
THE ECONOMIC AND SOCIAL
RESEARCH INSTITUTE

Not to be printed before

Transport in the Developing Economy of Ireland

by

JOHN BLACKWELL

August 1969

Paper No. 47

4 BURLINGTON ROAD DUBLIN 4

THE ECONOMIC AND SOCIAL RESEARCH INSTITUTE

COUNCIL 1968-69

- J. J. McELIGOTT, M.A., LL.D.,
President of the Institute.
- *G. O'BRIEN, D.LITT., LITT.D.,
Chairman of the Council.
- T. J. BARRINGTON,
Director, Institute of Public Administration.
- *J. P. BEDDY, D.ECON.SC., LL.D. (H.C.)
Chairman and Managing Director, The Industrial Credit Co. Ltd.
- R. D. C. BLACK, PH.D.,
Professor, Department of Economics, The Queen's University, Belfast.
- *F. B. CHUBB, M.A., D.PHIL.,
Professor, Department of Political Science, Trinity College, Dublin.
- VERY REV. D. CREGAN, C.M.,
President, St. Patrick's Training College, Drumcondra, Dublin.
- DR. G. DEAN,
Director, Medico-Social Research Board
- REV. PETER DEMPSEY, O.F.M.CAP., M.A., PH.D., D.D.,
Professor, Department of Applied Psychology, University College, Cork.
- *M. P. FOGARTY, M.A., D.POL.SOC.SC. (Louvain),
Director of the Institute.
- *W. A. HONOHAN, M.A., F.I.A.,
Secretary, Department of Social Welfare.
- *REV. JAMES KAVANAGH, M.A., S.T.L.,
Professor, Department of Social Science, University College, Dublin.
- IVOR KENNY, M.A.,
Director, Irish Management Institute.
- T. P. LINEHAN, B.E., B.SC.,
Director, Central Statistics Office.
- P. LYNCH, M.A.,
Chairman, Medico-Social Research Board.
- CHARLES MCCARTHY, B.L.,
Chairman, Human Sciences Committee.
- *M. D. MCCARTHY, M.A., PH.D.,
President, University College, Cork.
- G. A. MEAGHER, B.COMM., D.P.A.,
Chairman, An Foras Forbartha.
- *J. F. MEENAN, M.A., B.L.,
Professor of Political Economy, University College, Dublin.
- J. C. NAGLE, M.COMM.,
Secretary, Department of Agriculture.
- D. NEVIN,
Assistant General Secretary, Irish Congress of Trade Unions.
- RIGHT REV. MONSIGNOR J. NEWMAN, M.A., D.PH.,
President, St. Patrick's College, Maynooth.
- L. O'BUACHALLA, M.COMM.,
Professor, Department of Economics, University College, Galway.
- TADHG O CEARBHAILL,
Secretary, Department of Labour.
- REV. E. F. O'DOHERTY, M.A., B.D., PH.D.,
Professor, Department of Logic and Psychology, University College, Dublin.
- D. P. O'MAHONY, M.A., PH.D., B.L.,
Professor, Department of Economics, University College, Cork.
- *W. J. L. RYAN, M.A., PH.D.,
Professor of Political Economy, Trinity College, Dublin.
- DR. P. G. SHERRY,
Federation of Irish Industries.
- T. WALSH, D.SC.,
Director, An Foras Taluntais.
- *T. K. WHITAKER, M.SC. (ECON.), D.ECON.SC.,
Governor, Central Bank of Ireland.

*Members of Executive Committee.

Copies of this paper may be obtained from The Economic and Social Research Institute, 4 Burlington Rd., Dublin 4, price 5/- a copy.

Transport in the Developing Economy of Ireland

CONTENTS

	Page
Tables, Charts, Abbreviations and Symbols	vi
Acknowledgements	viii
Introduction	i
1. Projection of Private Car Ownership	2
2. Projection of Goods Vehicle Ownership	16
3. Projection of Other Vehicle Ownership	23
4. Projection of Total Vehicle Ownership	26
5. Vehicle Mileage on Irish Roads	29
6. Passenger Traffic by Road and Rail	36
7. Freight Traffic by Road and Rail	38
8. Aspects of Road Freight Transport	39
9. Summary	42
10. Possible Future Research Work	45
Appendices	47
A. Analyses Concerning Car and Motor Cycle Ownership	47
B. Variability of Light Goods Vehicle Ownership Among Irish Counties	59
C. Statistical Tables	61

