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Some Approaches to Election Night Forecasting in Australia

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Australian Electoral Commission

We outline the history of election night forecasting in Australia. We first identify the major structural features of the Australian voting system which determine how the problem must be approached: single-member constituencies; preferential voting; the counting on election night, in polling booths, of first preference votes only; and the existence of a two-party system. We note that the major statistical difficulty associated with election night forecasting in Australia is that progressive counts in a seat, far from being random samples of the votes cast, are non-random and systematically biased samples. We finally outline the increasingly sophisticated computer models which have been used to correct for this bias, culminating in the 'matched polling places' model implemented by the Australian Electoral Commission at the 1990 election, which has effectively eliminated the problem of bias.

Introduction

Australians' enthusiasm for a head-to-head contest is well-known. In the political world, such contests take the form of elections. The battle between the political contestants has long been paralleled in Australia by competition between television networks on election night to present the best coverage of the count; and 'best' in this context usually has been taken to mean that which tells the viewers earliest which party has won the election. This has led in recent years to an extension of the scope of such coverages from straight reporting of results to the forecasting of the outcome.

While the problem of election night forecasting has received considerable attention overseas,[1] no single approach to its solution has found general favour. The reason for this appears to be that the statistical framework of the problem is greatly influenced not only by the electoral system being used, but also by the vote counting mechanisms which apply on election night in different countries, and by such sociopolitical factors as the party structure and the political homogeneity of the electorate. All of these influences when combined have the potential to produce a vast range of different problems requiring distinctive solutions.

The aim of this paper is to provide an historical outline of how the problem has been approached in Australia. We commence by discussing the major

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1 A special issue of the *New Zealand Statistician* Vol.25, No.2, December 1990 is devoted exclusively to the problem of election night forecasting, and is the best source of bibliographical references on the subject.

institutional factors affecting the task. We then examine how election night commentators in Australia performed their task before and after the introduction of computerized tallying of election returns. The introduction of statistical modelling techniques during the 1980s is then discussed. We conclude by describing how the 'matched polling places' approach was implemented at the 24 March 1990 general election; and discuss various enhancements of that approach which are currently under consideration.

Institutional factors affecting approaches to election night forecasting in Australia

In this country, methods of election night forecasting have almost invariably been designed to cope with three institutional factors: single-member constituencies, preferential voting, and an election night vote counting regime under which only first preference votes are counted at each polling place, with the Divisional Returning Officer being advised by telephone of the result in each polling place, and calculating, several times during the night, a progressive total for the seat, which is made available with minimal delay to the National Tally Room.

The essential characteristic of the single-member constituencies system is that a general election has to be viewed not just as a single event, but also as a large number of separate elections, with different people voting independently in each one. Election night forecasting may be approached by attempting to predict the outcome in each constituency, and if there is no well defined party structure in the polity, that will be all that can be done: government will be determined by post-election negotiations between successful candidates acting as free agents, and it will make no sense to talk of an overall result of the election distinct from the result in each constituency.

If, however, there is a party structure such that votes for individual candidates can also be interpreted as votes for the parties which endorsed them, the objective of election night forecasting can be seen more broadly, as that of determining the party which will win government, rather than just determining which candidate will win each seat. Such a perspective on the problem enables the use of forecasting techniques which can predict the overall partisan balance of the Parliament without saying anything about the outcome in particular individual seats. Typically election night forecasting procedures are called upon to provide both an overall forecast and information about individual contests, but it is nevertheless useful to bear in mind the distinction between the two approaches.

In Australia, there is not merely a strong party structure, making attempts at forecasting the overall result worthwhile: there has been in place at Commonwealth elections since 1910 a strong *two*-party structure, in the sense that at no election since 1910 have more than two parties entered the campaign with a realistic chance of winning government. The existence of a two-party system obviously simplifies greatly the task of election night forecasting.

From tally boards to computers

Prior to 1974, election night information was made available to analysts on wooden tally boards which set out the progress totals of first preference votes for each candidate in each seat. At least into the 1950s—eyewitness reports from that era are hard to obtain—these tally boards were located not in a single National Tally Room, but in separate tally rooms for each State. This made it extremely difficult for commentators to analyse an election other than on a seat by seat basis, and in fact the impetus for the establishment of a National Tally Room came from newspaper chains, which were finding it necessary to organize their own national tally rooms.

