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TREND ESTIMATION WITH CONCURRENT SEASONAL ADJUSTMENT

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ABSTRACT. Recent studies have shown the advantages of calculating the most recent month's seasonal adjustment by using data up through that month (concurrent adjustment) over the traditional procedure of using projected year-ahead seasonal factors. The trend estimates produced by the X-11 procedure are partially determined by the type of seasonal factors used. Since an underlying motive for performing seasonal adjustment is to obtain an idea of the trend, it is of interest to compare the trend estimates produced using concurrent seasonal factors with those obtained via projected factors. The accuracy of concurrent trend estimates is examined on a set of Census Bureau economic time series using the Census X-11 methodology. Comparisons are noted in terms of month-to-month percentage changes and mean absolute deviations from historical estimates. The results indicate that the concurrent adjustment procedure leads in many cases to an improved trend estimation.

1. INTRODUCTION

The U.S. Census X-11 method of seasonal adjustment has enjoyed widespread acceptance by government agencies and private industries throughout the world. Many ways of applying Census X-11 have been proposed to improve the seasonal adjustment. Concurrent seasonal adjustment is one such application of X-11 that many agencies have adopted and which is currently being implemented by one Census Bureau division. Concurrent adjustment involves calculating the most recent month's seasonal adjustment by using data up through that month to estimate the seasonal factors. The traditional practice has been to project year-ahead seasonal factors to adjust the monthly data as they become available. Most studies comparing the two procedures have concentrated on the seasonally adjusted values. Many Census Bureau data users are actually more interested in estimates of the trend (which are not published) rather than in the seasonally adjusted data. The trend produced by X-11 is not an optimal estimate of trend; rather it serves as a tool in the seasonal adjustment procedure. However, to complete any comparisons of these two modes of using X-11, the resulting trend estimates should be examined.

Kenny and Durbin (1982) undertook an extensive examination of various estimates of trend for the most recent month. Our aim is not to evaluate different trend estimation procedures but to compare the trend estimation procedure of X-11 using the concurrent and projected factor approaches of seasonal adjustment with X-11. Twenty-three U.S. Census Bureau economic time series are examined in this empirical study. A working definition of trend is given in Section 2 along with the methods for extracting trend used in this study. Section 3 describes the time series used in the analysis. Two measures were chosen to evaluate the quality of the trend estimated by each procedure, the mean absolute error and a difference of month-to-month ratios. They are described in Section 4 together with a discussion of the results from the 23 selected series. The paper concludes with a summary of the main findings.

2. CONCEPT OF TREND

The concept of final or historical trend is not easy to define. The trend estimates for a given month change as more data become available. However, once enough data become available to obtain a final seasonal factor such that adding data points to the beginning or end of the series does not affect its value, further revisions in the trend estimates are negligible with Census X-11. Therefore, the final or target trend for a given month is taken to be the trend value from X-11 when enough data are available on either side of that month to yield an unchanging seasonal factor. When all such data are available, the target trend is the same with either concurrent adjustment or projected factor adjustment. X-11 estimates trend values by applying the Henderson moving average to deseasonalized data. The preferable procedure for trend estimation is the one that yields an estimate of trend for the current time point that is closest to the target trend, as defined above.

It is important to mention that by seasonally adjusted or deseasonalized data, we refer not only to the removal of the seasonal component but also to any calendar variation like trading day or holiday effects. Hence the deseasonalized or seasonally adjusted data consists of only a trend component and an irregular component.

The projected 12-months-ahead trend values were obtained as follows. First a seasonal adjustment was performed using data through December for each year. The resulting projected seasonal factors for the following year were used to adjust the raw data, thereby obtaining seasonally adjusted data on the projected factor basis. The completely asymmetrical (i.e. one-sided) Henderson filter was then applied to the deseasonalized data to obtain the trend estimate for the current month. The length of the Henderson filter applied depends on the nature of the series. The average absolute month-to-month percentage change of the irregular component ($\overline{I}$) is compared to the average absolute month-to-month percentage change of the trend component ($\overline{C}$). The resulting ratio ($\overline{I}/\overline{C}$) determines the length of the Henderson filter (Shiskin et al. 1967 and Dagum 1983). Large fluctuations in irregular relative to trend indicate the need for longer filters.

