

Development of an Indices-based Approach for Forecasting Gambling Expenditure at a Local Government Area Level

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Development of an Indices-based Approach for Forecasting Gambling Expenditure at a Local Government Area Level

TECHNICAL PAPER

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**The Office of Gaming and Racing
Victoria**

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Background to the Report

The Victorian Commission for Gambling Regulation collects data at local government area (LGA) level on electronic gaming machines (EGMs). Analysis of the patterns of EGM expenditure at LGA level assists policy makers and government to understand the nature of gaming consumption when mapped with movements in socio-economic status and population growth.

The purpose of the paper is the development of a simple model for forecasting the impact on changes in EGM numbers, population growth and changes in socio economic status on per capita gambling expenditure for Local Government Areas (LGAs) in Victoria.

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Contents

1	Summary	1
2	Objectives	2
3	Data	2
4	Statistical Model	6
5	Fitted Values	8
6	Validation	8
7	Forecasts	11
8	Suggestions for Further Work	11
	References	17
A	Regression Output	18
B	Varying Regression Coefficients	21

List of Tables

1	Predicted monthly average daily per Capita Gambling Expenditure by LGA, July 2007 to June 2008.	13
2	Predicted monthly average daily per Capita Gambling Expenditure by LGA, July 2007 to June 2008 (ctd).	14
3	Predicted monthly Gambling Expenditure by LGA, July 2007 to June 2008.	15
4	Predicted monthly Gambling Expenditure by LGA, July 2007 to June 2008 (ctd).	16
5	Varying Regression Coefficients.	21
6	Varying Regression Coefficients (ctd).	22

List of Figures

1	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007.	3
2	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).	4
3	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).	4
4	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).	5

5	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).	5
6	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted to Actual Values.	8
7	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted to Actual Values (ctd).	9
8	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted to Actual Values (ctd).	9
9	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted to Actual Values (ctd).	10
10	Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted to Actual Values (ctd).	10
11	Comparison of Forecast to Actual Values-log average daily per capita expenditure, July 2006 to June 2007.	12
12	Comparison of Forecast to Actual Values-log average daily gambling expenditure, July 2006 to June 2007.	12

1 Summary

This report summarises the development of a simple model for forecasting monthly per capita gambling expenditure for Local Government Areas (LGAs) in Victoria. Predictor variables include the adult population in the LGA, the concentration of Electronic Gaming Machines (EGM) in the LGA, the Socio-Economic Index for Areas (SEIFA, 2001) index of relative socio-economic disadvantage, as well as trend and seasonal terms. The model, fitted using hierarchical linear regression, provides forecasts for individual LGAs. Suggestions for extensions to the model are also described in the report.

The data set consisted of monthly expenditure data for each LGA from a dataset supplied by the Victorian Commission of Gambling Regulation, supplemented by data on their website. Only data from July 2003 to June 2007 was used, as data on adult population figures within each LGA was only available over this period. Only the 52 of the 69 LGAs where publication of figures were allowed have been used in the analysis. Spline interpolation, one of the most simple and easily applied methods of fitting a smooth curve through the actual annual data, was used to convert the available annual adult population figures to monthly figures, so that monthly per capita gambling expenditure and monthly concentration of gaming machines could be calculated.

Time series graphs of the per capita gambling expenditure were produced for each of the LGAs. They showed differing trends in the LGAs and a marked seasonal pattern.

A hierarchical linear regression was fitted to the data with the (natural) logarithm of the monthly average daily per capita expenditure as the dependent variable and explanatory variables including a linear trend and seasonal terms as well as the concentration of gaming machines and the index of relative disadvantage. The intercept, trend and part of the seasonal terms were allowed to vary by LGA with the remaining terms being fixed. The forecasts from the model match the actual data well, with a mean absolute percentage error of less than 10% for 80% of the LGAs. Exceptions include Bass Coast, Campaspe, and Swan Hill, which seem to have extreme seasonal patterns.

To validate the forecasts, the model was re-fitted using only data from July 2003 to June 2006, and forecasts were generated for the period July 2006 to June 2007 and compared with the actual values. The match was quite good for both monthly average daily per capita gambling expenditure and monthly gambling expenditure, with a mean absolute percentage error of 4.8%.

Finally, the model was used to generate forecasts for monthly average daily per capita gambling expenditure and monthly gambling expenditure for each of the LGAs. The model provides a useful method of forecasting gambling expenditure growth which takes into account differences in socio-economic status, adult population growth, concentration of gaming machines, and other factors.

2 Objectives

The objectives of the project is to develop a model for forecasting the impact on changes in EGM numbers, population growth, and changes in socio-economic status on per-capita gambling expenditure at a local government area level.

3 Data

The following data was used:

LGA Expenditure Data Monthly gambling expenditure data over the period July 1999 to November 2006 was supplied for each LGA. Data from December 2007 to June 2007 was also obtained from the Victorian Commission for Gambling Regulation (VCGR) website.

Number of EGMs per LGA The number of electronic gaming machines was also provided and supplemented with data from the VCGR website. For some LGAs with small numbers of venues this data was aggregated with nearby LGAs for confidentiality reasons.

Adult Population The adult population as at 30/6/03, 30/6/04, 30/6/05, 30/6/06, and 30/6/07 in each of the LGAs was obtained from the VCGR website.

Disadvantage Index The ABS provides an index of SocioEconomic Disadvantage, with the index used in this report based on the 2001 Census.

Since it was important to get data for all these variables, only the data from 30/6/03 to 30/6/07 was used in the modelling, with data from July 2006 onwards used for model validation. Spline interpolation (see, for example, Venables and Ripley (2002, p. 230)) was used to convert the annual adult population figures into monthly figures and to predict the adult population figures over the period July 2007 to June 2008 when making forecasts. Spline interpolation was used so that monthly average daily per capita gambling expenditure and concentration of electronic

gaming machines could be calculated. In spline interpolation a smooth curve is fitted through the annual adult population data. The curve is a piecewise cubic polynomial with continuous first derivatives but with possible discontinuities in the second derivatives at the data points. There are a number of splines that could be used. In this study “natural” splines have been used, which means that the interpolation function is linear beyond the range of the data, which usually is a sensible choice. In this context, splines give an easily applied approximation to the true but unknown monthly level of the adult population. The spline approximation is unlikely to be exactly correct, but given the observed smoothness of the data, it will provide a sufficiently accurate approximation for the analysis to be undertaken.

In addition, only the 52 LGAs where there were no restrictions on publishing the figures were used.

Figures 1 to 5 show time series plots of the (natural) log of the daily per-capita gambling expenditure for the 52 LGAs considered in this report over the period July 2003 to June 2007. The plots indicate that there is a strong seasonal pattern for almost all of the LGAs, while the trends and levels depend on the LGA.

