ANALYSIS OF HISTORICAL VEHICLE SCRAPPING AND SURVIVAL PATTERNS 1950 - 1976

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ABSTRACT: *This report examines vehicle scrapping in the period December 1971 to June 1976 and historical vehicle survival patterns for private and commercial vehicle types, on the basis of material published by the Australian Bureau of Statistics. Taking the 1971 Census of Motor Vehicles as the principle point of reference it was found that vehicle survival patterns were best accounted for by functions of a logistic form. One of the possible applications of such functions, the estimation of rates of diffusion of vehicle characteristics is illustrated, by using the function determined for cars and station wagons to estimate present and future vehicle numbers manufactured to comply to specified Australian Design Rules.*

1. INTRODUCTION

Vehicle scrapping patterns and survival behaviour should provide information of use in the study of a number of aspects of road transport. These include; examination of rates of propagation of design rules, draft regulations, and technical changes, analysis of allowances for and factors affecting vehicle depreciation, estimation of the replacement element of the demand for motor vehicles, and projections of motor vehicle populations.

This paper is primarily concerned with examining historical data from which scrapping patterns can be deduced. Analysis at this stage has been confined to published or readily available data the greater part of which has been compiled and published by the Australian Bureau of Statistics (ABS). Two avenues of analysis are pursued: estimation of what could be called crude scrapping rate or actual numbers of vehicles scrapped in successive periods and estimation of historical vehicle survival functions based on the 1971 Census of Motor Vehicles (ABS 1973). Analysis of economic factors underlying vehicle scrapping, and sensitivity of scrapping to individual economic factors has not been undertaken.

Several examinations of vehicle survival patterns in Australia have been carried out prior to this study, notably by the Industries Assistance Commission (Tariff Board 1973) in its examination of the demand for new motor vehicles and by Oceanics Pty. Ltd. (Oceanics 1976). However these vary substantially in either method, or coverage from procedures followed in this paper. In this context, it is hoped that the findings contained here will contribute to the productive application of this data. Statistics contained in this paper should not however be regarded as definitive, due to problems experienced with raw data, and limitations resulting from methods of analysis used: this qualification is weak, in that the majority of applications of such general survey data is vulnerable to the same criticisms at the point of attempted use.

2. CRUDE SCRAPPING RATES

Since the 1971 Census of Motor Vehicles ABS has published details of numbers of both total vehicles on register and registrations of new vehicles (ABS 1976) split into nine categories of vehicles, permitting more detailed analysis of vehicle scrappage by type of vehicle than previously possible in Australia.

Numbers of vehicles scrapped during a given period can be estimated as the difference between total vehicles on register at the commencement of the period, plus new vehicles registered in the period, less the total number of vehicles on register at the end of the period. Estimates of vehicles scrapped for each half yearly period between December 1971 and June 1976 using this method are set out in Table I for Australia for each of nine categories of vehicles. Estimates will vary from actual numbers of vehicles scrapped depending on the occurrence of re-registrations of previously registered vehicles, imports of secondhand vehicles, and modification of vehicles from one type to another.

Examination of Table I shows that estimates of numbers of 'Other Truck Types' scrapped in all but one period are negative and therefore unacceptable. While defective data may account for some of this aberration, it is also likely that this occurrence reflects conversion of vehicles already registered as trucks and light commercials into other truck types. While other categories

TABLE I

CRUDE SCRAPPING RATE - NUMBERS OF VEHICLES SCRAPPED (000's)

Time Period	Cars	Station Wagons	Light Commercial Type Vehicles		Trucks		Other Truck Types	Buses	Motor Cycles
			Open	Closed	Rigid	Articulated			
Dec 1971 - June 1972	90.6	15.3	16.5	7.0	5.8	0.5	-0.4	0.0(1)	5.7
June 1972 - Dec 1972	74.4	9.4	10.6	7.3	4.8	0.9	-1.0	0.5	16.2
Dec 1972 - June 1973	101.6	15.6	44.8	9.6	3.6	1.0	0.7	0.8	23.2
June 1973 - Dec 1973	79.8	16.5	14.	8.3	2.8	0.5	-0.4	0.8	16.1
Dec 1973 - June 1974	96.46	21.2	15.6	7.0	5.5	0.8	-0.5	0.9	20.4
June 1974 - Dec 1974	88.51	20.5	14.6	11.1	4.4	0.8	-0.7	0.8	21.1
Dec 1974 - June 1975	100.8	20.3	12.0	10.5	1.2	0.6	-6.9	0.8	23.8
June 1975 - Dec 1975	86.1	26.4	10.7	11.5	4.5	0.1	-1.3	1.3	24.0
Dec 1975 - June 1976	101.8	20.1	15.3	9.6	1.5	1.0	-0.3	0.9	22.0
Average $(\bar{X})$	91.1	18.37	17.16	9.10	3.79	0.69	-1.16	0.76	19.17
Coefficient of Variation $\left(\frac{\sigma_x}{\bar{x}}\right)$	0.10	0.25	0.58	0.18	0.41	0.41	-1.81	0.43	0.29

(1) 0.007 Source ABS (1976)

Coefficient of Variation $\left(\frac{\sigma_x}{\bar{x}}\right)$	0.10	0.25	0.58	0.18	0.41	0.41	-1.81	0.43	0.29

(1) 0.007 Source ABS (1976)