To obtain the concurrent estimate of trend, seasonal adjustment was performed with data up to and including each month in the experimental timeframe, thus simulating concurrent adjustment. The X-11 trend value for the most recent month is then the concurrent trend estimate. Figure 1 gives an example of the final, concurrent, and projected factor trend estimates for RHARDWARE, the retail sales of hardware.

It is worthwhile to note that there is one discrepancy between the procedures to obtain final and concurrent estimates and the procedure to obtain the projected factor estimates. For final and concurrent estimates, the whole iterative procedure of seasonal adjustment and trend estimation is internal to the X-11 program. The X-11 procedure will not seasonally adjust the raw datum for a month if that month has been flagged as an outlier. Instead, a replacement value for the raw datum determined by X-11 will be inserted and adjusted. We had to do the projected factor seasonal adjustment exterior to the X-11 program because theoretically not all raw data are yet available. Consequently, with no opportunity to flag an outlier, the raw data concurrent and projected factor trend estimates is thus confounded with the outlier replacement question. The effects, though, appear to be negligible.

3. DESCRIPTION OF DATA

A cross-section of 23 economic time series compiled by the U.S. Census Bureau were selected for the study. The group contains the 21 series used in McKenzie's concurrent adjustment study (1984) plus two additional series, RAUTODLRS, the retail sales of automotive dealers, and INS62VS, the value of shipments of beverages. The data come from four different production divisions at the Bureau of the Census; Business (BUS), Industry (IND), Foreign Trade (FTD), and Construction (CSD). These series were chosen for the study by the respective divisions because of their consistency in definition over a sufficiently long time span and their varied nature.

Unlike the series used by Kenny and Durbin (1982), these series have not undergone prior modification for extreme values. Also, no prior modification for calendar variation has taken place other than that which is done by the Industry Division at the company report level. Modifying for extreme values may yield series that are smoother than one would expect to encounter in actual production situations. This difference is evident in several descriptive measures as shown in Table 1.

The Months for Cyclical Dominance (MCD), defined as the minimum number of months necessary for the average absolute change in trend to exceed that of the irregular, is one measure of the smoothness of a series. Once extremes had been removed, Durbin and Kenny had nine series with an MCD of 1, ten with

MCD of 2 or 3, and four series with MCD of 4, 5, or 6. In contrast none of our series had an MCD of 1, fifteen had MCD of 2 or 3, five had MCD of 4, 5, or 6, and three had an MCD greater than 6 (with the largest value being an MCD of 10). The Henderson filter lengths, which depend on the relative amounts of irregular component to trend component, are also affected by the smoothness of the series. Nine of Kenny and Durbin's series have a filter length equal to 9 and eleven have a filter length equal to 13. In contrast, five of our series have a filter length equal to 9, seventeen have a filter length equal to 13, and one has a filter length equal to 23.

The BUS, FTD, and IND series span the period from January, 1967 to July, 1980. Because additional data were available prior to 1967 for some CSD series, they range from 1960, 1964, or 1967 to December, 1979. Due to the 7-year startup required by X-11 and additional observations necessary at the end of the data span for the computation of final seasonal factors, the actual experimental period varies among groups of series. The experimental period for IND and BUS is January, 1974 to July, 1977; for FTD series January, 1974 to July, 1975; for CSD series either January, 1974 to December, 1976, January, 1967 to December, 1974, or January, 1971 to December, 1974. All series have an experimental period including 1974 and most include 1975 as well. These years were a time of economic recession in the U.S. Hence not all test years are "normal". Kenny and Durbin's test period ranges from January 1969 to December 1973, just catching the period of inflation, rising unemployment, and drops in production in Britain (see the discussion by Stern, 1982). Because of the additional years of data needed to arrive at the target trend, these exceptional years may have adversely affected the estimation of target trend in the Kenny and Durbin study.

The X-11 seasonal adjustment options applied were those used by the Bureau in 1981. The analysis was conducted using X-11-ARIMA's version of X-11 (Dagum 1983). In other words, X-11-ARIMA was used but the ARIMA model selection option was not chosen and the series were not augmented by forecasts. Hence a seasonal adjustment by X-11 was simulated but it was possible to utilize the improved diagnostics in the X-11-ARIMA package. The diagnostic Q-statistic and modified Q (Monsell 1984) measuring the quality of the seasonal adjustment are shown in Table 1. Low values of Q (below 1) generally indicate that the X-11 procedure can be expected to do an adequate job of seasonal adjustment. Large values suggest that the series may be unsuitable for seasonal adjustment via X-11 methodology.