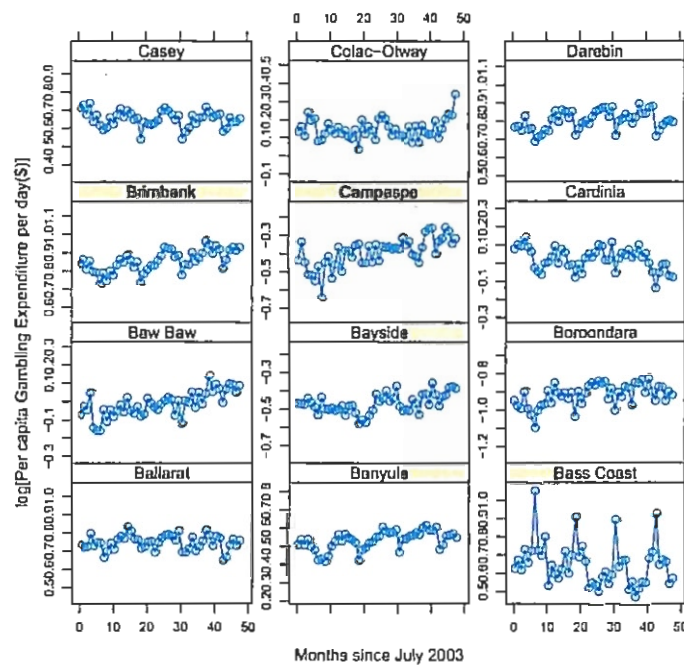


Figure 1: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007.

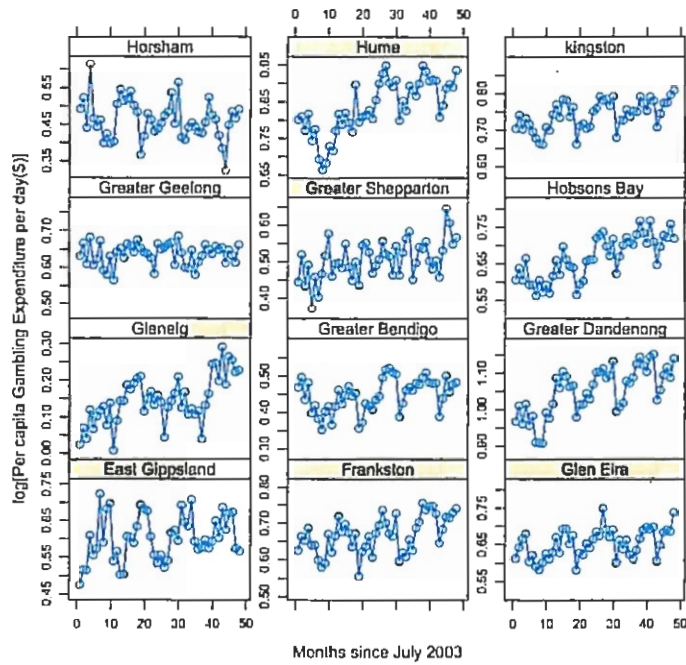


Figure 2: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).

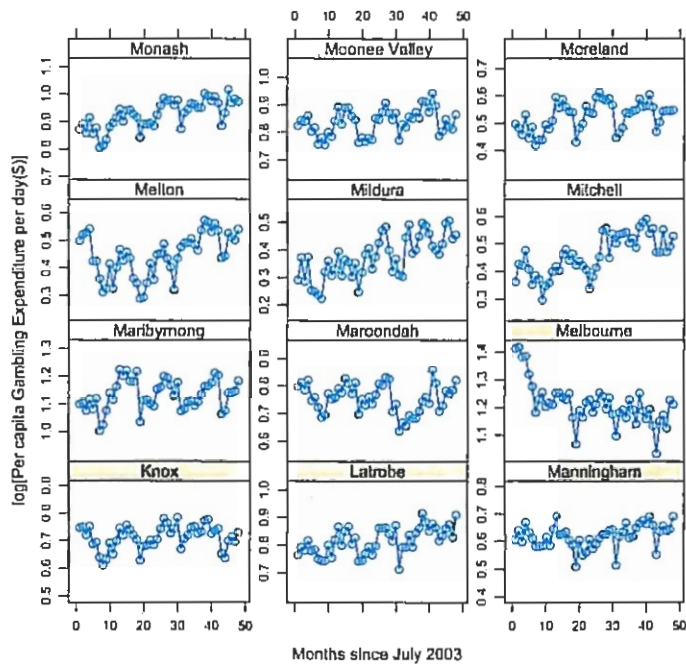


Figure 3: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).

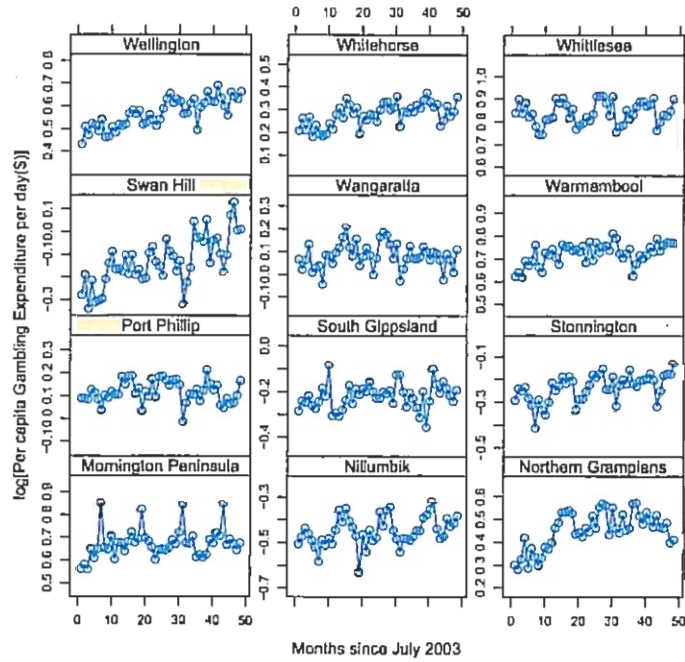


Figure 4: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).

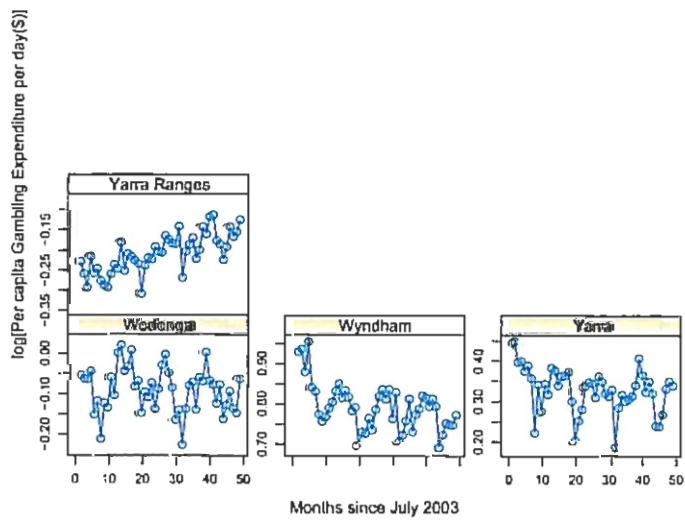


Figure 5: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2007 (ctd).