By the 1960s the institution of the National Tally Room was well established. Election night commentators, increasingly employed by television[2] as well as radio, usually sought as returns came in to identify each seat as having been won by either Labor or non-Labor; when over half of the seats had been so allocated to one side they would 'call the election'. The braver commentators might be prepared to call the election even before all seats had been allocated, if it seemed clear from the voting patterns in the allocated seats that one side had won a smashing victory. This approach is still used by election night analysts at presidential elections in the United States, where the candidate is described as going 'over the top' when he or she has secured more than half the votes in the Electoral College.

It is useful to reconstruct the mental processes of election night commentators of that period in some detail, since some of those processes have had to be replicated in the statistical models which have been used in the period since. In the first instance, most commentators identified a fair proportion of seats as 'safe', ie. most unlikely to be lost by the incumbent side. These seats were allocated to that side, and were only looked at again if it appeared that the incumbent side was polling particularly poorly at the election. In the remaining seats the progressive figures were analysed in three stages.

1. An estimate was made of what proportion of minor party and independent votes were likely in their later preferences ultimately to favour Labor, and what proportion were likely to favour non-Labor. These proportions were then used as the basis for notionally allocating the minor party votes as shown in the latest progressive figures for a seat to either side, so as to reduce the result to a 'two-party preferred vote' figure.

2. An informal estimate of the degree of uncertainty associated with that figure was then made, in the least sophisticated case on the basis purely of the percentage of the enrolled electors in the seat whose

2 Though the official figures from the Commonwealth Electoral Office were presented entirely manually prior to 1974, some early attempts were made by the television networks to use their own computers in election night forecasting. In one case, Sir Frank Packer, then owner of the Nine Network, ordered a commentator to be removed from the telecast after he had persisted in attaching significance to a patently incorrect computer-derived forecast of a Labor victory in the face of clear evidence to the contrary from the tally boards. Details of the model embodied in the computer's program are, not surprisingly, unobtainable.

votes had at that stage been counted, and the margin between Labor and non-Labor at the time.

3. On the basis of that informal estimate, the commentator determined whether to allocate the seat to Labor or non-Labor, or to await further figures.

It should be noted that this approach was in essence a deterministic one. Seats were classified as won by one side or the other or as still uncertain in their outcome, but there was no attempt made to quantify uncertainty by attaching probabilities to outcomes.

The major difficulty associated with such quantification—a difficulty of which commentators were well aware even in the pre-computer era—is that progressive figures are not a random sample of votes cast. If it could have been assumed that the figures shown on the boards at any stage of the count constituted such a random sample, there would scarcely have been any election night forecasting to be done. Ignoring errors generated by the need to estimate minor party preference flows, Labor's number of two-party preferred votes would have been a hypergeometric random variable. In a seat of 50,000 voters where the actual split of the vote was 51:49 in favour of Labor, the probability of Labor's appearing to be losing in the progressive count would have been 0.26 with 1,000 votes counted, shrinking to 0.067 with only 5,000 votes counted. Less closely contested seats, which make up the vast majority, would have been even more predictable on the basis of the early returns.

In fact the content of early returns is dramatically influenced by the manner in which votes are counted. The basic problem is that the partisan division of the vote is correlated with the size of polling places: by and large small polling places are rural, and are more likely to vote non-Labor than large polling places. Prior to 1987, votes from the smaller polling places tended (counter intuitively) to be included only in the later progressive figures. Partly because telephones were not available at the smaller polling places, and partly because a danger was perceived that the counting of votes at a small polling place might show that all who voted there had supported the same party, with a consequent loss of the secrecy of the ballot, votes taken at small polling places were usually amalgamated at a central counting centre before being counted. This meant that the early figures from a seat with a rural component tended to be biased, disproportionately favouring Labor. Commentators observing in the early figures a particularly strong vote for Labor could not tell whether that reflected an underlying trend, or whether Labor's best polling places simply happened to have been counted first.

Prior to 1974, there was little that commentators could do to mitigate the effects of this phenomenon. Records of the progressive figures posted on the tally boards on election night were not published, and analysts therefore lacked sufficient information to make numerical corrections to early progressive figures to eliminate their inherent bias. The only approach open to them therefore was caution; many commentators showed a marked reluctance to call a seat for one side or the other until the final figures were posted.