TABLE II

CRUDE SCRAPPING RATE - VEHICLES SCRAPPED AS A % OF REGISTRATIONS OF NEW VEHICLES

Time Period	Cars	Station Wagons	Light Commercial Type Vehicles		Trucks		Buses	Motor Cycles
			Open	Closed	Rigid	Articulated		
Dec 1971 - June 1972	33.0	62.7	87.3	65.4	45.5	40.0	0.7	22.6
June 1972 - Dec 1972	40.7	34.2	54.1	57.1	33.8	55.7	51.9	54.7
Dec 1972 - June 1973	53.2	54.9	11.2	62.8	23.8	55.2	66.0	64.4
June 1973 - Dec 1973	37.8	56.2	66.7	53.7	17.0	23.6	60.5	39.1
Dec 1973 - June 1974	49.0	76.8	76.8	50.8	40.5	45.8	75.0	46.4
June 1974 - Dec 1974	40.8	59.6	61.6	60.4	26.8	44.9	54.4	57.8
Dec 1974 - June 1975	46.6	57.8	55.8	57.7	7.7	36.5	53.5	76.8
June 1975 - Dec 1975	46.3	67.7	52.9	61.7	24.1	3.9	69.2	76.5
Dec 1975 - June 1976	52.3	51.5	65.7	48.7	7.1	45.5	50.0	76.9
Average $(\bar{X})$	46.6	57.9	59.1	57.6	24.2	39.0	53.5	57.2
Coefficient of Variation $\left(\frac{\sigma_x}{\bar{x}}\right)$	0.12	0.19	0.34	0.09	0.52	0.40	0.38	0.31

Source ABS (1976)

TABLE III

CRUDE SCRAPPING RATE - VEHICLES SCRAPPED % AS PROPORTION OF TOTAL VEHICLES ON REGISTER AT COMMENCEMENT OF EACH PERIOD

Time Period	Cars	Station Wagons	Light Commercial Type Vehicles		Trucks		Buses	Motor Cycles
			Open	Closed	Rigid	Articulated		
Dec 1971 - June 1972	2.7	2.1	4.2	4.6	1.5	1.5	0.0(1)	3.4
June 1972 - Dec 1972	2.2	1.3	2.7	4.7	1.3	2.6	2.2	8.8
Dec 1972 - June 1973	2.9	2.1	9.0	6.0	0.9	2.9	3.1	11.7
June 1973 - Dec 1973	2.2	2.2	3.5	5.0	0.7	1.4	3.0	7.7
Dec 1973 - June 1974	2.6	2.7	3.8	4.0	1.3	2.1	3.5	8.7
June 1974 - Dec 1974	2.3	2.6	3.5	6.2	1.1	2.2	3.2	8.2
Dec 1974 - June 1975	2.5	2.6	2.8	5.6	0.3	1.6	3.0	8.7
June 1975 - Dec 1975	2.1	3.3	2.4	5.8	1.0	0.2	5.9	8.5
Dec 1975 - June 1976	2.4	2.4	3.4	4.7	0.3	2.4	3.2	7.6
Average $(\bar{X})$	2.4	2.4	3.9	5.2	0.9	1.9	2.9	8.1
Coefficient of Variation $\left(\frac{\sigma_X}{\bar{X}}\right)$	0.10	0.22	0.48	0.14	0.44	0.40	0.42	0.25

(1) 0.029 Source ABS (1976)

of vehicles all show positive scrapping rates for each period examined there appears to be no discernable trends in vehicle scrappage over time. Care should also be taken in interpreting the results shown for articulated trucks as the figures tend to reflect scrappage of prime movers as opposed to trailers. Numbers of vehicles scrapped for each category vary from period to period, as is shown by the coefficient of variation computed for each category. Disregarding the category other truck types, the tendency towards variation is most marked for open light commercial vehicles, and least marked for motor cars.

Estimates of numbers of vehicles scrapped expressed as proportions of total new vehicles registered, and total numbers of vehicles on register at the commencement of each six monthly period are set out in Tables II and III respectively for each category except Other Truck Types. Data contained in Table II provides some indication of the replacement element of demand for new vehicles, while Table III provides some indication of the attrition of the vehicle fleet due to scrapping, assuming of course few new vehicles are scrapped during their first six months of registration.

For all vehicle classifications other than cars, rigid and articulated trucks, Table II indicates that on average numbers of vehicles scrapped during the period December 1971 to June 1976 amounted to more than 50 per cent of total new registrations in each category. This would appear to indicate that replacement demand in these categories accounted for over 50 per cent of demand for new vehicles. For cars, the scrappage figure was slightly less at 46 per cent, while for articulated and rigid trucks the ratios were substantially smaller indicating greater demand for vehicles for new business. A similar picture emerges in Table III where numbers of vehicles scrapped are expressed as a proportion of total vehicles on register at the commencement of each six monthly period. For all categories shown, other than rigid trucks, scrapping accounts for in excess of two per cent of total registrations during each six monthly period. The two highest average rates of attrition were recorded for Motor Cycles, and Closed Light Commercial Vehicles. Proportions contained in Tables II and III show tendencies to vary similar to those shown in Table I. Coefficients of variation computed in Tables II and III, while showing that variation tends to be small for the category motor cars, indicate differing patterns for other categories of vehicles. Scrapping patterns for rigid trucks irrespective of form of presentation during the period 31 December 1972 to 30 June 1976 show values below average rates for other groups, and show a tendency towards greater variation.

Estimates of numbers of vehicles scrapped, while providing some indication of recent trends in scrappage, provide no indication of two basic underlying determinants of scrappage, the age structure of the vehicle fleet, and the life expectancy of individual vehicle types. However in conjunction with the latter two factors and other information, crude scrapping rates can be used to monitor and generate projections of vehicle populations in years between successive censuses of motor vehicles.

