Assessment of the Australian Road System: Provision of Roads in Local Government Areas

Occasional Paper

This Paper has been prepared to provide input to the major Australian road system study conducted by the Bureau of Transport Economics, the results of which are presented in the Report 'Assessment of the Australian Road System: 1984'.

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Assessment of the Australian Road System:

Provision of Roads in Local Government Areas

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FOREWORD

This Paper presents part of the results of a study of the Australian road system undertaken by the Bureau of Transport Economics (BTE) in response to a direction by the then Minister for Transport in May 1982. The Terms of Reference required that the Bureau examine changes in condition and performance of the road system in recent years, trends in levels and patterns of funding, and economics of road investment and the probable impact of alternative future funding patterns and levels.

The results of the study are presented in the BTE publication, Report 56 'Assessment of the Australian Road System; 1984'. A number of discrete investigations were undertaken in support of the study. This Paper presents the results of an investigation of the provision of roads in local government areas for local transport needs. This work was carried out by Mr J. D'Arcy with the assistance of Mr N. Burton.

The Bureau reported on a previous assessment in 1979 and similar reports were prepared by the former Commonwealth Bureau of Roads in 1969, 1973 and 1975. A wider range of assessment criteria were explored in the present study than were used in previous work.

R. W. L. WYERS
Assistant Director
Special Studies Branch

Bureau of Transport Economics
Canberra
May 1984

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SUMMARY

This Paper has been prepared to provide input to the major Australian road system study conducted by the Bureau of Transport Economics, the results of which are presented in the Report 'Assessment of the Australian Road System: 1984'.

Local transport makes use of the whole variety of road classes, local, arterial and so on. Thus, this Paper focusses on the total road system in terms of its use for local transport purposes. Obviously the class of roads known as 'local roads' forms a significant proportion of the system examined, but the examination is not confined to local roads.

Due to the general lack of available detailed information on roads for local transport as well as a lack of appropriate methodology, an approach to the analysis of local road transport, which did not rely on economic assessment methods, was required. This Paper presents an approach which evaluates the degree of equity between local government areas in terms of the provision of roads.

It is argued that a general state of equity develops between overall community expectations and the road system over a long period of time, and the point of analytical interest concerns inequities which might occur with respect to the general balance.

Two statistical techniques are used to allow the relationship between the provision of roads and the amount of usage of the roads for local transport to be examined, with the aim of determining the areas where the provision of roads and usage are not matched. These mismatched areas are then examined to determine possible mechanisms to produce an improved balance between the provision and usage of roads for local transport.

The findings lend support to the hypothesis that equity between local government areas in regard to road usage has been a major determinant of the level of provision of roads in each local government area. The statistical analysis reveals that the provision of roads for local government areas with similar characteristics is fairly consistent across the nation and that most anomalies (ie mismatched areas) seem to be related to areas where some form of structural change is taking or has taken place.

CHAPTER 1—INTRODUCTION

This Paper has been prepared primarily to provide input to the major Australian road system study conducted by the Bureau of Transport Economics (BTE). In achieving this objective, the Paper documents an unusual application of the two statistical techniques, Discriminant Analysis and Cluster Analysis.

This Paper is concerned with the provision of roads for local transport, in Australia. This type of activity is generally associated with the 'local road' system. The label 'local roads' covers roads which support many transport functions and which have physical qualities ranging from the short narrow back streets of the large cities to the thousands of kilometres of unformed roads in the centre of Australia. One point of concern to this study is the general lack of available detailed information on these roads, both physical and financial, as compared with arterial roads. This lack of information and the diverse nature of local roads has inhibited the development of mathematical models which would be suitable for analysing the performance of local roads. For these and other reasons, the application of conventional economic assessment methods to local roads has not been as successful as in the case of arterial roads. Within this overall framework the need was noted for the adoption of an alternative approach to the analysis of local road performance and an approach designed to take equity considerations into account was adopted. This approach relies on the condition that much of the investment for local roads is determined on the basis of equity rather than direct economic efficiency. Even the most basic road transport system requires that transport in the local community meets a viable minimal standard, and this standard tends to be related more to community expectations than to the availability of quantifiable economic benefits.

The study specifically set out to examine the relationship between the road system and its usage for local transport within various areas of Australia. As such it was concerned with some assessment of the relative distribution of the road system in terms of providing effective local transport. Clearly, in addition to its use of the local road network, local transport can and does make extensive use of the arterial network within a localised area, and it was therefore considered necessary to include all classes of road in the study. All these roads were only considered in terms of their relationship to their usage for local transport needs.

The use of local roads for local transport was investigated during the course of this study and the results were similar to those for the total road system. The differences between the results for the two situations tended to support the validity of using the total road system for this type of investigation.

The statistical techniques (Cluster Analysis and Discriminant Analysis) were used to classify geographic areas into groups that were similar with respect to their road system. This then provided a basis on which the reasons for the similarities among areas in each group and the difference between areas in different groups could be analysed. This allowed the relationship between the provision of roads and the amount of usage of the roads for local transport to be examined, with the aim of determining the areas where the provision of roads and usage were not matched. These mismatched areas could then be examined to determine possible mechanisms to produce an improved balance between the provision and usage of roads for local transport.

This is not an exhaustive study. It does point to areas where there is a need for further assessment of the road system, but the techniques could be used to provide a much more detailed appraisal of the provision of roads, given suitable data. The techniques presented here are useful in that they allow the analysis to handle a system which is unwieldy but which can be described using available statistics.

Since local government is largely responsible for the local road network, it seemed most appropriate to use the local government areas (LGAs) as the regional system for the analysis. Thus the level of detail presented in this Paper does allow individual local government areas to be examined and some general observations concerning their road systems and funding for roads to be made.

Chapter 2 discusses the underlying assumptions of the study and the techniques used to implement the work and follows with a discussion of the implementation. Chapter 3 presents the results and discusses general observations regarding the results. Chapter 4 concludes the Paper with a discussion on the usefulness of the study and the relevance of the techniques used.

CHAPTER 2—ASSUMPTIONS AND TECHNIQUES

GENERAL STUDY OUTLINE

The analysis is based on the assumption that over a long period of time an acceptable balance has been achieved on average between the levels of economic and social development and the supply of infrastructure (in this case roads) for the various communities[1]. This is not to say that any two areas of Australia, when compared with respect to any one of many descriptive variables that could be used to determine the distribution of the road system, are necessarily the same. The implication is that certain areas have developed a certain type of road system appropriate for their needs and as areas change in their economic and social characteristics, their road system changes to one more like those of areas that already have those types of economic and social characteristics. The premise being proposed is that developments at the 'local' level are determined to some extent by the notion of 'peers' which causes the infrastructure to be arranged in order to create an overall equity within a peer group.

Clearly there will be particular areas that do not meet this assumption, and these areas are identified for further examination in the following chapter. However, given the general balance assumed above, the method of investigating the relationship between the roads in an LGA and the usage of roads for local transport was accomplished by modelling the general state of equity and then examining how individual LGAs relate to this state.

No attempt has been made to produce a complex mathematical relationship in which all the possible parameters of the physical characteristics of the roads and the usage of them are included. The approach adopted was firstly to use a classificatory technique (Cluster Analysis) to form the LGAs into groups, each containing LGAs that have similar road systems, based on some measured physical characteristics of the roads. The group to which each LGA was classified then became a variable to be used in the second part of the analysis. The aim of this second part (based on Discriminant Analysis) was to determine the extent to which some measure of the use of roads in an LGA is related to the 'supply' of roads in that LGA, as determined in the cluster analysis.

These two phases of the analysis firstly allowed the diverse roads information available for each LGA to be manipulated to form a relatively small set of groupings of similar road systems. Secondly, various aspects of these groupings could be investigated, for example, the funding of the roads both within and between the groups, and the relationship of this funding to the level of use of the roads.

The overall analysis provided an overview of the provision and usage of roads on a regional basis by refining the information contained in the available statistics into a more manageable form.

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1. As noted in Chapter 1 the analysis was performed in terms of a regional system based on local government areas (LGAs). The abbreviation 'LGA' will be used for both local government authority and local government area. The context will make clear which one is intended. The total Australian road network has not been included as suitable data were not available for the unincorporated areas. The Northern Territory has been excluded as data were only available for four small urban areas. The Australian Capital Territory was also excluded as data were not available.

APPLICATION OF CLUSTER AND DISCRIMINANT ANALYSIS TO ROADS IN LGAs

The techniques of Cluster Analysis and Discriminant Analysis are not widely used in transport research, and as they are central to this study, a brief description of them is provided in Appendix I. The capability of the two techniques that is significant here is their facility to provide more concise information where there is a diverse set of parameters describing a given system[1]. This capability, to identify generalised patterns from a mass of apparently unrelated data, is the main benefit of this type of approach.

The cluster analysis generates a set of groups (clusters) of LGAs that are as different as possible from each other with respect to their physical road systems. This is a conventional application of the technique and the groups generated each comprise LGAs that have statistically similar road systems. This analytically-derived 'new' property of an LGA (that it has a road system which is to a degree similar to certain other LGAs, namely those in the same group) is used in the subsequent discriminant analysis as the dependent variable.

In deciding which variables were suitable for forming the LGA groups, on the basis of their road system similarities, it was necessary to decide which factors properly describe the physical nature of the road system. Clearly this is a difficult problem which roads planners have been forced to contend with over the years, but as the aim of this study was to gain an overview of the road system, the choice of factors was restricted to the following:

- the density of the road system, relative to the area;
- the density of the road system, relative to the population; and
- composition of the roads by type, that is, sealed, paved, formed and unformed.

Improvements in any of these factors provide a road system that has more utility to the community, in that it is able to carry more traffic without congestion, provides alternative routes, causes less wear on vehicles and so on. The specific variables that were considered relevant in describing the above factors and hence in describing the overall nature of the road system, were as follows:

- total road length;
- total length of sealed road;
- total length of surfaced road;
- total length of formed-only road;
- total length of unformed road;
- percentage of total road length that was sealed;
- population per unit length of road;
- area of the LGA;
- the total length of road per area of the LGA;
- LGA classification (capital city LGA, major urban LGA, rural LGA); and
- terrain indicator (coastal, flat, undulating).

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1. There are two types of data sets that were used in this study:
   - data relating to the physical state of the roads such as, length, surface type, width, etc which were used in the cluster analyses; and
   - data considered to relate to the level of local use of the road system, such as number of vehicles garaged at a dwelling, type of employment in the area, etc, which were used in the discriminant analyses.

   Much of this information was obtained from the Standardised Local Government Finance Statistics (SLGFS), the Australian Municipal Information System (AMIS) and the 1981 Census of Population and Housing.

Pragmatically, the choice of these variables was determined by the availability of appropriate data as well as their relationship to the factors of interest mentioned previously. Several cluster analyses were undertaken using all the variables as well as selected subsets of them, with the aim of identifying those variables which were making a significant contribution to the formation of the groups. The analysis provides statistics indicating which variables contributed to the formation of the groups and the amount of this contribution.

The analysis showed that many of these variables are strongly correlated (related statistically) and it was possible to substitute variables within the analysis and not produce a great change in the results. The results also showed that there was no single variable that was significantly more useful than the others, although three variables together were found to produce marginally better results in the following analysis and these variables were used for the subsequent work. The relevant variables were:

- the percentage of the total road length that was sealed (PRS);
- the total length of the road per unit area of the LGA (RPA); and
- the population per unit length of road (PLR).

The number of groups formed by a cluster analysis is determined subjectively by the analyst with the aim of classifying the individuals (LGAs in this case) into enough groups to avoid grouping obviously dissimilar individuals. The converse situation involving the formulation of so many groups that it is not possible to explain the differences between them should also be avoided. ('Cluster Analysis' was initially conceived as an aid in understanding and communication.)

This decision process for arriving at the number of groups can usually be guided by the existence of some naturally occurring groups or from precedents from related work. In the current study the hypothesis that all the States had different types of road systems could be postulated, and further, that within each State there were three or four different types of systems corresponding to road surface type. This suggested the number of groups should be between 20 and 30 so the analysis was carried out for 10, 20 and 30 groups. Examination of the results showed that 10 groups were insufficient since obviously dissimilar LGAs were grouped together. Further it was not clear why some of the groups in the analysis involving even 20 groups had been formed. In this case the analysis was separating LGAs which subjectively appeared to be very similar in terms of their road systems. The analysis was repeated for 15 groups which appeared to produce an appropriate balance in which LGAs with obviously similar road systems were grouped together, while those with obviously dissimilar road systems were separated into different groups. These groups are described in Chapter 3.

A list of the LGAs in each group is contained in Appendix II.

RELATIONSHIP BETWEEN GROUPS AND ROAD USAGE

At this point of the study, each LGA had been classified to one of 15 groups or clusters, and the fact that an LGA belongs to a particular group implied that the road system in that LGA was in some sense similar to the road systems in other LGAs in the same group and different from the road systems of LGAs in other groups. In the second part of the study Discriminant Analysis was used to determine the relationship between the group road supply characteristics of an LGA and the variables related to the level of usage of the roads for local transport in that LGA.

The variables considered to relate to the level of usage of roads for local transport were:

- percentage of people over 15 years of age attending an educational institution;

- percentage of households in each of 3 household income categories (less than or equal to $10 000, more than $10 000 but less than or equal to $22 000, more than $22 000);
- percentage of people in each of 4 employment categories (paid employment, unpaid employment, unemployed, not in labour force);
- percentage of employed people in each of 3 categories of mode of transport to work (non-road, public road transport, private road transport);
- percentage of employed people in each of 8 occupational groups (professional, administrative and clerical, sales, mining, transport, trades, services, armed services); and
- number of private dwellings with a given number of vehicles parked outside as defined by the Population Census (0, 1, 2, 3, 4+ vehicles).

It was considered that all of the variables listed above contributed to the overall requirement for local road transport in a community.

Discriminant Analysis produces discriminant functions that describe the relationship between the dependent variable (in this case the group number of an LGA) and any set of independent variables used. Furthermore, this type of analysis will attempt to explain as much of the variance in the dependent variable as possible using these independent variables. This is the point where it is possible to inter-relate the two diverse sets of variables describing road supply and usage characteristics respectively. If as in the present case, the independent variables are chosen so that they relate to the level of usage of the road system for local transport, then the discriminant analysis will determine the amount of variation in the characteristics describing the provision of the road system which is actually related to the variation in the usage characteristics.

The discriminant analysis was undertaken using all the listed variables. The two variables 'percentage of people not in the labour force' and 'percentage of employed people using private road transport to work' were excluded from subsequent analyses as they were not statistically significant; that is, they did not assist in explaining any of the variation in road system supply characteristics.

RELATIONSHIP BETWEEN THE NATURE AND USAGE OF THE ROAD SYSTEMS IN LGAs

It has been noted that one aim of the study was to examine the relationship between the physical characteristics of the existing road system and the level of local use made of that system. In order to undertake this examination a discriminant analysis was used as an extension of the initial analysis with the aim of 'predicting' the particular group to which each LGA should be classified on the basis of its level of road use. Where there was a mismatch between the group membership determined by the original cluster analysis (based on existing road characteristics) and that predicted by the discriminant analysis, the LGA was at least a potential candidate for consideration as an 'outlier' (ie its road system as described by certain characteristics is not matched to the level of use of the road system as determined by the economic and demographic variables examined). However, it should be noted that LGAs really represent a continuum in terms of their individual characteristics and hence two LGAs that are misclassified in an apparently similar manner can nevertheless differ from each other to a varying extent. Hence the degree to which LGAs were mismatched was also taken into account in eventually defining the true outliers. This process ensures that LGAs that have been classified into an adjacent group by the discriminant analysis, but which still show road usage characteristics somewhat similar to their peers from the cluster analysis, are not treated in the same manner as LGAs with more obvious mismatches. Thus an LGA has to be reclassified by the discriminant analysis to a group that is not one of its adjacent groups before it is regarded as an outlier.

In addition, a second criterion was employed to identify genuine outliers. The second criterion used an output from the discriminant analysis. The classificatory functions in the analysis generate values for each LGA, and these values are then compared with the generated values for each group as a whole. The reclassification produced by the discriminant analysis uses this comparison to reclassify each LGA to the group with the closest value. It also enables comparisons with all the other groups so that it is possible to say which is the second most similar group to which the LGA of interest could have been classified by the discriminant analysis, and the third and fourth and so on. Thus the second criterion which was adopted specified that an LGA was not an outlier if the second most similar group was that originally determined for it by the cluster analysis.

This process can be illustrated graphically by considering Figure 2.1. To assist in illustrating the concept, Figure 2.1 assumes that the road system is described by a one dimensional quantity and an individual LGA will reside at some point on the line. If the point happened to be A, for example, then it is not unreasonable that errors in the measurement and manipulation of data could yield a statistical error (shown by 'e' in Figure 2.1) in determining the likely group membership using the discriminant analysis. Due to the small number of groups in this study it is unlikely that this error would be large. However to provide a conservative estimate of mismatches between the supply of roads and the level of their local usage, the inclusion of the adjacent Groups 6 to 8 in Figure 2.1 was considered to be an acceptable range for the LGA to belong to Group 7. If the reclassification based on the discriminant analysis placed the LGA at point B then there is clearly a mismatch between the group determined from the road system characterisation and the group based on usage. In this case the LGA could be regarded as a genuine outlier.

The above procedure assumes a one dimensional grouping. The three dimensional situation actually used to form groups was not readily transferable to a three dimensional ranking. The ranking of the groups that was used was based on a composite measure generated by the three variables describing the road system, and provided a reasonable indication of the 'nearness' of the various groups. This process is described in more detail in Appendix V where the groups are presented in terms of the three selection variables.

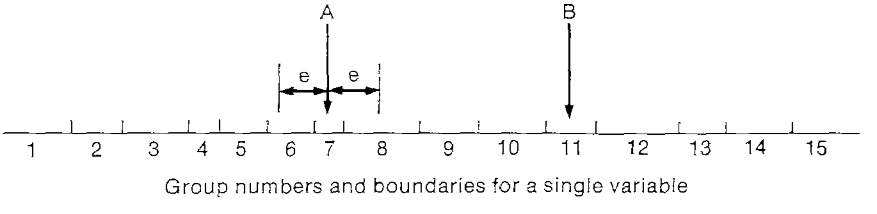

Figure 2.1—One dimensional illustration of group members

CHAPTER 3—RESULTS OF THE ANALYSIS

CHARACTERISATION OF LGA GROUPS

In assessing the groups of LGAs formed by the cluster analysis a question of interest is that of determining which groups represented LGAs with a 'better' road system than other groups. Unfortunately this is a matter which has no simple solution. Any road system has many attributes that can contribute to its physical state, and improvements in any of these attributes can produce a 'better' road system. As noted previously, this study has used three variables to describe the physical state of the road system and thus produced the groups containing LGAs with similar road systems. Change in any or all of these three variables can produce a 'better' or 'worse' road system. The study has used the assumption that all three factors carry equal weight when forming the groups and this assumption has been carried through in creating a ranking of the groups in increasing order of road system 'quality' for tabulation and discussion purposes. This ranking can be used as a guide to the 'quality' of the system, although it really only implies that LGAs in Group 1 have a lower average percentage of road sealed, a lower population per kilometre of road and less road per square kilometre than LGAs in groups with higher numbers. This general relationship holds reasonably among groups on the basis of all three variables used, but the values of individual variables can vary among the groups. This situation can be observed in Table III.1 in Appendix III which includes the average values of the three variables characterising the road system in LGAs for each group.

Appendix II contains the LGAs in each group as produced by the cluster analysis. The groups, while being recognisably different in a casual scanning, produce problems when an attempt is made to define these differences explicitly. It is likely, for example, that observations on disparate LGAs such as Manly (New South Wales, Group 11), Gladstone (Queensland. Group 9) or Broken Hill (New South Wales, Group 9) will vary with the background and preconceptions of the individual making those observations. Having noted this qualification a description of these groups is undertaken in the next few paragraphs.

As might be expected, the largest difference between LGAs in terms of the physical nature of their road system corresponds to the urban/rural dichotomy. This is shown in the cluster analysis where the first (and therefore most important) grouping of the data separates the LGAs in Groups 1 to 6 from the LGAs in Groups 7 to 15. The LGAs in Groups 7 to 15 have essentially no rural component[1], whereas the LGAs in Groups 1 to 6, while occasionally possessing some urban characteristics are mostly rural in land use.

Groups 1 and 2 are clearly the rural LGAs with very low population densities and a road system that is mainly unsealed. Group 1 covers much of the non-coastal area of Australia while Group 2 follows the east coast with pockets in West Victoria and Coastal Western Australia. These LGAs tend to be rural communities with small townships that geographically correspond with a medium rainfall of 50 to 75 cms per year.

Groups 3 and 4 are mostly coastal LGAs containing small to medium communities

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1. Group 7 is the single LGA Torres which appears to be an outlier with respect to most variables describing the road system.

with several pockets clustered through Victoria, northern New South Wales and near Sydney. LGAs in these groups might be characterised as comprising small rural towns with a stable environment and rural industry. Groups 5 and 6 are similar to Groups 3 and 4 in that they tend to be small rural areas, but in these cases the urban areas amount to a larger proportion of the total LGA areas. Furthermore, the population densities tend to be higher than in LGAs contained in the previous two groups.

Group 7 comprises the single LGA of Torres (Queensland). This LGA, due to its locality and physical state (it encompasses several islands and the tip of the mainland), has no peers in the terms of this study.

Groups 8 and 9 comprise large towns and cities in the rural areas such as Ballarat (Victoria) and Port Pirie (South Australia) and the large communities on the outskirts of capital cities such as Queanbeyan (New South Wales), Gawler (South Australia), Liverpool (New South Wales), and Sunshine (Victoria). These LGAs have characteristics that could be described as basically urban in a rural setting. They are large communities with the associated secondary industries but they have social and economic connections to the adjacent rural areas.

The LGAs in Groups 10 to 15 generally comprise suburbs of the capital cities. These LGAs generally show increases in the three variables defined in Chapter 2 from Group 10 to Group 15 ie, the percentage of the total road length that is sealed, the total length of the road per unit area of the LGA and the population per unit length of road. However, there are individual anomalies in Group 10 in the percentage of the total road length that is sealed, Group 11 for the population per unit length of road and Group 12 for the total length of road per unit area where larger increases occur. These overall increases in the variables coincide with the general increase in population density with the exception of Group 12 which has a high population density. Group 12 is composed of small, established inner suburbs with a dense network of roads.

COMPARISON OF LGAs BY ROAD SUPPLY AND USAGE

As described in Chapter 2 the result of the discriminant analysis at its simplest level is a list of LGAs that have road systems which are mismatched to the usage of roads relative to the other LGAs in Australia. In the terminology of Chapter 2 these LGAs are outliers. The formulation of this list of outliers is accomplished within the discriminant analysis using the eight discriminant functions that were statistically significant. Each function has a weighted effect on the outcome of the list and within each function the individual variables also have a weighting attached to them. This multi-dimensional process sometimes makes it difficult to understand why an LGA has been isolated by the analysis as being somehow similar to a particular group of LGAs when a casual examination will sometimes suggest there are no similarities at all.

This problem arises because of the difficulty in interpreting the various dimensions. Fortunately in most cases the limited approach of comparing individual variables for the outlier LGAs and the corresponding averages for the groups is sufficient to show why an LGA has been selected as an outlier by the discriminant analysis. Figure 3.1 and the figures in Appendix III can be used for the same purpose but it should be realised that they are only useful as guides. Figure 3.1 plots the average values of some of the significant variables for Groups 5 and 9 and the corresponding actual values for the LGA of Wyong (New South Wales). Wyong is an LGA in Group 5 which has been reclassified in Group 9 by the discriminant analysis. That is, Wyong's road characteristics are more rural in nature than would be consistent with its relative level of road usage.