4 Statistical Model

The data available suggests the use of a hierarchical regression model, since some predictors are at the LGA (group) level while other predictors vary within the LGA. In a hierarchical model, a regression coefficient within one LGA provides information on the same coefficients in other LGAs, and these coefficients are assumed to come from a common normal distribution with a standard deviation that is estimated from the data (see, for example, Gelman and Hill (2007)). Hierarchical regression provides a sensible compromise between *complete pooling* (where differences between LGAs are ignored) and *no pooling* (corresponding to a separate analysis for each LGA). It can be shown, both theoretically and empirically, that the resulting forecasts are usually much more reliable than the forecasts based on complete and no pooling respectively.

Based on an examination of Figures 1 to 5, the following hierarchical model was fitted to the data:

$$\log(y_i) = a_i + b \log x_{1i} + cx_{2i} + d_i x_{3i} + \sum_{k=1}^5 \left[e_{ki} \sin \left(\frac{2k\pi t}{12} \right) + f_{ki} \cos \left(\frac{2k\pi t}{12} \right) \right] + f_{6i} \cos(\pi t) + \varepsilon$$

where, for LGA i , $i = 1, 2, \dots, 52$

t = time = $1, 2, \dots, 48$ with $t = 1$ at July 2003

y = Average Daily per capita Gambling Expenditure
 $= \left(\frac{\text{Gambling Expenditure}}{\text{Number of Days in Month} \times \text{Adult Population}} \right)$

x_{1i} = Concentration of Gaming Machines
 $= \left(\frac{\text{Number of EGM Machines}}{\text{Adult Population}} \right)$

x_{2i} = Disadvantage index

x_{3i} = Linear Trend Variable = t at time t .

a_i = the average level of the logged average daily gambling expenditure for LGA i at June 2003.

b = the increase in logged average daily gambling expenditure corresponding to a unit increase in the concentration of gaming machines.

c = the percentage difference in average daily gambling expenditure corresponding to a unit increase in the disadvantage index.

- d_i = the trend in logged average daily gambling expenditure for LGA i .
- e_{ki}, f_{ki} = seasonal terms for LGA i which give rise to a repeated seasonal pattern of length 12 months.

Note that since the concentration of EGMs and the Disadvantage index are group (LGA) level predictors, the values of b and c are assumed to apply to all LGAs. On the other hand the a_i , d_i , and the seasonal terms, e_{ki} , $k = 1, \dots, 5$ and f_{ki} , $k = 1, \dots, 6$, depend on the LGA, and are assumed to follow a multivariate normal distribution.

The model was fitted using the `lmer` package in the R (R Development Core Team (2008)) statistical package. There were some convergence problems, which were overcome by only allowing the first two seasonal terms to vary by LGA and hence e_{ki} , $k = 2, \dots, 5$ and f_{ki} , $k = 2, \dots, 6$ were common over all LGAs. The results are given in Appendix A, while the coefficients that vary by LGA are given in Appendix B.

The interpretation of the fitted regression is as follows:

- The average daily per capita expenditure is increasing over this time period for most LGAs.
- The average daily per capita expenditure is higher for LGAs with a low Disadvantage index (i.e. more disadvantaged) such as Central Goldfields, Greater Dandenong, and Strathbogie than for those LGAs with a high Disadvantage index (i.e. less disadvantaged) such as Bayside, Boroondara, and Yarra.
- The average daily per capita expenditure is higher for LGAs with a higher concentration of EGMs (e.g. Melbourne, Maribyrnong, and LaTrobe) than for LGAs with a lower concentration of EGMs (e.g. Boroondara, Bayside, and Nillumbik).
- There is a marked seasonal pattern, with particular LGAs such as Bass Coast, showing significant seasonal variations..

Note: The model uses nominal expenditure levels and does not therefore account for the effect of inflation as would be the case with real values. Overall real expenditure on EGMs state-wide in the period July 2003 to June 2007, shows a 2.3% decline.

5 Fitted Values

Figures 6 to 10 give plots of the time series, (given as $-o-$), for all LGAs, as well as the fitted values, (given as $- \circ -$). Generally there is a good match between the two, with a mean absolute percentage error of less than 10% for 80% of the LGAs. However, it should be noted that there are some LGAs where extreme seasonal patterns are not modelled well, for example, Bass Coast, Campaspe, and Swan Hill.

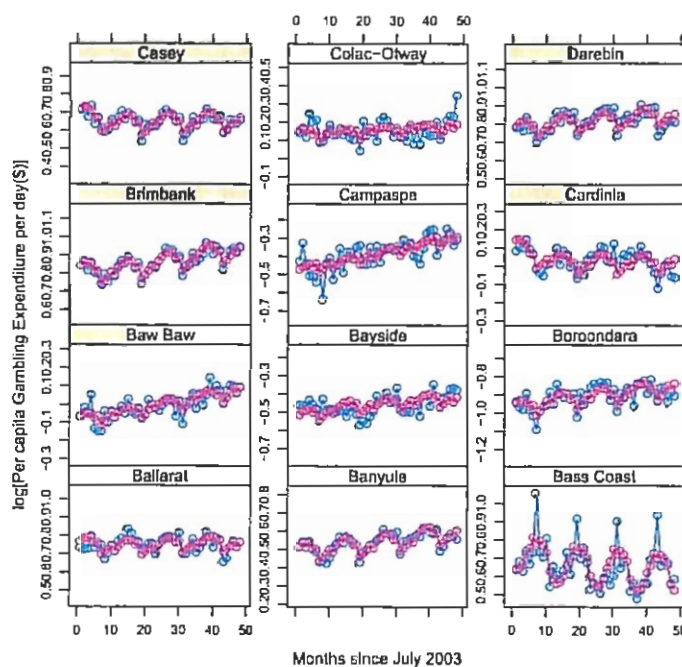


Figure 6: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted ($- \circ -$) to Actual ($-o-$) Values.