3. VEHICLE SURVIVAL RATES

3.1 METHODS OF ESTIMATION

By combining 1971 Motor Vehicle Census data disaggregating the vehicle population by year of model with data showing numbers of new vehicles registered in individual years preceding the Census, survival rates corresponding to each year of model can be generated. These rates show the proportion of total vehicles

Coefficient of Variation $\left(\frac{\sigma_x}{x}\right)$	0.10	0.22	0.48	0.14	0.44	0.40	0.42	0.25

(1) 0.029 Source ABS (1976)

originally registered in a given year remaining on register at the time of the Census. These rates in turn can be amalgamated into a table of values which, provided factors determining scrapping behaviour over time have not altered significantly, can be used to estimate the proportions of a given number of vehicles registered in any year prior to 1971 remaining on register in each intervening year up to the Census.

In order to assess whether survival functions can be satisfactorily explained mathematically, five mathematical functions have been fitted to data using least squares techniques. The functions used comprised a logistic function (Walker 1968) and standard linear, exponential, logarithmic and power functions. Fitting of functions also simplifies comparisons of survival rates between vehicle types, smooths out fluctuations in data, and facilitates use of historical survival data in time series analysis.

3.2 INADEQUACIES OF DATA

The number of separate vehicle types for which survival rates can be determined, and the reliability of survival rates estimated is limited by inadequacies in data employed.

New vehicle registration data (ABS 1970; 1974) for years prior to 1971 is available for fewer individual categories of vehicles than are employed in the 1971 Census. This restricts the number of separate categories which can be examined. Prior to 1971 new vehicle data for trucks was not disaggregated by ABS into rigid and articulated categories. In addition details on registrations of new vehicles are not available for some categories prior to 1952.

The Motor Vehicle Census data available from ABS suffers from two basic limitations in terms of coverage. With the exception of data for Victoria and New South Wales, statistics showing vehicles on register by year of model, for model years before 1960, are available only in amalgamations of 5 years. Separate year data for Australia as a whole would have permitted improved analysis of survival rates for very old models. The second limitation on use of Motor Vehicle Census data is the large number of vehicles not classified by year of model. These amounted to 6.8 per cent of total vehicles on Register at the time of the Vehicle Census. Queensland figures present a particular problem, vehicles unclassifiable by year of model in that state accounting for 75.5 per cent of total unknown vehicles for Australia as a whole. Similar problems of less magnitude were encountered in Northern Territoy and ACT data. These occurrences were attributable to the different and changing forms in which Motor Vehicle Registration Authorities maintained records over time. While considerable effort has been devoted to devising a method to allocate unknown vehicles to year of model categories and while results cross check with vehicle number estimates employed in the 1971 Motor Vehicle Usage Survey (ABS 1973), adjustment procedures are likely to have affected results. Unfortunately, it is not possible to quantify the exact extent of this source of distortion.

Changes to classifications of vehicles employed by ABS in analysing registration data seriously restrict the number of separate classifications of freight vehicles for which survival rates can be determined. Prior to the 1971 Motor Vehicle Census, three categories of freight vehicles were employed by ABS; utilities, panel vans and trucks in compiling both new registration and total registration figures. Vehicles were assigned to categories solely by body type. However new classifications, Open Light Commercial Vehicles, Closed Light Commercial Vehicles, Rigid Trucks and Articulated trucks were introduced with the 1971 Census. These categories vary significantly from those previously employed insofar as vehicles are classified into categories according to both

carrying capacity and body type. Vehicles previously defined as utilities and panel vans under the 1971 classification would be classed as trucks if carrying capacities exceeded one ton and trucks with carrying capacities under one ton would be classified as light commercial types.

As a result of the change in classifications information available on new registrations in years prior to 1971 is available only disaggregated by the pre 1971 classification while details of vehicles on remaining register are available only according to the new classification. Analysis of data indicates the new classification caused a significant net inter-category migration of vehicles previously classified as utilities and panel vans into the category trucks in 1971, the numbers being sufficiently large to prevent old and new classifications being treated as equivalent and therefore comparisons between individual categories are likely to give inaccurate results; which has proved the case. From published data it is therefore only valid to measure survival rates for freight carrying vehicle types amalgamated into a single group.

A solution to this problem would be to devise a procedure of modifying 1971 Census data to conform with pre 1971 definitions. Data providing cross classifications of freight vehicles by body type and carrying capacity and other characteristics is not adequate to permit satisfactory adjustments although some attempt has been made to adjust data, using material drawn from both the 1971 and 1962 motor vehicle censuses. The results of these adjustment processes are however suspect.

4. VEHICLE SURVIVAL RATES AND FUNCTIONS

4.1 INCIDENTAL RESULTS

It was originally intended that survival rates and functions would be calculated for all separately identifiable vehicle classifications for each State and Territory. However when this was commenced it was found that for certain states and territories survival rates in excess of 100 per cent were regularly estimated. Table IV which sets out estimated survival rates for each state and territory for motor cars clearly demonstrates this occurrence.

Further examination of registration data for Western Australia, Queensland, Northern Territory, and the ACT indicated that for each at the time of the 1971 Census, the number of cars on register built since December 1959 exceeded the sum of registrations of new cars for the period 31 December 1960 to 30 September 1971. These results imply significant net interstate movements of vehicles first registered elsewhere. The pattern which emerges is one where Queensland, Western Australia, Northern Territory and the ACT experienced net immigration from other states.

A check of data maintained by ABS and motor registration authorities revealed that due to the form in which registration data is compiled it would not be possible to quantify the extent of these movements without substantial reworking of data. However staff employed at certain motor registration authorities were of the opinion that interstate movements had been significant.

The conclusion that could be drawn is that survival rates computed for states experiencing significant net interstate movements could give misleading impressions of survival behaviour.