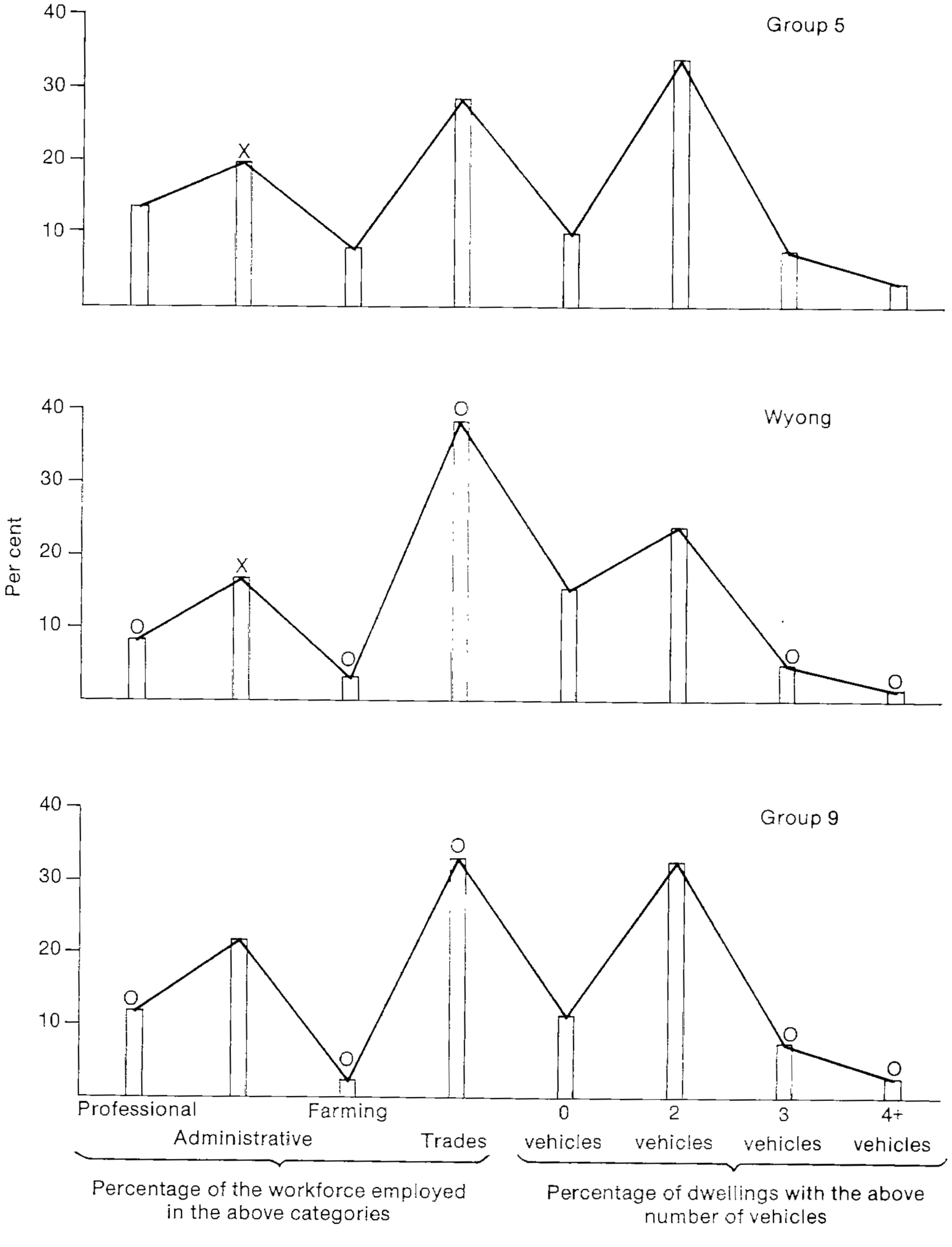


Figure 3.1—Comparison of selected variables for Wyong with the averages for group 5 and group 9

Bearing in mind that the variables are weighted in the discriminant analysis, this two dimensional representation of some of the usage variables shows why Wyong is closer in value to Group 9 than to Group 5. The circled vertices represent variables which are closer to the average for Group 9, the crossed ones which are closer to Group 5 and the unmarked ones where there is little difference between the averages for Groups 5 and 9.

Based on the above presentation, the LGAs classified as outliers are listed in Table 3.1. There are sixty-nine such LGAs, amounting to 8 per cent of the total. These

TABLE 3.1—LGAs DISPLAYING A MISMATCH BETWEEN ROAD SUPPLY AND USAGE VARIABLES

LGA	*State*	*Group number for road supply*	*Group number for usage*
	PART A Areas where road supply appeared high in relation to usage		
Holbrook	NSW	4	1
Junee	NSW	4	2
Snowy River	NSW	4	2
Belfast	Vic	4	2
Dundas	Vic	4	2
Hampden	Vic	4	2
Minhamite	Vic	4	1
Mortlake	Vic	4	2
Mt Rouse	Vic	4	2
Pyalong	Vic	4	2
Wannon	Vic	4	2
Warnambool	Vic	4	2
Mirani	Qld	4	1
Campbelltown	Tas	4	1
Renmark	SA	5	3
Koroit	Vic	6	4
Mulgrave	Qld	6	4
Queenstown	Tas	6	4
Sale	Vic	8	5
Sebastopol	Vic	8	6
Port Lincoln	SA	8	5
Broken Hill	NSW	9	4
Moe	Vic	9	6
Traralgon	Vic	9	6
Cairns	Qld	9	6
Ipswich	Qld	9	6
Devonport	Tas	9	5
Croydon	Vic	10	5
Mt Gambier	SA	10	5
Dandenong	Vic	11	9
Mackay	Qld	11	8
Waverley	Vic	13	9
Marion	SA	13	11
Woodville	SA	13	11
Holroyd	NSW	14	11
Chelsea	Vic	14	11
Moorabbin	Vic	14	11
Nunawading	Vic	14	9
Bayswater	WA	14	10

TABLE 3.1(Cont)—LGAs DISPLAYING A MISMATCH BETWEEN ROAD SUPPLY AND USAGE VARIABLES

LGA	*State*	*Group number for road supply*	*Group number for usage*
	PART B Areas where road supply appeared low in relation to usage		
Burke	Qld	1	7
Mornington	Qld	1	7
Cooma-Monaro	NSW	2	5
Yarrowlumla	NSW	2	10
Mansfield	Vic	2	8
Katanning	WA	2	8
Pirie	SA	2	8
Merredin	WA	2	8
Wagga Wagga	NSW	3	6
Noosa	Qld	3	8
Kadina	SA	3	8
Meadows	SA	3	5
Mt Barker	SA	3	5
Lilydale	Tas	3	6
Bega Valley	NSW	4	8
Wyong	NSW	5	9
Warragul	Vic	5	8
East Torrens	SA	5	13
Stirling	SA	5	13
Kingborough	Tas	5	10
Gosford	NSW	6	11
Hornsby	NSW	6	10
Charters Towers	Qld	6	8
Port Melbourne	Vic	8	11
Gawler	SA	8	10
Newcastle	NSW	9	14
Hobart	Tas	9	13
Adelaide	SA	10	12
Manly	NSW	11	14
Willoughby	NSW	11	14

LGAs have road systems that are not matched to the usage of the road system for local transport, in comparison with other LGAs. The analysis can therefore at least point to LGAs which might be examined for the possible institution of modifications to the local road system to reflect more adequately the particular needs of each community.

The LGAs that have larger differences between the *group numbers* for the road supply and road usage have a corresponding larger difference in the mismatch in the road supply and road usage than for LGAs with smaller differences in the group numbers. The upper part of Table 3.1 contains the outlier LGAs that have road usage more consistent with less developed LGAs while the lower part of the table contains outlier LGAs with the opposite mismatch of road supply and usage.

As discussed above it is usually possible to explain why any particular LGA has been classified differently in terms of its road supply and road usage characteristics respectively, by examining the variables used in the analysis. It is also interesting to note how the classification of the LGAs relates to the funding received by the LGA for the roads. The figures used for this are taken from AMIS as 'Road Revenue

Expenditure'[1]. While not being totally satisfactory for the purposes of this study, it was considered to give an indication of the amount of expenditure on maintenance of the roads within the LGAs.

Renmark (South Australia) has a road system more aligned with a rural municipality (Group 5) or town but has a lower proportion of tradesmen and a higher proportion of farmers than other Group 5 LGAs. Thus its demand for road usage more closely approximates that of a rural shire. Its road funding was consistently low over the period 1968 to 1980 compared to the other LGAs in Group 5, and this would have the effect over time of degrading the road system to a level more consistent with demand (as measured by the variables used in this study). There are a number of older established farming areas (the 14 LGAs in Group 4 shown in the upper part of Table 3.1), which have declining populations. These LGAs have lower demand now for roads than their peers in Group 4 and, like Renmark, have reduced their road funding in line with the apparently decreasing demand[2].

Areas noted in Table 3.1, where the road system is consistent with larger rural towns (Group 9) generally have a lower proportion of administrative workers than other LGAs in Group 9. This would indicate a demand for the roads which is closely aligned with the smaller towns in rural areas. Broken Hill (New South Wales) has a proportion of the workforce employed as tradesmen and administrators more consistent with a smaller rural town but has had road funding consistent with maintaining the road system of a large rural town despite this apparent lower demand. Moe (Victoria) and Ipswich (Queensland) initially had road funding consistent with the demand but over the period have steadily increased this expenditure to a level comparable with larger rural towns. This implies that these LGAs have actively pursued the development of a road system appropriate for a large rural town. The population of Moe is however, relatively small resulting in the mismatch noted in Table 3.1.

Some of the more urban areas shown in the upper part of Table 3.1 have declining populations and road funding which suggests that the condition of their road systems, as described by the three basic variables used in the cluster analysis, will decline over time to match the decreasing demand more closely. The exceptions are Mackay (Queensland), Marion (South Australia), Holroyd (New South Wales), Chelsea (Victoria) and Bayswater (Western Australia) where there has been a slow increase in expenditure over the period. However, they are all spending less than the average expenditure of their groups. Mount Gambier (South Australia) from Group 10 is the only LGA in the group that is not close to a capital city and the usage variables are also inconsistent with being in this group. Its 'usage' variables suggest that it should have a road system more consistent with those of Group 5, to which it is similar in physical and geographical terms, ie a rural town in a rural environment.

In the lower part of Table 3.1 are grouped the LGAs with road demand comparable with more developed LGAs. Some improvement in the road system in these areas would be required to match usage levels. The LGAs Burke (Queensland) and Mornington (Queensland) have both been classified by the discriminant analysis as having a usage of roads similar to the LGA Torres (Queensland). Apart from the geographic proximity of these LGAs they are also similar with respect to most variables used to estimate their usage of roads. There are a number of LGAs, such as Cooma-Monaro (New South Wales), with road systems typical of rural areas in Groups 2 and 3, but which tend to have relatively fewer farmers and correspondingly higher proportions of administrators and trades people, than in their peer LGAs. This demographic pattern is more typical of the more developed LGAs in terms

1. For a more detailed explanation of this variable see Appendix IV.
2. It is not suggested that the changing funding levels discussed in this section are a direct result of any explicit recognition of a mismatch between road supply and demand as identified by the analysis. Rather the discussion merely illustrates that there is a consistency between the analytical results and the behaviour of the authorities in allocating their financial resources.

of the road system. This imbalance between supply and usage appears to be a stable condition as all LGAs in this situation have had relatively low levels of road funding over the period 1968 to 1980. Many of the areas where the road systems appear less developed than would be expected are areas where development tends to outstrip the existing road system. In some of the rural areas the development of 'hobby farms' may well be a factor while some more developed areas (eg Wyong, Gosford, Hornsby) reflect the population pressure of large metropolitan areas in their immediate vicinity.

Gosford (New South Wales) is typical of a few of the LGAs in Groups 4, 5 and 6 which also have proportionately fewer farmers and higher proportions of administrators and trades people than the average for these groups. With respect to road funding, the LGAs in these groups divide into two categories. The first category is represented by LGAs that have relatively low expenditure on roads which is also remaining relatively constant in real terms. The second category comprises Bega Valley (New South Wales), Gosford (New South Wales) and Charters Towers (Queensland) in which expenditure is increasing but remains relatively low. These LGAs are therefore also unlikely to see a large change in their road system.

LGAs in Groups 8 and 9 have road systems similar to large rural towns or outer suburban regions. Port Melbourne (Victoria) is an inner city suburb and has a socio-economic environment consistent with this. The demand variables are more consistent with the inner city suburbs, such as relatively more trádesmen, fewer agricultural workers and fewer private vehicles per household compared with its peers in Groups 8 and 9. Road funding in Port Melbourne has surprisingly also been similar to that of an inner city suburb (which is higher than for Group 9 LGAs on average) without having to maintain a road system consistent with the inner city suburbs. Similar observations concerning Gawler (South Australia), Newcastle (New South Wales) and Hobart (Tasmania) can be made concerning the road system and the usage variables and also concerning funding for Newcastle. Gawler and Hobart have funding that is not likely to produce a change in the road system.

Adelaide (South Australia), and Manly (New South Wales) have road systems more typical of outer suburbs of metropolitan areas possibly because of the density and connectivity of their road systems. They do however have the socio-economic environment of an inner city suburb and this is reflected in the usage variables where, for instance, the proportion of administrators is high and the number of private vehicles is comparatively low. They have all had relatively high levels of road funding over the time period at least equal to the average for the groups that their usage is similar to. This suggests that local circumstances may be influencing the development of the road system in a direction not accounted for by the current analysis, since comparatively high funding levels have still resulted in the mismatches noted by Table 3.1.

CHAPTER 4—CONCLUDING REMARKS

This Paper documents two points:

- the use of quantitative techniques to condense diverse information (in this case, concerning road supply and road usage characteristics) into a form which can assist in understanding and interpretation; and
- the application of the techniques to provide some insight into the degree of regional equity involved in the provision of the Australian road network for local transport.

The first point, superficially, concerns the techniques as they were used in this study. However, more importantly, it concerns the general problem analysts face when dealing with large amounts of seemingly unrelated information and they have a requirement to understand the system described by that information. By suitable choice of variables it is possible to produce a compact set of groups that contain the information of interest and are small enough to be assimilated. Possible areas of use are in condensing survey results to identify areas for more intensive investigation, or forming geographic regions for specific studies. In this way it parallels the use of stratification in sample surveys.

With respect to the second point the Paper has examined the relative provision of roads for local transport. It has been argued in Chapter 1 that economic efficiency criteria are not really appropriate in the determination of an adequate road system for local transport. Rather, it is argued, a general state of equity develops between overall community expectations and the road system and the point of analytical interest concerns inequities which might occur with respect to the general balance. These inequities or mismatches between road supply and road usage at the local level have been the subject of this Paper.

By identifying where such mismatches occur through the application of Cluster and Discriminant Analysis, additional information becomes available which could be taken into account in decisions concerning the relative allocation of road funding. The analysis indicates that many of the mismatches occur in areas where some form of structural change is taking place or has taken place. The study was not able to determine a relationship between these changes and the general funding for roads in these areas although intuitively such a relationship should exist. The ability to determine mismatches and hence LGAs of particular interest, based on the type of variables used in this study, should be of use in the allocation of funds to reflect more closely the structural changes in LGAs.

The process of changing the supply of the road system to match the usage of the road system is a long term process which can be enhanced by projecting the usage of roads into the future. In this analysis the usage of roads has been determined using a set of demographic variables which have been fairly stable over time and would be relatively easy to project into the future. By inserting a set of projected variables into this analysis it would be possible to predict the relative state of the road system needed at a future time to match the projected usage of roads for local transport. Hence the implications of possible financial mechanisms to achieve an appropriate distribution of roads for local transport could at least be examined.

APPENDIX I—DESCRIPTIVE SUMMARY OF ANALYSIS TECHNIQUES

CLUSTER ANALYSIS

Cluster Analysis is a classificatory technique. Such techniques are generally used where there is a need to extract information relating to a specific subject from a broader set of general statistics. Because the techniques are used for highlighting pertinent information from the irrelevant, they can be considered as an aid in the communication and interpretation of information. Readers requiring a detailed exposition should consult a formal text (Williams 1976).

Cluster Analysis accomplishes this classificatory function by forming individuals in the population being examined into groups, each of which contain individuals which are similar with respect to the parameters or variables of interest, and which differ from the individuals in the other groups with respect to the same variables. Several methods are available for forming the groups and several measures can be used to determine the differences between the groups. To illustrate the basic principles a simple example will be discussed. Consider a requirement to classify all children in a school into the two categories of short and tall.

If the heights of the children are plotted on a scale as in Figure I.1, then a cluster analysis would find a point C where the mean value (ML) of all the children's heights below C, would be as different as possible from the mean value of the children's height above C (MH). In other words the analysis would maximise the value of L shown on Figure I.1. Clearly this illustration is elementary and in practice Cluster Analysis is used where the groups are formed using more than a single descriptive variable.

The cluster analysis undertaken in this study used a divisive, polythetic strategy to form the clusters. This type of strategy takes a large group of individuals and, based on several variables describing these individuals (polythetic), divides the large group into successively smaller ones.

The groups are formed stepwise, and at each step, only one group is divided (illustrated in Figure I.2). At each step the group chosen to be further divided is that which contains individuals which exhibit the greatest differences. The process continues until the number of groups is either equal to the number of individuals, with each group containing only one individual (a situation which is clearly worthless from an interpretive point of view) or until a specific number of groups has been formed.

The procedure to determine a measure of the difference between the individuals

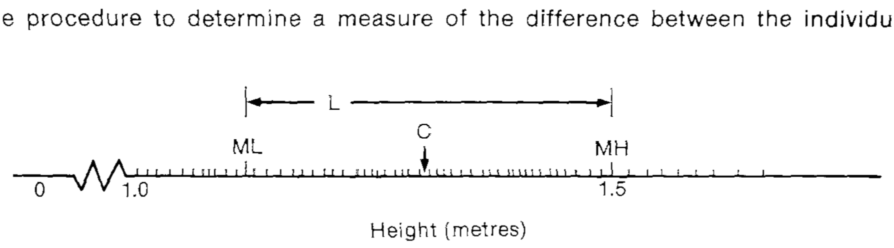


Figure I.1—Children's height

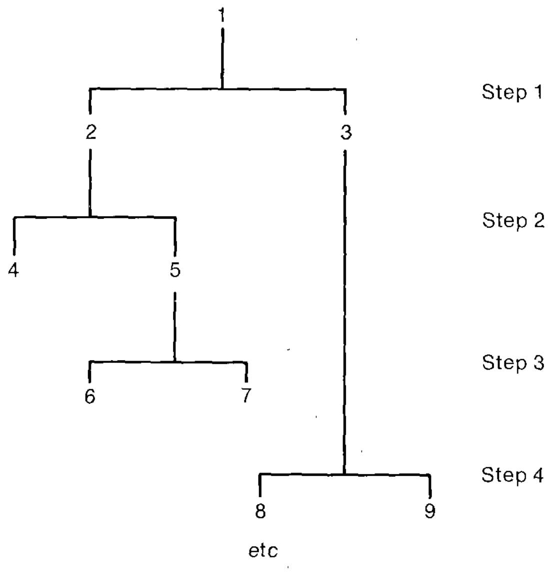


Figure I.2—Step-wise divisive strategy

of a group and the magnitude of this difference is both complex and time consuming even using powerful computers. However, as an aid in understanding the process a simple example is given below[1].

For the case where the analysis is to be performed on individuals having only two variables (attributes) describing them, the process can be represented graphically.

If LGAs are considered as the individuals to be classified, and the length of road and the population are the descriptive variables, then each individual point plotted on Figure I.3 represents the two variables descriptive of each LGA.

A line (principle component) through these points can be drawn. The line is such that, if lines as shown on Figure I.3 are drawn from each point to the principle component and the sum of the lengths of these short lines is calculated then this sum will be less for the principle component than for any other possible line. Put simply, the principle component is the line which is as close as possible to (on average) all points on the graph. More importantly, this means that points at one end of the principle component have attributes that are very different from the attributes of the points at the other end.

By choosing any point on the principle component (say Point A on Figure I.3) two groups can be formed. All LGAs that have perpendiculars that intersect with the principle component on the lower side (L) of A form one group and the remainder form the other group (U).

By moving the point A along the line the groups will contain different individual members (LGAs) and the point where the two groups are most different determines the correct configuration of the groups. The maximum differences between the two

1. For the statistically knowledgeable reader Williams (1976) gives an elegant summary of the process: 'The inter-attribute correlation matrix is calculated, the first principle component extracted, and the individual co-ordinates on this component obtained by using ... post-multiplication; these co-ordinates are then sorted into order, and the string dichotomised at the point at which the between-group sum of the squares of deviations from the mean is maximum'.

groups occurs when the sum of the distances between the group mean of one group and the individual points of the other group is a maximum.

Figure I.4 illustrates the distance (H_i) between the ith LGA (LGA_i) in the upper group and the mean (geometrical point) of the lower group. The distance K_i illustrates the converse situation. The sum of the distances $H_i + K_i$ for all i is maximum when the two groups have been correctly formulated.

DISCRIMINANT ANALYSIS

The following description of Discriminant Analysis is intended to allow the reader to gain some feeling for the technique and its use. Those readers requiring a more detailed understanding of the technique should consult a formal text (Stopher 1979).

Discriminant Analysis has many parallels in regression theory and this explanation will make extensive use of these parallels. The similarity between the two is not coincidental as Discriminant Analysis was developed as a generalisation of regression theory for the situation when the dependent variable is not continuous. Examples of this are how politicians will vote on certain issues, which car is most suitable for 'business' needs, etc. In both these examples the dependent variables, voting for or against an issue, and the car which is chosen, can only have discrete values. Conventional regression techniques are not applicable to these cases.

Discriminant Analysis can be used for two purposes; an analytical one, where it is used to determine the relationship between a discrete dependent variable and a set of discriminant variables (equivalent to the independent variables in a regression), and a predictive or classificatory one, where, given a set of discriminating variables, it is possible to predict the expected value of the dependent variable. It should be noted that this predictive function requires the prior determination of the analytical relationship.

The mechanism by which Discriminant Analysis quantifies the relationship between

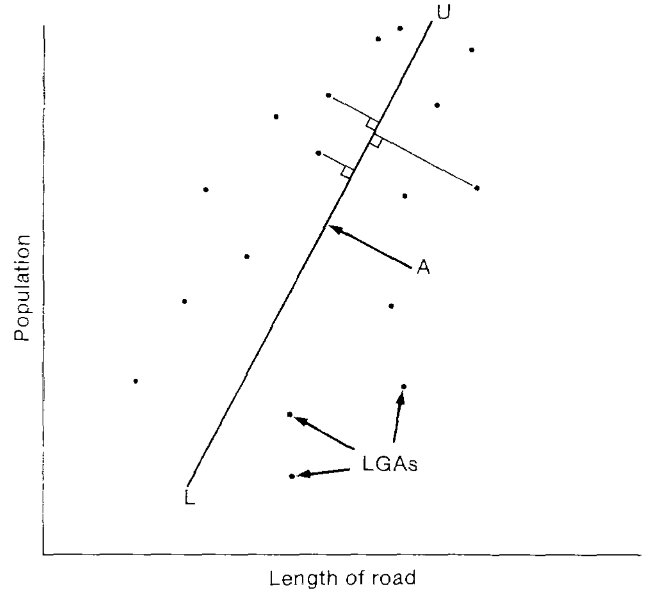


Figure I.3—Distribution of population and road length of LGAs

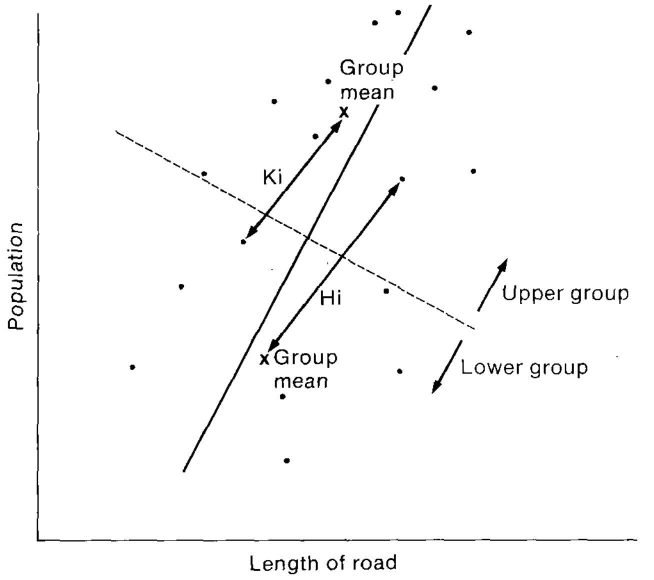


Figure I.4—Graphical representation of the difference measure

the dependent variables and the discriminating variables is most easily seen by way of an illustrative example.