6 Validation

Forecasts for the period July 2006 to June 2007 were obtained using only the data up to June 2006 to fit the model, and these were compared to the actual data from July 2006 to June 2007 in order to validate the model. To obtain forecasts we also need forecasts of some of the explanatory variables. Adult population has been predicted based on the spline formula, while Disadvantage and EGM numbers have been assumed to be stable. Figure 11 shows a comparison of the predicted log average daily per capita expenditure against the actual values, assuming the extrapolated adult population. The match is quite good with a mean absolute percentage

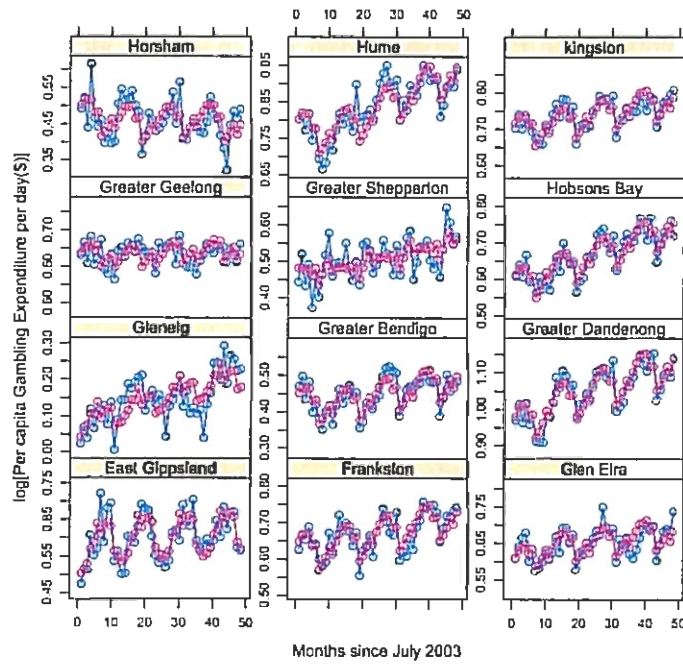


Figure 7: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted (-o-) to Actual (-o-) Values (ctd).

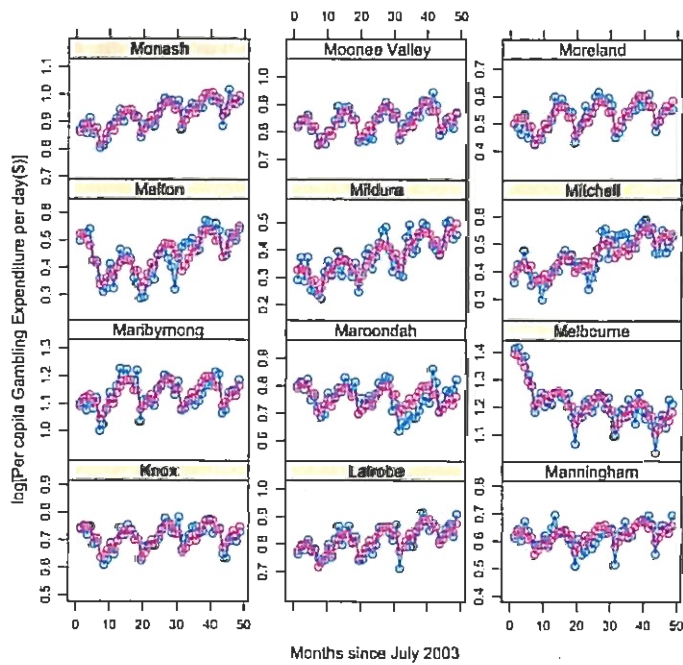


Figure 8: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted (-o-) to Actual (-o-) Values (ctd).

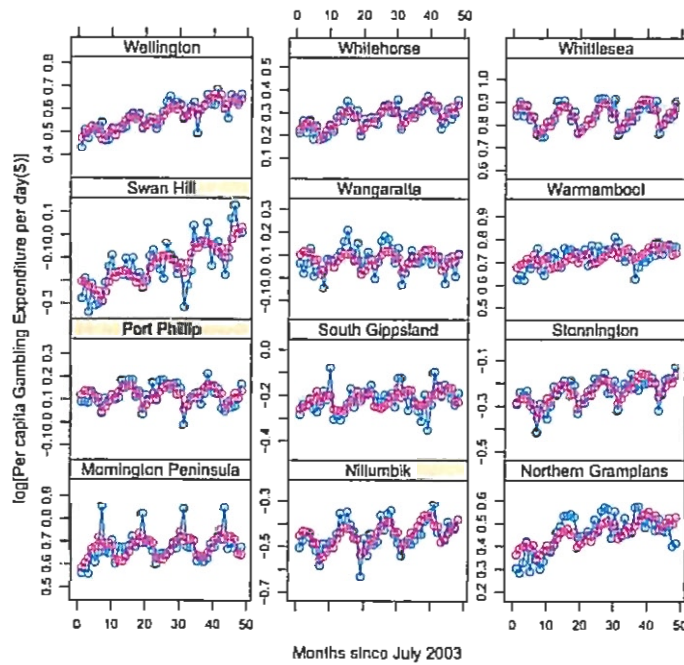


Figure 9: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted (-o-) to Actual (-o-) Values (ctd).

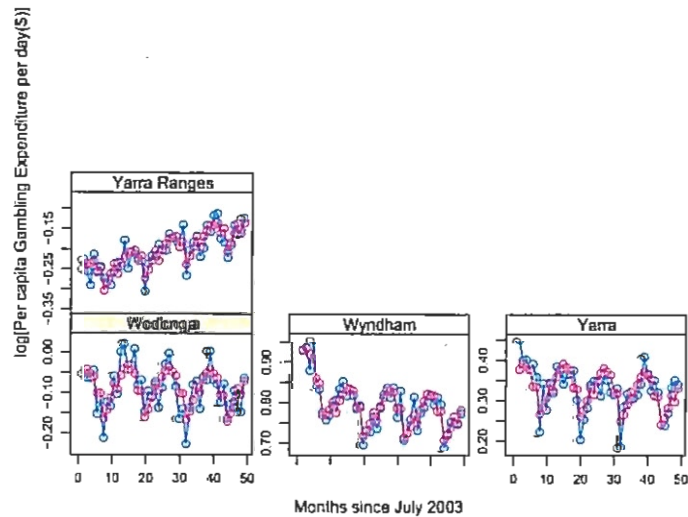


Figure 10: Time Series plots of per capita gambling expenditure over the period July 2003 to June 2006-Comparison of Fitted (-o-) to Actual (-o-) Values (ctd).

error of 4.8%. Since Adult population is “on both sides of the equation”, Figure 12 shows a plot of predicted average daily gambling expenditure against the actual values. Again the match is quite good, with the same mean absolute percentage error. This demonstrates that the model gives useful forecasts.