Table 1 also lists the month-to-month percentage contributions of the components to the variance for each series. Large percentages of irregular compared to that of seasonal components make the seasonal adjustment procedure difficult. In general, large percentages of irregular are found in conjunction with high MCD values and large Q-statistics. All of these characteristics will have an influence on our results.

4. ANALYSIS, RESULTS, AND DISCUSSION

Differences in the trend estimates and target trends were measured in terms of level change and month-to-month rates of change. A measure of each type was computed for each month in the experimental timeframe. The results were summarized in the form of the Mean Absolute Error (MAE) for level change and Average Absolute Difference of Month-to-Month Ratios (AADM) for month-to-month rates of change, which are defined as follows:

$$\text{MAE} = \sum_{t=1}^{N} \frac{|X_t - x_t|}{N}$$

$$\text{AADM} = \sum_{t=1}^{N-1} \frac{|X_{t+1}/X_t - x_{t+1}/x_t|}{N-1}$$

where

X_t = Initial trend estimate for month t with a particular seasonal adjustment mode

x_t = Final trend value for month t

N = Number of months in test period

The two modes of trend estimation were then compared on the basis of the MAE and AADM statistics. The results are somewhat different for the two statistics. They suggest that the use of concurrent seasonal factors more consistently improves the estimates of month-to-month change in the trend than it does the estimates of level.

Table 2 displays the results. Entries in the first column are the ratio of the MAE statistic using concurrent trend estimation to the MAE statistic using projected factor trend estimation. Geometric means by Census Bureau Division as well as the overall mean are presented. In contrast with the 12% overall improvement in MAE in the concurrent seasonally adjusted data (McKenzie 1984), there is an overall mean of 5% improvement in MAE in the concurrent estimation of trend level. However, not every series is improved. The results must be examined by division.

Assuming a 2-3% inherent error in the estimates, ratios between roughly .97 and 1.03 do not indicate a clear improvement for either type of trend estimate. Of the BUS series only RHARDWARE showed a definite reduction in MAE by concurrent trend estimation. FTDXU2 was the only FTD series to yield a reduction with concurrent adjustment. In contrast, five out of seven IND series and four out of five CSD series offered considerable reductions for concurrent adjustment.

The month-to-month ratio summary is displayed in the second column of Table 2. The improvement of concurrent trend estimates with regard to month-to-month ratios is on the whole more substantial. The overall mean reduction in AADM is 9% and furthermore, all divisions showed improvement on the average with concurrent estimates. Again this value is much lower than the 20% reduction in AADM for concurrent seasonally adjusted data (McKenzie 1984). Of the BUS series, WFURN and RGROC did not reveal an improved AADM statistic. FTDXULAR was the only one of five FTD series to perform worse with concurrent adjustment. There was a reduction in AADM for all five CSD series and four out of seven IND series, with the three remaining IND series revealing essentially no difference. Hence, on the basis of differences of month-to-month percentage changes, the evidence favors the use of concurrent adjustment to yield trend estimates.

The level change comparison suggests that concurrent trend estimation is more effective with IND and CSD series than with BUS and FTD series. By examining characteristics of these two sets of series, perhaps we can get an explanation for this behavior.

The BUS series are characterized by relatively strong trading day components and a moderate seasonal component. The FTD series have a moderate to strong seasonal component and a somewhat large irregular component. The IND and CSD series on the other hand tend to have strong seasonal components. The series that performed differently from the rest in their group are exceptions to these characterizations. For example, RHARDWARE, the only BUS series that showed an improved level statistic with concurrent adjustment has an 82% seasonal component, 20% larger than any other seasonal component among BUS series. Similarly CON-PRAOTH, the only CSD series where the concurrent MAE was worse, has the weakest seasonal component among the construction series studied. Of the other exceptions to their group, INS63TI has strong moving seasonality as indicated by the high F-statistic, and the X-11 procedure may therefore have difficulty capturing the seasonal component. FTDXU2 has the highest level of aggregation of any series in this study. To summarize, concurrent trend estimation seems most effective with series having strong seasonal components, weak irregular components, and very little trading day variation for X-11 to estimate and remove.

The month-to-month percentage change comparison indicates that gains are made with series from all four divisions by using concurrent trend estimates.