Consider the case where a decision has to be made as to whether a bridge should be repaired, rebuilt or replaced. The dependent variable in this case has three states and the discriminating variables are likely to be the age of the bridge, the materials used for its original construction, the level of usage, and the amount of time since the bridge was last repaired. Given these data for past decisions on repair or replacement of bridges it is possible to use a discriminant analysis to quantify the decision process.

A Discriminant Analysis generates a number of discriminating functions (two in this case) that linearly combine and weight the discriminant variables. These functions are formed so that when the values of the discriminating variables of individuals (bridges) are inserted into the functions, the resulting solutions for each of the three states are as different as possible. This can be seen graphically by examining Figure I.5, where the axes represent values of the two discriminant functions respectively.

If the discriminant variables for each bridge are inserted into the two discriminant functions then the results for the functions can be used as the co-ordinates to allow each bridge to be plotted as in Figure I.5. The discriminant functions maximise the separation between points A, B and C, where A, B and C are the average values of all bridges that were repaired, rebuilt, and replaced respectively.

The ability of Discriminant Analysis to classify individuals can also be shown using the example. For the situation where the future of a bridge is being reviewed, the discriminant variables for the bridge can be inserted into the discriminant functions discussed above and the position of the bridges plotted on a graph such as Figure I.5. The position of the bridge on the graph will show the most probable action required based on past decisions, ie if it is closest to point A, say, then it will require repairing, closest to B it will require rebuilding, and closest to C it will require replacing.

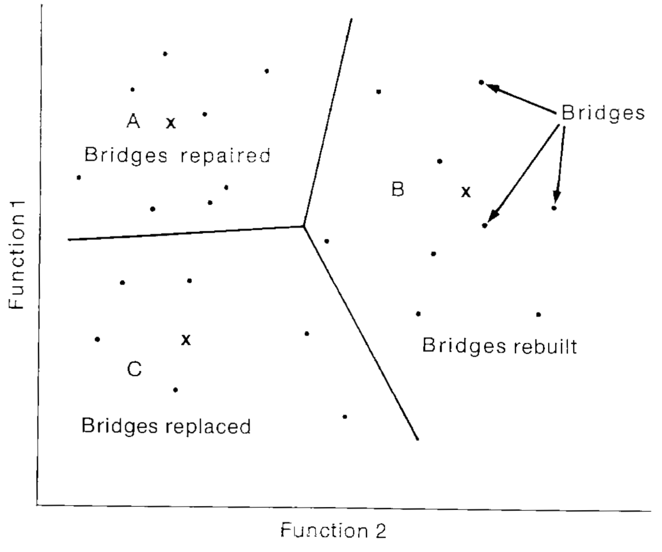


Figure I.5—Graphical representation of a discriminant analysis

APPENDIX II—IDENTIFICATION OF GROUP MEMBERS OBTAINED FROM ANALYSIS OF ALL ROAD CATEGORIES

This Appendix contains the LGA members of each of the groups used in the study. Each group contains LGAs that have road systems similar to each other and different from the road systems of the LGAs in the other groups. The following list shows the name, type and State of each LGA in the 15 groups.

The items (C), (S), (M), (B), (T) and (DC) identify cities, shires, municipalities, boroughs, towns and district councils respectively. The terms Part A and Part B refer to the town and country parts of those LGAs which had both a township and a country component.

Group 1

New South Wales

Balranald (S)
Bland (S)
Bogan (S)
Bourke (S)
Brewarrina (S)
Carrathool (S)
Central Darling (S)
Cobar (S)
Conargo (S)
Coonamble (S)
Lachlan (S)
Merriwa (S)
Wakool (S)
Walcha (S)
Walgett (S)
Wentworth (S)
Yallaroi (S)

Victoria

Donald (S)
Gordon (S)
Kaniva (S)
Kara Kara (S)
Karkarooc (S)
Kerang (S)
Korong (S)
Lowan (S)
Mildura (S)
Omeo (S)
Stawell (S)
Walpeup (S)
Wimmera (S)
Wycheproof (S)

Queensland

Aramac (S)
Aurukun (S)
Balonne (S)
Banana (S)
Barcaldine (S)
Barcoo (S)
Bauhinia (S)
Belyando (S)
Bendemere (S)
Biggenden (S)
Blackall (S)
Booringa (S)
Boulia (S)
Bulloo (S)
Bungil (S)
Burke (S)
Carpentaria (S)
Chinchilla (S)
Cook (S)
Croydon (S)
Dalrymple (S)
Diamantina (S)
Eidsvold (S)
Etheridge (S)
Fitzroy (S) Part B
Flinders (S)
Ilfracombe (S)
Inglewood (S)
Isisford (S)
Jericho (S)
Longreach (S)
McKinlay (S)
Millmerran (S)
Miriam Vale (S)
Monto (S)
Mornington (S)
Murrila (S)
Murweh (S)
Nebo (S)
Paroo (S)
Peak Downs (S)
Perry (S)
Quilpie (S)
Richmond (S)
Tambo (S)
Tara (S)
Taroom (S)
Waggamba (S)
Warroo (S)
Winton (S)

South Australia

Balaklava (DC)
Beachport (DC)
Blyth (DC)
Browns Well (DC)
Burra Burra (DC)
Bute (DC)
Carrieton (DC)
Cleve (DC)
Clinton (DC)
Coonalpyn Downs (DC)
Dudley (DC)
Elliston (DC)
Eudunda (DC)
Franklin Harbour (DC)
Georgetown (DC)
Hallett (DC)
Hawker (DC)
Jamestown (DC)
Kanyaka-Quorn (DC)
Karoonda-East Murray (DC)
Kimba (DC)
Kingscote (DC)
Lacepede (DC)
Lameroo (DC)
Le Hunte (DC)
Lincoln (DC) Part B
Lucindale (DC)
Mallala (DC)
Morgan (DC)
Mount Pleasant (DC)
Mount Remarkable (DC) Part B
Murat Bay (DC)
Naracoorte (DC)
Orroroo (DC)
Owen (DC)
Peake (DC)
Penola (DC)
Peterborough (DC)
Pinnaroo (DC)
Port Macdonnell (DC)
Port Wakefield (DC)
Redhill (DC)
Ridley (DC)
Riverton (DC)
Robe (DC)
Robertson (DC)
Saddleworth and Auburn (DC)
Snowtown (DC)
Spalding (DC)
Streaky Bay (DC)
Tatiara (DC)
Truro (DC)
Tumby Bay (DC)
Warooka (DC)

Western Australia

Boyup Brook (S)
Broomehill (S)
Chapman Valley (S)
Coorow (S)
Cranbrook (S)
Cuballing (S)
Cue (S)
Dalwallinu (S)
Dandaragan (S)
Denmark (S)
Dowerin (S)
Dumbleyung (S)
East Pilbara (S)
Esperence (S)
Gnowangerup (S)
Halls Creek (S)
Kellerberrin (S)
Kent (S)
Kojunup (S)
Kondinin (S)
Koorda (S)
Kulin (S)
Lake Grace (S)
Laverton (S)
Leonora (S)
Meekatharra (S)
Menzies (S)
Morawa (S)
Mount Magnet (S)
Mount Marshall (S)
Mukinbudin (S)
Mullewa (S)
Murchison (S)
Nannup (S)
Narembeen (S)
Narrogin (S)
Northhampton (S)
Nungarin (S)
Perenjori (S)
Ravensthorpe (S)
Sandstone (S)
Shark Bay (S)
Tambellup (S)
Tammin (S)
Three Springs (S)
Trayning (S)
Upper Gascoyne (S)
Wandering (S)
West Arthur (S)
West Kimberley (S)
West Pilbara (S)
Westonia (S)
Wickepin (S)
Williams (S)
Wiluna (S)
Woodanilling (S)
Wyalkatchem (S)
Wyndham-East Kimberley (S)
Yalgoo (S)
Yilgarn (S)

Tasmania

Bothwell (M)
Bruny (M)
Esperance (M)
Fingal (M)
Flinders (M)
Portland (M)
Ringarooma (M)
Ross (M)
Strahan (M)

Group 2

New South Wales

Barraba (S)
Bingara (S)
Bombala (S)
Boorowa (S)
Cabonne (S) Part B
Coolah (S)
Coolamon (S)
Cooma-Monaro (S)
Coonabarabran (S)
Copmanhurst (S)
Corowa (S)
Crookwell (S)
Dumaresq (S)
Evans (S) Part B
Forbes (S)
Gilgandra (S)
Gloucester (S)
Gundagai (S)
Gunnedah (S)
Gunning (S)
Guyra (S)
Hay (S)
Hume (S)
Inverell (S) Part A
Jerilderie (S)
Kyogle (S)
Lockhart (S)
Manilla (S)
Moree Plains (S)
Mudgee (S)
Mulwaree (S)
Murray (S)
Murrumbidgee (S)
Murrurundi (S)
Narrabri (S)
Narrandera (S)
Narromine (S)
Nundle (S)
Nymboida (S)
Oberon (S)
Parry (S)
Parkes (S)
Quirindi (S)
Richmond River (S)
Scone (S)
Severn (S)
Tallaganda (S)
Temora (S)
Tenterfield (S)
Tumbarumba (S)
Ulmarra (S)
Uralla (S)
Urana (S)
Warren (S)
Weddin (S)
Wellington (S)
Windouran (S)
Yarrowlumla (S)
Yass (S)

Victoria

Alberton (S)
Arapiles (S)
Ararat (S)
Avoca (S)
Avon (S)
Bairnsdale (S)
Bet Bet (S)
Birchip (S)
Charlton (S)
Dimboola (S)
Dunmunkle (S)
East Loddon (S)
Euroa (S)
Glenelg (S)
Goulburn (S)
Kowree (S)
Leigh (S)
McIvor (S)
Mansfield (S)
Narracan (S)
Nathalia (S)
Orbost (S)
Otway (S)
Oxley (S)
Rochester (S)
Swan Hill (S)
Tambo (S)
Tungamah (S)
Upper Murray (S)
Violet Town (S)
Wangaratta (S)
Waranga (S)
Warracknabeal (S)
Yea (S)

Queensland

Bowen (S)
Broadsound (S)
Calliope (S)
Cloncurry (S)
Crows Nest (S)
Duaringa (S)
Emerald (S)
Gayndah (S)
Glengallan (S)
Herberton (S)
Kilcoy (S)
Kilkivan (S)
Kingaroy (S)
Kolan (S)
Livingstone (S)
Mareeba (S)
Mundubbera (S)
Nanango (S)
Rosalie
Rosenthal (S)
Tiaro (S)
Wambo (S)
Wondai (S)
Woocoo (S)

South Australia

Central Yorke Peninsula (DC)
Clare (DC)
Crystal Brook (DC)
Gladstone (DC)
Kapunda (DC)
Laura (DC)
Loxton (DC)
Mannum (DC)
Meningie (DC)
Minlaton (DC)
Paringa (DC)
Pirie (DC) Part B
Port Broughton (DC)
Strathalbyn (DC)
Waikerie (DC)
Yankalilla (DC)
Yorketown (DC)

Western Australia

Albany (S)
Augusta-Margaret River (S)
Beverley (S)
Boddington (S)
Boulder (S)
Bridgetown-Greenbushes (S)
Brookton (S)
Broome (S)
Bruce Rock (S)
Carnamah (S)
Carnarvon (S)
Chittering (S)
Coolgardie (S)
Corrogin (S)
Cunderdin (S)
Donnybrook-Balingup (S)
Dundas (S)
Gingin (S)
Goomalling (S)
Greenough (S)
Irwin (S)
Katanning (S)
Manjimup (S)
Merredin (S)
Mingenew (S)
Moora (S)
Pingelly (S)
Plantagenet (S)
Quairading (S)
Toodyay (S)
Victoria Plains (S)
Wagin (S)
Wongan Ballidu (S)
York (S)

Tasmania

Circular Head (M)
Deloraine (M)
Glamorgan (M)
Green Ponds (M)
Hamilton (M)
Huon (M)
King Island (M)
Oatlands (M)
Richmond (M)
Scottsdale (M)
Spring Bay (M)
Tasman (M)

Group 3

New South Wales

Berrigan (S)
Cowra (S)
Culcairn (S)
Great Lakes (S)
Leeton (S)
Nambucca (S)
Wade (S)
Wagga Wagga (C)

Victoria

Bass (S)
Buln Buln (S)
Bungaree (S) Part B
Buninyong (S)
Chiltern (S)
Cobram (S)
Creswick (S)
Daylesford and Glenlyon (S)
Deakin (S)
Grenville (S) Part B
Heytesbury (S)
Huntly (S) Part B
Kilmore (S)
Korumburra (S)
Lexton (S)
Maldon (S)
Marong (S)
Mirboo (S)
Newham and Woodend (S)
Newstead (S)
Nemurkah (S)
Pakenham (S) Part B
Ripon (S)
Rodney (S)
Romsey (S)
Rutherglen (S)
Shepparton (S) Part A
South Gippsland (S)
Talbot and Clunes (S)
Traralgon (S)
Tullaroop (S)
Woorayl (S)
Yarrawonga (S)

Queensland

Allora (S)
Boonah (S)
Cambooya (S)
Clifton (S)
Laidley (S)
Murgon (S)
Noosa (S) Part B

South Australia

Angaston (DC)
Barmera (DC)
Barossa (DC)
Gumeracha (DC) Part B
Kadina (DC)
Light (DC) Part B
Meadows (DC) Part B
Millicent (DC)
Mount Barker (DC)
Mount Gambier (DC) Part A
Murray Bridge (DC) Pt A
Port Elliot and Goolwa (DC)
Willunga (DC) Part B

Tasmania

Kentish (M)
Latrobe (M) Part B
Lilydale (M) Part A
Penguin (M) Part A
Port Cygnet (M)
Sorrell (M) Part B
Wynyard (M) Part B

Group 4

New South Wales

Bega Valley (S)
Bellingen (S)
Blayney (S) Part B
Cessnock Greater (C) Part B
Cootamundra (S)
Dubbo (C)
Dungog (S)
Eurobodalla (S)
Harden (S)
Hastings (M)
Hawkesbury (S)
Holbrook (S)
Junee (S)
Kempsey (S)
Lismore (C)
Lithgow Greater (C)
Maclean (S)
Muswellbrook (S)
Rylstone (S)
Shoalhaven (C)
Singleton (S)
Snowy River (S)
Taree Greater (C)
Tumut (S)
Wingecarribee (S)
Wollondilly (S)
Young (S)

Victoria

Alexandra (S)
Bacchus Marsh (S)
Ballan (S)
Bannockburn (S) Part A
Barrabool (S) Part B
Beechworth (S)
Belfast (S)
Benalla (C)
Bright (S)
Broadford (S)
Cohuna (S)
Colac (S)
Dundas (S)
Hampden (S)
Healesville (S) Part A
Kyneton (S)
Maffra (S)
Metcalfe (S)
Minhamite (S)
Mortlake (S)
Mt Rouse (S)
Myrtleford (S)
Portland (S)
Pyalong (S)
Rosedale (S)
Seymour (S)
Strathfieldsaye (S) Part B
Tallangatta (S) Part B
Upper Yarra (S)
Wannon (S)
Warrambool (S)
Winchelsea (S)
Yackandandah (S) Part B

Queensland

Atherton (S)
Ayr (S)
Beaudesert (S) Part A
Caboolture (S) Part B
Cardwell (S)
Douglas (S)
Eacham (S)
Esk (S)
Gatton (S)
Gooburrum (S) Part B
Hervey Bay (T)
Hinchinbrook (S)
Isis (S)
Johnstone (S)
Jondaryan (S)
Landsborough (S) Part B
Mirani (S)
Moreton (S) Part B
Mount Isa (C)
Mount Morgan (S)
Pioneer (S) Part B
Pittsworth (S)
Proserpine (S)
Sarina (S)
Stanthorpe (S)
Thuringowa (S) Part A
Widgee (S)
Woongarra (S) Part B

South Australia

Victor Harbor (DC)

Western Australia

Busselton (S)
Capel (S)
Collie (S)
Dandanup (S)
Exmouth (S)
Harvey (S)
Murray (S)
Northam (S)
Port Hedland (S)
Roebourne (S)
Serpentine-Jarrahdale (S)
Waroona (S)

Tasmania

Beaconsfield (M) Part A
Brighton (M) Part A
Campbell Town (M)
Evandale (M) Part A
George Town (M)
Gormanston (M)
Longford (M) Part A
New Norfolk (M) Part B
Ulverstone (M) Part B
Waratah (M)
Westbury (M) Part A
Zeehan (M)

Group 5

New South Wales

Ballina (S)
Blue Mountains (C)
Byron (S)
Coffs Harbour (S)
Deniliquin (M)
Glen Innes (M)
Grafton (C0
Kiama (M)
Orange (C)
Tweed (S) Part B
Wyong (S)

Victoria

Ballarat (S) Part B
Bellarine (S) Part B
Castlemaine (C)
Cranbourne (S) Part A
Echuca (C)
Eltham (S)
Flinders (S)
Gisborne (S)
Hastings (S)
Lillydale (S)
Maryborough (C)
Melton (S)
Mornington (S)
Morwell (S) Part B
Phillip Island (S)
St Arnaud (T)
Sherbrooke (S)
Stawell (T)
Warragul (S)
Wonthaggi (B)

Queensland

Dalby (T)
Maroochy (S) Part B
Maryborough (C)
Redland (S)
Roma (T)

South Australia

Berri (DC)
East Torrens (DC)
Moonta (M)
Munno Para (DC)
Naracoorte (M)
Onkaparinga (DC) Part B
Renmark (M)
Stirling (DC)
Tanunda (DC)

Western Australia

Mundaring (S)

Tasmania

Burnie (M) Part A
Kingsborough (M) Part B
St Leonards (M) Part A

Group 6

New South Wales

Bathurst (C)
Camden (M)
Casino (M)
Gosford (C)
Hornsby (S)
Lake Macquarie (M)
Maitland (C)
Port Stevens (S)

Victoria

Bulla (S)
Camperdown (T)
Corio (S) Part B
Kerang (B)
Koroit (B)
Port Fairy (B)
Portland (T)
South Barwon (C) Part B
Werribee (S)
Whittlesea (S)
Wodonga (Rural C)

Queensland

Albert (S) Part B
Charters Towers (C)
Goondiwindi (T)
Mulgrave (S) Part B
Pine Rivers (S) Part B

South Australia

Whyalla (C) Part B

Western Australia

Armadale (T)
Kalamunda (S)
Kwinana (T)
Mandurah (S)
Rockingham (S)
Swan (S)

Tasmania

Queenstown (M)

Group 7

Queensland

Torres (S)

Group 8

New South Wales

Armidale (C)
Queanbeyan (C)

Victoria

Ararat (C)
Bairnsdale (T)
Ballarat (C)
Benalla (C)
Bendigo (C)
Colac (C)
Doncaster and Templestowe (C)
Eaglehawk (B)
Hamilton (C)
Horsham (C)
Port Melbourne (C)
Queenscliffe (B)
Sale (C)
Sebastopol (B)
Shepparton (C)
Swan Hill (C)
Wangaratta (C)
Warrnambool (C)

Queensland

Gympie (C)
Redcliffe (C)
Warwick (C)

South Australia

Gawler (M)
Jamestown (M)
Peterborough (M)
Port Augusta (C) Part A
Port Lincoln (C)
Port Pirie (C)
Wallaroo (M)

Western Australia

Canning (C)
Geraldton (T)
Narrogin (T)
Northam (T)

Group 9

New South Wales

Albury (C)
Baulkham Hills (S)
Blacktown (C)
Broken Hill (C)
Campbelltown (C)
Goulburn (C)
Liverpool (C)
Newcastle (C)
Penrith (C)
Shellharbour (M)
Sutherland (S)
Tamworth (C)
Warringah (S)
Wollongong (C)

Victoria

Altona (C)
Berwick (C)
Diamond Valley (S)
Keilor (C)
Knox (C)
Kyabram (T)
Mildura (C)
Moe (C)
Springvale (C)
Sunshine (C)
Traralgon (C)

Queensland

Brisbane (C)
Bundaberg (C)
Cairns (C)
Gladstone (C)
Ipswich (C)
Logan (C)
Rockhampton (C)
Toowoomba (C)
Townsville (C)

South Australia

Noarlunga (C)
Salisbury (C) Part A
Tea Tree Gully (C)

Western Australia

Albany (T)
Belmont (C)
Bunbury (C)
Cockburn (C)
Gosnells (C)
Kalgoorlie (T)
Wanneroo (C)

Tasmania

Clarence (M)
Devonport (M)
Glenorchy (C)
Hobart (C)

Group 10

New South Wales

Ku-Ring-Gai (M)

Victoria

Croydon (C)
Geelong (C)

South Australia

Adelaide (C)
Campbelltown (C)
Elizabeth (C)
Mt Gambier (C)
Port Adelaide (C)

Western Australia

Bassendean (T)
Fremantle (C)
Melville (C)
Nedlands (C)

Tasmania

Launceston (C)

Group 11

New South Wales

Auburn (M)	Hunters Hill (M)	Rockdale (M)
Bankstown (C)	Kogarah (M)	Ryde (M)
Botany (M)	Manly (M)	Strathfield (M)
Fairfield (C)	Parramatta (C)	Willoughby (M)

Victoria

Broadmeadows (C)	Geelong West (C)	Preston (C)
Dandenong (C)	Newtown (C)	Ringwood (C)
Footscray (C)	Oakleigh (C)	Williamstown (C)
Frankston (C)		

Queensland

Gold Coast (C)	Mackay (C)

South Australia

Enfield (C) Part A	Henley and Grange (C)	Mitcham (C)

Western Australia

Stirling (C)

Group 12

Victoria

Brunswick (C)	Fitzroy (C)	Richmond (C)
Collingwood (C)		

South Australia

Kensington and Norwood (C)

Group 13

New South Wales

Concord (M)

Victoria

Box Hill (C)	Kew (C)	Sandringham (C)
Brighton (C)	Malvern (C)	South Melbourne (C)
Camberwell (C)	Melbourne (C)	Waverley (C)
Coburg (C)	Mordialloc (C)	

South Australia

Brighton (C)	Payneham (C)	Unley (C)
Burnside (C)	Prospect (C)	Walkerville (M)
Hindmarsh (M)	St Peters (M)	West Torrens (C)
Marion (C)	Thebarton (M)	Woodville (C)

Western Australia

Claremont (T)	Mosman Park (T)	South Perth (C)
Cottesloe (T)	Peppermint Grove (S)	Subiaco (C)
East Fremantle (T)	Perth (C)	

Group 14

New South Wales

Ashfield (M)
Burwood (M)
Canterbury (M)
Drummoyne (M)
Holroyd (M)
Hurstville (M)
Lane Cove (M)
Leichardt (M)
Mosman (M)
North Sydney (M)
South Sydney (M)
Sydney (C)
Woollahra (M)

Victoria

Caulfield (C)
Chelsea (C)
Essendon (C)
Hawthorn (C)
Heidelberg (C)
Moorabbin (C)
Northcote (C)
Nunawading (C)
Prahran (C)

South Australia

Glenelg (C)

Western Australia

Bayswater (S)

Group 15

New South Wales

Marrickville (M)
Randwick (M)
Waverley (M)

Victoria

St Kilda (C)

APPENDIX III—SELECTED VARIABLES FOR GROUPS AND OUTLIERS

Table III.1 contains the variables used in the cluster analysis based on all road classes, showing averages for the 15 groups and the respective values for the individual outliers. Three other variables, total road length, population and area have also been included for information. Table III.2 contains selected variables as used in the discriminant analysis to determine the 'usage' of roads for local transport. These variables are also presented as averages for the groups and as individual values for the outliers.

