Australian Bureau of Statistics
INFORMATION PAPER

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TIME SERIES DECOMPOSITION — AN OVERVIEW

NEW ISSUE

INQUIRIES If you want to know more about this topic telephone the Supervisor, Seasonal Analysis, on Canberra (062) 526103, or write to: ABS, PO Box 10, Belconnen, ACT 2616

Please note: To assist readers, graphical presentation and text have been brought together in the six-page fold out design of this publication.

Introduction

1. Much of the information published by the Australian Bureau of Statistics is in the form of *time series*. The purpose of this brief overview paper is to present some fundamental and important concepts related to the interpretation of movements in such series. For further reading refer to *A Guide to Smoothing Time Series — Estimates of "Trend" (1316.0)*; published March 1987. A further information paper titled *Concepts and Methods of Seasonal Analysis (1315.0)* is planned.

Time Series Decomposition

Time Series

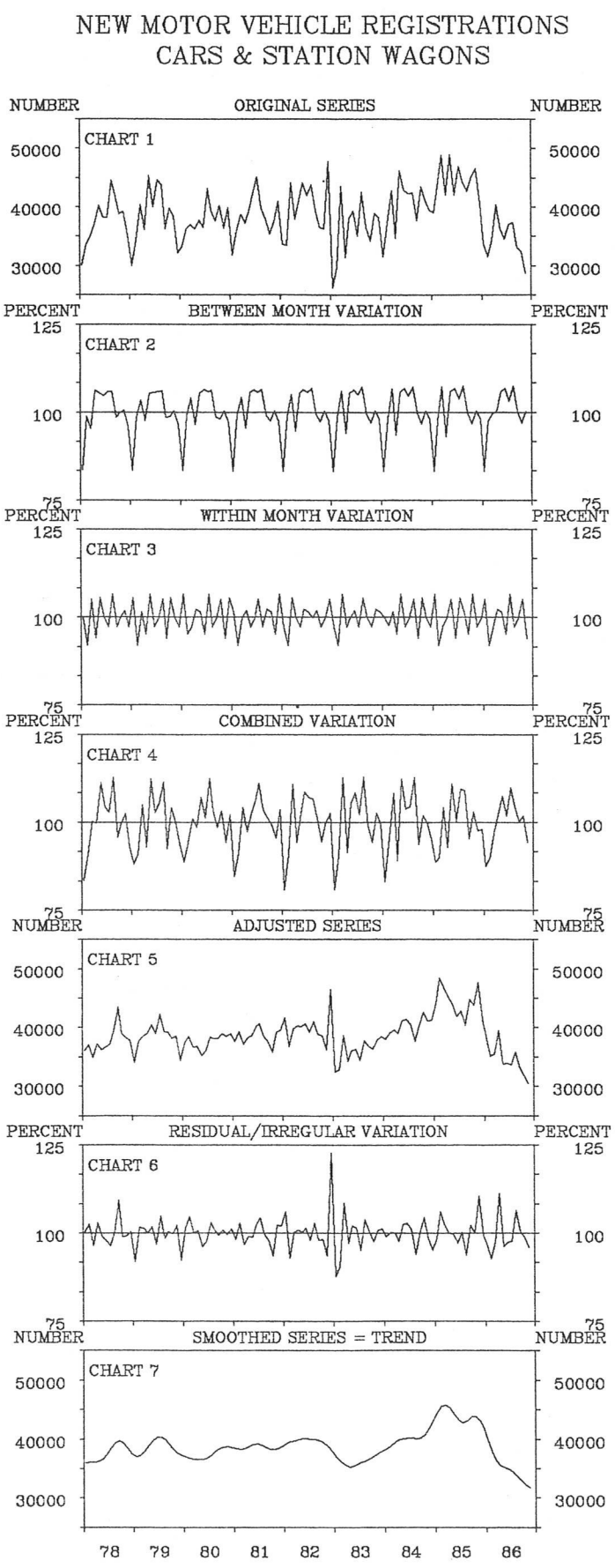
2. Time series as collected by the Australian Bureau of Statistics are statistical records of particular social or economic activities measured at regular intervals of time over a long period. They are collected on this basis to assist current understanding of the 'real world', and this paper's purpose is to increase the usefulness of such series. Although *monthly* series will be used for illustration in this paper, the concepts, principles and methods discussed here also apply to *quarterly* series.