Only four series prove to be exceptions. FTDXULAR, which behaved poorly in conjunction with concurrent adjustment for both statistics, should probably not be seasonally adjusted at all with the X-11 procedure: the Q-statistic assessing the quality of the seasonal adjustment is well above 1. The irregular component dominates the seasonal, thereby making it doubtful whether enough identifiable seasonality exits. If the seasonal factors cannot be adequately identified, then the resulting trend estimates are meaningless. RGROC, an extremely stable series dominated by trading day effects, has the smallest percentage contribution of seasonality present of any series studied. It is not clear why the combination of strong trading day components and weak seasonal components would yield such a result because both effects are being estimated and removed together. INS46VS is second to FTDXULAR with respect to the small amount of identifiable seasonality present as indicated by the F-test for seasonality. With 40% of its variance contributed by the irregular component, there is no doubt that the quality of either concurrent or projected factor seasonal adjustment is questionable. For WFURN, concurrent trend estimates were inferior with respect to level and month-to-month percentage change, but detailed investigation brought forth no explanations for this behavior.

The Kenny and Durbin study (1982) measured level change with the Root Mean Square Error statistic (RMSE). They found an overall improvement of 3.5% in the RMSE with concurrent trend estimates. In addition, Kenny and Durbin grouped their series by MCD values to analyze trend estimates since series with the same MCD gave roughly similar results. They recorded an average reduction in RMSE of 1.5% from the group with an MCD of 1, 4% from the group with an MCD of 2 or 3, and 10% from the group with an MCD of 4 or more. Results by individual series were not given.

Dividing our twenty-three Census Bureau series into groups by MCD, there are twelve with an MCD of 2 or 3 and eleven with an MCD of 4 or higher. Computing the geometric averages of the MAE and AADM ratios for each group, it is found that the averages of both statistics for the group with higher MCD values improved by about 5.5% over the respective averages for the group with lower MCD values. The corresponding average RMSE improvement in Kenny and Durbin's study was 6%. The values are displayed below.

	Average RMSE Ratio (Kenny and Durbin)	Average MAE Ratio	Average AADM Ratio
MCD 1	.9851	-----	-----
MCD 2,3	.9596	.9818	.9352
MCD 4+	.8977	.9244	.8795
Overall	.9651	.9536	.9078

This improvement suggests that the advantages of using concurrent trend estimates are most evident with series that are not especially smooth.

5. SUMMARY

One might expect the improvement in trend estimates obtained by using concurrent seasonal adjustment to be similar to the amount of improvement in the seasonally adjusted data. While there is overall improvement in concurrent estimates of trend, the magnitude of improvement is less than that for concurrent seasonally adjusted data.

The concurrent procedure provided reductions in Average Absolute Difference of Month-to-Month percentage changes of trend. In 19 out of 23 series the concurrent adjustment procedure produced reductions over the presently-used projected factor adjustment, with an average reduction of 9%. There were noticeable reductions in level differences of trend in 11 of the 23 series with a notable lack of advantage on most BUS and FTD series. Considering that the AADM would be the more highly weighted statistic by most users with the possible exception of FTD users, our results appear favorable towards concurrent trend estimation.

Concurrent trend estimation seems to be particularly effective with series dominated by strong seasonal components relative to the irregular and trading day effects. The 5.5% differential in the statistics of series with MCD's of 4 or more over those of series having MCD's of 2 or 3 suggests larger benefits are obtained by using concurrent trend estimates on less smooth series. Since the less smooth series are more difficult, in general, to adjust, the concurrent trend results are especially promising.

Despite the average overall improvement, there were 5 series out of 23 where concurrent trend estimation did perform poorly. Of course it is not expected that the concurrent trend estimation would show improvement in all series. On most series that do favor concurrent trend estimation (15 out of 23 in this study), the degree of improvement is convincing. Interpreting the X-11 trend as merely a tool in the seasonal adjustment procedure, the concurrent trend estimates are certainly preferred in accordance with the results of McKenzie's study. This study evaluated the trend estimates themselves for accuracy, and found that in many cases, the concurrent adjustment procedure still produces the better estimate of trend.