The study required that comparisons be made both for particular variables across all groups and outliers, and for each group and outlier across several important variables. As an aid in these comparisons the data were prepared in two diagramatic forms, examples of which are given in Figures III.1 to Figure III.4. For each outlier Figures III.1 and III.2 allows comparisons of each of its descriptive variables to be made with the group average for that variable and also with the corresponding value of variable of other outliers. Figures III.3 and III.4 facilitate the identification of particular variables that explain why an outlier is more akin to one group than another in terms of road usage characteristics.

TABLE III.1—VALUES OF VARIABLES USED IN THE CLUSTER ANALYSIS; BY GROUP AND OUTLIER, ALL ROAD CATEGORIES, 1981

	State	*Percentage of the road system with sealed surface*	*Population per kilometre of road*	*Length of road per square kilometre of area*	*Total road length (km)*	*Population*	*Area (km^2)*
Group 1		15.25	1.51	0.35	1 533	2 312	19438
Burke	Qld	1.59	1.15	0.03	1 129	1 300	41 802
Mornington	Qld	0.00	2.57	0.28	331	850	1 192
Group 2		29.32	3.89	0.43	1 168	4 498	5 799
Cooma-Monaro	NSW	19.24	7.72	0.25	1 211	9 350	4 881
Yarrowlumla	NSW	41.87	5.56	0.23	683	3 800	2 987
Mansfield	Vic	26.89	4.07	0.30	1 179	4 800	3 915
Pirie	SA	9.39	5.20	0.88	884	4 600	1 004
Kattaning	WA	30.41	6.68	0.49	753	5 030	1 524
Merredin	WA	31.40	3.63	0.49	1 379	5 000	3 372
Group 3		35.99	8.81	1.00	811	7 053	915
Wagga Wagga	NSW	29.58	13.06	0.75	3 648	47 650	4 886
Noosa	Qld	29.57	15.42	1.08	947	14 600	875
Kadina	SA	21.86	5.58	1.15	851	4 750	738
Meadows	SA	38.68	24.67	1.57	910	22 450	579
Mount Barker	SA	42.01	18.55	1.38	488	9 050	354
Lilydale	Tas	27.20	17.19	0.78	533	9 160	684

TABLE III.1(Cont)—VALUES OF VARIABLES USED IN THE CLUSTER ANALYSIS; BY GROUP AND OUTLIER, ALL ROAD CATEGORIES, 1981

	State	*Percentage of the road system with sealed surface*	*Population per kilo-metre of road*	*Length of road per square kilometre of area*	*Total road length (km)*	*Population*	*Area (km²)*
Group 4		50.42	12.99	0.47	803	99 967	2 559
Bega Valley	NSW	32.33	11.11	0.29	1 723	19 150	6 050
Holbrook	NSW	50.31	3.81	0.25	656	2 500	2 590
Junee	NSW	59.21	6.07	0.48	988	6 000	2 045
Snowy River	NSW	53.97	5.39	0.21	1 271	6 850	6 035
Belfast	Vic	68.41	3.99	0.81	421	1 680	518
Dundas	Vic	56.14	1.92	0.51	1 767	3 400	346
Hampden	Vic	46.34	4.78	0.61	1 597	7 630	2 621
Minhamite	Vic	51.72	2.68	0.57	783	2 100	1 365
Mortlake	Vic	51.00	2.92	0.59	1 251	3 650	2 137
Mount Rouse	Vic	58.72	3.46	0.53	751	2 600	1 419
Pyalong	Vic	55.11	1.40	0.62	372	520	604
Wannon	Vic	73.05	3.52	0.47	924	3 250	1 977
Warnambool	Vic	58.49	4.72	0.87	1 378	6 510	1 582
Mirani	Qld	44.29	8.93	0.17	560	5 000	3 292
Cambelltown	Tas	51.90	5.36	0.20	289	1 550	1 435
Group 5		53.35	41.40	2.15	473	18 814	369
Wyong	NSW	60.73	50.27	1.35	1 118	56 200	826
Warragul	Vic	50.11	25.24	1.27	447	11 280	352
East Torrens	SA	45.24	20.64	2.16	252	5 200	117
Renmark	SA	56.02	29.86	1.46	216	6 450	148
Stirling	SA	68.84	39.47	3.13	337	13 300	108
Kingsborough	Tas	46.22	29.96	1.57	556	16 660	355
Group 6		78.09	68.22	1.52	459	31 949	459
Gosford	NSW	87.51	63.73	1.29	1 329	84 700	1 028
Hornsby	NSW	57.99	115.50	1.87	945	109 150	504
Koroit	Vic	100.00	34.64	1.91	44	1 480	23
Charters Towers	Qld	72.63	85.79	2.29	95	8 150	41
Mulgrave	Qld	83.15	45.67	0.37	635	29 000	1 737
Queenstown	Tas	96.61	70.85	0.42	59	4 180	142
Group 7		53.33	416.67	0.01	15	6 250	2 796
Group 8		81.47	95.88	6.73	155	16 672	24
Port Melbourne	Vic	98.67	121.33	7.05	75	9 100	11
Sale	Vic	70.31	101.56	4.30	128	13 000	30
Sebastopol	Vic	96.15	128.85	7.36	52	6 700	7
Gawler	SA	91.18	94.12	7.75	68	6 400	9
Port Lincoln	SA	69.63	76.30	13.33	135	10 300	10
Group 9		88.52	134.30	3.46	529	75 477	191
Broken Hill	NSW	91.36	130.00	3.25	220	28 600	68
Newcastle	NSW	86.31	180.10	3.63	774	139 400	214
Moe	Vic	90.70	129.85	5.36	129	16 750	24
Traralgon	Vic	88.71	141.21	6.20	124	17 510	20
Cairns	Qld	93.00	144.36	4.62	257	37 100	56
Ipswich	Qld	89.35	134.60	4.31	526	70 800	122
Devonport	Tas	87.35	90.87	2.18	253	22 990	116
Hobart	Tas	96.33	163.40	3.76	300	49 020	80

TABLE III.1(Cont)—VALUES OF VARIABLES USED IN THE CLUSTER ANALYSIS; BY GROUP AND OUTLIER, ALL ROAD CATEGORIES, 1981

	State	*Percentage of the road system with sealed surface*	*Population per kilometre of road*	*Length of road per square kilometre of area*	*Total road length (km)*	*Population*	*Area (km²)*
Group 10		99.62	146.95	8.37	229	34 448	29
Croydon	Vic	100.00	179.02	6.08	205	36 700	34
Adelaide	SA	100.00	104.72	8.30	127	13 300	15
Mount Gambier	SA	100.00	116.56	8.61	163	19 000	19
Group 11		93.39	217.96	8.72	305	65 391	90
Manly	NSW	95.28	286.22	8.36	127	36 350	15
Willoughby	NSW	91.62	273.56	8.61	191	52 250	22
Dandenong	Vic	96.12	216.28	7.12	258	55 800	36
Mackay	Qld	96.38	155.80	6.66	138	21 500	21
Group 12		99.01	173.07	22.86	130	22 960	6
Group 13		99.99	187.65	11.26	187	34 961	18
Waverly	Vic	99.84	195.98	10.62	622	121 900	59
Marion	SA	100.00	176.01	7.29	396	69 700	54
Woodville	SA	100.00	163.03	10.88	468	76 300	43
Group 14		99.00	256.34	12.74	217	54 210	19
Holroyd	NSW	98.53	242.23	8.69	341	82 600	39
Chelsea	Vic	98.25	240.35	9.32	114	27 400	12
Moorabbin	Vic	98.19	205.63	9.71	497	102 200	51
Nunawading	Vic	99.06	225.35	10.25	426	96 000	42
Bayswater	WA	96.86	158.63	9.22	255	40 450	28
Group 15		97.39	414.77	13.40	210	82 488	18

TABLE III.2—VALUES OF VARIABLES USED IN THE DISCRIMINANT ANALYSIS; BY GROUP AND OUTLIER, ALL ROAD CATEGORIES, 1981

		Percentage of workforce employed in the following categories				*Percentage of dwellings with the following number of motor vehicles*			
	State	*Professional*	*Administrative*	*Farming*	*Tradesmen*	*0*	*2*	*3*	*4+*
Group 1		6.72	8.86	43.99	14.25	9.39	29.50	13.93	12.44
Burke	Qld	10.58	5.98	27.59	18.62	45.11	11.41	2.72	5.98
Mornington	Qld	9.26	8.15	15.19	43.70	78.69	4.10	1.64	0.00
Group 2		8.32	11.46	35.10	18.32	7.96	32.78	12.15	7.58
Cooma-Monaro	NSW	17.50	19.62	11.27	20.36	11.08	29.91	8.26	3.17
Yarrowlumla	NSW	21.25	27.21	15.30	15.45	3.61	46.58	13.67	6.28
Mansfield	Vic	11.13	12.22	18.67	21.13	8.90	36.13	12.34	4.79
Pirie	SA	10.26	15.89	10.34	33.81	5.26	33.58	10.60	4.08
Katanning	WA	9.61	17.11	18.14	26.49	8.57	35.74	11.60	6.56
Merredin	WA	9.42	19.09	18.49	20.48	8.17	35.82	9.03	8.09
Group 3		10.59	13.98	24.68	24.13	7.72	35.19	11.15	6.05
Wagga Wagga	NSW	11.27	18.11	8.98	21.26	10.80	32.67	8.59	3.45
Noosa	Qld	10.61	19.62	9.16	25.89	8.73	30.89	7.98	3.07
Kadina	SA	11.28	14.36	18.31	22.15	11.35	30.09	8.21	5.22
Meadows	SA	18.69	29.30	6.94	21.07	1.51	48.35	7.66	3.20
Mount Barker	SA	13.11	20.11	9.84	29.78	5.94	36.19	9.19	4.93
Lilydale	Tas	9.67	19.25	6.65	36.03	8.82	37.28	9.93	4.43

TABLE III.2(Cont)—VALUES OF VARIABLES USED IN THE DISCRIMINANT ANALYSIS; BY GROUP AND OUTLIER, ALL ROAD CATEGORIES, 1981

		Percentage of workforce employed in the following categories				*Percentage of dwellings with the following number of motor vehicles*			
	State	*Professional*	*Administrative*	*Farming*	*Tradesmen*	*0*	*2*	*3*	*4+*
Group 4		9.73	13.32	21.42	25.06	8.30	33.66	10.11	5.39
Bega Valley	NSW	9.45	16.97	15.92	24.03	8.80	31.68	8.59	2.84
Holbrook	NSW	5.87	10.39	40.74	13.66	9.31	30.65	13.52	6.95
Junee	NSW	6.47	11.57	26.13	18.68	13.03	24.69	9.41	6.39
Snowy River	NSW	13.57	19.99	11.86	17.43	5.75	37.36	14.10	6.65
Belfast	Vic	4.07	5.12	64.31	9.34	3.70	41.73	16.30	11.11
Dundas	Vic	7.92	7.16	53.73	8.74	2.37	39.94	17.84	15.66
Hampden	Vic	8.79	7.84	45.65	13.52	7.32	33.43	12.95	7.06
Minhamite	Vic	5.60	4.31	57.16	10.73	3.56	39.16	17.80	10.68
Mortlake	Vic	6.30	6.81	57.88	8.12	4.75	32.87	14.99	11.08
Mount Rouse	Vic	6.22	6.65	51.90	13.46	6.56	31.66	15.06	9.65
Pyalong	Vic	12.19	6.30	53.78	9.24	5.06	35.44	17.72	12.03
Wannon	Vic	6.78	8.99	52.74	10.17	9.17	34.22	14.40	7.89
Warnambool	Vic	7.49	7.19	48.47	14.18	3.45	38.62	16.14	9.52
Mirani	Qld	5.44	6.65	44.02	22.70	5.42	32.34	11.96	9.38
Cambelltown	SA	10.03	11.72	30.78	18.37	13.04	28.57	6.63	8.28
Group 5		13.70	19.51	7.75	28.18	10.12	33.81	7.79	3.02
Wyong	NSW	9.14	16.89	3.36	38.08	15.27	24.11	5.13	1.63
Warragul	Vic	12.57	16.89	16.27	26.44	10.51	34.84	10.12	4.20
East Torrens	SA	26.46	25.80	13.79	14.20	3.96	45.20	12.47	6.04
Renmark	SA	9.53	16.44	27.50	22.33	8.36	30.93	11.41	4.30
Stirling	SA	30.25	27.03	4.03	15.12	6.05	42.84	8.34	3.06
Kingsborough	Tas	23.07	28.90	4.68	18.56	6.36	41.25	8.68	3.19

TABLE III.2(Cont)—VALUES OF VARIABLES USED IN THE DISCRIMINANT ANALYSIS; BY GROUP AND OUTLIER, ALL ROAD CATEGORIES, 1981

		Percentage of workforce employed in the following categories				*Percentage of dwellings with the following number of motor vehicles*			
	State	*Professional*	*Administrative*	*Farming*	*Tradesmen*	*0*	*2*	*3*	*4+*
Group 6		11.81	19.41	4.69	31.50	10.56	32.86	7.46	2.80
Gosford	NSW	13.39	23.57	3.04	29.09	16.68	24.67	4.99	1.51
Hornsby	NSW	22.91	31.97	2.28	19.07	11.64	35.24	8.76	3.25
Koroit	Vic	10.19	11.70	16.60	28.30	14.39	33.78	5.90	5.66
Charters Towers	Qld	12.97	16.31	5.02	23.62	18.79	26.38	7.89	3.87
Mulgrave	Qld	11.53	18.52	11.05	27.23	9.36	34.74	8.37	3.76
Queenstown	Tas	13.28	11.97	0.74	27.15	15.17	26.26	5.02	1.90
Group 7		14.73	12.78	6.55	22.41	66.02	7.77	1.40	0.76
Group 8		13.10	19.58	3.97	29.04	14.30	29.39	6.91	2.38
Port Melbourne	Vic	7.62	17.27	0.28	46.59	37.04	13.72	2.26	0.34
Sale	Vic	16.60	18.11	2.82	25.03	10.16	30.16	6.11	2.25
Sebastopol	Vic	7.29	14.33	2.42	41.71	10.45	34.43	6.97	3.12
Gawler	SA	16.36	22.44	4.97	27.58	17.28	26.19	6.56	2.13
Port Lincoln	SA	11.43	24.10	5.85	29.51	11.16	32.28	6.28	1.93
Group 9		11.96	21.87	2.13	33.11	11.46	32.80	7.57	2.54
Broken Hill	NSW	12.71	14.25	1.26	25.09	16.22	23.51	6.32	2.34
Newcastle	NSW	14.53	18.27	0.80	36.25	22.13	23.60	5.64	1.75
Moe	Vic	10.91	11.84	1.22	50.28	13.80	27.66	6.75	2.09
Traralgon	Vic	13.19	15.63	1.49	42.79	9.59	34.16	7.96	2.91
Cairns	Qld	11.92	21.92	2.74	27.22	14.57	29.58	7.46	2.68
Ipswich	Qld	9.73	16.59	0.89	36.51	13.78	29.25	8.31	3.29
Devonport	Tas	13.02	21.67	3.62	33.35	11.35	34.60	8.10	2.33
Hobart	Tas	25.96	30.57	1.25	15.92	21.32	25.57	6.26	1.99

TABLE III.2(Cont)—VALUES OF VARIABLES USED IN THE DISCRIMINANT ANALYSIS; BY GROUP AND OUTLIER, ALL ROAD CATEGORIES, 1981

		Percentage of workforce employed in the following categories				*Percentage of dwellings with the following number of motor vehicles*			
	State	*Professional*	*Administrative*	*Farming*	*Tradesmen*	*0*	*2*	*3*	*4+*
Group 10		17.86	24.40	1.87	27.92	16.50	29.63	7.19	2.32
Croydon	Vic	14.74	26.19	1.48	30.80	7.36	39.90	8.19	3.05
Adelaide	SA	33.62	23.95	1.69	11.19	34.79	16.03	2.77	0.85
Mount Gambier	SA	13.05	20.28	5.15	33.33	10.75	30.75	7.80	2.73
Group 11		13.92	24.58	1.05	32.53	18.11	26.51	6.10	1.92
Manly	NSW	19.37	33.90	0.73	17.19	27.03	21.70	4.12	1.31
Willoughby	NSW	24.17	33.70	0.73	16.10	19.40	26.81	5.67	1.71
Dandenong	Vic	7.90	20.67	1.08	43.86	12.43	31.92	6.15	1.97
Mackay	Qld	10.87	20.86	3.24	29.60	15.35	28.85	8.12	2.93
Group 12		19.99	18.72	0.69	31.56	36.28	14.40	2.99	0.75
Group 13		22.50	27.57	1.35	21.77	19.20	26.99	6.43	2.01
Waverly	Vic	18.44	31.55	0.81	24.24	5.14	43.39	10.38	3.45
Marion	SA	13.96	27.43	1.05	28.44	14.06	28.51	7.31	2.28
Woodville	SA	11.72	24.64	1.32	34.78	16.10	28.05	6.04	1.61
Group 14		17.82	27.66	0.72	25.25	25.13	22.64	4.80	1.52
Holroyd	NSW	9.53	23.65	0.66	38.66	14.57	28.38	6.51	2.19
Chelsea	Vic	10.51	25.53	1.14	34.60	19.06	26.15	5.65	1.99
Moorabbin	Vic	13.83	27.57	1.11	31.36	12.46	31.49	8.23	2.40
Nunawading	Vic	17.95	29.72	0.76	26.24	9.25	37.05	8.81	2.96
Bayswater	WA	10.77	27.41	1.16	30.89	10.42	34.81	9.78	3.43
Group 15		14.62	24.88	0.50	26.59	34.53	14.42	2.40	0.77

