4.7914
			-17.442	-0.1029		

TABLE 12.*

Summary of absolute percentage revisions to coefficients due to differing methods of estimation

	Max.	Min.±o	Mean	Std. Deviation
Initial data - Constants (	9.9548	0.1174	2.6953	3.3281
			(2.64[illegible]2)	(3.5273)
Mixed data - Constants (	40.488	0.0186	6.9420	12.435
			(2.7487)	(3.9613)
Latest data - Constants (	1012.4	0.0228	115.61	317.10
			(3.5124)	(5.6434)
Initial data - b coefficients (	13.5771	0.0011	3.0125	3.9690
Mixed data - b coefficients (	20.436	0.0510	2.8481	4.0672
Latest data - b coefficients (	17.442	0.0609	3.0286	4.4594

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* Figures in brackets allow for the exclusion of constant term a_2.

TABLE 13.

(Summary of forecasting errors (absolute percentage errors from actual observations)

		GNP	CD	CND	YP	ΔNFS	ID	I	M	IM	KCD	KID	KI	NFS	YPD	TPL
OLS Initial	Max.	9.14	19.77	4.74	10.5	1,015	14.5	14.6	2.25	12.0	0.68	0.50	0.37	8.62	8.75	20.5
	Min.	0.35	0.03	0.45	0.81	29.2	1.76	3.04	0.11	0.15	0.00	0.05	0.09	0.45	0.78	9.91
	Mean	4.39	9.01	2.31	6.15	382	9.68	8.44	1.05	4.78	0.28	0.33	0.26	5.10	4.92	14.3
	Std.Deviation	2.83	5.68	1.40	3.68	342	4.33	3.45	0.77	4.46	0.20	0.15	0.09	2.95	3.66	3.57
Mixed	Max.	6.24	14.33	3.54	5.80	917	7.44	19.70	2.59	12.4	0.37	0.26	0.50	12.96	9.18	14.67
	Min.	0.31	0.27	0.33	0.00	5.77	1.78	1.34	0.01	1.19	0.11	0.06	0.04	0.16	1.83	6.25
	Mean	2.55	5.51	1.95	2.91	278	4.91	7.81	0.91	6.02	0.16	0.17	0.23	4.15	3.01	9.69
	Std.Deviation	1.99	4.86	1.10	2.02	277	1.68	5.54	0.85	4.59	0.13	0.06	0.13	3.68	1.00	3.01
Latest	Max.	6.99	16.9	4.29	4.62	948	7.51	20.1	3.12	13.3	0.43	0.23	0.51	13.42	5.68	13.4
	Min.	0.55	1.10	0.80	1.65	13.1	0.34	1.68	0.34	1.57	0.04	0.01	0.05	0.37	1.01	4.10
	Mean	2.82	6.22	2.09	2.92	298	3.81	7.78	1.17	6.48	0.17	0.13	0.23	4.44	3.02	8.10
	Std.Deviation	2.22	5.52	1.20	1.04	284	1.91	5.74	0.85	4.88	0.15	0.06	0.13	3.49	1.42	3.24
2SLS Initial	Max.	8.72	19.4	4.70	10.3	920	14.3	14.6	2.16	11.9	0.66	0.49	0.37	8.45	9.53	20.2
	Min.	0.02	0.16	0.41	0.66	5.71	1.62	3.04	0.17	0.18	0.00	0.05	0.07	0.86	0.58	9.63
	Mean	4.14	8.86	2.31	5.88	352	9.38	8.44	1.01	4.79	0.27	0.32	0.26	4.72	4.68	14.01
	Std.Deviation	2.75	5.51	1.39	3.65	317	4.34	3.45	0.77	4.46	0.19	0.15	0.09	2.87	3.61	3.58
Mixed	Max.	6.09	14.1	3.53	5.89	891	7.78	19.7	2.94	12.0	0.36	0.27	0.50	12.6	9.23	14.8
	Min.	0.31	0.33	0.33	0.04	5.43	2.05	1.34	0.19	1.10	0.01	0.07	0.04	0.15	1.77	6.35
	Mean	2.51	5.46	1.95	2.92	268	5.05	7.81	1.08	5.85	0.16	0.17	0.23	3.99	3.01	9.77
	Std.Deviation	1.95	4.77	1.10	2.06	268	1.76	5.54	0.83	4.41	0.13	0.06	0.13	3.79	1.03	3.01
Latest	Max.	6.77	16.7	4.26	4.66	906	7.33	20.1	3.11	12.7	0.43	0.22	0.51	12.8	5.60	13.6
	Min.	0.61	1.31	0.80	1.61	11.4	0.24	1.68	0.35	1.42	0.04	0.01	0.05	0.32	0.96	4.32
	Mean	2.77	6.19	2.09	2.92	284	3.84	7.78	1.17	6.19	0.17	0.13	0.23	4.22	3.02	8.20
	Std.Deviation	2.15	5.40	1.20	1.06	271	1.89	5.74	0.85	4.61	0.14	0.06	0.13	3.75	1.41	3.25

TABLE 14.