TABLE IV

ESTIMATED HISTORICAL VEHICLE SURVIVAL RATES :
MOTOR CARS - NUMBERS OF VEHICLE SURVIVING AT 30/9/1971 AS A PERCENTAGE OF NEW VEHICLES ORIGINALLY REGISTERED

Year of Model	No. of Vehicles remaining on Register at 30/9/71 as a Percentage of New Vehicles Originally Registered								
	NSW	Vic	Qld*	S.A.	W.A.	Tas	A.C.T.	N.T.*	Aust.
1950/54	9	15	15	20	13	19	n.a.	n.a.	13 est.
1955/59	32	44	48	51	39	49	43	68	41
1960	59	67	84	75	65	72	72	91	67
1961	69	79	107	87	77	80	71	105	79
1962	80	87	109	87	84	84	85	138	86
1963	86	91	105	92	94	90	85	147	91
1964	90	95	109	94	105	97	110	158	96
1965	88	95	65	91	101	89	101	128	89
1966	93	97	98	94	99	96	99	122	96
1967	97	99	106	98	106	98	113	129	99
1968	97	98	101	95	102	98	110	108	98
1969	96	99	102	94	102	97	112	110	98
1970	95	99	108	104	104	100	110	118	99

* Estimates impaired by large proportions of vehicles not classified by year of model.

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4.2 FITTING OF FUNCTIONS

Due to problems experienced with apparent interstate migrations of vehicles, detailed examination of survival rates involving fitting of alternative functions has been restricted to Australia wide and Victorian data. Victorian data - while subject to the influences of interstate movements - warrants separate analysis as it is one of the two states for which census data showing year of model of vehicles is disaggregated by individual years prior to 1960.

A summary of the results of fitting the five alternative functions previously mentioned to survival data is contained in Table V. With one exception the logistic function provides a better fit to survival patterns than alternative functions, although this could be expected given that cumulative data is being examined. Generally curve fits are good, as can be seen from examination of coefficients of determination and from Fig 1 where survival rates, and the best fitting logistic function for the category motor cars and station wagons are plotted for Australia wide data. It is also of interest that in general linear functions provide the second best approximation to survival patterns in all but one case, indicating such functions may provide a useful shorthand means of estimating scrapping behaviour where general orders of magnitude only are required.

No analysis of survival rates for 'Other Truck Types' has been carried out, as if these rates are to be treated seriously, survival rates increase with age. This non-acceptable result parallels results achieved in estimating total numbers of Other Truck Types scrapped during the period 30 September 1971 to 30 June 1976.

Survival rates determined for buses on an Australia wide basis are unique, insofar as alone among the vehicle categories examined they are best accounted for by a linear relationship. However this would appear to reflect problems experienced with data and the particular form of logistic curve used. Number of buses not identified by year of model amounted to 12 per cent of total buses on register at the time of the 1971 Vehicle Census, a proportion only exceeded by the group motor cycles. It is also significant that there were significant numbers of unidentified vehicles in states other than Queensland. These and other factors result in survival rates for buses in excess of unity being estimated for buses built in each year 1966 to 1970. A further factor in explaining the linear fit is the formula of the specific logistic function employed

$$Y_t = \frac{1}{[A + (1 - A)e^{bX}]}$$

which is insensitive to survival rates in excess of unity. It should also be noted that the value of the coefficient of determination r^2 is the lowest recorded for each category of vehicle examined in Table V.

In comparison survival rates estimated for buses in Victoria follow the general pattern insofar as survival behaviour is best explained by a logistic relation. Vehicle Census data for Victoria is good, as only 0.7 per cent of buses on register could not be identified by year of model. Therefore Victorian data could be treated as providing a better indication of survival patterns than Australia wide data although it may be adversely affected by interstate transfers of vehicles.

TABLE V

REGRESSION FUNCTIONS FITTED TO SURVIVAL DATA

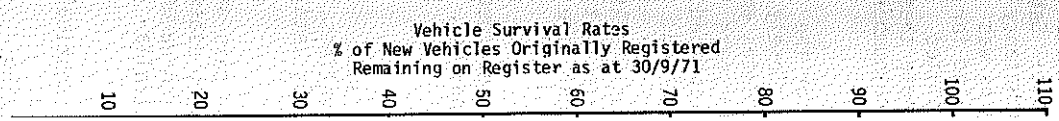
Vehicle Category	Australia		Victoria	
	Regression Function	r^2	Regression Function	r^2
MOTOR CARS				
Function of best fit : Logistic	$Y_t = \frac{1}{0.989 + 0.011e^{0.34(X-0.25)}}$	0.99	$Y_t = \frac{1}{0.992 + .008e^{0.36(X-0.25)}}$	0.99
Second best fit : Linear	$Y_t = 1.2130 - 0.055\ (X-0.25)$	0.93	$Y_t = 1.228 - 0.054\ (X-0.25)$	0.92
STATION WAGONS				
Function of best fit : Logistic	$Y_t = \frac{1}{0.994 + 0.006e^{0.33(X-0.25)}}$	0.88	$Y_t = \frac{1}{0.995 + 0.005e^{0.39(X-0.25)}}$	0.98
Second best fit : Linear	$Y_t = 1.1308 - 0.0345\ (X-0.25)$	0.87	$Y_t = 1.2684 - 0.0628\ (X-0.25)$	0.86
MOTOR CARS AND STATION WAGONS				
Function of best fit : Logistic	$Y_t = \frac{1}{0.990 + 0.010e^{0.35(X-0.25)}}$	0.99	$Y_t = \frac{1}{0.994 + 0.006e^{0.38(X-0.25)}}$	0.99
Second best fit : Linear	$Y_t = 1.1830 - 0.499\ (X-0.25)$	0.87	$Y_t = 1.2243 - 0.0545\ (X-0.25)$	0.92
LIGHT COMMERCIAL VEHICLES AND TRUCKS				
Function of best fit : Logistic	$Y_t = \frac{1}{0.985 + 0.015e^{0.33(X-0.25)}}$	0.99	$Y_t = \frac{1}{0.985 + 0.015e^{0.32(X-0.25)}}$	0.99
Second best fit : Linear	$Y_t = 1.1837 - 0.0550\ (X-0.25)$	0.98	$Y_t = 1.1739 - .0520\ (X-0.25)$	0.92
BUSES				
Function of best fit Linear/Logistic	$Y_t = 1.1449 - 0.0254(X-0.25)$	0.61	$Y_t = \frac{1}{0.996 + 0.004e^{0.34(X-0.25)}}$	0.91
Second best fit Exp./Linear	$Y_t = 1.1369e^{-0.0269(X-0.25)}$	0.58	$Y_t = 1.1813 - 0.0413\ (X-0.25)$	0.86
MOTOR CYCLES				
Function of best fit Logistic	$Y_t = 0.708 + 0.292e^{0.26(X-0.25)}$	0.99	$Y_t = \frac{1}{0.996 + 0.004e^{0.98(X-0.25)}}$	0.93
Second best fit Linear	$Y_t = .8923 - 0.0616\ (X-0.25)$	0.96	$Y_t = 1.0023 - 0.0687\ (X-0.25)$	0.73