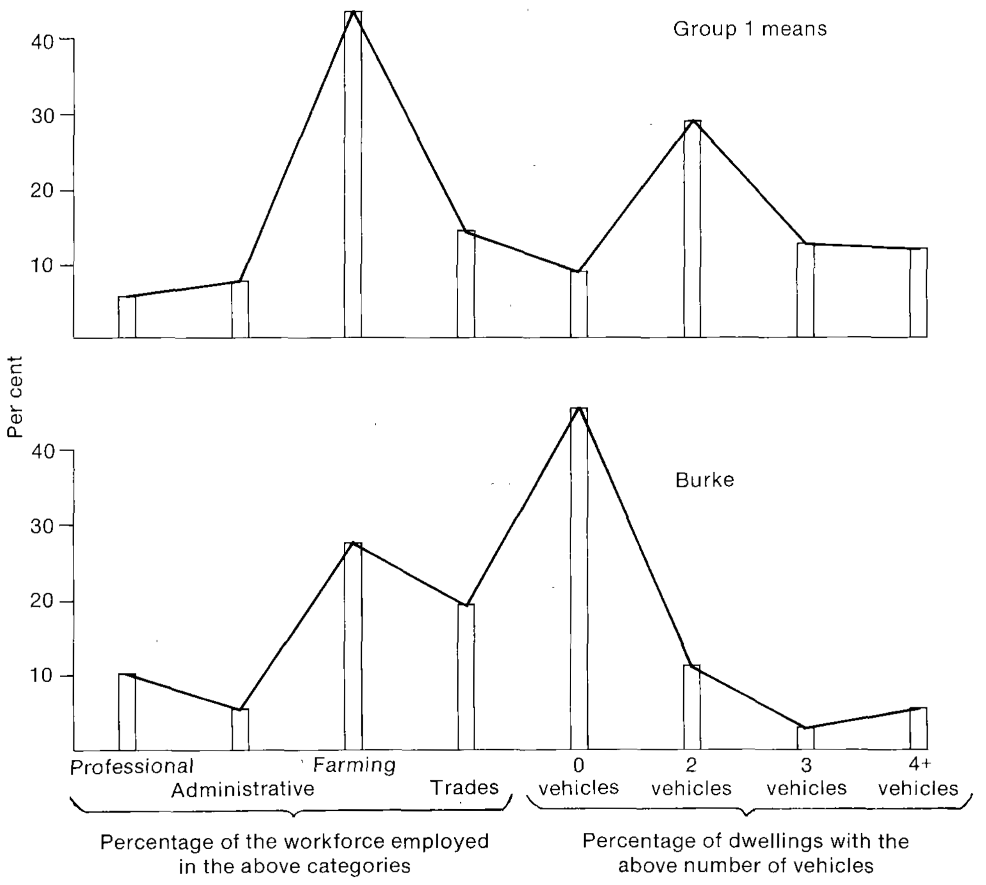


Figure III.1—Selected variables for the group mean and outliers in group 1

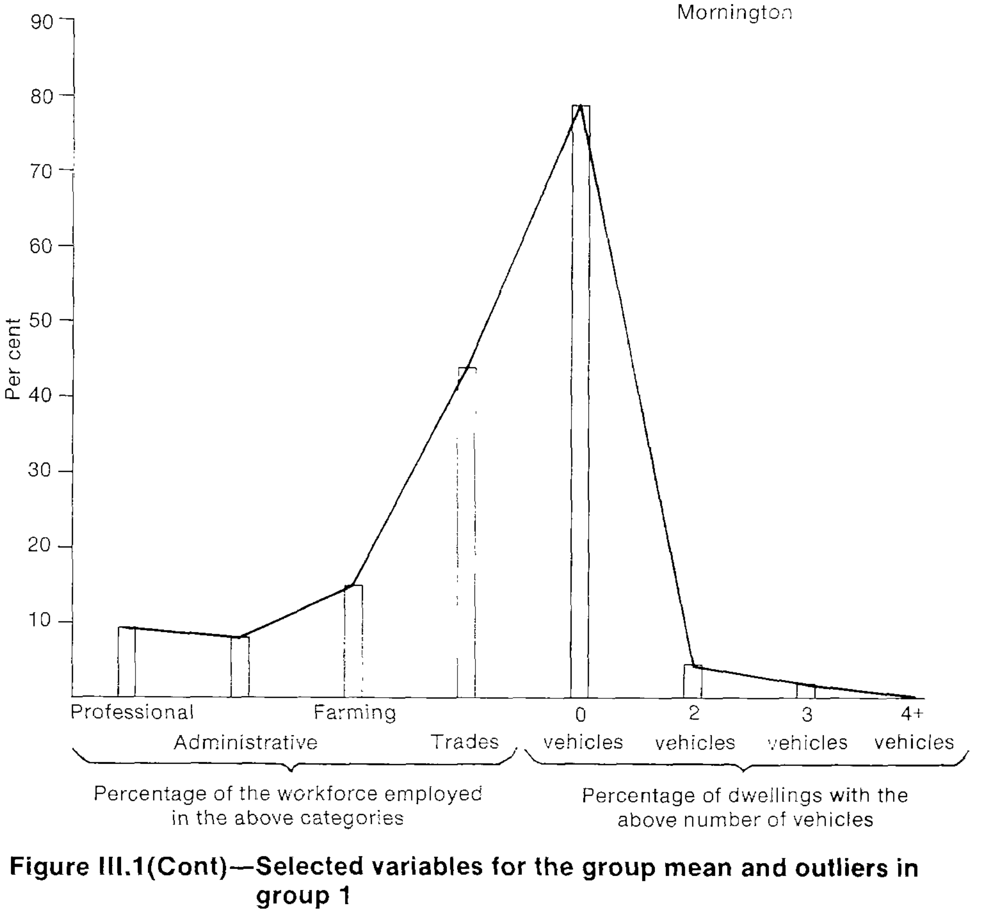


Figure III.1(Cont)—Selected variables for the group mean and outliers in group 1

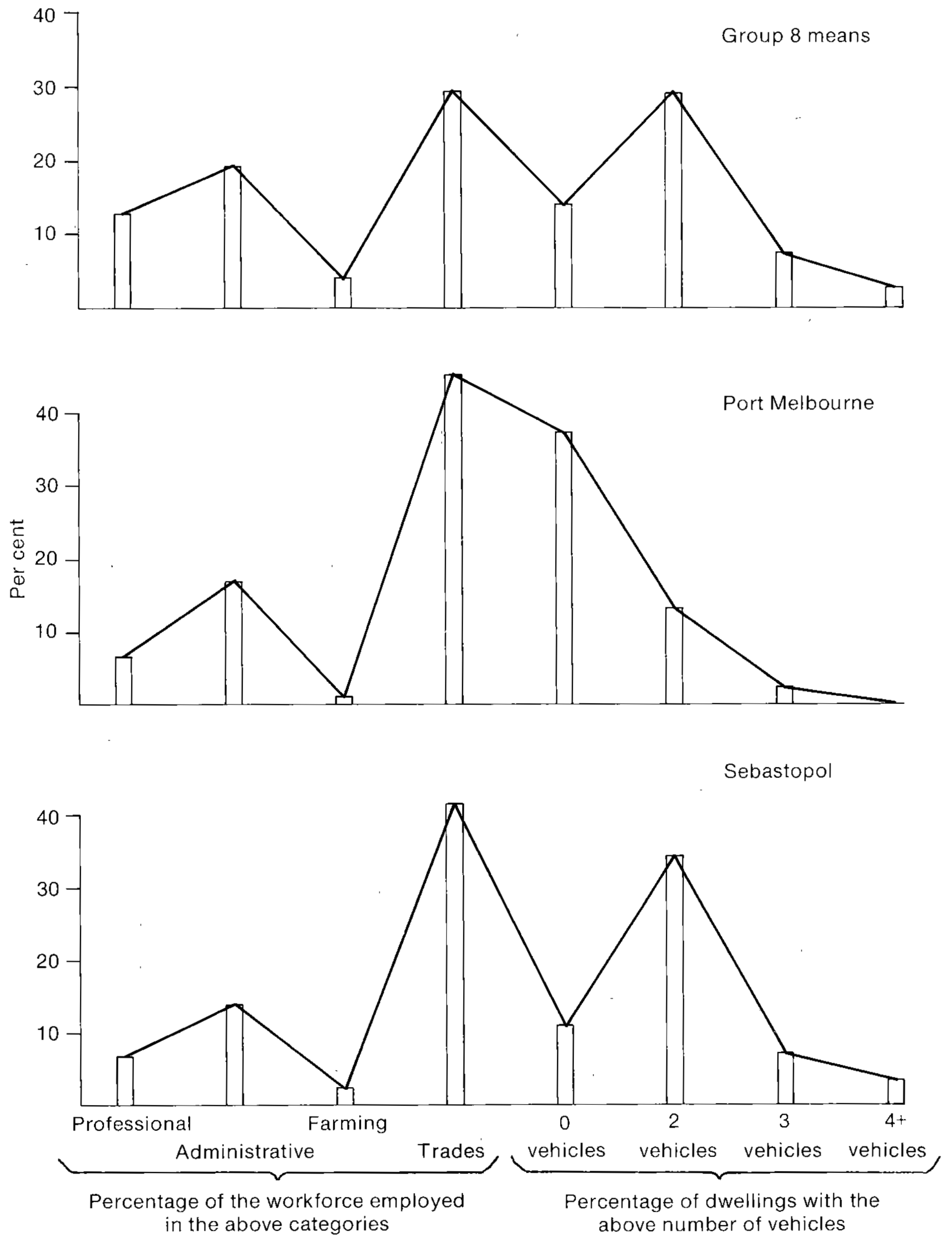
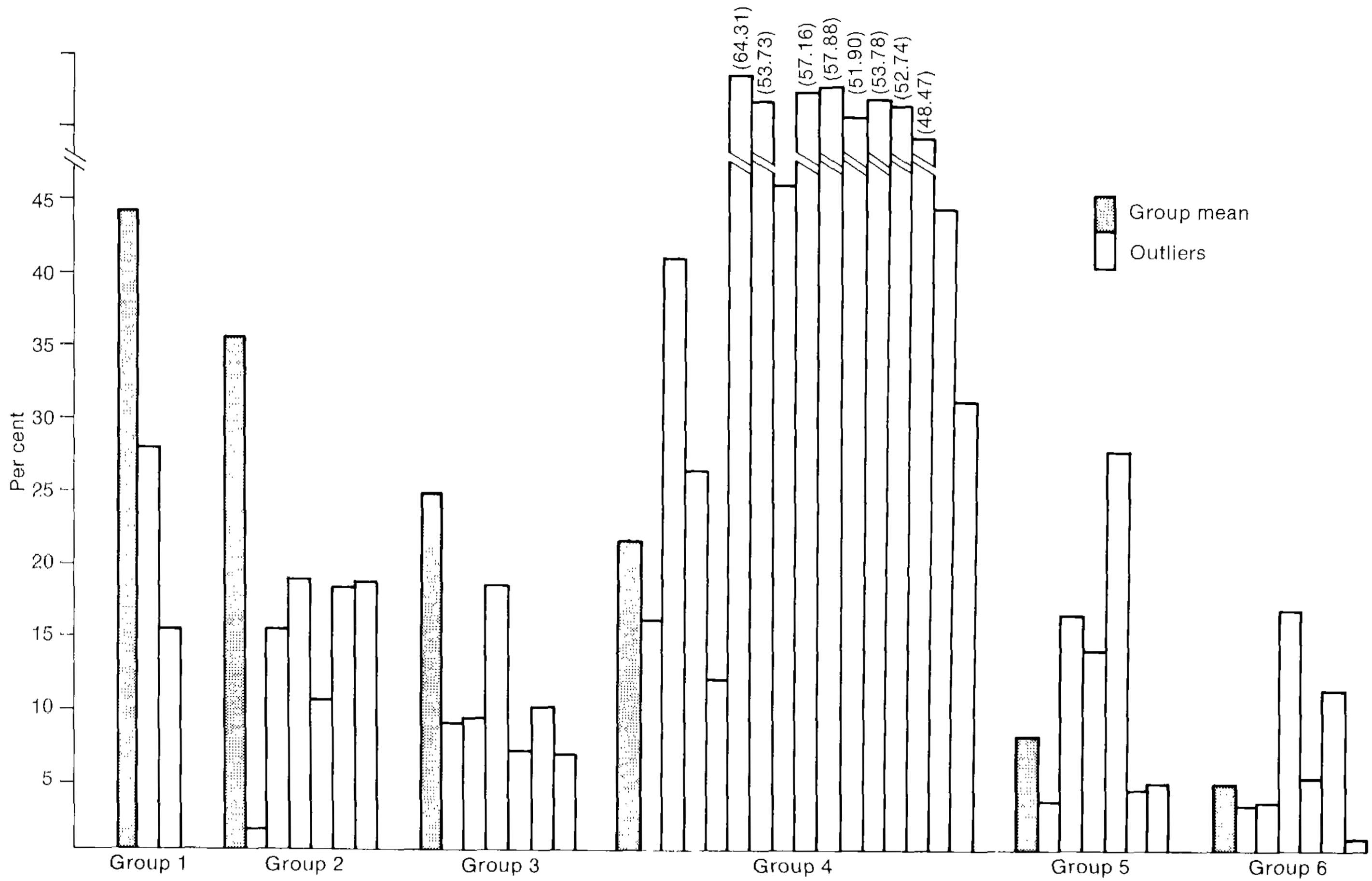
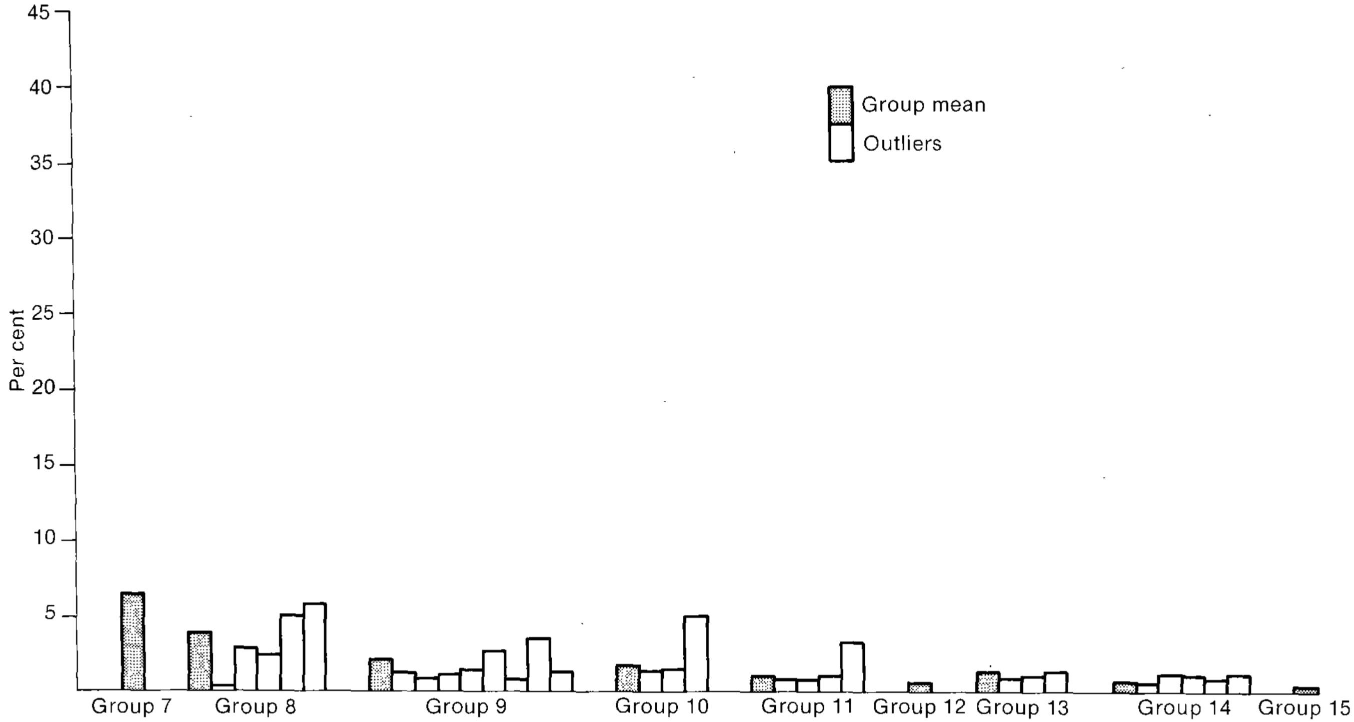


Figure III.2—Selected variables for the group mean and outliers in group 8



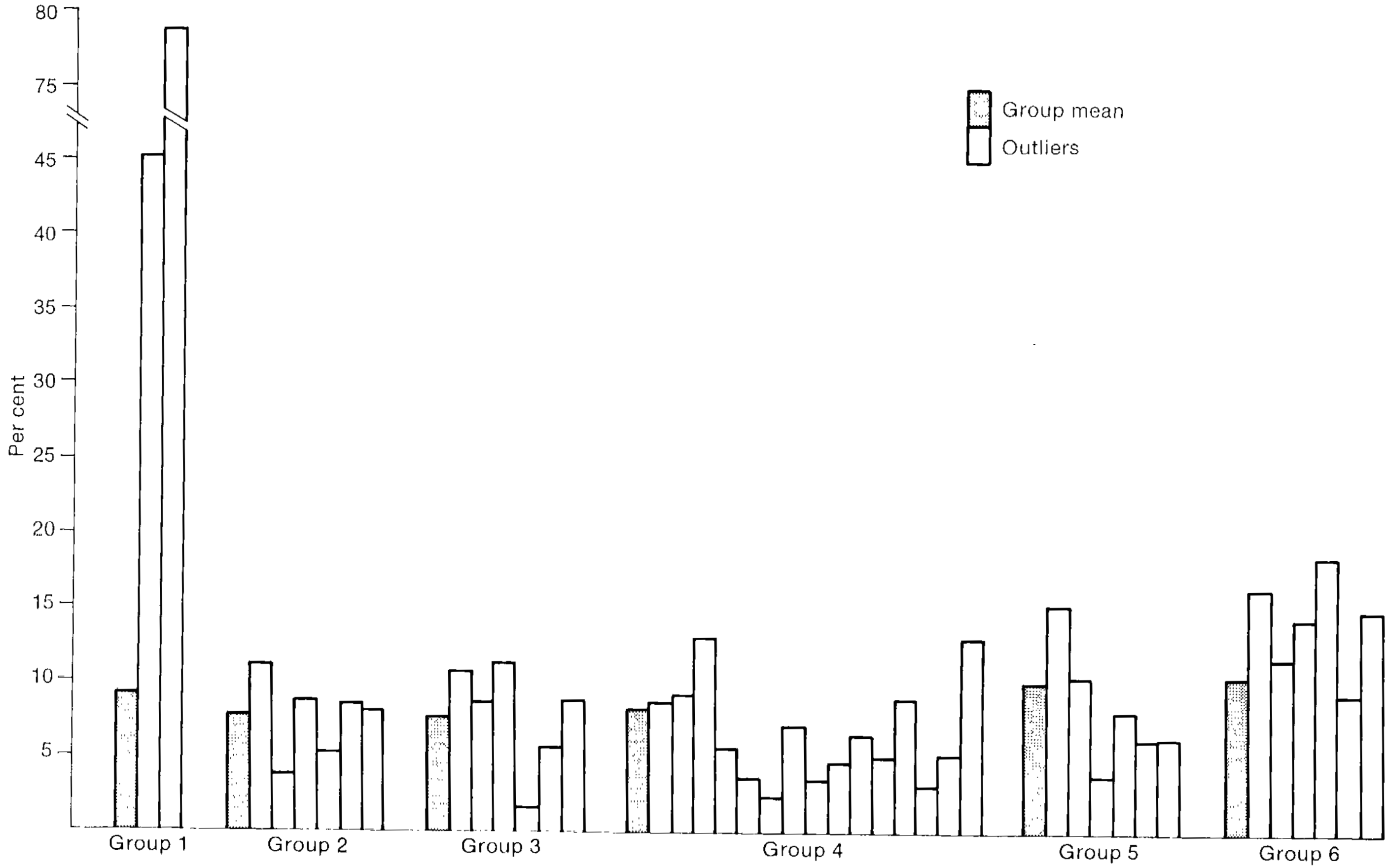
Note: This figure shows the data for the groups and outliers in the same order as it was presented in Table III.2

Figure III.3—Percentage of workforce employed in farming by group means and outliers



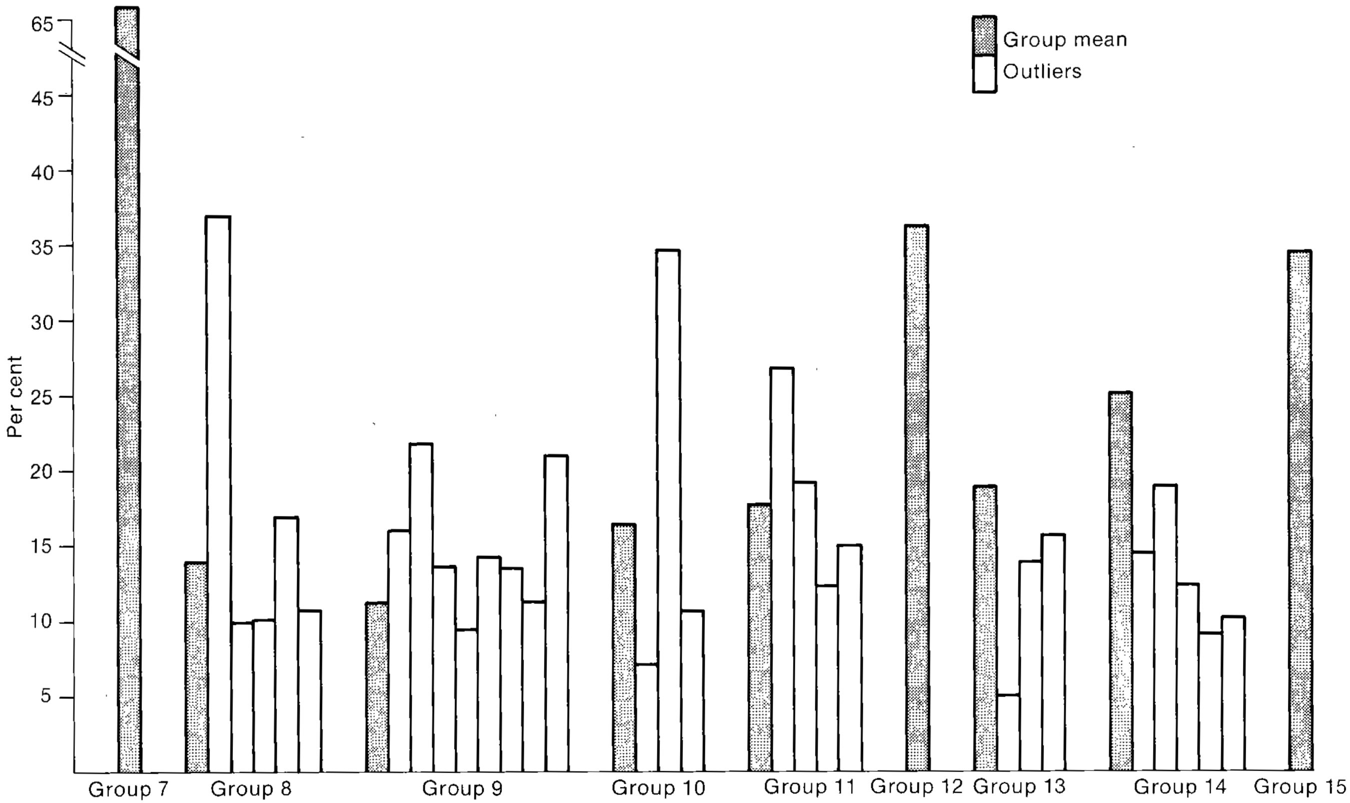
Note: This figure shows the data for the groups and outliers in the same order as it was presented in Table III.2

Figure III.3(Cont)—Percentage of workforce employed in farming by group means and outliers



Note: This figure shows the data for the groups and outliers in the same order as it was presented in Table III.2

Figure III.4—Percentage of households with zero vehicles by group means and outliers



Note: This figure shows the data for the groups and outliers in the same order as it was presented in Table III.2

Figure III.4(Cont)—Percentage of households with zero vehicles by group means and outliers

APPENDIX IV—RELATIONSHIP OF GROUPS AND OUTLIERS TO ROAD FUNDING

The generation of groups of LGAs with similar road systems allows other parameters of the LGAs to be examined with respect to these groups. It is reasonable to assume that if these parameters are related to the road system then there should exist some uniformity in these parameters within a group, and a lack of uniformity between the groups.

The parameter of importance to the study is funding for maintenance of roads in LGAs as this should relate to the 'quality' of the road system. Since the general state of a road system is developed over a period of years, time series information on funding is required for a number of years to determine the general trends in funding levels and the long term effect on the road system. Year-to-year fluctuations in funding levels are of no interest in this exercise. The only suitable available data on funding are compiled from AMIS and have been used for the years 1968 to 1980[1].

Individual States have incomplete records and this has been taken into account by presenting the results in Figures IV.1 to IV.16 in terms of a base figure for 1968 and a trend across the time period. The funding to an LGA for roads is divided into two parts; funding from revenue and funding from loans. These two components arise as a result of the method of accounting used by AMIS and are not directly usable to obtain maintenance expenditure or construction expenditure. However, as the funding from loans is generally used for construction, the funding from revenue can be used as at least an indication of the trends in maintenance funding. Revenue figures have therefore been used for the following comparisons. The figures in the table are deflated to a 1966 base figure and are calculated for each kilometre of road in the LGA. Because the data have been shown as a base year figure and a linear trend through time, this has smoothed out the year-to-year fluctuations in the data to give the overall trend of the funding to the LGA groups over the period.

Figure IV.1 shows, as expected, that an average LGA with increasing amounts of sealed road, greater population per road length, and so on, as discussed in Chapter 3, also received more revenue per length of road. The exceptions to this are Groups 12 and 13 which could be generally described as aging inner urban LGAs where the apparent lack of revenue is consistent with the decreasing population in these groups.

Figures IV.2 to IV.16 show the time trends for the average funding level of each group, together with the individual trends for the LGA outliers from the group. The group to which the outlier was classified on the basis of road usage is shown in brackets after the LGA name.

There are generally two situations of interest shown on the graphs:

- The first situation refers to where an LGA has a level of local usage of its road system that is more consistent with LGAs in another group but where the LGAs

1. Data for 1969, 1972, 1975, 1978 and 1980 are available for New South Wales. Data for 1972. 1980 are available for South Australia. Data for 1969, 1972–80 are available for Western Australia. Data for 1972 onward are available for Tasmania. Data for all years from 1968 to 1980 are available for Victoria and Queensland.

funding is similar to members of its own group. In this case the funding is maintaining the standard of the road system and changes in the road system to match its own usage characteristics more closely will not be accomplished until the funding is adjusted. For example Mansfield from Group 2 has a revenue profile that is close to the mean profile for the average of the group but the LGA road usage parameters suggest the funding should be more like that appropriate to LGAs in Group 8.

- The second situation refers to where the local usage of a road system in an LGA is more consistent with the LGAs of another group and the funding is also more akin to LGAs in this group, eg Port Melbourne from Group 8 has usage parameters similar to those of LGAs in Group 11 and also has a funding profile close to the mean profile of Group 11. This is a case of interest since the outlier LGAs have been receiving funding for roads in excess of their peers while their road systems are essentially similar. This could be due to a time lag in the effects of change in the LGAs circumstances, a situation which is particularly likely to apply to inner suburbs of large cities. Similar situations occur where the usage and funding of an LGA is more akin to an LGA with lower funding and usage requirements. This usually occurs due to a population shift away from rural areas.