A major advance in the tallying of votes on election night was implemented at the election of 18 May 1974: results ceased to be transmitted to the National Tally Room by telephone, and instead were entered at input centres in each State into a nationwide computer system, the Polling Results Processing Package, which was accessed interactively from the National Tally Room. This assisted election night forecasting two important ways:

1. For the first time, commentators had access to total vote figures by party, not only for each seat, but also for each State and Territory, for the nation as a whole, and for sets of seats defined by their socio-demographic status, and by their safety for the incumbent party.
2. Half-hourly records were kept of the progressive figures entered for each seat.

The provision of aggregate figures meant that for the first time forecasts of the overall result could be attempted other than by forecasting the result in each seat. It had been observed early in the nineteenth century by Bienayme (Heyde and Seneta 1977) and late in the century by Edgeworth (1898) that the proportion of seats won by the winning party under single-member constituencies typically exceeds its proportion of the vote. These observations gave rise to numerous investigations of the 'seats-votes' relationship, one high point of which is the study by Kendall and Stuart (1950) of the so-called 'cube law', an empirical tendency for the ratio of seats won by the winning party to seats won by the losing party to equal the cube of the ratio of votes won by the winning party to votes won by the losing party. At the time of the 1974 election, the preceding literature had been elegantly surveyed by Tufte (1973). He argued for the use of a national seats-votes relationship obtained by simple regression of seats won against votes cast. Figure 1 plots the non-Labor share of seats won against the non-Labor share (in two-party preferred terms) of votes cast for Commonwealth elections from 1946 to 1972 inclusive.

In 1974, commentators for the first time had data before them on election night on the basis of which they could at least attempt to postulate non-Labor's overall share of the two-party preferred vote, and the use of the actual percentage (in two-party terms) polled by non-Labor in 1974, 48.34 per cent, in the equation defining the least squares line-of-best-fit in Figure 1 would have provided a point forecast that non-Labor would win 62 seats, a forecast which would have been in error by only one seat. Such a forecast would of course have said nothing about the outcome in any individual seat.

Those who were sceptical about or ignorant of the regression approach had another option open to them. It has been asserted by a number of commentators (including Kendall [1961] from the ranks of statisticians) that under single-member constituencies it can safely be assumed that for a given national swing seats will change hands in the same numbers as if the swing were uniform in all seats. In 1974, this assumption, like the regression approach, could have been applied to the actual percentage (in two-party terms) polled by non-Labor in 1974 to produce an estimate which was out by only one seat.

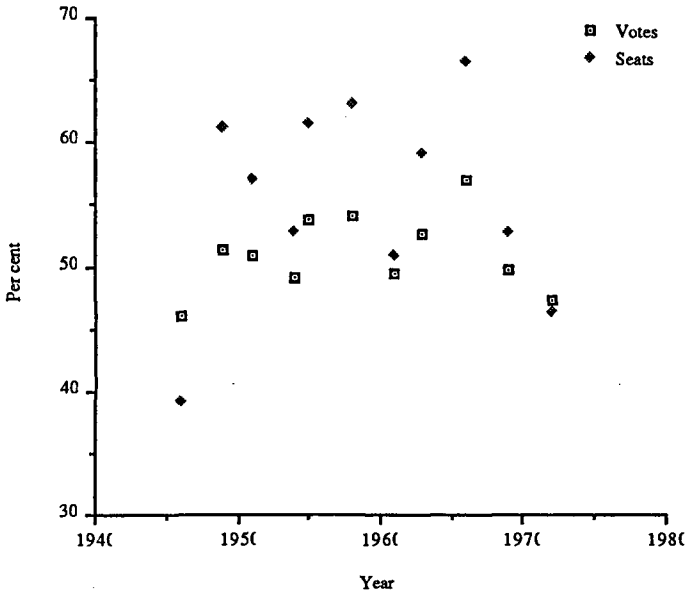

Figure 1: Two-party preferred vote figures for 1946 to 1972

For the elections from 1959 to 1972, the two-party preferred vote figures used in Figure 1 are those provided by Mackerras (1980). For the elections from 1946 to 1955, the estimates are those given in Maley (1979). The seat of Batman is not included in the seats data for the 1966 election, when it was won by an independent.