Key:

X = Average age of vehicles as at 30/9/71

Y_t = Expected survival rate at time t.

0.25 = Correction Factor: To simplify curve fitting, average ages of vehicles were considered in whole year terms only. (i.e. 1970 models which had an average age of 1.25 years at 30/9/71 considered as one year old).



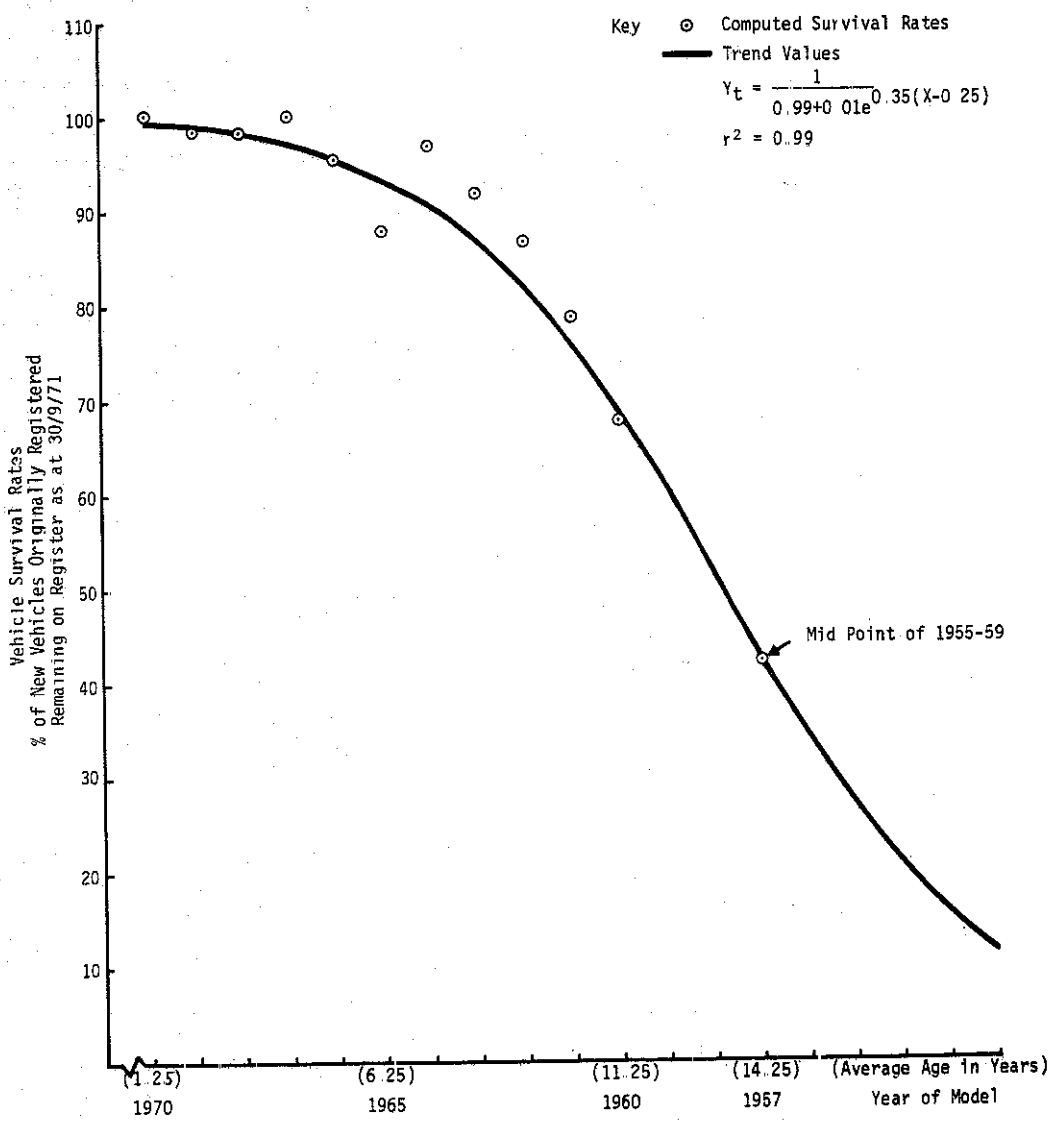


Fig 1 - Computed survival rates and fitted logistic function
Motor Cars and Station Wagons: Australia

(i.e. 1970 models which had an average age of 1.25 years at 30/9/71 considered as one year old).

