Methodology Advisory Committee Paper
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Agenda Item 3: Use of State Space Models for Small Domain Trend Estimation in the Labour Force Survey

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Background

1. This paper summarises research at the ABS into state space modelling of regional labour force series. The findings of this research have been released in three papers: Pfeffermann and Signorelli (1995), Pfeffermann, Bell and Signorelli (1996) and Bell and Carolan (1996). This review describes major results from the second and third papers (both attached) and lists some issues following on from them.

A modelling approach to trend estimation

2. The Australian Labour Force Survey (LFS) collects labour force data for all individuals in a sample of dwellings. The dwellings are selected from a geographic sample of Census collector's districts (CDs). Selected CDs are grouped into eight 'rotation groups', and for each month seven of the rotation groups select the same dwellings as the previous month. In the remaining rotation group the dwellings selected previously are 'rotated out' of the sample and replaced by other dwellings, normally from the same CDs. This pattern continues until the survey is redesigned (which occurs every five years) or when the usable dwellings in the CDs have been exhausted.

3. The estimates from a particular rotation group will be highly autocorrelated between months when the 'panel' of dwellings selected in the rotation group is common. They may also be autocorrelated, but to a lesser extent, between months with different panels, since successive panels of dwellings are selected from the same CDs.

4. At regional level, estimates from the LFS are subject to large sampling error, suggesting that users should base decisions on a trend series rather than individual monthly movements. Unfortunately, time series analysis using the X11 program and its derivatives does not perform well for these series. The sampling errors display strong autocorrelation due to the rotation pattern of the survey, and the time series filters attribute much of this to the trend. This gives a trend that is strongly affected by sampling error. Ignoring the autocorrelations distorts the estimation of the trend, depending on the cycles induced by the autocorrelation pattern.

5. The approach taken in the papers for estimating trends in situations like this is to postulate separate time series models for the population components - trend, seasonality and irregulars, and for the survey errors, and then extract the population trend from the combined model. The papers introduce a state space model that specifically incorporates a time series model for sampling error. They use a local linear model for trend, a moving seasonality and a white noise irregular. In the earlier papers the sampling error is modelled with an AR2 model. Bell and Carolan (1996) introduces an unobservable components model for sampling error at 'rotation group' level, that accounts for high correlations between rotation group estimates from the same panel of dwellings and lower correlations between estimates where rotation has introduced a new panel of dwellings.

Parameters used for the models

6. Both sampling error models assume a known standard error, calculated for each region by a random group method and smoothed over time. Other parameters of the sampling error models are chosen to give appropriate autocorrelations. Pfeffermann et al (1996) chose AR2 parameters to match estimated autocorrelations for each region. Bell and Carolan (1996) suggests that autocorrelations for specific regions are measured with high error, and used autocorrelations smoothed across many regions.

7. The amount of variability explained by the trend, seasonal and irregular components is controlled by parameters giving the variance of innovations in the model. Initially an attempt was made to set these parameters separately for each region using maximum likelihood. Pfefferman et al (1996) compares this approach with the use of a single set for all regions, arguing that these parameters are constants describing a 'typical' labour force trend. The results seem to favour this approach, using for all regions a set of parameters based on maximum likelihood on the Australian series. Bell and Carolan (1996) uses this approach throughout.

Results of modelling

8. The methods were applied to regional data to gauge the differences between the resulting trends. All methods incorporating sampling error gave much smoother trend series than a naive X11 approach. There were small differences between trends from the two sampling error models (AR2 and rotation group). An outlier approach was developed for the rotation group model, which had some marginal impact on the trends. The only quantitative measure on these real series was size of revisions, ie the difference between the historical trend for a time point, and the trend estimated using the time series up to that point. The results show X11 leading to the largest revisions and the outlier approach having the lowest revisions.

9. Simulations were conducted to measure the quality (mean squared error) of the trends produced. In the simulations a true trend, seasonal and irregular were known, and sampling error was generated. In all cases the naive X11 approach was markedly inferior to the other approaches. The outlier approach performed best in cases with outliers and comparably to the other methods in cases with no outliers

Other work

10. Some effort was expended trying to model against other data available at region level. The time series available for this work did not correlate well enough with the labour force series to make this approach very practical. In the US an appropriate time series of unemployment benefits data is available for a long time series, see Zimmerman,T. et al (1994). The corresponding data for Australia is not currently available for more than a couple of years.

11. Should the ABS be collecting and maintaining some key external series? For example, the regional 'unemployment benefit recipients' counts are available regularly but are not maintained as a series. If the ABS collected this data it would be available for analytical uses, such as time series modelling.

12. The state space models can be run as hierarchical bayes models to obtain a posterior distribution for the unknown parameters. Markov Chain Monte Carlo methods were used for this, which were very computer intensive. This work suggested that there were actual differences between sampling error parameters from different regions. It also gave a range of feasible values for the parameters specifying the variance of innovations.

13. Would this be a better basis for choosing these parameter values?

14. The rotation group model for sampling error was applied to data at Australia level in an evaluation of the effect of telephone interviewing. For this work the real-world value (observed minus sampling error) was allowed to vary freely from time point to time point rather than presupposing a decomposition into trend, seasonal and irregular. This gave new estimates of the real-world value adjusted for the known autocorrelation structure of the sampling error. This is in effect using a composite estimator (Bell, W.R. and Hillmer, S.C. (1990))

15. This may also work at regional level, separating 'signal' from sampling error. The resulting series could then be treated using the normal X-11 approach, or using a state-space model approximating X-11. Performing trend smoothing by X-11on the signal extraction estimates may reduce the bias due to the autocorrelation of the sampling errors. The method would avoid the need to choose values for the variance of innovations, since an X-11 trend is being estimated for. Is there any downside to this approach?

Other issues for consideration

16. The models have been applied to estimates of rate (unemployment rate, participation rate) rather than original values. Perhaps the estimates by rotation group could be adjusted to add to some benchmarks. This could improve the estimates, and would allow modelling of level estimates. This seems feasible for Australian estimates, but unlikely to work for regions because of small sample counts.

17. To what extent can autocorrelated sampling errors be accounted for in X-11 by choice of filters? Can a standard approach be developed to choosing a filter given knowledge of the sampling error and autocorrelation structure?

18. The ABS publishes X-11 trends for the State/Australia estimates. Is there any way to ensure the model based trend estimates for regions will be "consistent", in some sense, with the higher level estimates ? We tried simultaneously fitting all the region models in a state subject to an additivity constraint. This process works but is very computer intensive. There is also a conceptual issue: is it defensible to control model based trends by Henderson average at a higher level?

References

(1) Pfeffermann, D. and Signorelli, D. (1995) 'Estimation of autocorrelations of survey errors with application to trend estimation in small areas' ABS document, submitted to Journal of Business and Economic Statistics.

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(3) Bell, P. and Carolan, A. (1996) 'Trend estimation from a rotating panel survey' ABS document, to be published as an ABS working paper.

(4) Zimmerman, T., Evans, T. & Tiller, R (1994) 'State unemployment rate time series models'. Proceedings of the Survey Research Methods Section, American Statistical Association.

(5) Bell, W.R., and Hillmer, S.C. (1990) 'The Time Series Approach to Estimation for Repeated Surveys' , Survey Methodology, 16, 195-215.