Original series

3. At any point in time a particular observation in a time series is the net result of *four* notional influences, each interacting with the others and having its own distinguishing character. The four factors are:-

- systematic between month influences
- systematic within month influences
- trend
- residual/irregular factors

GRAPH 1.



4. These concepts are illustrated using *motor vehicle registrations* in **Graph 1** (referred to as a **Shiskin** graph). Chart 1 of **Graph 1** shows the behaviour of the *original* monthly data over the years; clearly the series varies considerably from month to month. Charts 2, 3, 6 and 7 account for this variation as discussed in this paper.

Between month variation

5. Chart 2 displays the features of the systematic *between month influence*, composed of the *seasonal pattern* that repeats each year, and the *moving holiday effects* (such as Easter, which usually occurs in April but occasionally shifts to March, as in 1986). The changing pattern of the between month influences can be seen from Chart 2. The changing strength of these patterns can also be seen from the scatter diagrams of **Graph 2**, which shows for each *calendar* month the behaviour of both the *between month* and *residual/irregular influences*. It can be seen from **Graph 2** that January is the seasonally lowest and stable month compared to March, which is the highest, and becoming more so over time. November on the other hand, is neither very seasonally high nor low, and in comparison with January is a month generally subject to more irregular influences. Note how February is one of the most irregular months.

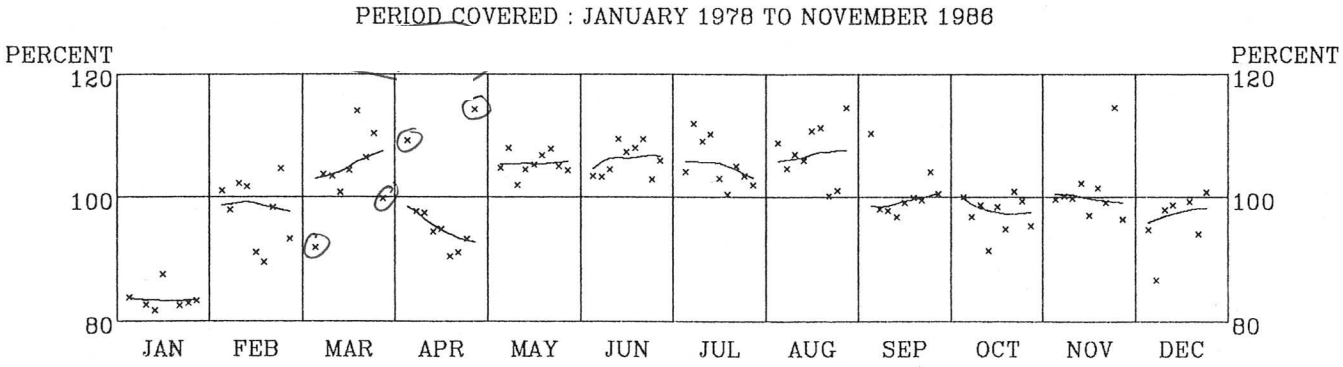
Within month variation

6. Chart 3 displays the features of the systematic *within month* variation. This so called "trading-day" effect is brought about by the number of high or low activity days varying for a *particular* calendar month over the years. Comparing Charts 2 and 3, the relative strength of these two systematic influences can be seen at any point in time. The scatter diagrams of **Graph 3** illustrate just *two* of the *twenty-two* different *within month* influences that may operate. Chart A of **Graph 3** represents the *within month* and *residual/irregular* influences operating in the "most active" type of month, which for this series is a 31 day month having five Mondays, Tuesdays and Wednesdays, and four of each other day. Chart B of **Graph 3** represents one of the "least active" type of month: a 30 day month having five Saturdays and Sundays, and four of each other day. Note that the interval between such month types is not regular.