4.3 ANALYSIS OF SURVIVAL FUNCTIONS

In order to facilitate comparisons between functions fitted to survival data for different vehicle categories, in Tables VI and VII average vehicle ages corresponding to given survival rates have been calculated. Figures are derived from data contained in Table V.

Examination of Table VI indicates that motor cars and station wagons apparently exhibited different survival behaviour for Australia wide data. Data indicates that cars in the period 1950 to 1971 had an average life expectancy of about 13.6 years while the average life expectancy for station wagons was nearly 16 years. A longer life expectancy on station wagons is exhibited for each survival rate evaluated. When cars and station wagons are amalgamated into a single group, average ages at selected survival levels approximate those recorded for motor cars, because at the time of the 1971 Census cars outnumbered station wagons by a ratio of 4.6 to 1.

Unexpectedly, Australia wide data generated survival patterns for the category light commercial vehicles and trucks which approximated very closely the survival function computed for cars and station wagons. Data indicates an average life expectancy for light commercial vehicles and trucks of 13 years compared with an average life expectancy for cars and station wagons combined of 13.4 years. This close similarity occurred for each percentile examined.

Problems experienced with bus data have been discussed previously. At best the data for buses contained in Table VI could be taken to indicate that, of the vehicle categories analysed separately, buses recorded the highest life expectancy during the period 1950 to 1971.

Information contained in Table VI indicates that motor cycles recorded the lowest rates of survival of any group in the period 1950 to 1971 having an average life expectancy of about six years, or less than half that recorded for motor cars and station wagons.

Comparisons between Australia wide data contained in Table VI and Victorian data contained in Table VII generate some interesting observations. It will be recalled that Victoria was one of two states for which Census data was available for single years of model prior to 1960.

Victorian and Australian survival functions computed for motor cars and station wagons, and light commercial vehicles and trucks, correspond very closely. In comparison, given survival values for buses, motor cycles and station wagons were achieved at different average vehicle ages for Victorian and Australia wide data.

Station wagon survival patterns for Victoria are practically identical with motor car survival rates recorded for both Victoria and Australia. Assuming that interstate transfers are treated as unimportant, and taking account of the small number of station wagons not classified by year of model in 1971 in Victoria, 0.5 per cent compared with 7.5 per cent for Australia as a whole, it could be suggested that Victorian figures give a better approximation of survival patterns than Australia wide data, which required considerable manipulation.

Similarly, values derived from functions fitted to Victorian bus survival data may provide a better indication of bus survival rates, assuming interstate transfers are not significant, and Victorian behaviour approximates

TABLE VI

VARIATION OF ESTIMATED VEHICLE SURVIVAL RATES WITH AVERAGE AGE OF VEHICLE TREND VALUES - AUSTRALIA

Estimated

TABLE VI

VARIATION OF ESTIMATED VEHICLE SURVIVAL RATES WITH AVERAGE AGE OF VEHICLE TREND VALUES - AUSTRALIA

Estimated Numbers of Vehicles Surviving (Percent)	Average Age of Vehicles (Years)					
	Motor Cars	Station Wagons	Motor Cars and Station Wagons	Light Commercial Vehicles and Trucks	Buses	Motor Cycles
95	5.4	7.2	5.5	4.8	7.9	0.9
90	7.3	9.3	7.4	6.7	9.9	1.5
85	8.6	10.6	8.6	8.0	11.9	2.1
80	9.6	11.6	9.6	9.0	13.8	2.6
75	10.4	12.5	10.4	9.8	15.8	3.2
70	11.1	13.2	11.1	10.5	17.8	3.7
65	11.8	13.9	11.7	11.2	19.7	4.3
60	12.4	14.6	12.3	11.8	21.7	4.8
55	13.0	15.1	12.9	12.4	23.7	5.4
50	13.6	15.8	13.4	13.0	25.6	6.0
45	14.1	16.4	14.0	13.6	27.6	6.6
40	14.7	17.0	14.6	14.2	29.6	7.2
35	15.4	17.6	15.2	14.9	31.6	7.93
30	16.0	18.3	15.8	15.6	33.5	8.7
25	16.8	19.1	16.6	16.3	35.5	9.6
20	17.7	20.0	17.4	17.2	37.5	10.6
15	18.6	21.0	18.4	18.2	39.4	11.9

TABLE VII

VARIATION OF ESTIMATED VEHICLE SURVIVAL RATES WITH AVERAGE AGE OF VEHICLE TREND VALUES - VICTORIA

Estimated Numbers of Vehicles Surviving (Percent)	Average Age of Vehicles (Years)					
	Motor Cars	Station Wagons	Motor Cars and Station Wagons	Light Commercial Vehicles and Trucks	Buses	Motor Cycles
95	5.9	6.5	6.3	5.0	8.0	3.0
90	7.8	8.3	8.1	6.9	10.1	3.7
85	9.0	9.5	9.2	8.2	11.5	4.1
80	9.9	10.3	10.1	9.2	12.5	4.5
75	10.7	11.1	10.9	10.1	13.3	4.8
70	11.4	11.7	11.5	10.8	14.0	5.0
65	12.0	12.3	12.1	11.5	14.7	5.3
60	12.6	12.8	12.7	12.2	15.3	5.5
55	13.1	13.3	13.2	12.8	15.9	5.7
50	13.7	13.8	13.7	13.4	16.5	5.9
45	14.2	14.4	14.3	14.0	17.1	6.1
40	14.8	14.9	14.8	14.7	17.7	6.3
35	15.4	15.4	15.4	15.3	18.3	6.5
30	16.0	16.0	16.0	16.0	19.0	6.8
25	16.7	16.7	16.7	16.8	19.7	7.0
20	17.5	17.4	17.4	17.7	20.6	7.3
15	18.5	18.3	18.3	18.8	21.6	7.7