7 Forecasts

Given the validation of the model in the previous section, forecasts for the period July 2007 to June 2008 have been made, and these are given in Tables 1 and 2 for monthly average daily per capita gambling expenditure and Table 3 and 4 for monthly average daily gambling expenditure respectively. When making the forecasts, the adult population has been predicted based on the spline formula, while Disadvantage and EGM numbers have been assumed to be stable. Note that if changes in EGM numbers of socio-economic status were expected these could be applied to produce different forecasts.

8 Suggestions for Further Work

A number of directions for further development of the model are given below:

- A new SEIFA index based on the 2006 census was released in March 2008. It would be useful to include this indicator, either in addition or instead of the SEIFA 2001 index, in the regression model.
- Including the other SEIFA indexes in the model may be worthwhile. However, based on a preliminary analysis the SEIFA indices appear to be highly correlated and therefore the predictive performance of the model may not improve much.
- A fixed trend and fixed seasonal pattern has been used for each LGA. It would be worthwhile modifying the model to have an adaptive trend and seasonal pattern similar to the Holt-Winters forecasting formula (see, for example, Makraditis et al, 1998). This is a research problem, worthy of investigation, that might lead to better forecasts.

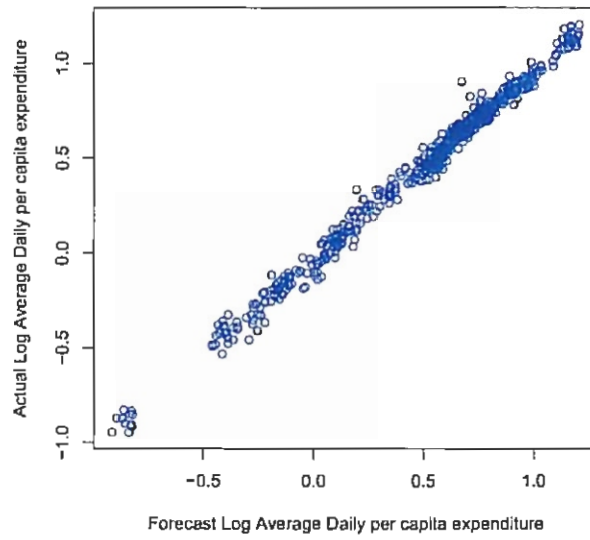


Figure 11: Comparison of Forecast to Actual Values-log average daily per capita expenditure, July 2006 to June 2007.

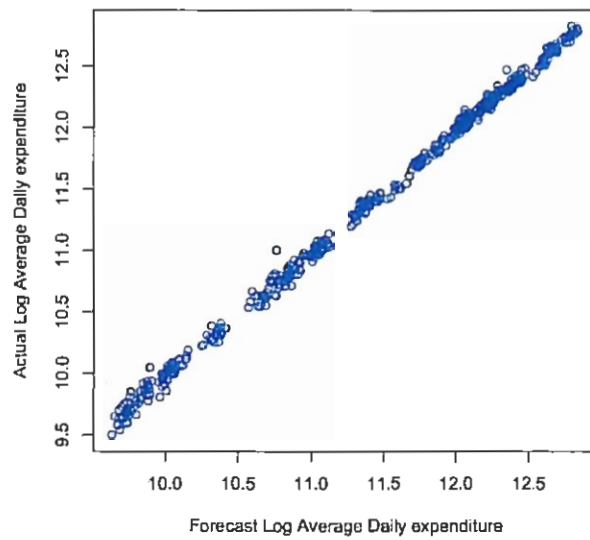


Figure 12: Comparison of Forecast to Actual Values-log average daily gambling expenditure, July 2006 to June 2007.

LGA	Jul07	Aug07	Sep07	Oct07	Nov07	Dec07	Jan08	Feb08	Mar08	Apr08	May08	Jun08
Ballarat	2.17	2.21	2.21	2.23	2.16	2.18	2.05	2.07	2.11	2.15	2.10	2.15
Banyule	1.86	1.90	1.90	1.90	1.83	1.84	1.72	1.74	1.78	1.83	1.80	1.87
Bass Coast	1.64	1.66	1.71	1.81	1.88	2.01	1.96	2.00	1.96	1.89	1.71	1.65
Baw Baw	1.10	1.12	1.12	1.12	1.09	1.11	1.05	1.08	1.11	1.14	1.11	1.14
Bayside	0.66	0.67	0.68	0.68	0.66	0.67	0.63	0.64	0.66	0.67	0.65	0.67
Boroondara	0.44	0.44	0.44	0.44	0.43	0.43	0.40	0.41	0.42	0.44	0.43	0.44
Brimbank	2.64	2.69	2.69	2.69	2.60	2.60	2.44	2.48	2.54	2.62	2.59	2.68
Campaspe	0.75	0.76	0.76	0.77	0.76	0.78	0.74	0.76	0.77	0.79	0.76	0.78
Cardinia	1.05	1.06	1.06	1.06	1.02	1.02	0.96	0.97	1.00	1.02	1.01	1.04
Casey	1.99	2.03	2.02	2.02	1.95	1.95	1.82	1.85	1.89	1.94	1.91	1.97
Colac-Otway	1.21	1.22	1.21	1.22	1.19	1.21	1.15	1.18	1.20	1.23	1.19	1.22
Darebin	2.39	2.44	2.44	2.45	2.37	2.37	2.22	2.25	2.29	2.35	2.30	2.37
East Gippsland	1.75	1.76	1.79	1.86	1.88	1.98	1.92	1.96	1.97	1.95	1.82	1.79
Frankston	2.12	2.16	2.16	2.17	2.10	2.10	1.97	2.00	2.04	2.10	2.06	2.13
Glen Eira	2.01	2.05	2.06	2.07	2.01	2.03	1.91	1.93	1.97	2.01	1.95	2.01
Gleneig	1.20	1.22	1.24	1.27	1.27	1.31	1.26	1.28	1.29	1.29	1.23	1.23
Greater Bendigo	1.67	1.70	1.70	1.71	1.66	1.67	1.57	1.59	1.63	1.67	1.63	1.68
Greater Dandenong	3.20	3.26	3.27	3.27	3.16	3.16	2.96	3.00	3.07	3.16	3.11	3.23
Greater Geelong	1.91	1.94	1.95	1.97	1.94	1.97	1.86	1.89	1.91	1.93	1.87	1.90
Greater Shepparton	1.75	1.76	1.75	1.76	1.73	1.77	1.70	1.75	1.80	1.83	1.77	1.80
Hobsons Bay	2.17	2.21	2.21	2.21	2.15	2.16	2.04	2.08	2.13	2.19	2.15	2.21
Horsham	1.59	1.61	1.61	1.61	1.55	1.56	1.45	1.47	1.49	1.52	1.48	1.52
Hume	2.64	2.70	2.71	2.72	2.64	2.65	2.49	2.53	2.58	2.66	2.62	2.72
Kingston	2.24	2.28	2.28	2.29	2.23	2.24	2.11	2.14	2.19	2.24	2.19	2.25
Knox	2.15	2.19	2.19	2.20	2.13	2.13	2.00	2.02	2.06	2.12	2.08	2.15
Latrobe	2.44	2.49	2.49	2.50	2.42	2.43	2.28	2.32	2.37	2.43	2.38	2.46

Table 1: Predicted monthly average daily per Capita Gambling Expenditure (\$) by LGA, July 2007 to June 2008.