Overall summary of the absolute percentage forecasting errors

		Max.	Min.	Mean	Std. Deviation
OLS	- Initial data	1,015	0.00	30.23	129.24
		(20.5)		(5.07)	(5.14)
	Mixed data	917	0.00	21.87	99.04
		(19.7)		(3.57)	(4.02)
	Latest data	948	0.01	23.15	103.92
		(20.1)		(3.53)	(4.01)
2SLS	- Initial data	920	0.00	2[illegible].[illegible]2	119.32
		(20.2)		(4.94)	(5.06)
	Mixed data	891	0.01	21.22	95.83
		(19.7)		(3.57)	(3.99)
	Latest data	906	0.01	22.17	99.07
		(20.1)		(3.49)	(3.96)

Figures in brackets exclude the series of forecasts for ΔNFS.

TABLE 15.

Overall summary of the actual percentage forecasting errors, excluding ΔNFS from consideration

		%+ve	%-ve	Mean	Std. Deviation
OLS	- Initial data	81.0	19.0	3.60	6.26
	Mixed data	50.0	50.0	0.09	5.38
	Latest data	45.2	54.8	-0.77	5.29
2SLS	- Initial data	79.3	20.7	3.43	6.18
	Mixed data	49.2	50.8	0.14	5.35
	Latest data	45.2	54.8	-0.70	5.23

(iii) The Results - Forecasting.

The previous section has concentrated on the effects of data revisions and estimation procedures on the parameters of the model. It has brought forward the suggestion that not enough attention is paid to recognised errors in variables, for in many respects their impact is greater on the parameter estimates than that of alternative estimation procedures. Such work is important in the quest for accurate structural specification.

What of the performance of the model as a whole? To make some assessment along these lines, the six structural estimates of the model (OLS with initial, mixed and latest data, and 2SLS with initial mixed and latest data) were used to generate their reduced forms. These reduced forms were then used for forecasting for the nine quarters 1970(3) to 1972(3). Forecasting was not dynamic, but simply done by substituting the actual values of the predetermined variables into the reduced form. The absolute and actual errors, as percentages of the actuals, were then calculated for each of the six models, nine quarters, and fifteen equations respectively. These results are summarised in Tables 13, 14 and 15.

A first glance at these results shows the consistently poor performance of the equation for ΔNFS in all models. This was foreshadowed earlier, on the basis of the first fitted relationship. For the purpose of this analysis we will thus concentrate on the summary of errors excluding the ΔNFS series (figures in brackets in Table 14).

It should be emphasised that no claims are made that the model is particularly good for forecasting. There are some large percentage errors, even excluding ΔNFS, but there is no evidence that the forecasts get significantly worse as the forecast period is increased. However, this study is not concerned with the ability to forecast <u>per se</u>, but the comparison between forecasts generated by different estimates of the same model. It could be postulated that a better model may change the findings - only a study on such grounds will verify this notion.

If the six models were to be ranked in terms of their forecasting performance the following table could be constructed

	<u>Max. Error</u>	<u>Mean</u>	<u>Standard Deviation</u>
<u>Best</u>	OLS - mixed)	2SLS - latest	2SLS - latest
Small	(2SLS - mixed)	OLS - latest	OLS - latest)
difference	(OLS - latest)	2SLS - mixed	2SLS - mixed)
	2SLS - latest)	OLS - mixed	OLS - mixed
	2SLS - initial	2SLS - initial	2SLS - initial
<u>Worst</u>	OLS - initial	OLS - initial	OLS - initial

Whilst the differences in some cases are not great (there was no real difference between models for minimum errors) at least the ranking given by mean and standard deviation is consistent with prior reasoning. It is to be hoped that the 2SLS - latest model performs best, and at least on this very simple test it does. The OLS - initial model similarly does badly. Probably of more significance is that there is little apparent difference in performance between the mixed data models and the latest data models. While the parameter estimates do exhibit some consistent differences, of reasonably small magnitude, the accuracy of the forecasts do not show such consistent differences. The initial data models do however reflect their lack of ability in forecasting. Table 15 analyses these forecasts by taking the sign of the error into account. It allows overestimates (-ve) to cancel out underestimates (+ve), to see whether the different models exhibit different characteristics in this respect. Again in partial confirmation of Burns hypothesis the initial model shows consistent underestimation of the actual figures (using both estimation methods). Approximately 80% of the forecasts of this model underestimate the actual values. The average error of approximately +3½% confirms the tendency to underestimate, and the basic inaccuracy of the model. Variability of forecasting error was greater than for the mixed and latest models.