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that for Australia as a whole. Victorian data for buses on register at the time of the 1971 Vehicle Census is good, as less than one per cent of buses were not classified by year of model, and data listing years of models in single years is available for years between 1960 and 1952. As in the overall Australian data, buses survived longer than vehicles in other groups, the average historical life expectancy of a bus being 16.5 years. Survival rates are however lower than those generated by the linear function fitted to Australia wide bus data.

The situation with respect to trend values derived from Victorian motor cycle data is the reverse of that for station wagons and buses. Motor Vehicle Census data for motor cycles registered in Victoria is less reliable than that for Australia as a whole, over 47 per cent of motor cycles being unclassified by year of model compared with the national average of less than 24 per cent. This and other factors led to survival rates in excess of unity being computed for a number of successive years, which has in turn affected the shape of the function of best fit.

Unfortunately, the data base provided by published material is insufficient to adequately reconcile Australia wide and Victorian data. Reconciliation may be accomplished when results of the 1976 Census of Motor Vehicles become available, this data hopefully providing a more detailed and reliable coverage than that available from the 1971 Vehicle Census.

As noted previously, there are problems in deriving survival rates for trucks and light commercial vehicles as separate groups. However, by using carrying capacity and tare weight data taken from the 1962 (CBCS 1964) and 1971 Motor Vehicle Census, it was possible to roughly adjust 1971 Census data so that reasonable survival rates could be estimated for trucks and light commercial vehicles separately. No great reliance is however to be placed on the resulting data.

As with other data, alternative functions have been applied to determine the best fitting functions. Trends in data were best fitted by logistic functions and in Fig 2, the logistic functions estimated for Light Commercial Vehicles, and Trucks are plotted separately. The functions indicate that after the first five years of life survival functions computed for trucks and light commercial vehicles diverge, light commercial vehicle survival values decreasing more rapidly than those for trucks with each succeeding year. Examination of the plotted functions indicates that the average historical life expectancy of trucks was approximately 13.8 years while that for light commercial vehicles was around 12.4 years.

5. AN APPLICATION OF VEHICLE SURVIVAL FUNCTIONS

As a demonstration of the uses to which vehicle survival functions can be put, the survival function computed for cars and station wagons has been combined with 1971 Vehicle Census data, new registration and total registration data, to generate projections of future numbers of cars and station wagons classified by year of model. These projections can be used to estimate rates of diffusion for selected Australian Design Rules (DoT 1971-). The results of this analysis are summarised in Table VIII.

Application of historical survival data to time series projections involves assuming that the economic and operational factors which have determined