LIST OF TABLES

Table		Page	Table		Page
1	Private Cars <i>Per Capita</i> : Ireland, Great Britain and USA, 1947-1967	2	18	Projection of Other Vehicles 1967-1985	26
2	Car Ownership Regressions: Slope Coefficients, 1947-1957 and 1958-1966	8	19	Vehicle Ownership Regressions Slope Coefficients 1947-1957 and 1958-1966	28
3	Alternative Projections of Private Car Ownership, based on different assumptions of Income Growth	10	20	Projection of Vehicles, Classified by Type of Vehicle 1967-1985, together with Projection Using Regression Analysis	29
4	Projection of Private Car Ownership Based on Regression Results	10	21	Fuel Consumption by Private Cars and Taxis 1964	31
5	Fitting of Exponential Curves to USA and Swedish Cars per 1,000 Persons: Sum of Squared Deviations	12	22	Annual Vehicle Mileage by Engine Size of Car in Great Britain 1965	32
6	Projection of Car Ownership 1967-1985 Using Logistic Curve	14	23	Fuel Consumption by Motor Cycles 1964	32
7	Projection of Private Car Numbers, 1967-1985	16	24	Petrol Consumption Data for the Road Freight Fleet 1964	33
8	Ton-mileage and Certain Economic Indicators, 1960-1967	18	25	Estimated Mileage per Vehicle on Irish Roads, 1958, 1961, 1964 and 1966	34
9	Projected Ton-mileage, 1967-1985	19	26	Total Vehicle Mileage 1964	35
10	Estimated Carrying Capacity of Commercial Goods Vehicles in Ireland, 1960-1967	20	27	Average Weekly Vehicle Mileage per Vehicle by Type of Vehicle and Size of Area, 1965	35
11	Projected Carrying Capacity, 1967-1985	20	28	Average Weekly Mileage per Vehicle for Vehicles in Households, 1965	36
12	Percentage Changes in Goods Vehicle Numbers, by Unladen Weight, 1950-1967	21	29	Vehicle Miles and Passengers Carried on Omnibus Passenger Road Services (excluding cross-border services) 1955-1966	37
13	Postulated Annual Average Percentage Changes in Goods Vehicles by Unladen Weight, 1967-1985	22	30	Railway Passenger Traffic, 1958/59-1966/67	37
14	Projection of Goods Vehicle Numbers, 1967-1985	22	31	Estimated Passenger Mileage, 1966	37
15	Motor Cycles <i>Per Capita</i> : Ireland and Great Britain, 1947-1967	23	32	Railway Freight Traffic (tons), 1958/59-1966/67	39
16	Motor Cycle Ownership in Households 1965-1966: HBI Data	24	33	Railway Freight Traffic (ton-miles) 1958/59-1966/67	39
17	Projection of Motor Cycles, 1967-1985	25	34	Proportion of "Own Account" Road Freight Traffic in a Number of European Countries, 1966	40
			35	Utilisation of Carrying Capacity in 1964	41