The mixed and latest models both perform fairly well, with almost equal proportions of overestimates and underestimates, though there is a slight tendency for the latest data model to overestimate, and the mixed data model to underestimate to a lesser extent. Both show very small average errors with overestimates effectively cancelling out the underestimates. If anything the mixed data model performs marginally better than the latest model. However when making all these comments it should be borne in mind that the series of "actuals" themselves are not latest data. Since they cover 1970(3) to 1972(3) it will be readily seen they embody from latest to initial data in terms of our previous definitions. As such the high proportion of underestimation in the last three quarters for all series forecast by the mixed and latest models may in itself be a problem of revisions to the "actuals". These are most likely to be revised by significant amounts, and the results above slightly changed. Only time will tell if there is any real difference between the two models; the evidence at present is too flimsy to support any conclusions about a real difference.

(iv) Overall Impact.

In general it would be very risky to come to many firm conclusions based on the data presented in this section. However for this model it would appear that the choice of data is an important decision to be consciously considered, and not ignored. It may be that in some cases loss of observations may be preferable to the inaccuracies of newly released "initial" data. The findings here support the comment by Burns [18, p.29] " ... the theoretical expectation of inducing errors by the choice of mixed data and the suggested possible magnitude of such errors suggest that econometricians should take some account of the statistical properties of successive revisions to data".

These findings also support Denton's conclusions [7 and 8] that choice of data has more effect than choice of estimation method. Our findings are in contrast to those of Holden [11]; but the fact that he used constant price, seasonally adjusted data which had undergone only a few revisions may explain this disparity in views.

There would now seem to be a fairly consistent collection of results on an international basis to place the changes due to data revisions above those due to estimation procedures.

3. POLICY IMPLICATIONS OF DATA REVISIONS

We now examine the impact of revisions in relation to annual fiscal initiatives as presented in the Budget. As with much of the preceding data revision research, there seems to be no Australian assessment of this issue. However, an overseas study by Balacs [1] found that for the United Kingdom "... the size of the revisions is often larger than the initial impact of the instruments which the policy-maker is using" (p.45). It is of interest to see if such a conclusion is borne out in the Australian context.

For the period 1960/61 to 1970/71, various important policy initiatives as outlined in the Treasurer's Budget Speech for each respective year are considered. The monetary magnitude of these measures is then compared with the size of the revision to annual values of GNP, total private investment expenditure and total personal consumption expenditure respectively for the year corresponding to the fiscal measure. Revisions to these annual figures were calculated as the difference between the annual value as given in the *Supplement* to *QE* Bulletin No.46, 1971(4), and the first published annual figure for that year. (Note here that the size of the annual revisions for years from about 1969/70 will undoubtedly be subject to further - perhaps quite large - revision over the next few years). The comparison between the values of the fiscal measures and the extent of the revisions is presented in Table 16.

The figures quoted here give a clear indication of the relative magnitude of data revisions to some important aggregates. Indeed, for example, in three years (1962/63, 1964/65 and 1969/70) the size of revisions to GNP and consumption are, respectively, in excess of the planned government budget deficit.

In an area closely related to policy formulation, balance of trade (BT) statistics are further figures subject to revision. Consider the revision to BT figures (defined as the difference between, respectively, exports and imports of goods and services) where the revision is calculated as the difference between the annual figure published in the *Supplement* to *QE* Bulletin No. 46, 1972(4) and the first published *annual* figure given in the appropriate *QE*.

TABLE 16.

BUDGET INITIATIVES COMPARED WITH ABSOLUTE REVISIONS TO GROSS NATIONAL PRODUCT, PRIVATE INVESTMENT EXPENDITURE AND PERSONAL CONSUMPTION EXPENDITURE ($M.)

Year	Budget Initiative and Estimated Full Year Effect	Size of Revision GNP	Inv.	Cons.
1960/61	Increased taxation and charges, 82.	285	61	107
1961/62	(i) Increase in expenditures charged to Consolidated Revenue Fund, 236. (ii) Cost of social service benefits, 21.	387	152	129
1962/63	Budget deficit, 237.	494	124	330
1963/64	(i) Increase in Loan Council borrowing, 34. (ii) Expenditure on housing, 180.	515	123	491
1964/65	(i) Budget deficit, 448. (ii) Increase in defence expenditure, 73.	629	146	468
1965/66	(i) Increase in Commonwealth expenditure, 550. (ii) Increase in defence expenditure (largest increase of any single item), 163.	169	37	263
1966/67	Increased expenditure on (i) defence, 252, (ii) grants to States, 59, (iii) education, 30.	28	159	209
1967/68	(i) Deficit, 596. (ii) Total expenditure on education, 194.	66	188	284
1968/69	(i) Total Commonwealth increase in expenditure, 252. (ii) Sales tax increase, 44.	101	42	282
1969/70	(i) Deficit, 30. (ii) Expenditure on social services, repatriation, health and housing, 192.	91	17	44
1970/71	(i) Reduction in personal income taxation, 289. (ii) Increase in defence expenditure, 233.	58	23	97

TABLE 17.