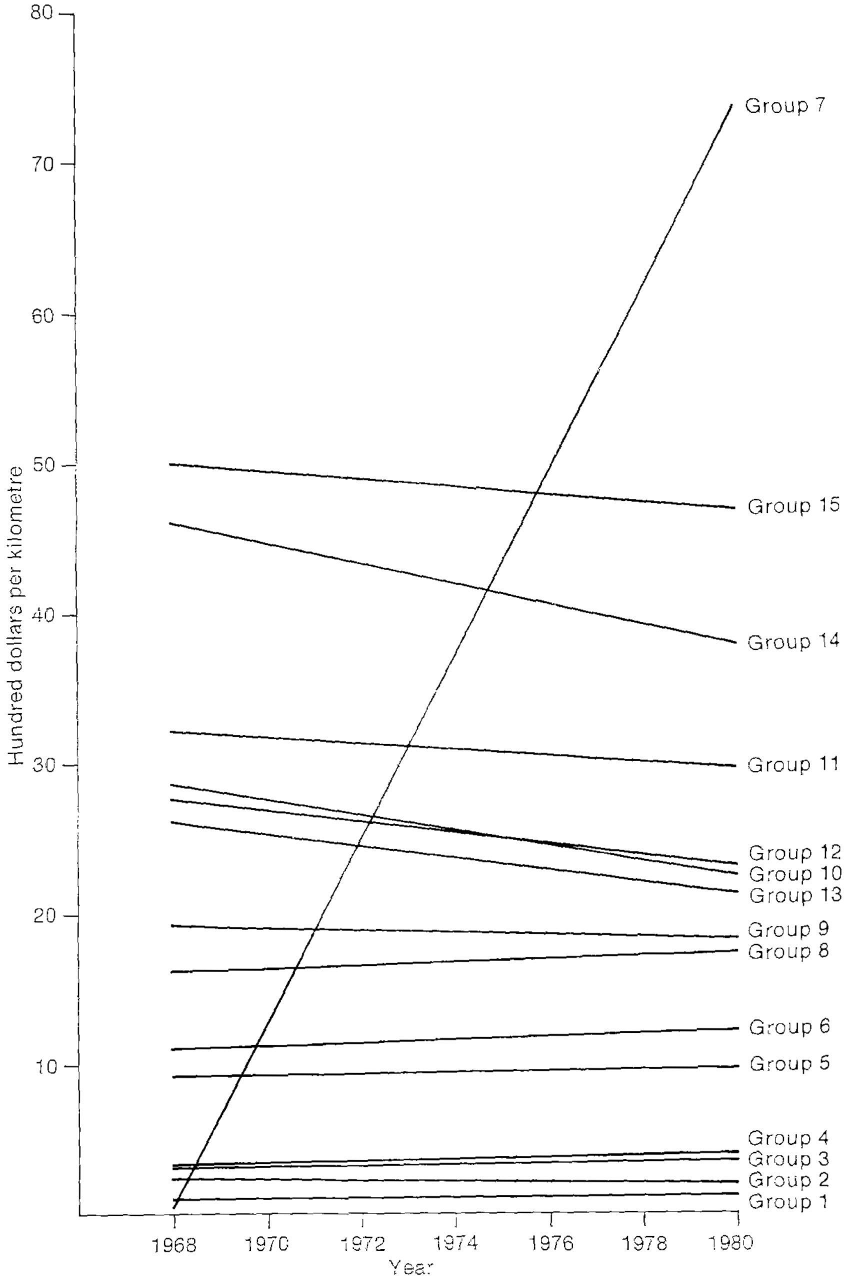
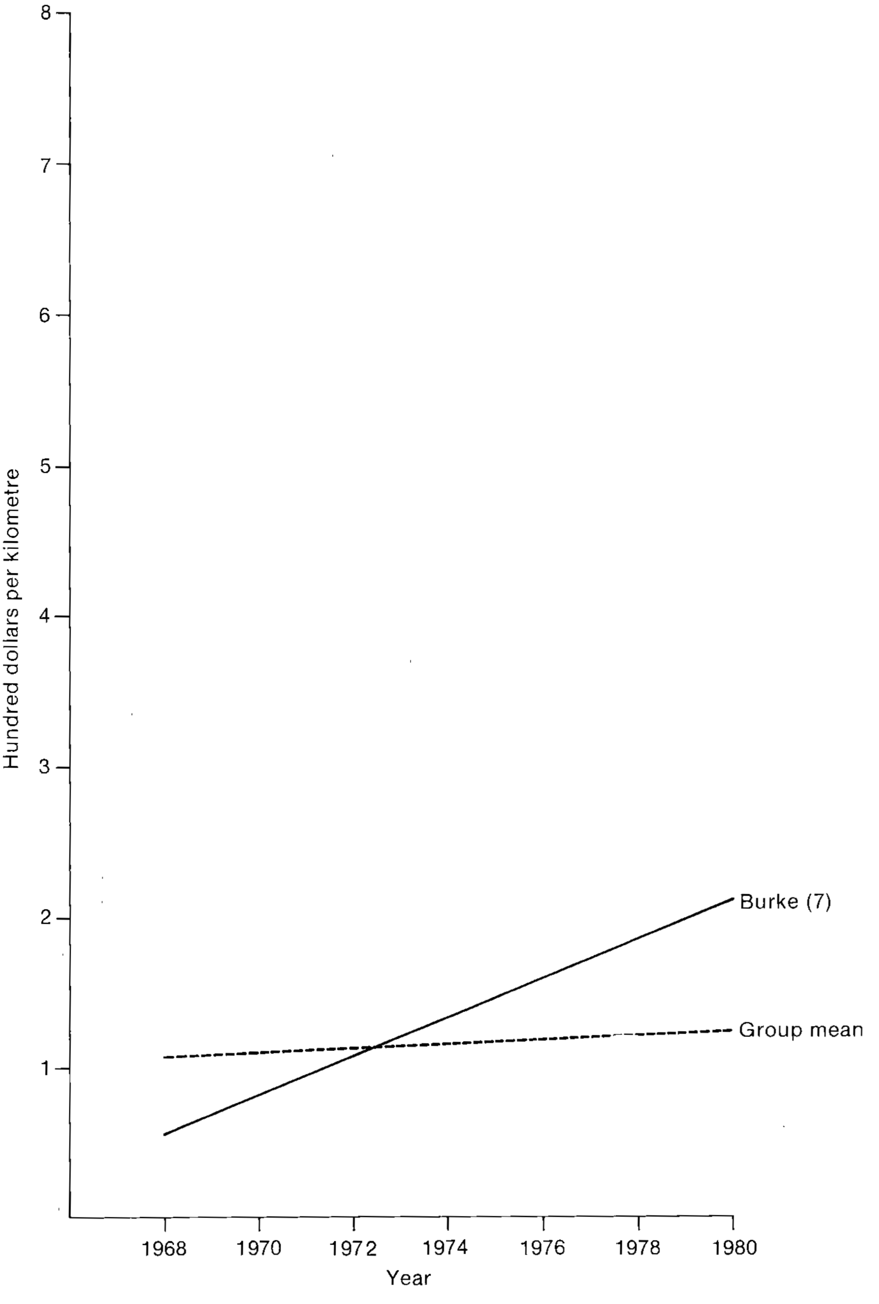


Figure IV.1—Expenditure for all groups, 1968-80



Note: Mornington had insufficient data for results to be plotted.