There are a number of reasons why commentators did not apply such analyses in 1974. Many of them, sadly, would have been unaware of the regression approach to the seats-votes relationship, though some of them would have been aware of the rule of thumb, consistent with the 1946–72 equation, that around three seats would be lost by a party for every percentage point of swing (ie. net change in its two-party preferred vote) against it. Those who were aware of the regression approach may well have been rightly cautious about using it for forecasting the overall result, given that the 95 per cent confidence interval for the point forecast of 62 seats was in fact 62 seats plus or minus 9 seats—an interval encompassing comfortable wins for either party. Some may have doubted the extent to which data from 1946 could be legitimately used to estimate a seats-votes equation to be applied nearly 30 years later. Others may have doubted the postulate of a linear relationship with only one explanatory variable.[3] Some may have regarded as flawed the theoretical basis for forecasting on the basis of an assumption of uniform swing.

Primarily, though, most of them would have found it almost impossible, early in the count, to estimate the final swing. The 1974 election was marked by

3 A number of these issues have been explored in the literature since 1973. A case for the use of non-linear regression is made by Linehan and Schrodt (1977), but the specification which they propose is subject to difficulties of the type documented by Haworth and Vincent (1979). More recently, sophisticated models have been advanced by King and Browning (1987), King (1989) and King and Gelman (1990).

a sharp difference in the patterns of voting in urban and rural Australia, with the rural areas swinging to non-Labor to a far greater extent than the urban areas. The net effect was that the early figures, including the newly available national total figures, favoured Labor disproportionately. Early bias remained a fundamental problem.

Analysis and correction of bias

The half-hourly records of progressive figures retained by the Polling Results Processing Package became available to commentators after the 1974 election, and served to illuminate election night analyses in 1975 and 1977 (though the results of those elections were so one-sided in favour of non-Labor that forecasting the result from the early figures was relatively simple). Further half-hourly data figures were generated at those elections, providing a clearer picture of the patterns of distortion in individual seats. These data dumps formed the basis for the pathbreaking work of Cunningham (1979), the first application of which (at the 1980 election) is outlined in Cunningham and Malafant (1982).

His fundamental approach was to determine for each seat a 'bias curve', which plotted per cent bias against per cent of the vote counted. (Tufte 1974 refers to such curves as 'mu curves'.) These curves estimated for each seat the degree of correction to raw figures required at any particular stage of the count. The goodness of fit of the bias curve to the historical data was reflected in a variance figure which was one element in a variance calculated for the projected two-party preferred vote in a seat. Furthermore, the application of statistical modelling methods provided estimates of the two-party preferred vote in seats where no count had been reported.

Rather than seats being 'called' for one party or the other as the count progressed, the model estimated the probability of a Labor win in each seat. The estimated total number of seats won by Labor together with estimated standard errors provided the information necessary for the calculation of confidence intervals and estimates of the probability of a Labor win. Cunningham's model, which was implemented with stunning success by the TEN Television Network at the 1980, 1983 and 1984 elections, marked the first serious attempt to use probabilistic techniques for election night analysis in Australia.[4]

Also at the 1980 election, a model was developed by staff of the Australian Electoral Office. It was not successful, and details of it are now almost impossible to obtain. Oral history indicates that it involved an attempt to identify particular polling places as bellwethers: ones which historically had provided a good indication of the swing pattern in the nation as a whole. Most of the polling places so identified happened to be in Victoria, and because the swing to Labor in 1980 in Victoria was much greater than in the rest of the

4 The success of Cunningham's work at the 1980 election may well have prompted the attempts made by the Nine Network to engage in election night forecasting at the 1983 and 1984 elections. Details of the models used are not readily available, and the forecasting attempts were unsuccessful, apparently because of hardware problems encountered on the night. The ABC, despite its substantial expenditure over the years on election night coverages, has tended to shy away from the use of predictive models, relying instead on rather basic data analysis.

country, the model incorrectly predicted a Labor victory at the election. Further work within the Australian Electoral Office on such models was immediately abandoned.