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Table 1. Characteristics of the Series

Series	MCD		F-Test for Seasonality (all data)		Month-to-Month % Contribution of Components to Variance of Unadjusted Series (all data)			Quality Control Statistic of X-11-ARIMA's X-11 (all data)		Length of Henderson Filter
	first 7 years	all data	mov-ing	stable	I	S	TD	X-11-ARIMA Q	Monsell's 1/ modified Q	all data
RAUTODLRS	3	3	1.30	90	9	56	33	0.32	0.35	13
RFURNDLRS	2	2	2.44	181	4	57	37	0.23	0.24	13
RGROC	2	2	0.48	90	3	18	77	0.27	0.28	9
RHARDWARE	3	3	1.01	203	3	82	14	0.29	0.29	13
RTAUTO	3	3	1.33	96	8	57	33	0.31	0.33	13
WFURN	2	3	0.96	133	6	62	31	0.25	0.26	13
FTDXUCAN	3	3	0.72	110	13	79	6	0.33	0.38	13
FTDXUCARSC 2/	4	4	1.70	47	20	75	4	0.61	0.63	13
FTDXULAR	6	4	1.49	7	54	32	8	1.07	1.21	13
FTDXUWH	4	3	1.67	24	19	70	8	0.47	0.64	13
FTDXU2	3	3	1.67	49	34	55	5	0.50	0.60	13
INS21VS	5	8	3.20	28	22	77	0	1.03	1.04	9 3/
INS36VS	3	3	1.19	78	14	85	0	0.41	0.43	9 3/
INS46VS	3	3	0.82	14	40	55	0	0.84	0.95	13
INS62VS	5	4	0.77	113	19	79	0	0.44	0.46	13
INS63TI	4	3	7.45	53	20	74	0	0.48	0.52	13
INS80UO	2	2	1.64	36	18	70	0	0.51	0.58	9
INS86VS	3	3	0.70	152	14	84	0	0.32	0.33	13
CON-BPNC1	8	4	3.24	497	10	84	6	0.30	0.31	13
CON-BPNE1	4	4	1.12	394	12	80	6	0.33	0.33	13
CON-HSNC1	4	7	2.41	205	20	77	3	0.44	0.45	13
CON-HSNC5	8	10	6.72	24	46	52	1	1.06	1.14	23
CON-PRAOTH	2	2	5.45	21	30	44	0	0.66	0.71	9

1/ The M2 component of the original Q-statistic has been modified to better accommodate the effect of more variable trends. U.S. series are found to have more variable trends than the Canadian series studied by Lothian and Morry (1978) on which the measure was established; see Monsell (1984) for details.