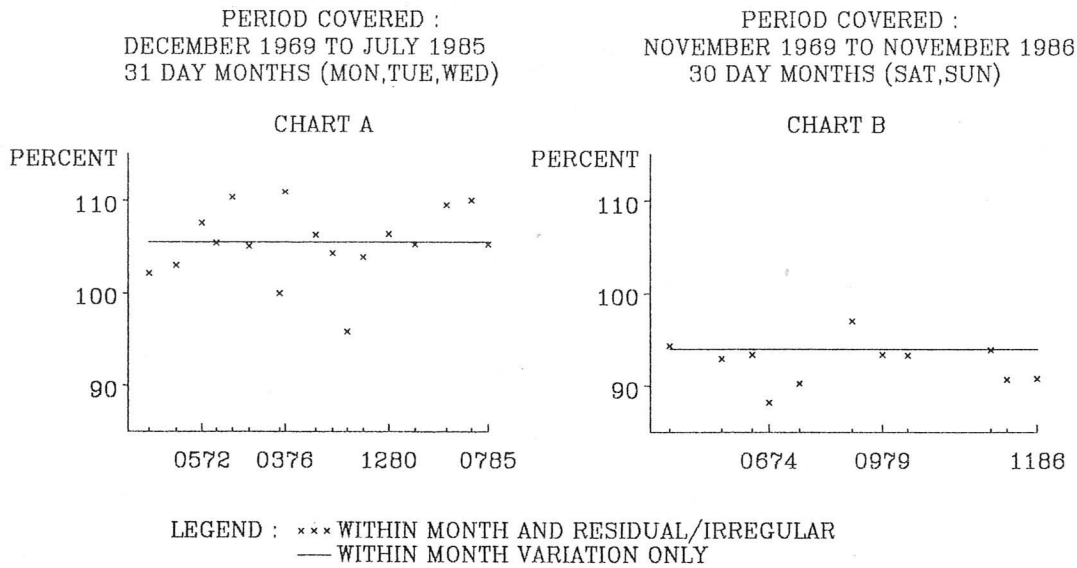
Seasonally adjusted series: trend and residual/ irregular effects

7. Chart 4 of **Graph 1** represents the combined effects of the *between* and *within* month *systematic* influences. It can be seen that the net effect is not the same each year, which is an important consideration when making year apart comparisons of the original series. When the *combined* influences are removed from the *original* series the *seasonally adjusted* series (Chart 5) is produced, the latter representing

GRAPH 2.



GRAPH 3.



the net effect of the *trend* (Chart 7) and the *residual/irregular* influences (Chart 6). It is evident from Chart 5 that the *seasonally adjusted* series is still quite variable, but not as variable as the *original* series. The remaining variability is due largely to the *residual/irregular* influences displayed in Chart 6. In this case it is evident that the *residual/irregular* influences are often more variable than the *within month* effects or those of the monthly changes in the *trend* (the trend representing the underlying direction of the series).

Proxies of trend

8. Clearly, **Graph 1** shows that neither the *original* nor *seasonally adjusted* series is a good proxy of a *trend*. This is especially so if either the *combined systematic monthly* variations and/or the *residual/irregular* effects are prominent. To obtain an estimate of *trend*, therefore, the *residual/irregular* influences in the *seasonally adjusted* series have to be significantly dampened. The Australian Bureau of Statistics does this when it produces *smoothed seasonally adjusted* series, as displayed in Chart 7 of **Graph 1**.

Monthly growth decomposition

9. Given the joint publication of *smoothed seasonally adjusted, seasonally adjusted* and *original* series, analysts may decompose the monthly growth movements of the *original* series into each component's contribution. How this decomposition is performed is illustrated in **Table 1.** The percentage monthly movements of original motor vehicle registrations is given in Column 1. These movements (computed from Column 7) are accounted for by the movements appearing in Columns 3 to 5, which respectively represent movements due to the combined effects of *between and within month* influences, *trend*, and *residual/irregular* influences. Column 3 is derived by computing the movement in the ratio of the *original* (Column 7) to the *seasonally adjusted* series (Column 8). Column 5 is derived by computing the movement in the ratio of the *seasonally adjusted* to the *smoothed seasonally adjusted* or trend series (Column 9). Columns 4 and 6 are the movements of the *smoothed* and *seasonally adjusted* series respectively. Column 2 is the summation of Columns 3 to 5 and, in relation to Column 1, provides a clear indication of the approximate nature of this growth decomposition. In general, the approximation becomes less accurate whenever two or more of the component movements are large.

10. From **Table 1,** Column 3, it can be seen quite clearly how much the *combined between/within month influences* vary from year to year, and month to month. For instance, October/November percentage movements from 1983 to 1986 have been +8.8, -2.1, -5.3, and -7.4, and March/April movements for 1985 and 1986 were -10.8 and +5.5. Large changes from month to month can be seen from May to August 1986, when the percentage movements were +5.1, -5.3, +8.0, and -5.0.