The next major developments in the analysis of election night data were implemented at the 1987 election. The Polling Results Processing Package which had been used since 1974 was finally replaced by a new and enhanced database system, TENIS (The Election Night Information System). For the first time, TENIS made available to analysts not just raw first preference figures, but also estimates of the two-party preferred vote for each seat, State and Territory, and for the nation as a whole. The estimates of minor party and independent preference flows which underpinned the estimates were published by the Australian Electoral Commission prior to the election, and it was made clear to commentators that the estimates had no special status, and that commentators were as in the past free to substitute their own estimates. For commentators who were prepared to accept the Commission's own estimates, a great deal of the computational work which had increasingly been performed by computer systems provided by each TV network was avoided.

The 1987 election paradoxically also saw the worst performances by election night commentators for many years. This was due to a highly significant but largely ignored change in vote counting procedures. Electoral laws had since the 1984 election been amended to provide that votes cast in the smallest polling places should be counted at those polling places and immediately phoned through to the Divisional Returning Officer, rather than being taken to a counting centre to be amalgamated with other votes. The net effect of this change was that rural, non-Labor votes, rather than being reported late in the count, were reported early. Many commentators, accustomed to seeing an early bias in favour of Labor, interpreted the early figures as indicating a non-Labor victory. Computer systems designed to take account of bias patterns of the past could not be used, as quantification was not possible. An important stage of the analysis was therefore reduced to guesswork. The best televised interpretation of the developing election result was given by Labor Senator Robert Ray, who obtained reports from selected Labor scrutineers in marginal seats which told him from where the early votes were coming: his success was acclaimed as a victory of humanity over the computer.

The method of matched polling places[5]

The performance of commentators at the 1987 election emphasised the need for yet further improvements in election night forecasting techniques; the success of Senator Ray by coincidence showed the way ahead. For some years prior to 1987 steps were being taken within the Australian Electoral Commission to implement the system of 'matched polling places' (of the type described by Tufte 1974) under which the Commission's computers would accept not just progressive figures from each seat, but also codes to indicate the

5 The discussion in this section draws heavily upon but also expands upon that contained in Maley and Medew (1990).

polling places represented in each batch of votes input. The computer would then extract from a database the results from the same polling places at the previous election, and using them as a base figure, would determine the underlying swing to or from Labor. This approach is similar in intent to the ratio estimation technique employed in survey sampling. In 1986 Cunningham had conducted on behalf of the Australian Electoral Commission a detailed study of the approach, which had indicated that under favourable conditions the distortion in early figures could be virtually eliminated, and the variance of swing estimates considerably reduced. It had been planned to implement matched polling places in TENIS from the outset, but the early calling of the election in 1987 prevented that from being done. Matched polling places was tested successfully at a number of by-elections in 1988, and was fully implemented at the 24 March 1990 general election.

The TENIS system as modified to implement matched polling places stores for each seat as the count progresses records of 'historical votes' and 'current votes'. At the beginning of the night both these database fields are zero; as data arrive both fields are incremented. The transactions arriving at the database contain the current total votes for each candidate and the codes for the polling places represented in the transaction. The historical data record for each of these polling places is extracted from the database and incremented to each candidate's historical data. The difference between a party's percentage of the vote in the current and historical records represents the swing to or from the party in that seat. The historical votes record is reduced to a two-party preferred vote figure using the observed flow of minor party and independent votes in that seat at the previous election; estimates have to be made of the likely flow of preferences at the current election to reduce the current votes record to two-party preferred terms. Once this is done for both records, an estimated two-party preferred swing is calculated.

At the tests of the system at by-elections in 1988 it was decided that each transaction should contain data from approximately four polling places. In each test the traditional method of 'unmatched swings' was also used, and comparisons of the old and new methods were made. Invariably the 'matched polling places' swing converged to what turned out to be the true value with far fewer of the votes counted than in the case of 'unmatched swing'.

It might be thought that the capture of historical data is an easy task, and capturing raw data is. However when polling places are abolished or created, or when the existing electoral boundaries are changed, the effect on polling place data can be dramatic, and the system has to be able to cope with all these contingencies, since for every polling place which will report at the current election there must be a corresponding historical record in the database. In the case of polling place abolitions, the Divisional Returning Officer is required to make an estimate of the likely impact of voting patterns at surrounding polling places; this estimate is factored into the database, and the historical records are amended accordingly. Similar corrections are made when a polling place is created.