REVISIONS TO BALANCE OF TRADE STATISTICS ($M.)

Year	Initial	Latest	Revision
1960/61	-504	-428	-76
1961/62	210	265	55
1962/63	-118	-126	8
1963/64	310	290	-20
1964/65	-424	-436	12
1965/66	-475	-491	16
1966/67	-216	-224	8
1967/68	-618	-587	-31
1968/69	-347	-375	28
1969/70	-11	-9	-2
1970/71	11	-68	-79

A major point of interest here is the likelihood that the initial BT figure might be of the wrong sign. This occurs only once (for 1970/71), but the time at which this figure would have been released was dominated by international trade and monetary arrangements. Consequently, when Australia revalued relative to the US dollar in December 1971, the latest available annual BT figure was of the wrong sign and only one sixth of its revised magnitude. Additionally, the September 1971 quarterly figures (which would have been available in December 1971) were in fact a large overestimate of the latest available figure - the first published figure for 1971(3) of $38 mil. was revised down to $12 mil. (as given in the QE for 1973(1)).

While the change in the parity of the Australian dollar was clearly motivated by the movement in the US dollar, it is hardly conducive to accurate policy assessments when the initial BT statistics are eventually revised to such an extent.

Another major estimation problem relating to a particularly policy-oriented series concerns capital inflow. The Commonwealth Treasury's exposition on the problem is worth considering.[9]

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[9] See Commonwealth Treasury, Overseas Investment in Australia, Treasury Economic Paper No. 1, Australian Government Publishing Service, Canberra, 1972, Appendix A.

For example, the fact that "net apparent capital inflow" is notoriously difficult to measure accurately is borne out in the Treasury's comments and the quoted figures for 1969-70.[10] Here the initial published figure for the inflow was $867 mil. On the basis of preliminary returns from the Bureau's Survey of Overseas Investment the initial figure was revised to $780 mil. When the final survey figures were known, the final published figure for 1969-70 became $798 mil. - a total downward revision of $69 mil. or 8.0%. (To help put this figure in perspective, the revision to "net apparent capital inflow" for 1969-70 was more than twice the absolute magnitude of the estimated budget deficit for that year.)

What then are the inferences to be drawn from these illustrative figures? While the national accounting presentation of budget estimates should be regarded as necessary and worthwhile, we do feel that budget estimates are accorded undue precision. It must be remembered that the current year's Budget is closely related to the previous year's statistics (note the emphasis on various expenditures changing by 20% of last year's value) and last year's statistics are going to be revised to such an extent that there seems to be at least a prima facie case to be made that the general economic situation may "change" - perhaps, in a policy sense, significantly. Furthermore, it seems inappropriate to quote various growth rates in expenditures in terms of percentage points correct to one decimal place. Rather, if some agreed standard error is not attached to policy and growth estimates, then at least a range of values might conceivably be appended to published figures.

On the whole, the extent of the annual data revisions outlined in this section point to the conclusion that the problems of data collection are such as to hinder the fine tuning of the economy that economists would ideally seek to institute.

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[10] Op. cit., Table 37, p. 130.

4. SUMMARY AND CONCLUSIONS

This paper has attempted to demonstrate the significance of data revisions, with particular emphasis on National Income and Expenditure estimates. From the outset it has been recognized that this study is but a small sized sample from a large population embracing all time series subject to revisions. It makes no attempt to consider cross-section implications. To draw too precise a set of conclusions would be foolhardy, but to ignore the submitted evidence of the magnitude of the problem would be similarly irresponsible. Econometricians, and others using published series, have long acknowledged the potential problems associated with errors in variables, but few have attempted to analyse the magnitude and implications of such problems. This study has attempted to show that they are worthy of more attention. The effect of data revisions has been shown to be large; sometimes greater than that of different estimation procedures; sometimes such as to make policy statements and directives appear almost insignificant in their shadow. Maybe part of the difficulty in failing to finely tune the Australian economy is not due to economic theory but purely due to inaccuracies of the data on which many decisions have to be based.

If any plea arises from this study it is for a greater publication of the magnitude of errors or at least reliability gradings which users of published series may expect in the data. Such information would help highlight the problem and warn persons using such data that the most sophisticated of techniques may be limited if due account is not paid to the accuracy of the basic information being consumed.

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