Figure IV.2—Expenditure for group 1, 1968-80

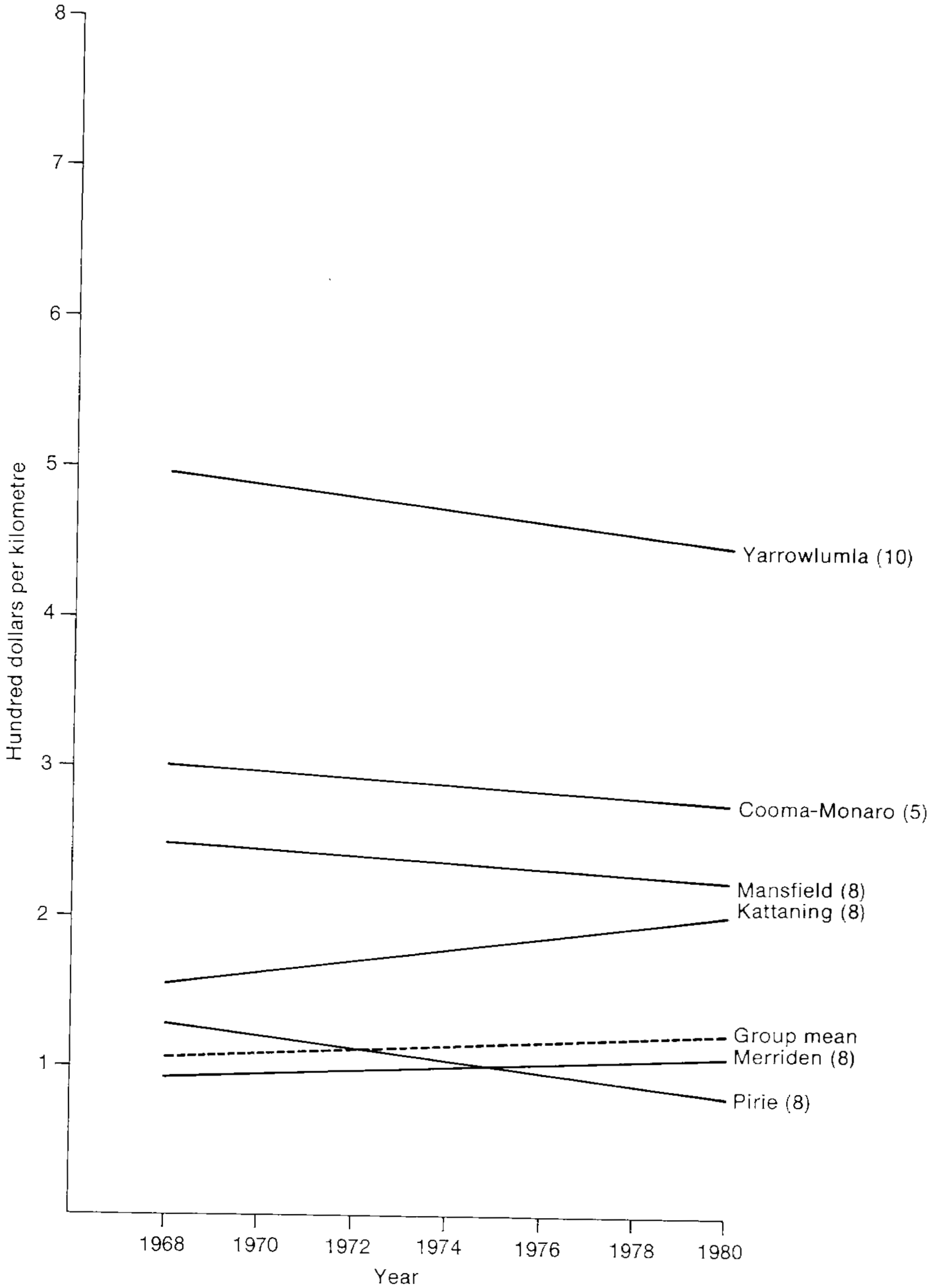


Figure IV.3—Expenditure for group 2, 1968-80

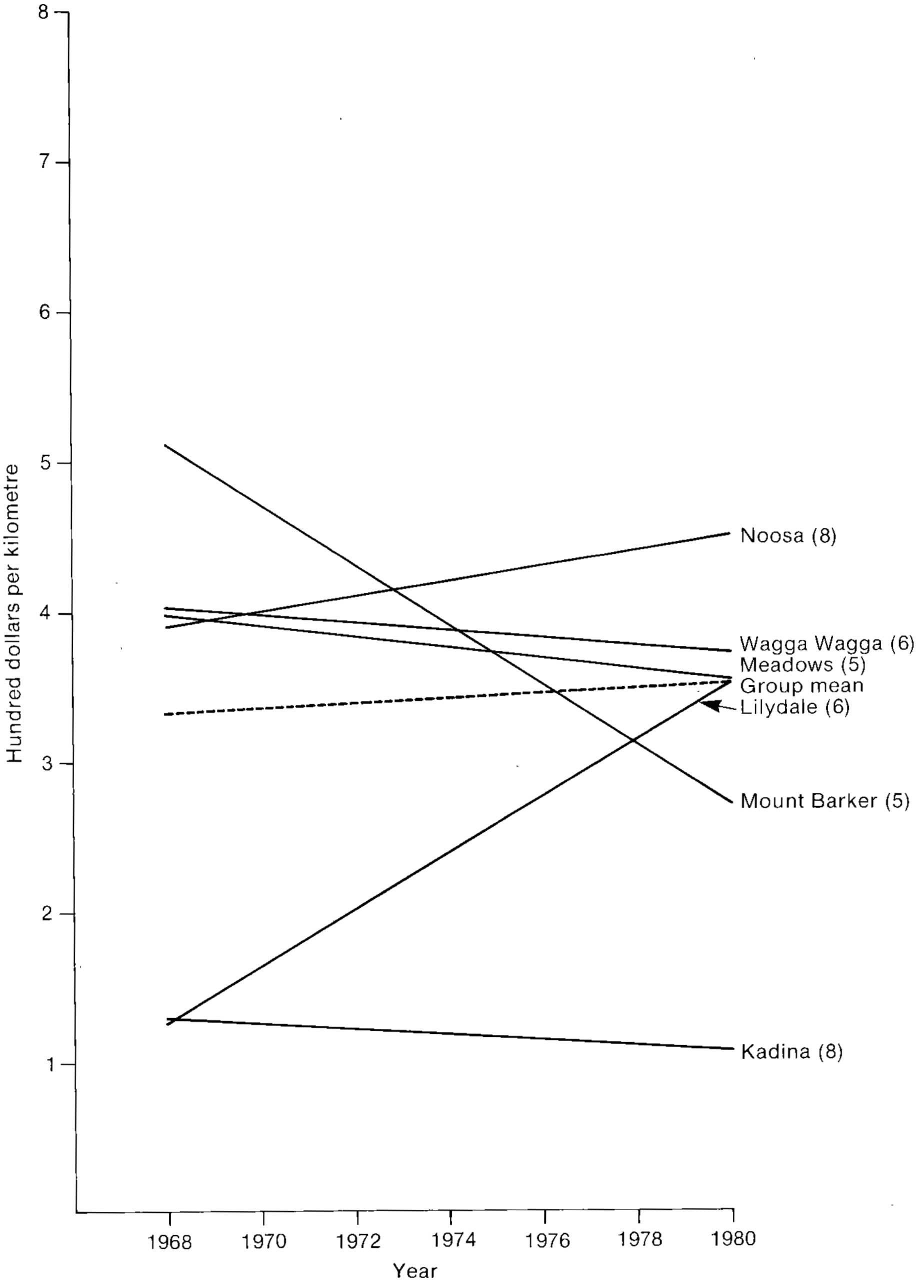


Figure IV.4—Expenditure for group 3, 1968-80

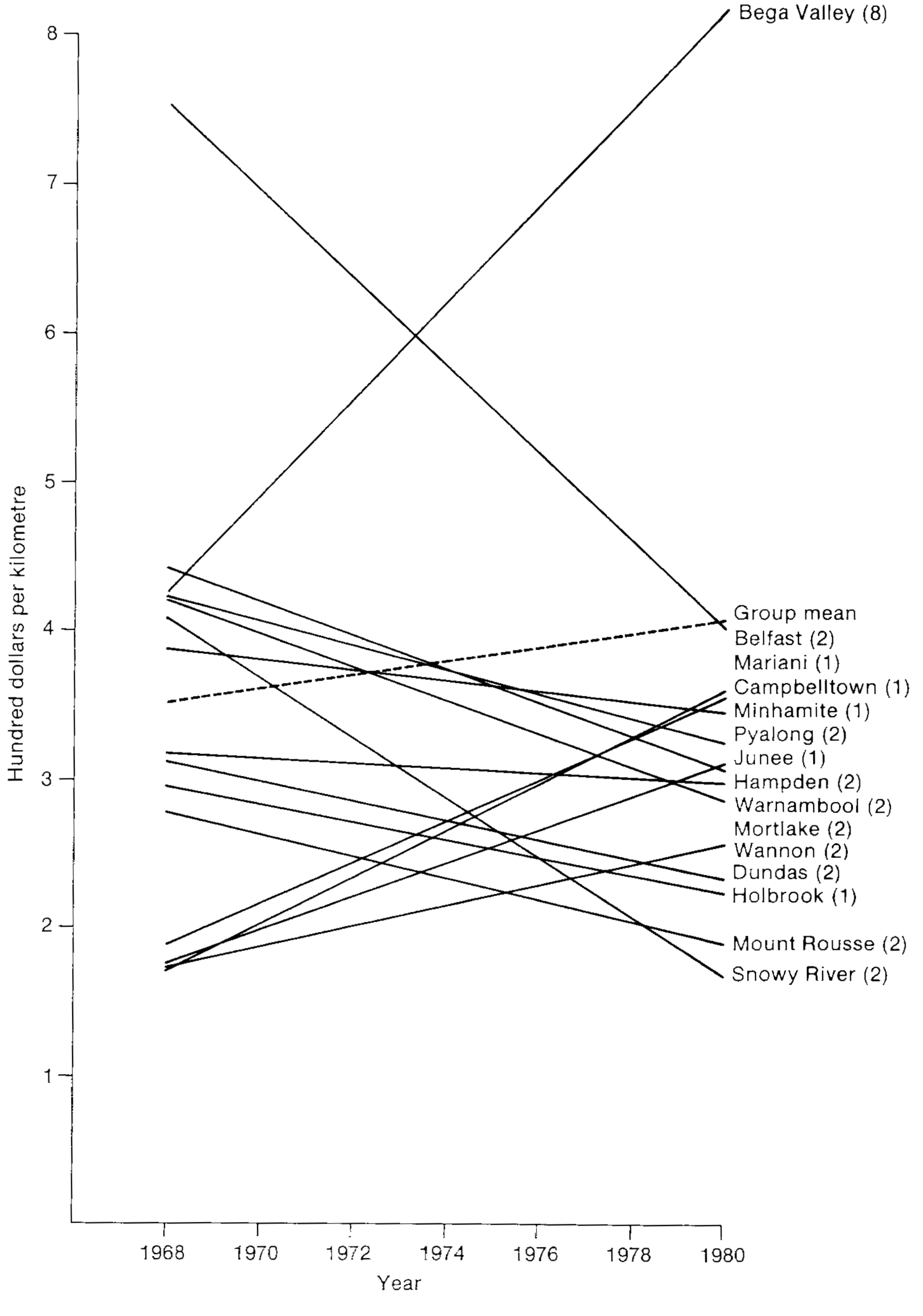


Figure IV.5—Expenditure for group 4, 1968-80

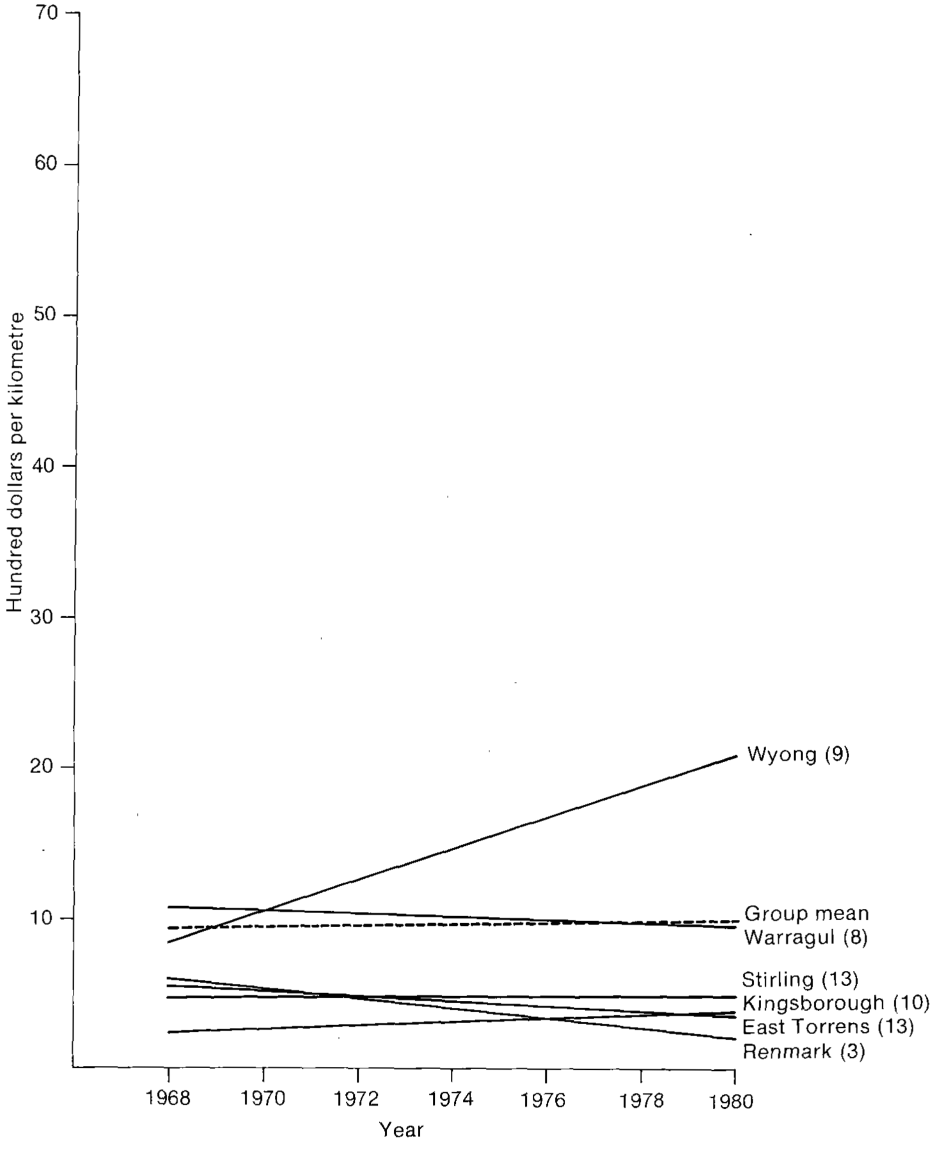


Figure IV.6—Expenditure for group 5, 1968-80

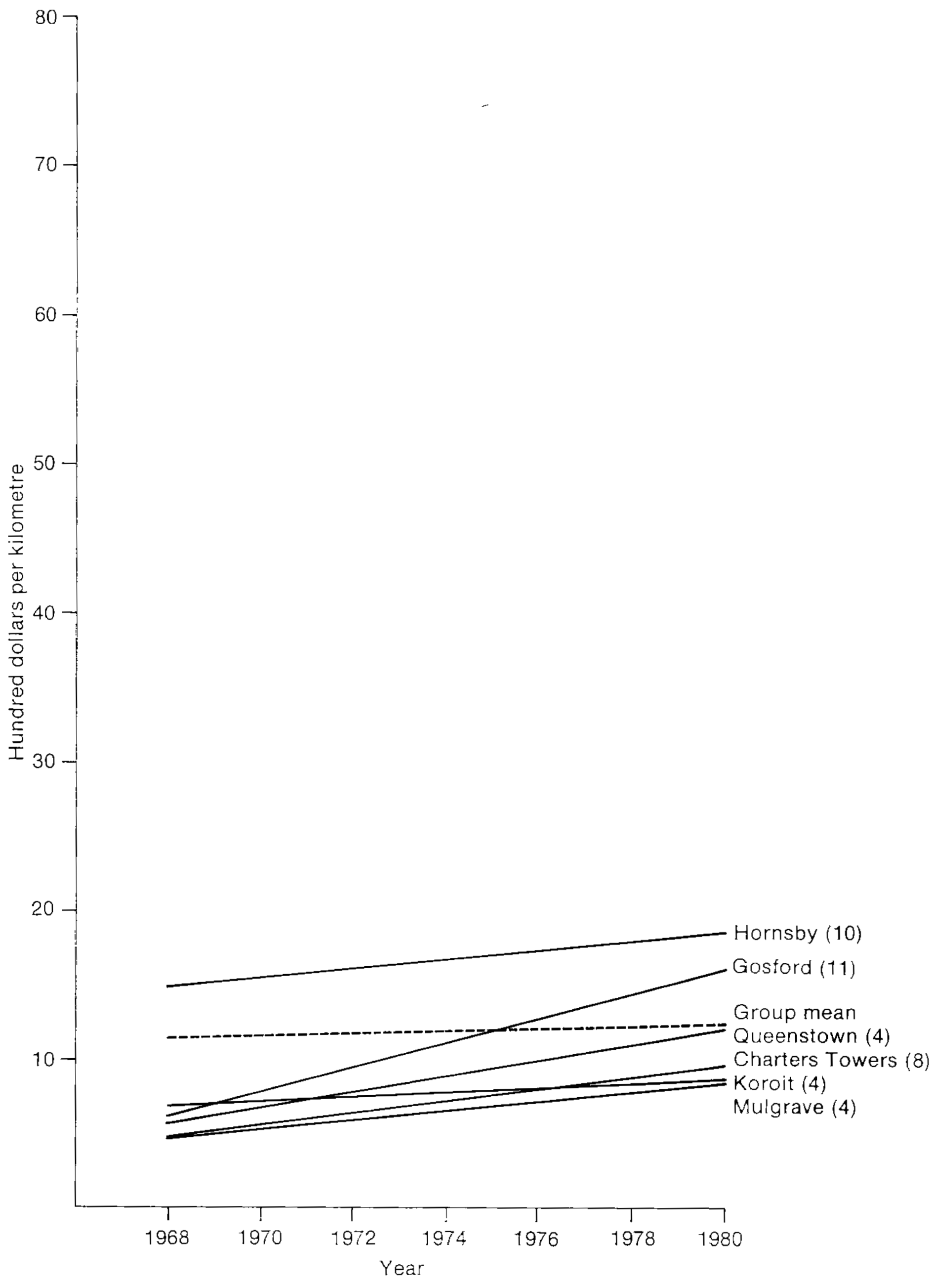


Figure IV.7—Expenditure for group 6, 1968-80

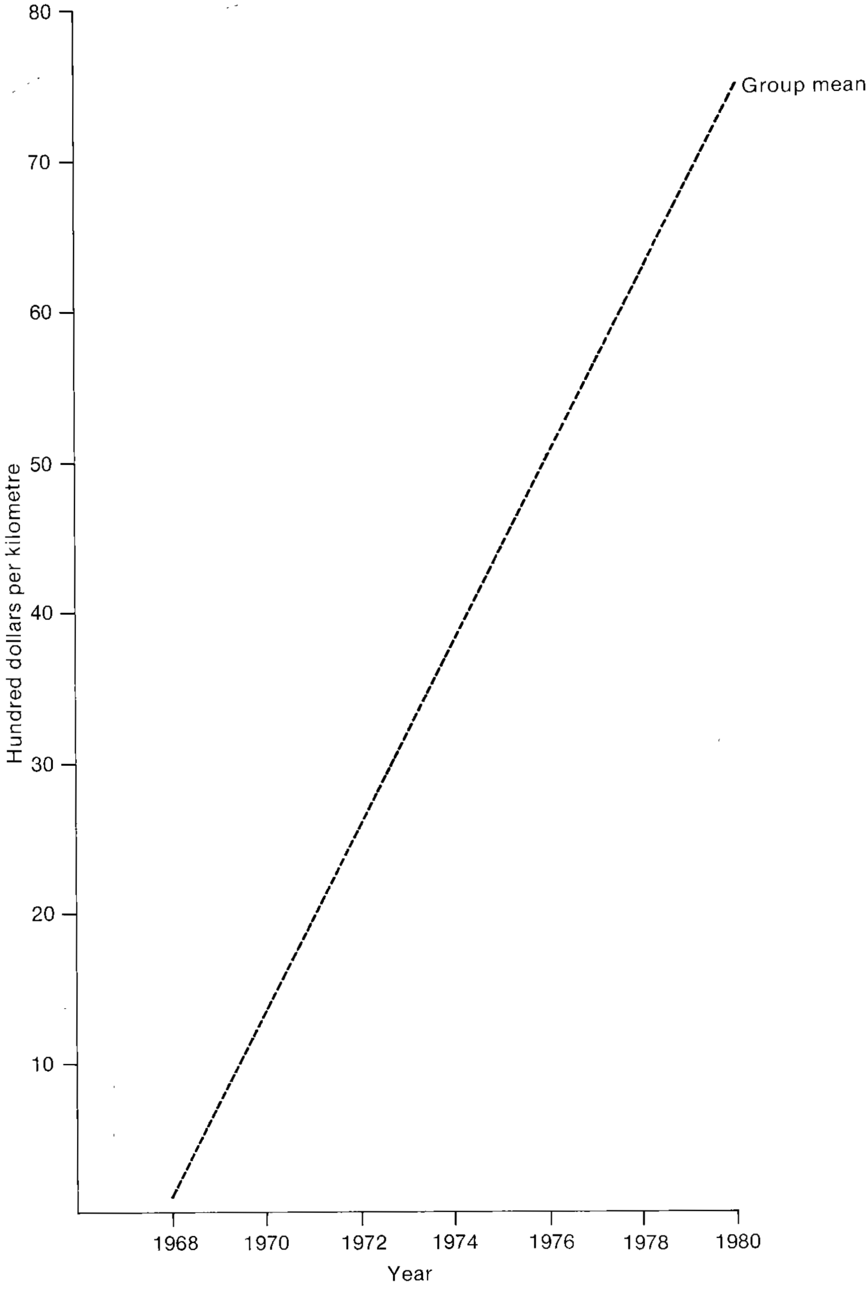


Figure IV.8—Expenditure for group 7, 1968-80

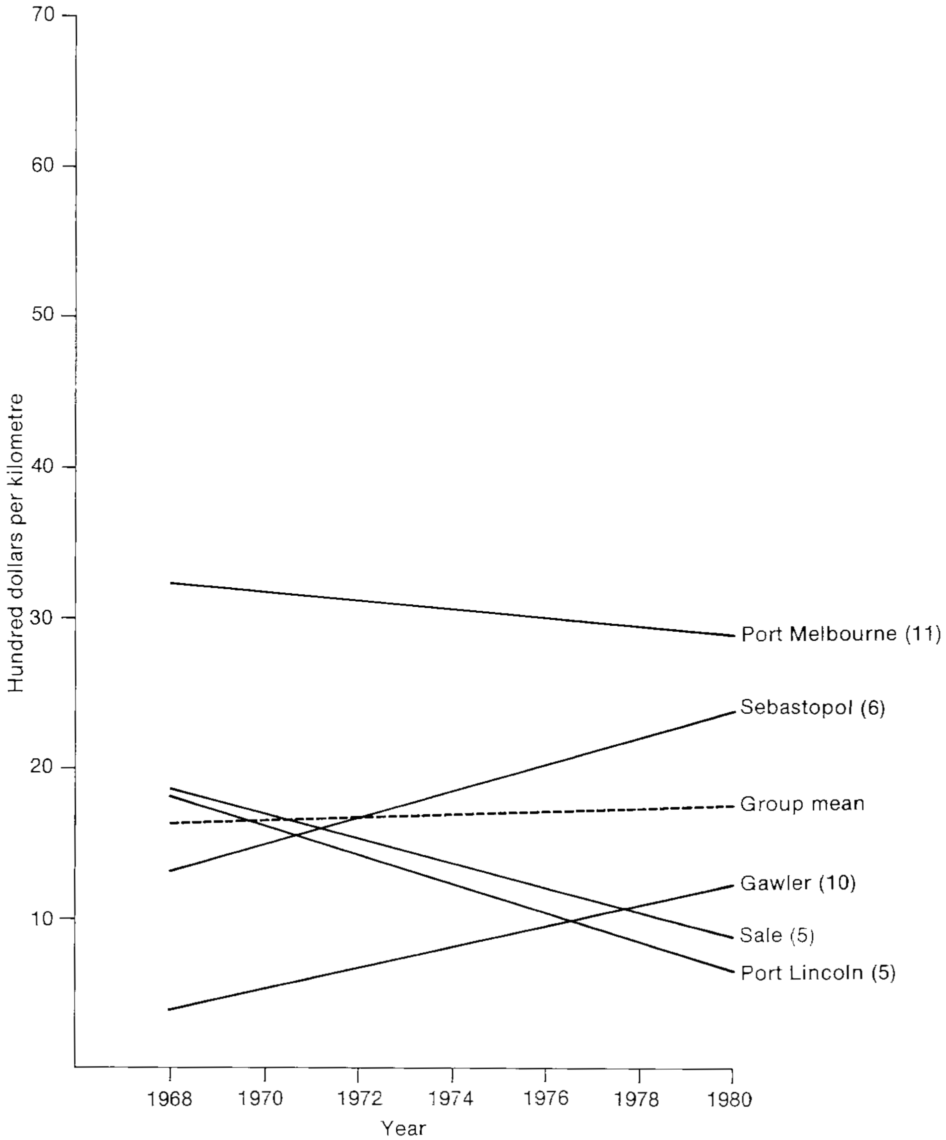


Figure IV.9—Expenditure for group 8, 1968-80

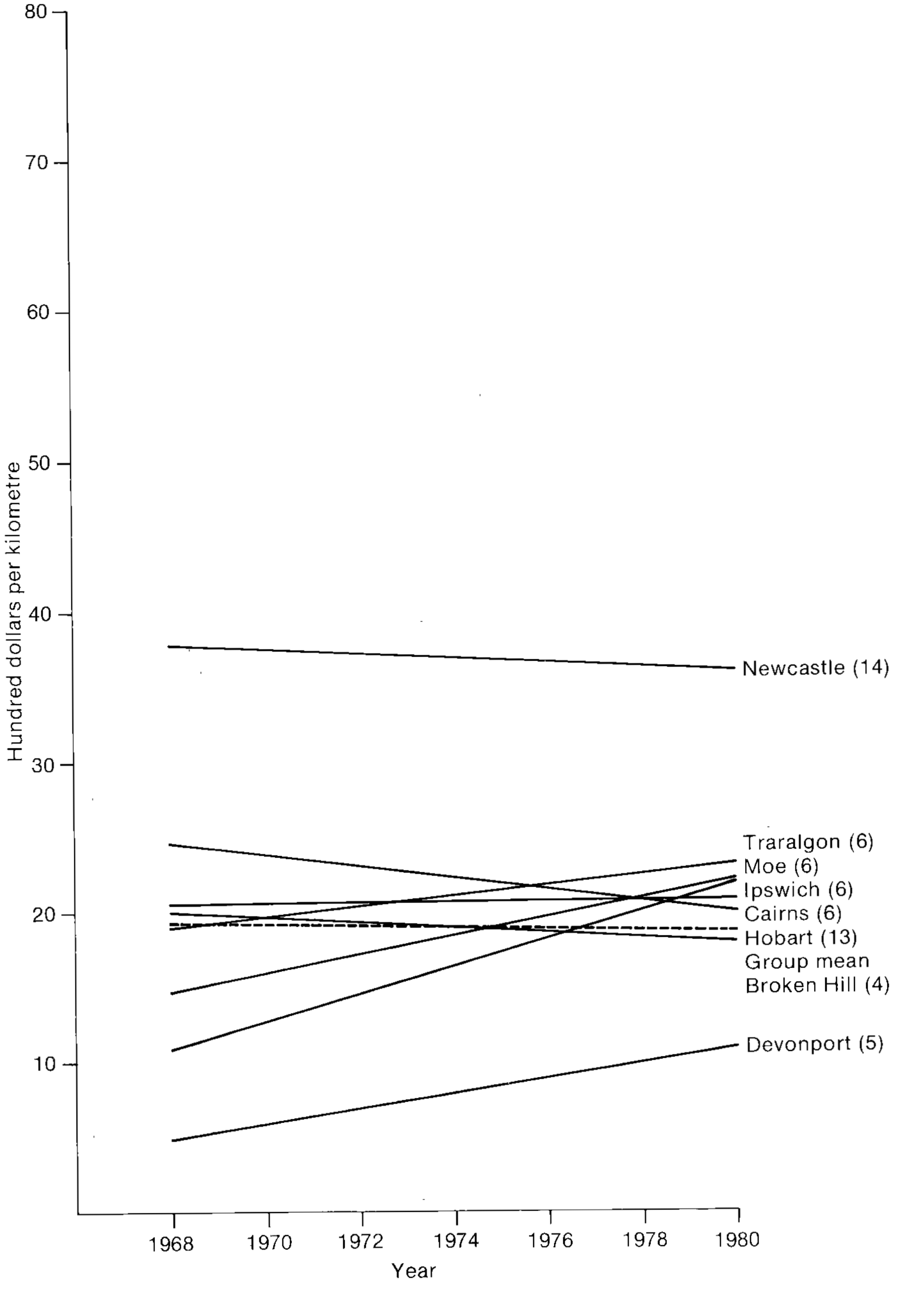


Figure IV.10—Expenditure for group 9, 1968-80

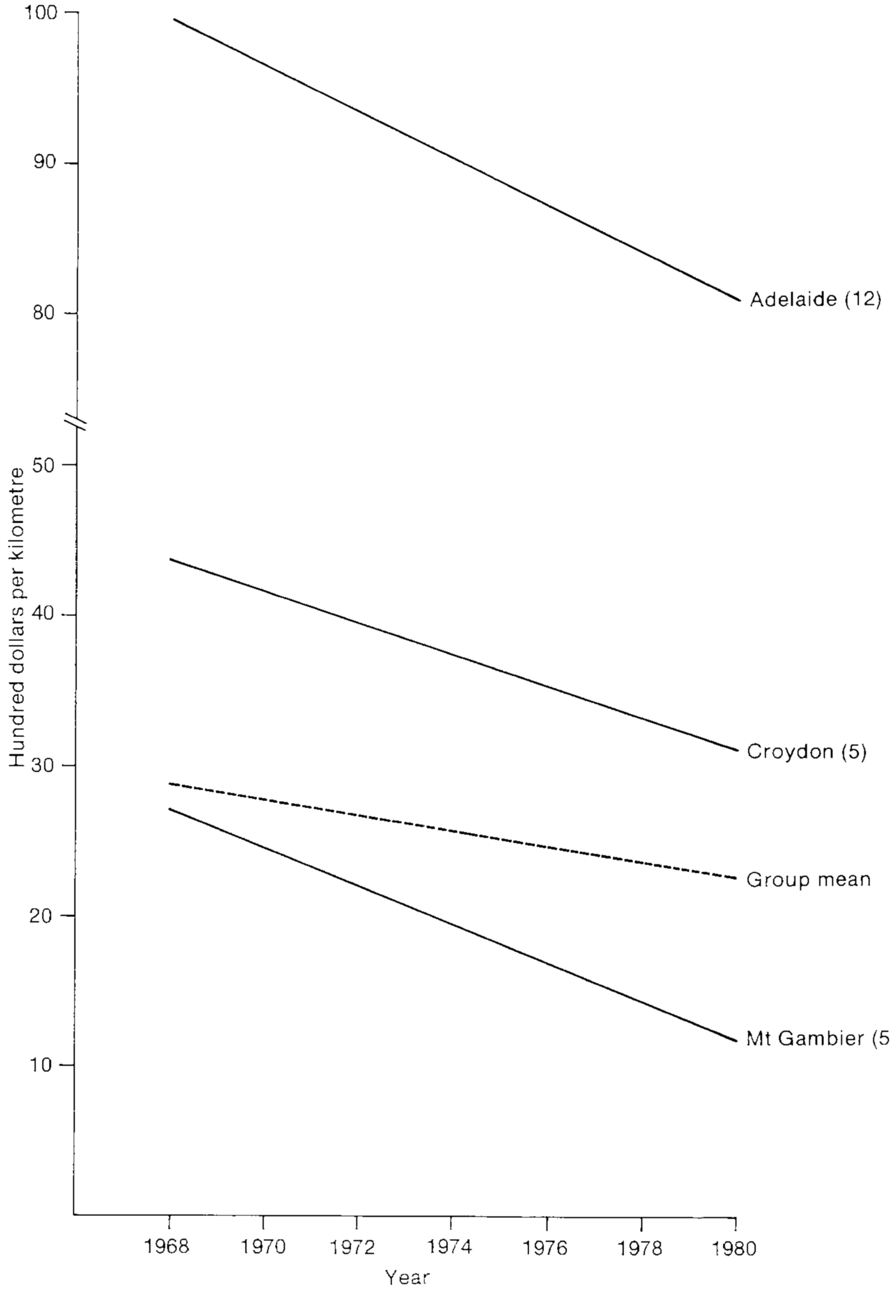


Figure IV.11—Expenditure for group 10, 1968-80

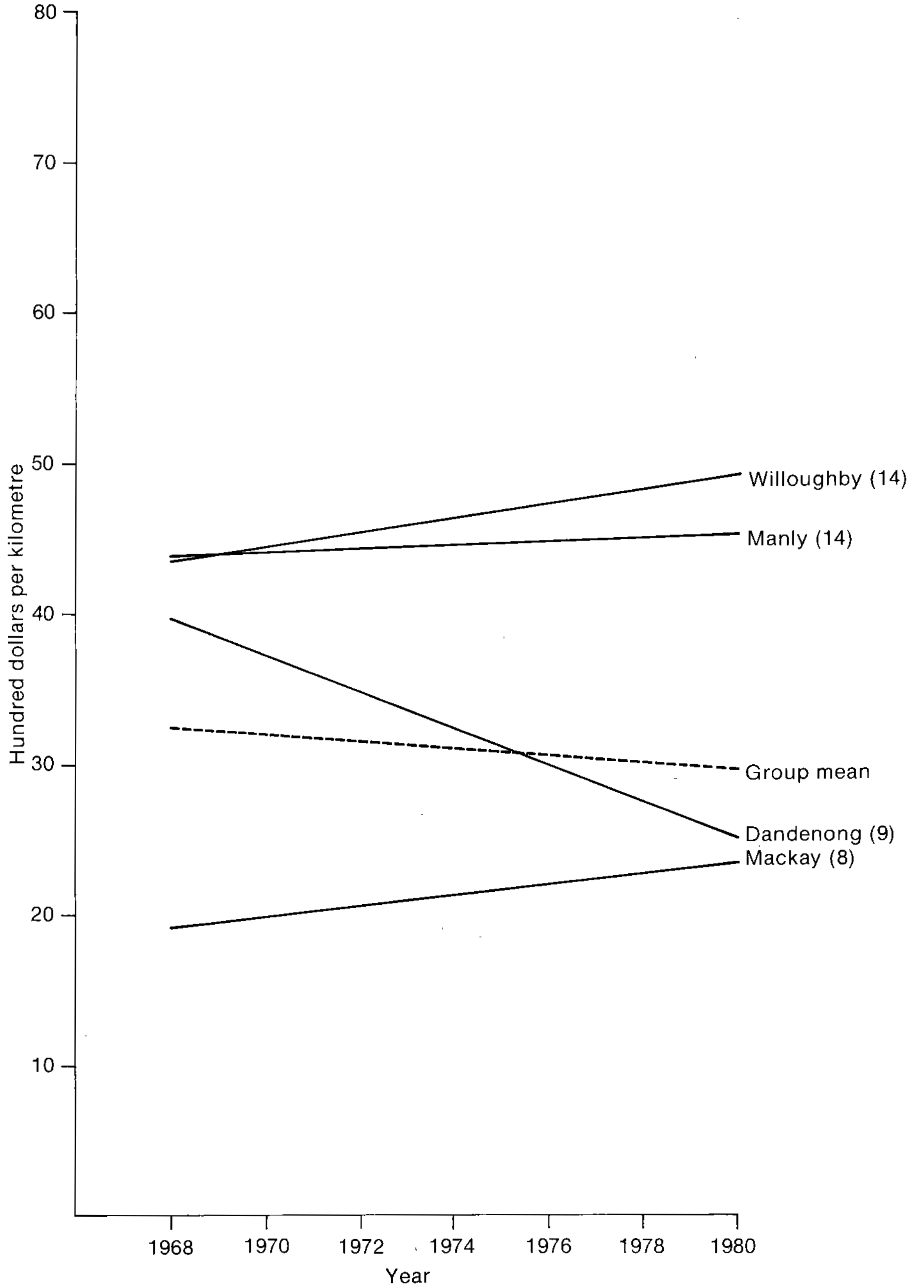


Figure IV.12—Expenditure for group 11, 1968-80

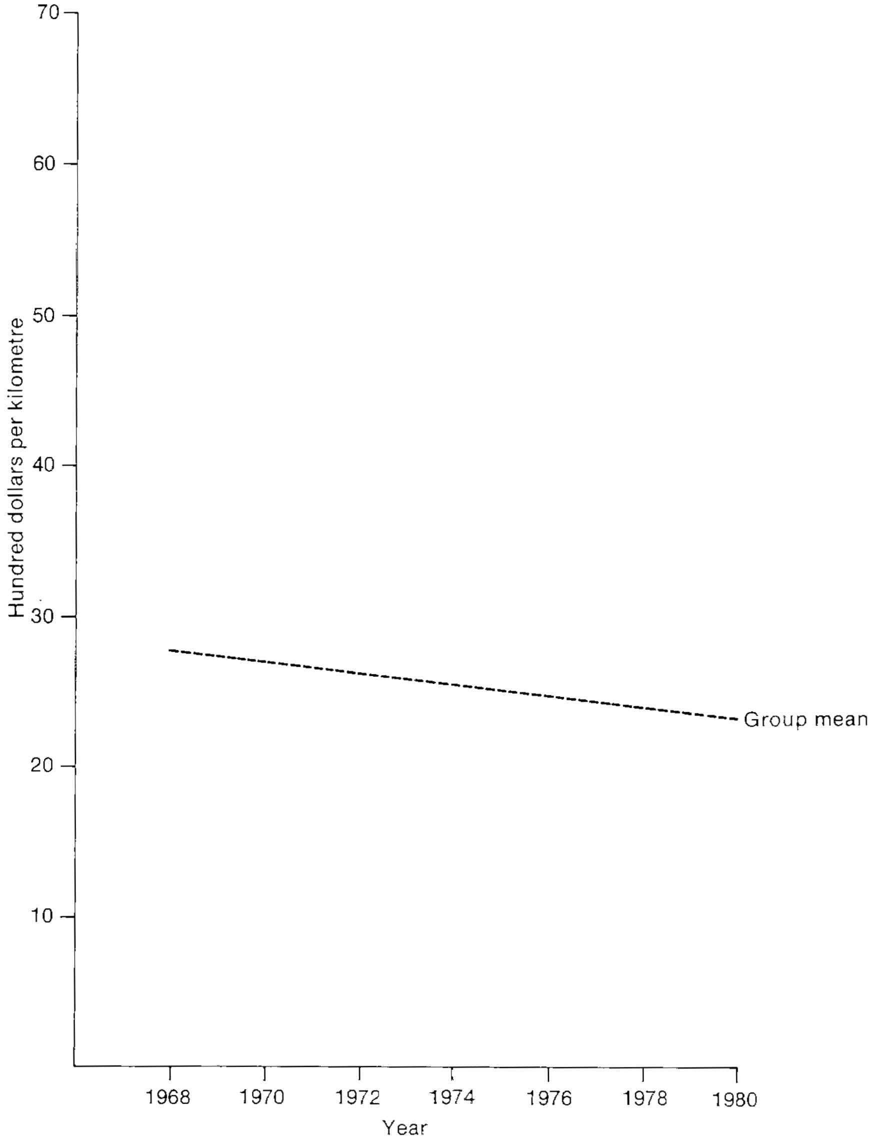


Figure IV.13—Expenditure for group 12, 1968-80

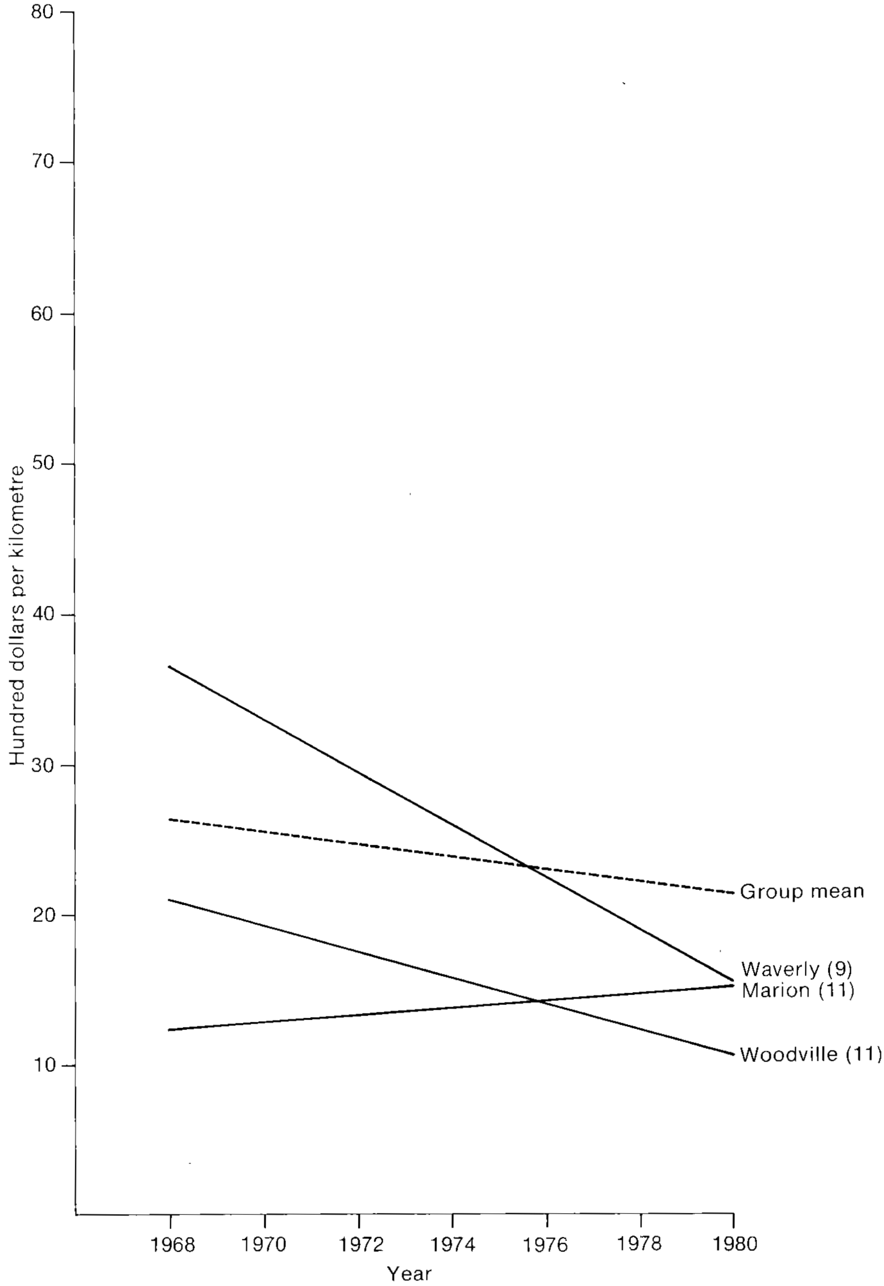


Figure IV.14—Expenditure for group 13, 1968-80

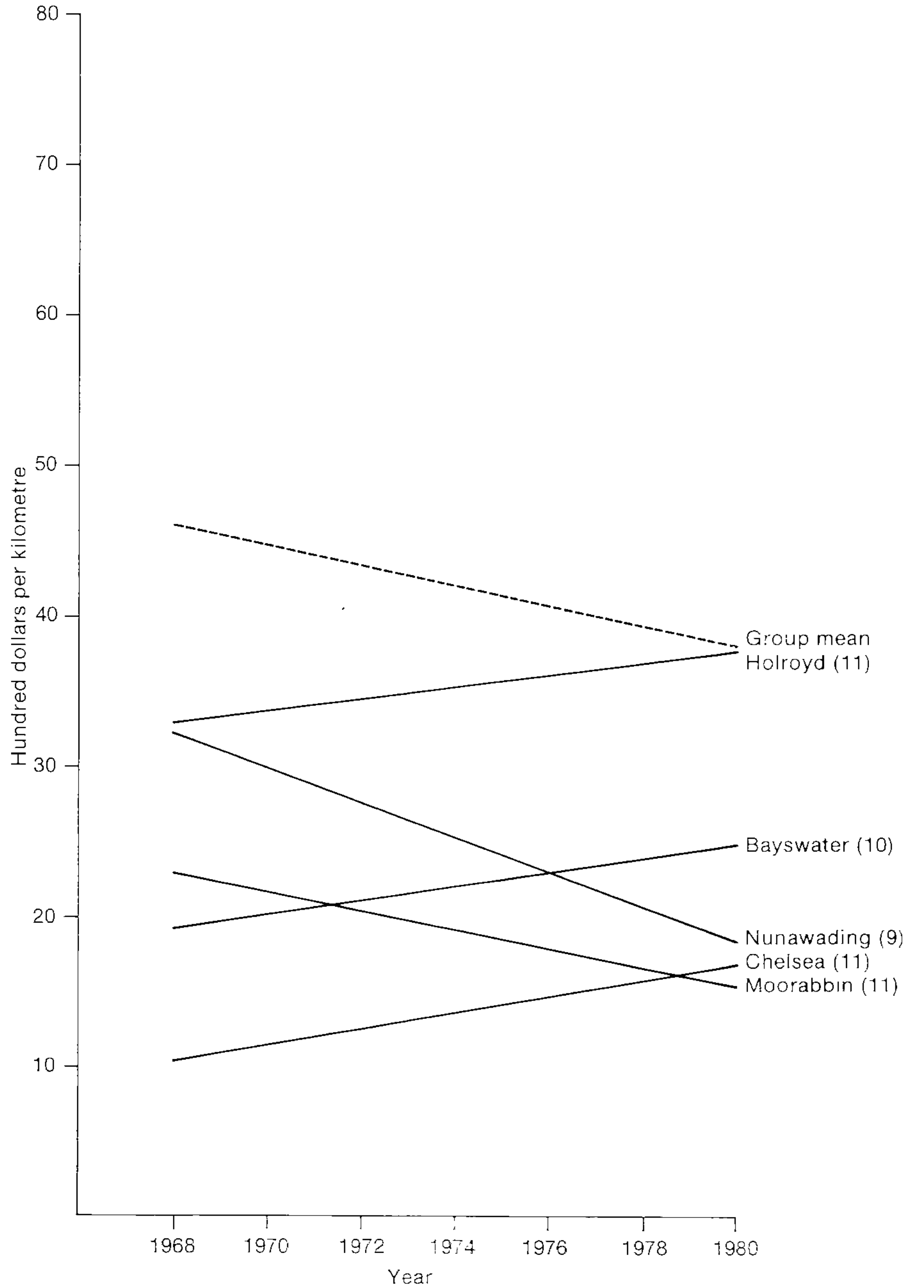


Figure IV.15—Expenditure for group 14, 1968–80

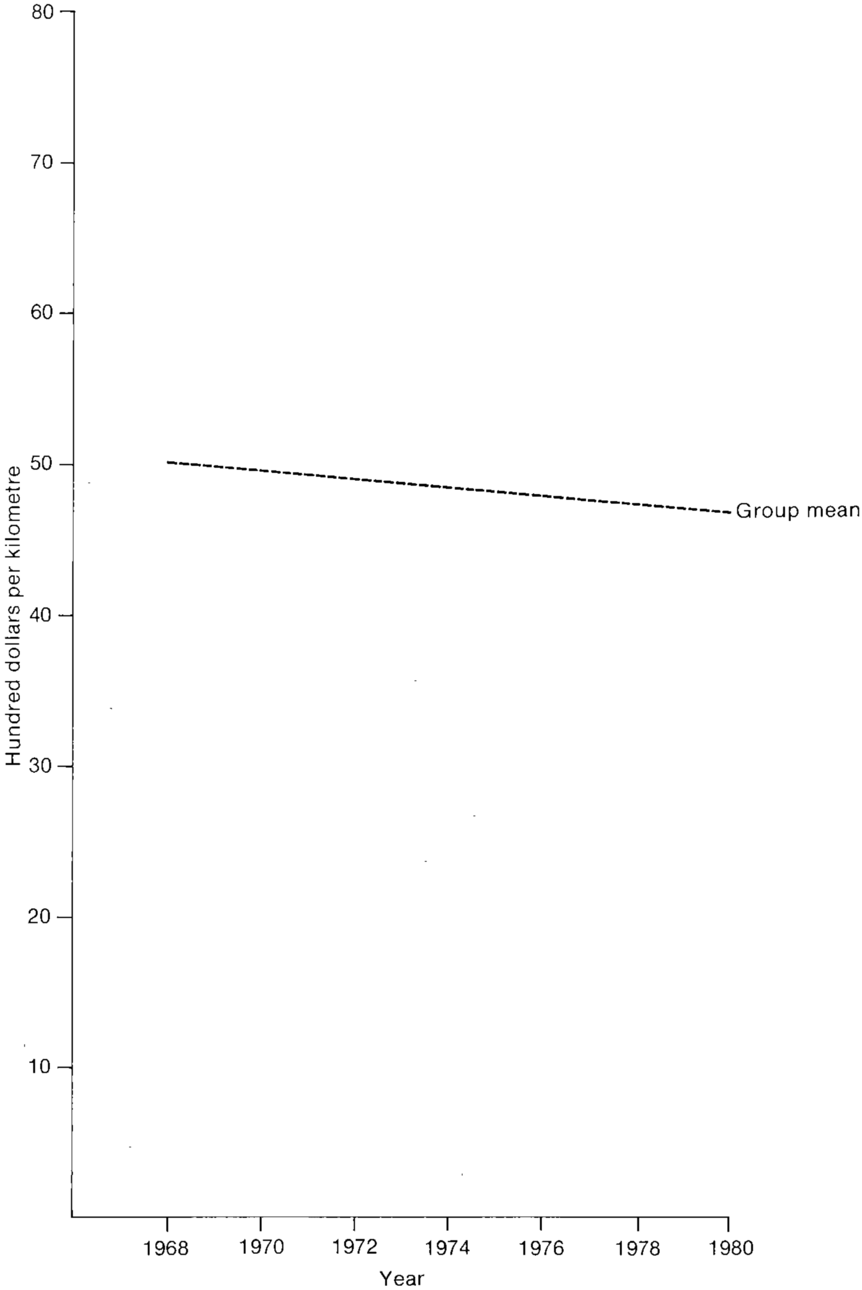


Figure IV.16—Expenditure for group 15, 1968-80

APPENDIX V—RANKING OF LGA GROUPS IN MORE THAN ONE DIMENSION

The main aim of performing the cluster and discriminant analyses was to identify those LGAs with road systems where there is substantial mismatch with the level of local usage relative to other LGAs. This task reduced to one of identifying 'outliers', or LGAs which had been classified into a 'usage' group other than that of their 'supply' group. The determination of outliers involved a two stage process, detailed in Chapter 3, which in essence selects only those LGAs that have a substantially different level of road usage from the other LGAs in its group. Central to this process was the ranking of the groups into an order that allowed comparisons to be made between groups based on their position in the ranking. The details of this ranking process are contained in the following paragraphs.

A score for each group was produced by summing the individual position numbers of the three road supply variable means for the group. This score was then used to rank the group. Where two groups had equal scores, the median rank for each group was used to differentiate. The numbers subsequently used to identify the groups correspond to the rank assigned to them. Outliers were then defined to be those LGAs which had been classified by the discriminant analysis into a group two or more groups away from their group derived from the cluster analysis.

The one dimensional ranking used throughout this study (instead of a three dimensional one) has not had a significant effect on the determination of the outliers, even though the groups were determined using three variables, which would imply a loss of information if only one dimension was used to rank the groups. This is brought about by the groups essentially falling on a line through the three dimensional space defined by the three variables. This can be seen by examining Figures V.1 to V.3.