Changes in the boundaries of seats are more complex. In 1988 boundaries

were changed in two States, Western Australia and Victoria, and in addition Victoria gained a seat and Western Australia lost one. Due to the changes in boundaries polling place locations were changed and the areas they served were also changed, giving rise to a need to simulate what the voting pattern might have been in 1987 given the new polling place structure. This involved the collection of additional data.

In Australia the smallest spatial unit for which demographic data are readily obtainable is the Census Collection District (CCD) used in population censuses. At the time of the last Australian census there were approximately 36,000 of these. Each unit consists of approximately 250 habitations. Using these units it is possible to identify, allowing for some error, a 'catchment area' for each polling place. A CCD is assumed to be part of the catchment area of a particular polling place if 60 per cent of the electors within the CCD vote at the polling place. Since the Commission has records available to it of the addresses of all people who vote at a particular polling place—a by-product of the optical mark reading system used in Australia to identify non-voters and multiple voters—and since records exist of which addresses are located in which CCDs, it is possible to identify the catchment area of each polling place. Once a catchment area is identified it is assumed the entire area has voted similarly and each CCD is tagged with the polling place's voting pattern.

After a redistribution has occurred a new catchment area must be estimated. In the first instance, each new polling place's 'position' is defined as the centroid of the CCD in which it is located. Each CCD's 'position' is defined as its centroid. The problem to be solved is that of determining the boundaries of the catchment area of a given polling place, say polling place y. This is done using Reilly's gravity model (1931). Although this model was originally used to identify the flow of retail trade, in modern social science it is used to explain movement of people and other social phenomena. In the formula

$$d_{iy} = (d_{xy} / (1 + (p_x / p_y)^{0.5}))$$

the subscripts x and y represent two polling places. The quantity d_{iy} is the distance along the route from y to x to the point of equal attraction, in this case the limit in the direction of polling place x of y's catchment area. The quantity d_{xy} is the distance between the polling places, and p_x and p_y are the populations of the CCDs in which the two polling places are located. In practice the spatial distribution of polling places enables this rule to be applied to the three polling places nearest to y, in such a way that if the three points of equal attraction so defined are joined, all CCD's whose centroids fall within the triangle so defined can be agglomerated to form a workable catchment area.

This method does not recognize geographical landscape realities or topography and as such a certain amount of error must be allowed for. Nonetheless the underlying methodology has proven to be sound. Once the new polling place catchment area is identified the new polling booth voting pattern can be identified by aggregating the votes contained in each of the CCD's within the catchment area.

Tables 1 and 2 set out for two seats the first preference swing to the ALP calculated using the 'matched' and 'unmatched' polling places method at various stages of the count, and indicate the absolute extent to which the swings so calculated differed from the true swing as determined at the declaration of the poll.

Table 1: Progress of the Count in the Seat of Throsby (New South Wales)—First Preference Swing to the Australian Labor Party

Time	Per cent Counted	Matched Swing(%)	Deviation	Unmatched Swing(%)	Deviation
18 :58	0.71	6.95	10.24	-24.57	21.28
19 :23	4.70	-5.61	2.32	-13.33	10.04
21 :33	19.07	-2.23	1.06	-4.32	1.03
21 :35	30.01	-0.81	2.48	-8.75	5.46
21 :36	37.74	-1.70	1.59	-7.01	3.72
21 :37	42.98	-2.05	1.24	-6.91	3.62
22:47	58.35	-2.71	0.58	-3.43	0.14
22 :48	70.31	-3.06	0.23	-2.59	0.70
22:51	82.44	-3.11	0.18	-2.63	0.66
13:01 (25/3/90)	85.36	-3.55	0.26	-3.01	0.28

Table 2: Progress of the Count in the Seat of Rankin (Queensland)—First Preference Swing to the Australian Labor Party

Time	Per cent Counted	Matched Swing(%)	Deviation	Unmatched Swing(%)	Deviation
18 :57	2.72	-2.80	-27.75	24.81	0.14
19:08	4.32	-0.97	-24.34	21.40	1.97
19:14	11.65	0.60	-11.36	8.42	3.54
19:25	31.28	-2.53	-6.16	3.22	0.41
19:31	35.11	-2.29	-6.75	3.8 1	0.65
19:43	44.59	-2.84	-6.59	3.65	0.10
19:52	49.06	-2.62	-5.39	2.45	0.32
19:59	59.39	-2.19	-6.58	3.64	0.75
20:14	70.73	-2.57	-4.48	1.54	0.37
21:08	83.57	-2.97	-2.44	0.50	0.03
21:48	83.73	-2.93	-2.51	0.43	0.01