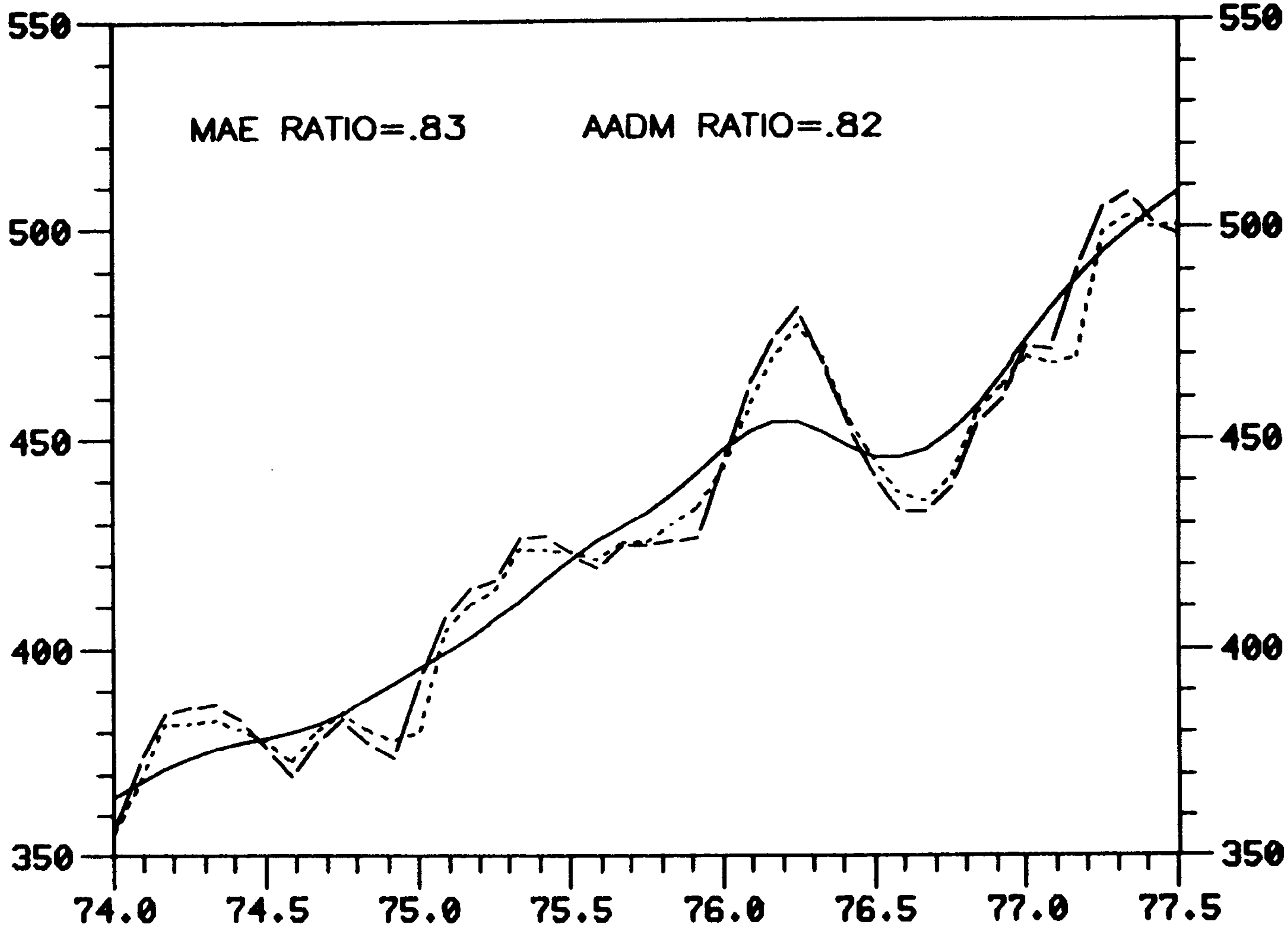
2/ Trading-day adjustment option is applied for trend estimation study but was not applied for seasonal adjustment study.

3/ Henderson filter lengths are fixed to 9 on input.

Table 2. Comparison of Mean Absolute Error and Average Absolute Difference of Month-to-Month Ratios, Ratio of Concurrent to Projected 12-Months-Ahead.

Economic Area (Period of Observations)	Series	Ratio: MAE for Concurrent / MAE for Projected	Ratio: AADM for Concurrent / AADM for Projected
Business --			
	RAUTODLRS	.9898	.9701
Retail and Wholesale Trade	RFURNDLRS	1.2140	.8841
(Jan. 1974 - July 1977)	RGROC	.9816	1.2231
	RHARDWARE	.8262	.8194
	RTAUTO	.9961	.9808
	WFURN	1.3271	1.1672
	MEAN	1.0431	.9973
Foreign Trade --			
	FTDXUCAN	1.0080	.9005
Exports	FTDXUCARSC	1.0120	.9026
(Jan. 1974 - July 1975)	FTDXULAR	1.0878	1.1044
	FTDXUWH	1.0610	.7970
	FTDXU2	.9541	.9196
	MEAN	1.0253	.9197
Industry --			
	INS21VS	.9965	.9937
Shipments, Orders, Inventories	INS36VS	.7354	.7332
(Jan. 1974 - July 1977)	INS46VS	.9066	1.0020
	INS62VS	.7689	.7911
	INS63TI	1.0249	.9996
	INS80UO	.9261	.8665
	INS86VS	.9103	.8363
	MEAN	.8897	.8829
Construction --			
	CON-BPNC1	.9661	.8312
Building Permits	CON-BPNE1	.9522	.8522
(Jan. 1967 - Dec. 1974)			
Housing Starts	CON-HSNC1	.7791	.7940
(Jan. 1971 - Dec. 1974)	CON-HSNC5	.8151	.9541
Value Put in Place	CON-PRAOTH	1.1611	.9355
(Jan. 1974 - Dec. 1976)			
	MEAN	.9274	.8609
OVERALL MEAN		.9536	.9078

FIGURE 1: COMPARISON OF TREND ESTIMATES FOR RHARDWARE 1-74 TO 7-77



DASH=PROJ12-AHEAD DOT=CONCURRENT SOLID=FINAL TREND