Figures V.1 and V.2 are plots of the group means for the road supply groups for the three variables used. Figure V.1 shows the percentage of sealed road against population per kilometre of road, and Figure V.2 shows kilometres of road per square kilometre of LGA area also against population per kilometre of road. An impression of the three dimensional relationships of the groups can be gleaned from examining Figure V.3.

Apart from Group 7, which consists of a single LGA, the groups tend to follow a line curving through three dimensional space. The group numbers tend to increase along the line. The linearity of the groups' placement is disturbed slightly in the region of Groups 11 to 14. In this area, a borderline member of, for example, Group 11 could be approaching Groups 13 or 14. Due to both problems mentioned, LGAs could be erroneously classified as outliers with the ranking that was used.

Table V.1 lists the distances between groups, calculated after standardising the groups means. If the ranking produced was a true representation of the closeness of groups, then the inter-group distances around the zero diagonal should be minimum for each group. As can be seen, this is generally the case, although once again Group 7 disturbs the sequence somewhat. The distribution of Groups 11 to 14 is also reflected in the distance figures.

In conclusion, the method used to rank groups and ultimately identify outliers appears to be a reasonable technique. Where it does produce error, this is on the side of identifying more LGAs as outliers than are desired. From examining the results, only three or four LGAs could fall into this category.

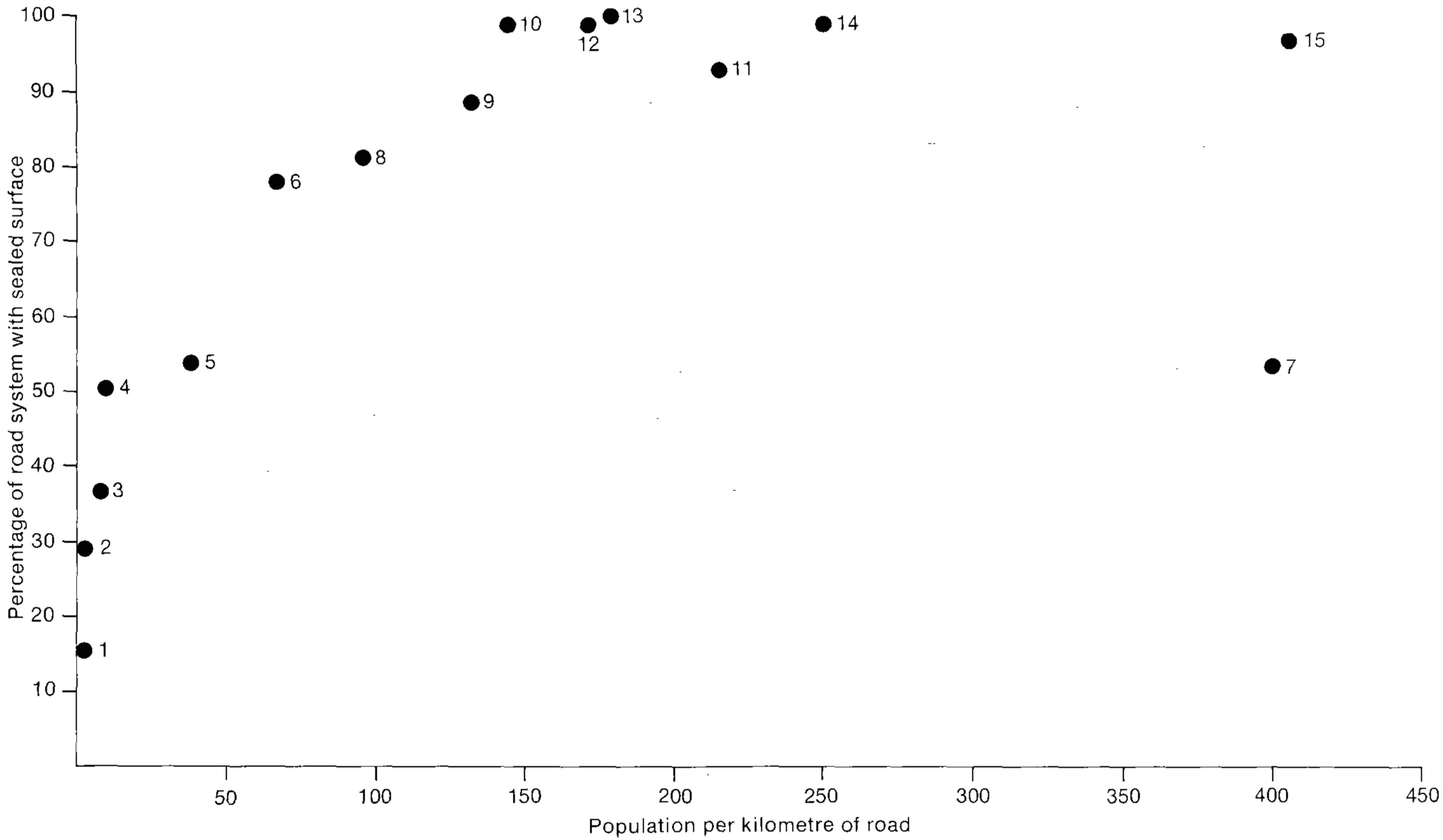


Figure V.1—Group by percentage of road length sealed and population per length of road

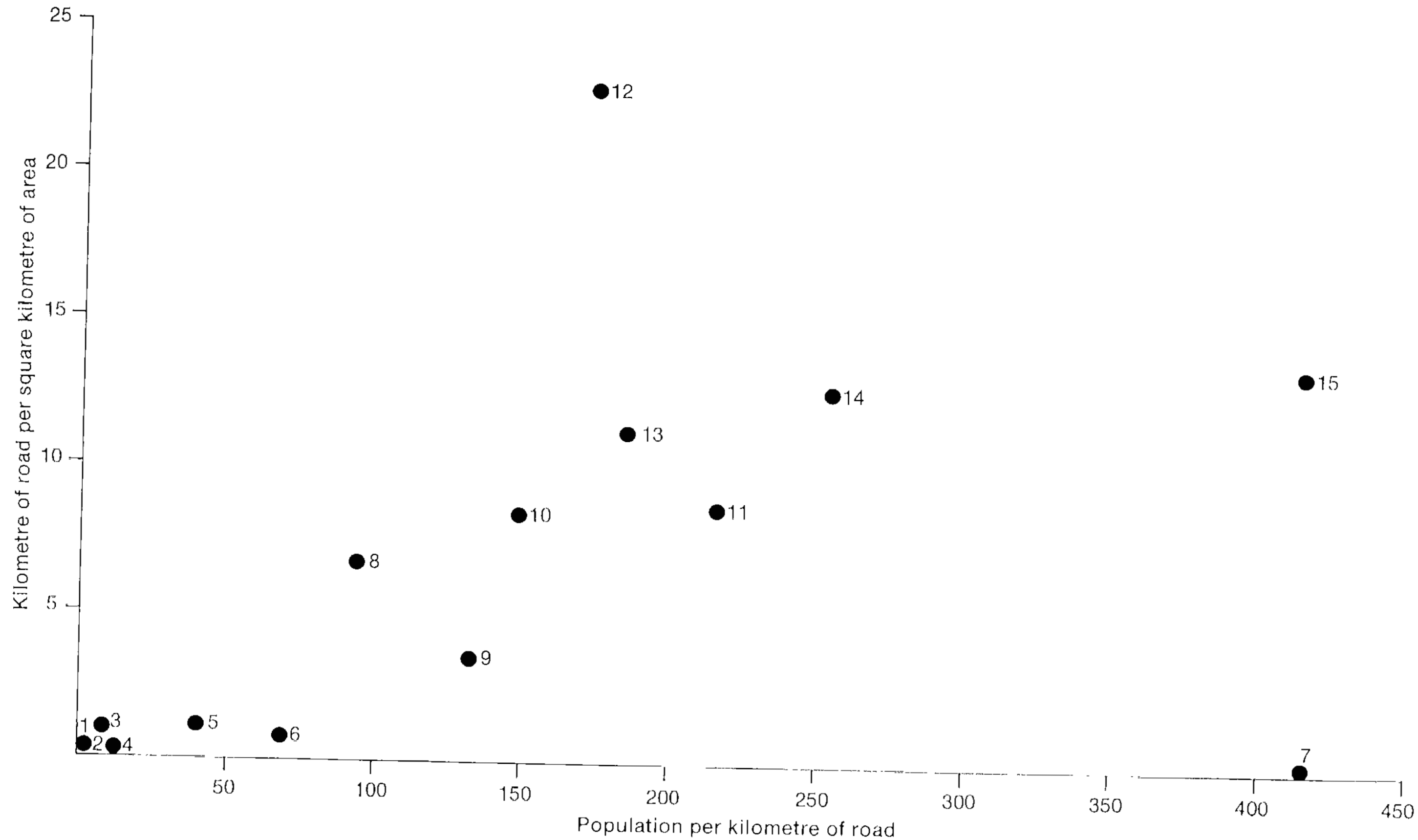


Figure V.2—Group by length of road per LGA area and population per length of road

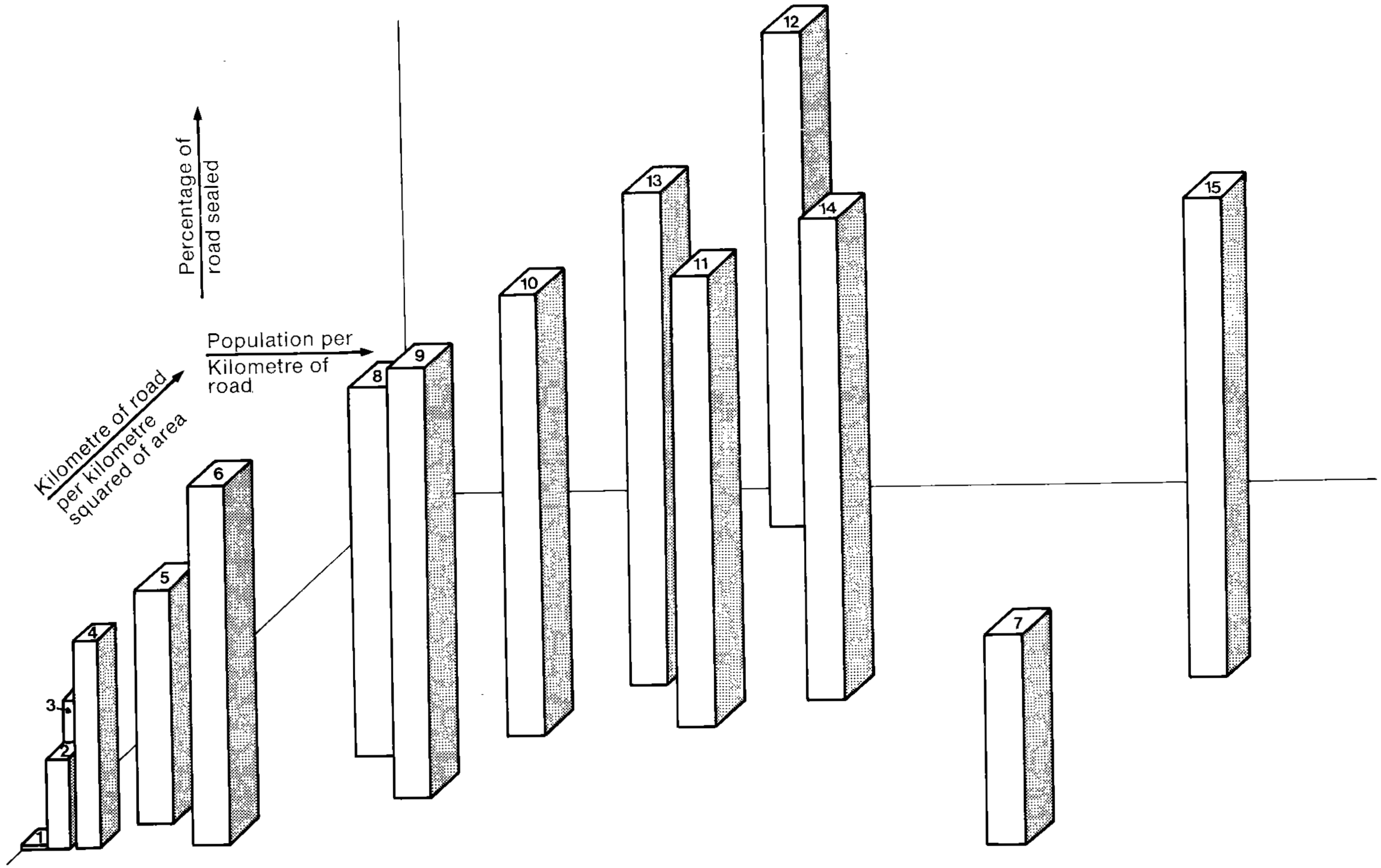


Figure V.3—Three dimensional plot of groups

TABLE V.1—MEASURE OF THE DISTANCE BETWEEN GROUPS FOR STANDARDISED GROUP MEANS

Group number	*Group number* 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.00	0.50	0.74	1.25	1.41	2.29	3.42	2.64	2.82	3.41	3.46	4.77	3.72	4.02	4.72
2	0.50	0.00	0.26	0.75	0.94	1.80	3.23	2.20	2.36	2.98	3.07	4.46	3.32	3.65	4.41
3	0.74	0.26	0.00	0.52	0.69	1.56	3.15	1.95	2.12	2.73	2.84	4.25	3.08	3.43	4.22
4	1.25	0.75	0.52	0.00	0.36	1.08	3.06	1.60	1.69	2.36	2.52	4.07	2.76	3.15	4.00
5	1.41	0.94	0.69	0.36	0.00	0.90	2.86	1.29	1.44	2.06	2.20	3.74	2.44	2.81	3.66
6	2.29	1.80	1.56	1.08	0.90	0.00	2.79	0.85	0.69	1.44	1.68	3.50	1.93	2.36	3.27
7	3.42	3.23	3.15	3.06	2.86	2.79	0.00	2.82	2.53	2.92	2.47	4.32	2.97	2.83	2.59
8	2.64	2.20	1.95	1.60	1.29	0.85	2.82	0.00	0.63	0.79	1.06	2.65	1.19	1.65	2.68
9	2.82	2.36	2.12	1.69	1.44	0.69	3.53	0.63	0.00	0.86	1.05	3.06	1.35	1.75	2.64
10	3.41	2.98	2.73	2.36	2.06	1.44	2.92	0.79	0.86	0.00	0.58	2.27	0.55	1.06	2.17
11	3.46	3.07	2.84	2.52	2.20	1.68	2.47	1.06	1.05	0.58	0.00	2.24	0.52	0.71	1.66
12	4.77	4.46	4.25	4.07	3.74	3.50	4.32	2.65	3.06	2.27	2.24	0.00	1.81	1.71	2.36
13	3.72	3.32	3.08	2.76	2.44	1.93	2.97	1.19	1.35	0.55	0.52	1.81	0.00	0.57	1.75
14	4.02	3.65	3.43	3.15	2.81	2.36	2.83	1.65	1.75	1.06	0.71	1.71	0.57	0.00	1.21
15	4.72	4.41	4.22	4.00	3.66	3.27	2.59	2.68	2.64	2.17	1.66	2.36	1.75	1.21	0.00

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