The pattern apparent in these tables was repeated to a greater or lesser extent in every seat. The use of the matched polling places technique effectively eliminated the bias which had so plagued election commentary in the past, and enabled the present authors to determine, when less than 5 per cent of the national vote had been counted, that the result of the election would be so close that it would depend on the distribution of preferences. Bias proved to have been effectively eliminated even in the two States where significant manipulation of the historical data had been made necessary by changes in electoral boundaries. It is fair to say that a new era in election night forecasting in Australia has just begun.[6]

6 In this context, it is noteworthy that the Joint Standing Committee on Electoral Matters (1990: 38) has specifically remarked upon the effectiveness of the method of matched polling places, and commended the Australian Electoral Commission for its introduction.

Since 'matched polling places' is a statistical technique underpinned by well-developed sampling theories, it is planned that the system will be developed to provide not only estimated swings, but also variance estimates for these. It seems reasonable to assume that swing estimates follow the normal distribution, thus providing estimates of the probability of a government win (and the complementary probability of an opposition win) in each seat. Estimates of total numbers of seats won by each side and associated confidence intervals will provide a means of forecasting the fate of the government. These enhancements have been a feature of systems developed by Cunningham since 1980, and have proven highly effective and useful in practice.

References

Cunningham, R.B. 1979. *Election Night Forecasting: Australian House of Representatives Elections*. M. Sc. Thesis, Australian National University.

Cunningham, R.B. and K.W.J. Malafant. 1982. 'Forecasting Outcomes of Australian House of Representatives Elections on Election Night.' *The Mathematical Scientist* 7:105–14.

Edgeworth, F.Y. 1898 'Miscellaneous Applications of the Calculus of Probabilities.' *Journal of the Royal Statistical Society* Series A61:534–44.

Haworth, J.M. and P.J. Vincent. 1979. 'The Stochastic Disturbance Specification and its Implications for Log-Linear Regression.' *Environment and Planning* A11:781–90

Heyde, C.C. and E. Seneta. 1977. *I.J. Bienayme—Statistical Theory Anticipated*. Berlin: Springer-Verlag.

Joint Standing Committee on Electoral Matters. 1990. *1990 Federal Election: Report from the Joint Standing Committee on Electoral Matters*. Canberra: Australian Government Publishing Service.

Kendall, M.G. 1961. 'Natural Law in the Social Sciences.' *Journal of the Royal Statistical Society, Series* 24:1–16.

Kendall, M.G. and A. Stuart. 1950. 'The Law of the Cubic Proportion in Election Results.' *British Journal of Sociology* 1:183–96.

King, G. 1989. 'Representation Through Legislative Redistricting: A Stochastic Model.' *American Journal of Political Science* 33:787–824.

King, G. and R.X. Browning. 1987. 'Democratic Representation and Partisan Bias in Congressional Elections.' *American Political Science Review* 81:1251–76.

King, G. and A. Gelman. 1990. 'Estimating the Electoral Consequences of Legislative Redistricting.' *Journal of the American Statistical Association* 85:274–82.

Linehan, W.J. and P.A. Schrodt. 1977. 'A New Test of the Cube Law.' *Political Methodology* 4:353–67.

Mackerras, M. 1980. *Elections 1980*. Sydney: Angus & Robertson.

Maley, M. 1979. *Five Measures of Electoral Bias*. BA (Hons) Sub-Thesis, Department of Political Science, the Faculties, Australian National University.

Maley, M. and R.J. Medew. 1990. 'The New Approach to Election Night Forecasting in Australia.' *New Zealand Statistician* 25:80–2.

Morton, R.H., ed. 1990. *New Zealand Statistician* 25.

Reilly, W. 1931. *The Law of Retail Gravitation*. New York: Pilsbury.

Tufte, E.R. 1973. 'The Relationship between Seats and Votes in Two-Party Systems.' *American Political Science Review* 67:540–54.

Tufte, E.R. 1974. *Data Analysis for Politics and Policy*. Englewood Cliffs: Prentice Hall.