11. It is evident, by comparing Columns 4 and 5, that the *residual/irregular* influence is quite often the prime mover of the *seasonally adjusted* series. For example, consider the April and May 1986 movements of the *residual/irregular* (+14.2 and -13.6 respectively) to that of the *trend* (-2.4 and -1.1 respectively). Clearly, **Table 1** illustrates that monthly movements of the *original* and *seasonally adjusted* series are not good approximations of the trend's behaviour. This is also true for any other time span.

TABLE 1

Growth Decomposition — New Cars and Station Wagons Registrations

	Percentage monthly movement of:						*Monthly amount:*		
Period	*Col. 1 Original Series*	*Col. 2 Sum*	*Col. 3 Combined between/ within mth influences*	*Col. 4 Trend (smoothed adjusted)*	*Col. 5 Residual/ irregular influences*	*Col. 6 Seasonally adjusted series*	*Col. 7 Original series*	*Col. 8 Seasonally adjusted series*	*Col. 9 Smoothed seasonally adjusted (trend)*
	O	*K+T+R*	*K*	*T*	*R*	*A=T+R*	*O*	*A*	*T*
1983-84—									
Oct							34,214	36,303	37,175
Nov	13.6	13.2	8.8	1.1	3.3	4.5	38,865	37,919	37,597
1984-85—									
Oct							43,462	42,603	40,791
Nov	-5.3	-5.2	-2.1	2.6	-5.8	-3.3	41,159	41,195	41,866
Mar							48,787	46,825	45,768
Apr	-13.9	-14.3	-10.8	-1.1	-2.3	-3.4	42,027	45,229	45,264
1985-86—									
Oct							45,172	43,845	43,864
Nov	3.0	3.6	-5.3	-1.6	10.5	8.7	46,523	47,679	43,150
Mar							34,320	35,431	36,350
Apr	17.6	17.3	5.5	-2.4	14.2	11.5	40,369	39,495	35,495
May	-10.1	-9.5	5.1	-1.1	-13.6	-14.5	36,285	33,764	35,114
June	-4.9	-4.9	-5.3	-0.7	1.2	0.5	34,507	33,923	34,862
July	7.1	7.2	8.0	-1.4	0.6	-0.9	36,956	33,633	34,364
Aug	1.2	1.7	-5.0	-2.0	8.7	6.6	37,400	35,840	33,686
Sept	-11.3	-11.7	-4.0	-2.1	-5.6	-7.6	33,173	33,111	32,973
Oct	-2.3	-2.3	1.7	-2.3	-1.6	-3.9	32,417	31,831	32,221
Nov	-11.4	-11.8	-7.4	-1.4	-2.9	-4.3	28,723	30,471	31,773

Cautions

12. To smooth *seasonally adjusted* series and thereby produce an estimate of *trend*, the Australian Bureau of Statistics uses a procedure that is an integral and important part of its "seasonal" analysis procedures. Generally, these indicators of trend behaviour are subject to little revision. However, the most recent point estimates are always provisional because it is not possible to estimate trend behaviour reliably without the benefit of a few months hindsight. Therefore, reliable conclusions about *trend* behaviour may be made from the *smoothed seasonally adjusted* series excluding the last few estimates. The current estimates should only be used very cautiously in conjunction with other relevant information if more timely indicators of *trend* behaviour are required. *They should not be used* **alone** *to conclude that a turning point or point of inflexion has* **just** *occurred in the series.*

Trend Sensitivity Analysis

13. As additional observations become available the most recent *trend* estimates are subject to revision. In these circumstances a simple analysis of the trend's sensitivity to an extra observation may be of assistance to the user. In general, this analysis involves the user in making a decision as to what degree of revision to the current estimate (either up, down or both), would be regarded as implying a distinctly different trend behaviour than presently shown. That extent of "Revision" is fed into the following formula to determine a *seasonally adjusted* value for the *forthcoming* month. The user can then make a judgement as to whether this *artificial seasonally adjusted* value is likely to be attained next month, given the history of the series and the present socioeconomic circumstances.