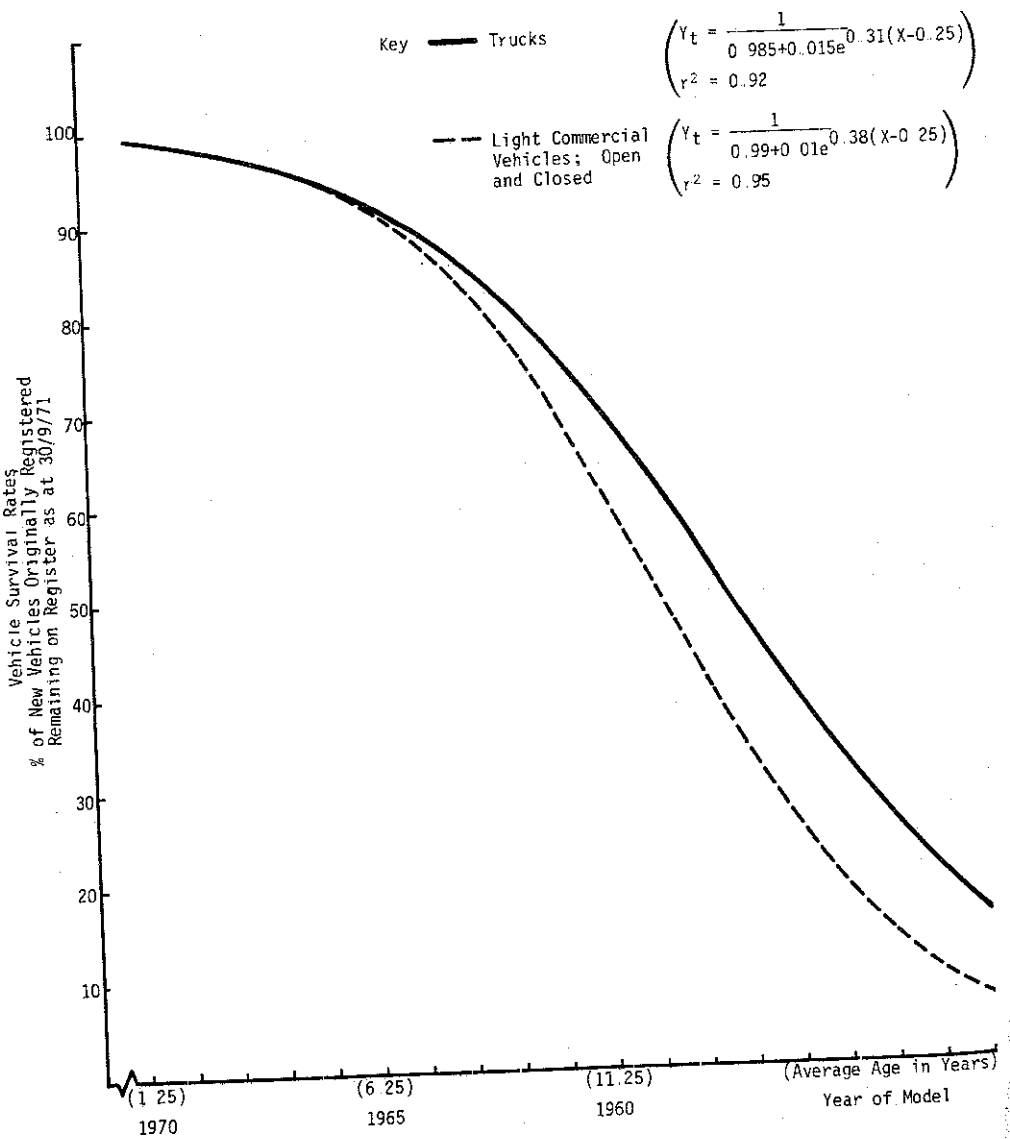

Fig 2 - Vehicle survival rates for light commercial vehicles and trucks (adjusted data) Australia

TABLE VIII

ESTIMATED NUMBERS OF CARS AND STATION WAGONS MANUFACTURERD TO COMPLY WITH AUSTRALIAN DESIGN RULES
ESTIMATED NUMBERS AS AT 31 DECEMBER 1975 AND 31 DECEMBER 1980
(Numbers expressed as a percentage of total cars and station wagons on register)

TABLE VIII

ESTIMATED NUMBERS OF CARS AND STATION WAGONS MANUFACTURERD TO COMPLY WITH AUSTRALIAN DESIGN RULES
ESTIMATED NUMBERS AS AT 31 DECEMBER 1975 AND 31 DECEMBER 1980
(Numbers expressed as a percentage of total cars and station wagons on register)

Australian Design Rules/Date Effective From	Estimated Proportion of Vehicle Population manufactured to comply with A.D.R.'s		
	31 December 1975	31 December 1980	
		Case A 7.2 million Vehicles	Case B 6 million Vehicles
	%	%	%
A.D.R.'s effective from 1 January 1969 - 4(a) 5A(a) etc.	62	88	86
A.D.R.'s effective from 1 January 1970 - 7 etc.	55	85	82
A.D.R.'s effective from 1 January 1971 - 2(1), 3(i), 5A(a,b), 10A, 15(i), 8 etc.	47	81	77
A.D.R.'s effective from 1 January 1972 - 1(i), 3(ii) 11(i) 22(i) 25(i) 26	39	76	71
A.D.R.'s effective from 1 January 1973 - 6(i), 10B, 12(i), 15(ii), 18, 21, 24(i)	31	71	65
A.D.R.'s effective from 1 January 1974 - 4A(i) 23, 28(i)	22	66	58
A.D.R.'s effective from 1 January 1975 - 24 (ii), 4B(a), 5B(i) 22A(i)	12	59	51
A.D.R.'s effective from 1 January 1976 - 4c(i), 34, 27(A)	-	53	43

past survival rates remain relatively unchanged in the future. Such an assumption may become more unrealistic the further into the future projections are made. However, assuming Vehicle Censuses continue to be carried out at regular five yearly intervals sufficiently current survival data should be available to enable continuing use of this type of projection.

Two widely differing estimates of total numbers of cars and station wagons for 31 December 1980 have been used in Table VIII and could be taken to represent the highest and lowest expected values, between which the actual future population is likely to fall. The upper bound of 7.2 million cars and station wagons is obtained from projections of household disposable income, making use of the close correlation between trends in numbers of cars and station wagons and this variable. An exponential projection of historical motor registration, data yields a similar result. The 7.2 million figure implicitly assumes economic growth rates will return to pre 1974 levels and saturation of ownership will not influence vehicle numbers although a population vehicle ratio of 2 to 1 is implied. The lower limit is generated from a projection which assumes lower levels of economic and population growth, decreasing proportions of household disposable income being spent on purchase and operation of vehicles, and saturation of the vehicle market occurring. Data contained in Table VIII indicates that estimated diffusion rates of ADR's are less sensitive to changes in total numbers of vehicles than might have been expected.

A similar analysis could be undertaken for ATAC draft regulations dealing with retrospective modifications to vehicles manufacturer prior to ADR's becoming effective. However, as different states have legislatively adopted different model years as lower bound for implementation, analysis would be more complex.

6. SUMMARY AND FURTHER POSSIBLE ANALYSIS

Vehicle survival functions if reliably estimated should provide a useful tool to persons working in the field of road transport. Use of the functions derived in this paper are subject to a number of reservations, and should be used only as interim measures till measures based on the 1976 Vehicle Census become available.

It is anticipated that 1976 Census data will be more complete than the 1971 data, allowing more accurate computation, and analysis of additional vehicle categories. Unfortunately, separate analysis of survival behaviour of lightcommercial vehicles and rigid trucks will be severely handicapped because as from 1 July 1976 ABS reverted to the 1962 classification of light commercial vehicles into utilities and panel vans based on body type. This will create similar problems to those experienced with 1971 data. Such problems could be avoided if registration data could continue to be compiled according to superseded classifications, in addition to new classifications, where it could be demonstrated that time series analysis would benefit significantly.

Further areas not treated in this paper invite examination, namely analysis and comparison of survival tates in individual states and territories and economic factors determining scrapping decisions. Such analysis would not be possible from published data and would involve sample surveys and possibly detailed reworking of raw motor registration data.

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