LGA	Jul07	Aug07	Sep07	Oct07	Nov07	Dec07	Jan08	Feb08	Mar08	Apr08	May08	Jun08
Manningham	1.95	1.98	1.98	1.99	1.94	1.95	1.84	1.87	1.91	1.95	1.90	1.95
Maribyrnong	3.26	3.32	3.32	3.32	3.21	3.21	3.00	3.03	3.09	3.16	3.11	3.21
Maroondah	2.18	2.22	2.22	2.22	2.15	2.16	2.02	2.04	2.08	2.12	2.08	2.14
Melbourne	3.30	3.33	3.31	3.29	3.16	3.16	2.97	3.01	3.08	3.17	3.11	3.21
Melton	1.77	1.81	1.80	1.80	1.74	1.74	1.64	1.67	1.72	1.78	1.77	1.84
Mildura	1.67	1.68	1.67	1.67	1.61	1.62	1.54	1.58	1.64	1.70	1.67	1.73
Mitchell	1.74	1.79	1.82	1.85	1.82	1.84	1.73	1.76	1.78	1.80	1.75	1.80
Monash	2.75	2.80	2.81	2.82	2.74	2.75	2.59	2.63	2.69	2.76	2.70	2.79
Moonee Valley	2.45	2.51	2.52	2.52	2.44	2.43	2.27	2.29	2.33	2.39	2.34	2.43
Moreland	1.82	1.85	1.85	1.85	1.78	1.78	1.67	1.70	1.73	1.78	1.76	1.82
Mornington Peninsula	1.89	1.93	1.96	2.04	2.05	2.13	2.04	2.07	2.07	2.04	1.92	1.91
Nilumbik	0.70	0.71	0.71	0.71	0.68	0.68	0.63	0.64	0.66	0.68	0.67	0.70
Northern Grampians	1.72	1.76	1.77	1.79	1.74	1.76	1.66	1.68	1.70	1.74	1.70	1.75
Port Phillip	1.16	1.18	1.18	1.17	1.13	1.13	1.06	1.08	1.11	1.14	1.11	1.15
South Gippsland	0.79	0.80	0.80	0.83	0.83	0.86	0.83	0.85	0.85	0.85	0.81	0.80
Stonnington	0.86	0.87	0.87	0.87	0.84	0.84	0.79	0.80	0.83	0.85	0.84	0.87
Swan Hill	1.04	1.04	1.02	1.02	0.99	1.01	0.97	1.01	1.05	1.09	1.08	1.10
Wangaratta	1.12	1.14	1.14	1.14	1.10	1.11	1.04	1.06	1.08	1.11	1.08	1.11
Warrnambool	2.09	2.12	2.14	2.18	2.17	2.23	2.13	2.17	2.20	2.21	2.11	2.13
Wellington	1.93	1.97	1.99	2.02	1.99	2.02	1.91	1.94	1.96	2.00	1.94	1.98
Whitelhorse	1.42	1.45	1.45	1.46	1.41	1.42	1.33	1.35	1.38	1.41	1.38	1.43
Whittlesea	2.46	2.51	2.51	2.51	2.42	2.41	2.25	2.27	2.31	2.38	2.35	2.44
Wodonga	0.95	0.95	0.94	0.93	0.90	0.89	0.84	0.86	0.88	0.91	0.90	0.93
Wyndham	2.23	2.27	2.26	2.26	2.18	2.18	2.04	2.06	2.10	2.15	2.12	2.19
Yarra	1.41	1.43	1.42	1.41	1.35	1.34	1.26	1.28	1.31	1.35	1.33	1.37
Yarra Ranges	0.88	0.90	0.90	0.90	0.88	0.89	0.84	0.86	0.88	0.90	0.88	0.90

Table 2: Predicted monthly average daily per Capita Gambling Expenditure (\$) by LGA, July 2007 to June 2008 (ctd).

LGA	Jul07	Aug07	Sep07	Oct07	Nov07	Dec07	Jan08	Feb08	Mar08	Apr08	May08	Jun08
Ballarat	4596	4681	4547	4729	4455	4641	4367	4003	4510	4457	4494	4469
Banyule	5427	5538	5367	5551	5192	5373	5036	4616	5222	5200	5290	5305
Bass Coast	1219	1233	1232	1355	1365	1511	1476	1358	1482	1381	1297	1210
Baw Baw	994	1008	975	1014	958	1006	956	886	1008	1003	1015	1008
Bayside	1456	1480	1437	1497	1415	1479	1397	1283	1447	1429	1437	1425
Boroondara	1712	1735	1673	1727	1617	1681	1585	1462	1661	1657	1683	1680
Brinbank	10863	11088	10739	11101	10378	10743	10081	9259	10503	10489	10699	10752
Campaspe	663	674	657	688	656	692	659	609	689	680	682	674
Cardinia	1572	1601	1550	1604	1504	1563	1474	1360	1548	1548	1579	1585
Casey	9902	10093	9768	10096	9441	9776	9174	8420	9539	9508	9676	9701
Colac-Otway	612	617	596	619	585	615	584	541	613	607	609	600
Darebin	7980	8149	7911	8204	7691	7970	7470	6835	7709	7649	7754	7757
East Gippsland	1769	1783	1754	1884	1853	2014	1954	1810	2014	1927	1861	1773
Frankston	6007	6130	5945	6158	5770	5982	5613	5147	5821	5790	5882	5891
Glen Eira	6334	6455	6274	6531	6156	6415	6037	5531	6228	6153	6201	6167
Glenselg	564	574	565	600	581	620	593	545	609	590	581	565
Greater Bendigo	3881	3957	3842	3991	3755	3909	3680	3380	3822	3794	3842	3836
Greater Dandenong	9893	10114	9812	10154	9496	9822	9203	8434	9547	9518	9701	9750
Greater Geelong	9613	9781	9536	9994	9504	9987	9452	8673	9735	9549	9537	9402
Greater Shepparton	2515	2528	2438	2541	2420	2564	2460	2292	2608	2581	2582	2533
Hobsons Bay	4429	4508	4368	4530	4258	4434	4182	3852	4368	4349	4413	4408
Horsham	726	739	716	742	696	722	677	620	699	692	699	697
Hume	9043	9269	9025	9380	8814	9158	8613	7916	8975	8957	9134	9188
Kingston	7725	7867	7632	7928	7460	7770	7318	6720	7591	7525	7606	7578
Knox	7748	7898	7653	7922	7420	7689	7213	6610	7469	7423	7532	7535
Latrobe	4030	4106	3979	4125	3872	4023	3783	3473	3929	3904	3957	3953

Table 3: Predicted monthly Gambling Expenditure (Thousands of \$) by LGA, July 2007 to June 2008.