14. **M+1** = [Revision + 0.129**M** + 0.099 **M-1** + 0.07 **M-2** + 0.04 **M-3** + 0.01 **M-4** - 0.02 **M-5** - 0.049 **M-6**] ÷0.279

M represents the *seasonally adjusted* data for the various months; **M** being the current month, **M-1** the last but one, **M-6** the last but six and **M+1** the next month. In some circumstances users may be interested in knowing what the next month's *seasonally adjusted* value would need to be for a certain percentage movement to occur between the latest two *trend* estimates. The formula to ascertain this is:

M+1 = [Percentage change x (0.292 **M** + 0.254 **M-1** + 0.174 **M-2** + 0.08 **M-3** + 0.002 **M-4** - 0.038 **M-5** - 0.043 **M-6**) -100 (0.061 **M** -0.01 **M-1** -0.054 **M-2** -0.068 **M-3** -0.06 **M-4** -0.054 **M-5** +0.043 **M-6**)] ÷ (14.2 - Percent change x 0.279).

Note that these formulae are relevant only if the trend series has been produced by directly applying the 13-term Henderson smoothing procedure (as currently used by the ABS).

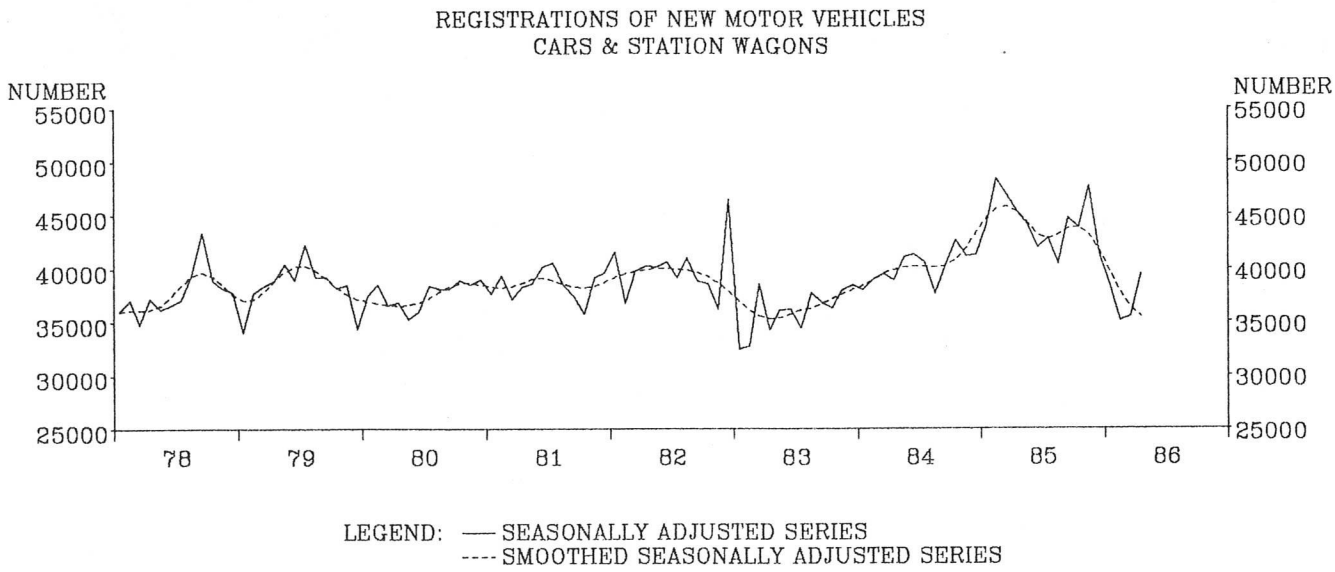
15. This *simple trend sensitivity analysis* is illustrated using Cars and Station Wagons Registrations to April 1986, refer to **Graph 4.** Given the April seasonally adjusted figure has risen to 39,495 the questions of interest may be:

1. whether the April *trend* estimate of 36,020 could be revised to be level with January's 39,691?

2. whether the *trend* decline has ceased and the April/May percentage movement will be as large as the March/April fall of 2.1, but opposite in direction?

For case 1 to occur, the seasonally adjusted figure for May has to be 48,686, which is higher than any value shown on the graph. For Case 2 to occur, the seasonally adjusted May figure has to be 45,385.

GRAPH 4.



Conclusion

16. It is not possible to regularly and reliably ascertain the **present** trend direction from the **most recent** monthly movement **alone**. Such a task requires accurate decomposition of the current original movement into a changing trend path, varying seasonal pattern, evolving trading-day and moving holiday influences, as well as the volatile residual/irregular effects. However, apart from the most recent estimates smoothed seasonally adjusted figures are subject to little revision and should assist greatly the interpretation of trend behaviour.

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