LGA	Jul07	Aug07	Sep07	Oct07	Nov07	Dec07	Jan08	Feb08	Mar08	Apr08	May08	Jun08
Manningham	5550	5640	5467	5681	5352	5581	5262	4833	5455	5397	5440	5404
Maribyrnong	5238	5345	5180	5357	5008	5177	4844	4429	4998	4965	5040	5048
Maroondah	5428	5532	5365	5562	5216	5409	5071	4639	5226	5176	5234	5221
Melbourne	6446	6539	6300	6491	6062	6283	5912	5445	6188	6180	6288	6289
Melton	3324	3402	3302	3421	3209	3339	3155	2921	3342	3366	3458	3494
Mildura	2023	2046	1968	2028	1901	1983	1882	1750	2005	2015	2056	2057
Mitchell	1300	1337	1315	1386	1320	1386	1309	1199	1346	1325	1333	1327
Monash	11455	11674	11322	11747	11037	11477	10800	9920	11219	11146	11296	11281
Moonee Valley	6770	6930	6737	6983	6533	6748	6300	5745	6465	6410	6506	6523
Moreland	6458	6580	6364	6570	6136	6346	5949	5457	6181	6161	6272	6290
Mornington Peninsula	6605	6725	6650	7137	6973	7499	7191	6596	7302	6997	6804	6556
Nillumbik	965	985	953	983	916	944	882	808	915	915	935	942
Northern Grampians	521	533	520	543	513	535	503	461	519	512	517	515
Port Phillip	2764	2805	2707	2794	2613	2709	2546	2340	2650	2637	2675	2670
South Gippsland	516	521	510	542	527	566	544	503	562	544	532	514
Stonnington	2083	2116	2042	2106	1969	2042	1921	1769	2010	2008	2044	2046
Swan Hill	512	512	488	502	472	497	478	450	520	524	533	529
Wangaratta	721	732	708	733	688	715	672	617	698	692	700	697
Warrnambool	1553	1575	1540	1628	1567	1668	1596	1473	1652	1611	1593	1554
Wellington	1878	1919	1877	1970	1873	1967	1861	1708	1920	1890	1896	1879
Whitehorse	5211	5313	5156	5352	5028	5225	4910	4502	5082	5039	5100	5090
Whittlesea	7537	7712	7479	7726	7205	7427	6936	6341	7167	7146	7292	7342
Wodonga	795	804	771	790	735	759	714	659	752	754	770	772
Wyndham	6299	6437	6247	6470	6058	6276	5888	5402	6117	6097	6210	6236
Yarra	2774	2811	2701	2771	2574	2654	2485	2281	2589	2586	2634	2639
Yarra Ranges	2939	2982	2887	3001	2832	2962	2804	2587	2931	2908	2934	2913

Table 4: Predicted monthly Gambling Expenditure (Thousands of \$) by LGA, July 2007 to June 2008 (ctd).

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A Regression Output

Linear mixed-effects model fit by REML

Formula: $I(\log(\text{gambexp}/\text{numdays}) - \log(\text{adpop})) \sim \text{trend} + \text{disadv} + I(\log(\text{numegm}) - \log(\text{adpop})) + I(\sin(2 * \pi * \text{trend}/12)) + I(\cos(2 * \pi * \text{trend}/12)) + I(\sin(4 * \pi * \text{trend}/12)) + I(\cos(4 * \pi * \text{trend}/12)) + I(\sin(6 * \pi * \text{trend}/12)) + I(\cos(6 * \pi * \text{trend}/12)) + I(\sin(8 * \pi * \text{trend}/12)) + I(\cos(8 * \pi * \text{trend}/12)) + I(\sin(10 * \pi * \text{trend}/12)) + I(\cos(10 * \pi * \text{trend}/12)) + I(\cos(12 * \pi * \text{trend}/12)) + (1 + \text{trend} + I(\sin(2 * \pi * \text{trend}/12)) + I(\cos(2 * \pi * \text{trend}/12))) \mid \text{LGA}$

Data: indicesdata

AIC	BIC	logLik	MLdeviance	REMLdeviance
-8368	-8222	4209	-8582	-8418

Random effects:

Groups	Name	Variance	Std.Dev.	Corr
LGA	(Intercept)	6.2467e-02	0.2499336	
	trend	2.7791e-06	0.0016671	-0.310
	$I(\sin(2 * \pi * \text{trend}/12))$	6.1293e-04	0.0247575	0.348 0.173
	$I(\cos(2 * \pi * \text{trend}/12))$	4.6770e-04	0.0216265	0.042 0.266 0.763
	Residual	1.4076e-03	0.0375175	

Number of obs: 2496, groups: LGA, 52

Fixed effects:

	Estimate	Std. Error	t value
(Intercept)	5.7555813	0.6100721	9.434
trend	0.0027595	0.0002491	11.077
disadv	-0.0014320	0.0006447	-2.221
$I(\log(\text{numegm}) - \log(\text{adpop}))$	0.7957234	0.0532517	14.943
$I(\sin(2 * \pi * \text{trend}/12))$	0.0275794	0.0036000	7.661
$I(\cos(2 * \pi * \text{trend}/12))$	0.0057685	0.0031820	1.813
$I(\sin(4 * \pi * \text{trend}/12))$	-0.0081375	0.0010666	-7.629

I(cos(4 * pi * trend/12))	-0.0070323	0.0010635	-6.612
I(sin(6 * pi * trend/12))	0.0075797	0.0010635	7.127
I(cos(6 * pi * trend/12))	-0.0074322	0.0010635	-6.988
I(sin(8 * pi * trend/12))	0.0037530	0.0010625	3.532
I(cos(8 * pi * trend/12))	0.0059645	0.0010635	5.608
I(sin(10 * pi * trend/12))	0.0018775	0.0010621	1.768
I(cos(10 * pi * trend/12))	-0.0042229	0.0010635	-3.971
I(cos(12 * pi * trend/12))	0.0070690	0.0007515	9.407

Correlation of Fixed Effects:

	(Intr)	trend	disadv	I((-1))	I(s(2*p*t/12))	I(c(2*p*t/12))	
trend		-0.003					
disadv		-0.914	0.107				
I(lg()-1())		0.046	0.297	0.359			
I(s(2*p*t/12))		0.018	0.163	-0.004	-0.011		
I(c(2*p*t/12))		0.002	0.228	-0.001	-0.002	0.685	
I(s(4*p*t/12))		-0.001	0.015	-0.006	-0.018	0.005	-0.002
I(c(4*p*t/12))		0.000	-0.010	0.002	0.006	-0.003	0.001
I(s(6*p*t/12))		-0.001	0.009	-0.004	-0.010	0.003	-0.001
I(c(6*p*t/12))		0.000	-0.009	0.003	0.008	-0.003	0.001
I(s(8*p*t/12))		0.000	0.005	-0.002	-0.006	0.002	-0.001
I(c(8*p*t/12))		0.001	-0.009	0.003	0.009	-0.003	0.001
I(s(10*p*t/12))		0.000	0.002	-0.001	-0.003	0.001	0.000
I(c(10*p*t/12))		0.001	-0.009	0.003	0.009	-0.003	0.001
I((12*p*t/1		0.000	-0.006	0.002	0.007	-0.002	0.001
					I(s(4*p*t/12))	I(c(4*p*t/12))	I(s(6*p*t/12))
trend							
disadv							
I(lg()-1())							
I(s(2*p*t/12))							
I(c(2*p*t/12))							
I(s(4*p*t/12))							

I(c(4*p*t/12))	-0.005		
I(s(6*p*t/12))	0.005	-0.003	
I(c(6*p*t/12))	-0.005	0.003	-0.003
I(s(8*p*t/12))	0.003	-0.002	0.002
I(c(8*p*t/12))	-0.005	0.003	-0.003
I(s(10*p*t/12))	0.001	-0.001	0.001
I(c(10*p*t/12))	-0.005	0.003	-0.003
I((12*p*t/1	-0.003	0.002	-0.002
	I(c(6*p*t/12))	I(s(8*p*t/12))	I(c(8*p*t/12))

trend

disadv

I(lg()-1())

I(s(2*p*t/12))

I(c(2*p*t/12))

I(s(4*p*t/12))

I(c(4*p*t/12))

I(s(6*p*t/12))

I(c(6*p*t/12))

I(s(8*p*t/12)) -0.002

I(c(8*p*t/12)) 0.003 -0.002

I(s(10*p*t/12)) -0.001 0.000 -0.001

I(c(10*p*t/12)) 0.003 -0.002 0.003

I((12*p*t/1 0.002 -0.001 0.002

I(s(10*p*t/12)) I(c(10*p*t/12))

trend

disadv

I(lg()-1())

I(s(2*p*t/12))

I(c(2*p*t/12))

I(s(4*p*t/12))

I(c(4*p*t/12))

I(s(6*p*t/12))

$I(c(6*p*t/12))$
 $I(s(8*p*t/12))$
 $I(c(8*p*t/12))$
 $I(s(10*p*t/12))$
 $I(c(10*p*t/12)) -0.001$
 $I((12*p*t/1 -0.001 \quad 0.002$

B Varying Regression Coefficients

	LGA	a_i	d_i	e_{1i}	f_{1i}
1	Ballarat	5.792004	0.001631	0.031866	0.003545
2	Banyule	5.933821	0.002676	0.044129	0.013334
3	Bass Coast	5.776626	-0.000129	-0.069415	-0.083719
4	Baw Baw	5.357190	0.004849	0.020931	0.014068
5	Bayside	5.641475	0.002062	0.025163	0.002800
6	Boroondara	5.672701	0.002494	0.033274	0.020159
7	Brimbank	5.995816	0.003811	0.045050	0.016665
8	Campaspe	5.141775	0.004910	0.013553	-0.000339
9	Cardinia	5.582344	0.004369	0.038814	0.018957
10	Casey	6.102603	0.002509	0.042732	0.015464
11	Colac-Otway	5.516519	0.001575	0.012707	0.011323
12	Darebin	5.867474	0.002052	0.041804	0.007732
13	East Gippsland	5.572449	0.001582	-0.041485	-0.041151
14	Frankston	6.027895	0.002891	0.041706	0.011408
15	Glen Eira	6.006622	0.001859	0.031810	0.002276
16	Glenelg	5.426661	0.003068	-0.005987	-0.028029
17	Greater Bendigo	5.670497	0.003186	0.035193	0.008261
18	Greater Dandenong	5.819018	0.003514	0.046813	0.013371
19	Greater Geelong	5.791089	0.001629	0.017466	-0.007822
20	Greater Shepparton	5.735187	0.003190	-0.001296	0.011529
21	Hobsons Bay	5.744546	0.003862	0.034149	0.013135
22	Horsham	5.562033	0.000251	0.036534	0.007752
23	Hume	5.936580	0.005977	0.043802	0.010695
24	Kingston	5.926583	0.002520	0.032815	0.007553
25	Knox	6.038437	0.002080	0.040913	0.011317
26	Latrobe	5.679822	0.002692	0.036959	0.010894

Table 5: Varying Regression Coefficients.

	LGA	a_i	d_i	e_{1i}	f_{1i}
27	Manningham	6.103910	0.001742	0.028711	0.006403
28	Maribyrnong	5.853920	0.001355	0.044611	0.010749
29	Maroondah	5.944360	0.000951	0.038719	0.006908
30	Melbourne	6.015147	0.001556	0.037781	0.021855
31	Melton	5.732500	0.008377	0.043771	0.023002
32	Mildura	5.539083	0.005242	0.029179	0.029732
33	Mitchell	5.530035	0.005956	0.029413	-0.013148
34	Monash	6.113633	0.003045	0.036106	0.010004
35	Moonee Valley	6.052018	0.001665	0.047981	0.005860
36	Moreland	5.850547	0.002275	0.043973	0.016329
37	Mornington Peninsula	5.963803	0.001753	-0.018493	-0.045322
38	Nillumbik	5.626983	0.002813	0.051238	0.018084
39	Northern Grampians	5.547567	0.003485	0.034222	-0.001391
40	Port Phillip	5.810836	0.001093	0.036666	0.016787
41	South Gippsland	5.420091	0.001805	-0.020617	-0.026139
42	Stonnington	5.709291	0.002741	0.038505	0.020436
43	Swan Hill	5.100812	0.005795	0.008200	0.041485
44	Wangaratta	5.490304	0.001276	0.033408	0.011563
45	Warrnambool	5.702471	0.002789	-0.003763	-0.016741
46	Wellington	5.545977	0.004118	0.023536	-0.007555
47	Whitehorse	6.012110	0.002375	0.036792	0.007589
48	Whittlesea	6.160086	0.002572	0.051851	0.013772
49	Wodonga	5.533381	0.001287	0.039763	0.030785
50	Wyndham	6.099048	0.003218	0.044547	0.012959
51	Yarra	5.924149	-0.000018	0.043856	0.024719
52	Yarra Ranges	5.590401	0.003117	0.024172	0.010057

Table 6: Varying Regression Coefficients (ctd).