APPENDIX TABLES

A1	Private Car Ownership and Other Economic Variables, Irish Counties, 1960	48	C4	Car Ownership in Irish Counties and County Boroughs 1951-1966	63
A2	Regression of Car Ownership (P) on Sets of Independent Variables: Irish Counties: Linear Equations	49	C5	Car Ownership in USA and in Sweden 1920-1966, Together with Calculated Ownership Derived from Fitted Logistic Curves	64
A3	Car Ownership in Households: HBI Data	51	C6	Car and Motor Cycle Ownership, Income and Other Variables in Irish Households: Data Grouped According to Disposable Household Income X Household Size	65
A4	Car Ownership on Irish Farms: by Acreage 1966/67	54	C7	Regressions of New Car Registrations (R) on Sets of Independent Variables	65
A5	Car Ownership on Irish Farms by Family Farm Income 1966/67	54	C8	Goods Vehicles in Ireland Classified by Unladen Weight, 1947-1967	66
A6	Cumulative Distribution of Disposable Household Income; 1965/66	54	C9	Estimated Average Annual Mileage Per Goods Vehicle: Ireland (1964) and Great Britain (1952, 1958 and 1962)	66
A7	Private Cars Ireland: New Registrations and Scrappage 1950-1967	56	C10	Estimated Average Load Per Goods Vehicle: Ireland (1964) and Great Britain (1952, 1958 and 1962)	66
A8	Projection of New Registrations per 1,000 Persons, Assuming Alternative Growth Rates of Income	58	C11	Estimated Average Carrying Capacity Per Goods Vehicle: Ireland (1964) and Great Britain (1952, 1958 and 1962)	67
A9	Projection of New Car Registrations and of Car Ownership, 1967-1985	58	C12	Motor Cycle Ownership, National Income <i>Per Capita</i> and Population Density in 29 Countries 1965	67
B1	Ownership of Light Commercial Vehicles, and Certain Economic Variables, Irish Counties 1962	59	C13	Other Data on Vehicles in Ireland 1947-1967: (a) New Private Car Registrations (b) Total Vehicle Ownership	67
B2	Regression of Light Commercial Vehicle Ownership on Sets of Independent Variables: Irish Counties: Linear Equations	60	C14	Private Cars Classified by Horse Power: 1958, 1961 and 1966	67
B3	Regression of Light Commercial Vehicle Ownership on Sets of Independent Variables: Irish Counties: Log-Log Equations	60	C15	Estimated Average Annual Mileage for Each Class of Vehicle in Great Britain, 1960, 1963 and 1967	67
C1	Number of Mechanically-Propelled Vehicles in Ireland 1947-1967 (at 10 August each year)	61	C16	Estimated Average Annual Mileage Per Private Car in Certain Countries	68
C2	Macro-Economic Data for Ireland, 1947-1966	62	C17	Weekly Mileage Per Vehicle in Fully Productive Households in Britain, 1965	68
C3	Car Ownership, <i>Per Capita</i> GDP and Population Density in 58 Countries, 1964	62			

LIST OF CHARTS

Chart Number		Page	Chart Number		Page
1	Private Car Ownership 1947-1967: Ireland, Great Britain and USA (Semi-Logarithmic Scale)	3	A2	Car Ownership in Ireland, Compared with Household Income	52
2	Total Vehicles by Main Category of Vehicle, 1960-1985 (Semi-Logarithmic Scale)	30	A3	Distribution of Household Disposable Income, 1965-66	55
A1	Private Car Ownership and Personal Income <i>Per Capita</i> : Irish Counties 1960	50	A4	Private Cars, Ireland, New Registrations and Scrappage, 1950-1966	57

ABBREVIATIONS AND SYMBOLS

CIE	C�ras Iompair �ireann (Irish Transport Company)	MDS	<i>Monthly Digest of Statistics</i>
CP	CSO, <i>Census of Population of Ireland</i>	NIE	CSO, <i>National Income and Expenditure</i>
CSO	Central Statistics Office	NTS	British Ministry of Transport, <i>National Travel Survey</i>
DLG	Department of Local Government	RRL	Road Research Laboratory
ERI	Economic Research Institute (now ESRI)	RVS	Department of Health, <i>Report on Vital Statistics</i>
ESRI	Economic and Social Research Institute	SA	CSO, <i>Statistical Abstract of Ireland</i>
FMS	Farm Management Survey (An Foras Tal�ntais)	SSRF	CSO, <i>Sample Survey of Road Freight Transport, 1964</i>
GDP	Gross Domestic Product		
GNP	Gross National Product		
HBI	CSO, <i>Household Budget Inquiry</i>		
ISB	<i>Irish Statistical Bulletin</i>		
ITJSB	<i>Irish Trade Journal and Statistical Bulletin</i> (now <i>ISB</i>)		

The following symbol has also been used:
 "....." not available.

ACKNOWLEDGEMENTS

The writer is indebted to all those who commented on previous drafts of this paper, and who made many stimulating suggestions, particularly the research staff of The Economic and Social Research Institute; staff of the Central Statistics Office, C oras Iompair  ireann, Department of Local Government, Dublin Corporation and An Foras Forbartha; Professor C. E. V. Leser, Mr. D. L. Munby, Mr. J. B. Polak and Mr. R. J. Tarling. Section 2 of the paper and Appendix B have been greatly influenced by suggestions made by Mr. R. J. Tarling, and by some of his unpublished work.

The Central Statistics Office has helped greatly by providing on request a special analysis of car and motor cycle ownership from the Household Budget Inquiry 1965-66. The HBI was not explicitly designed with the provision of this information in mind; the data were requested by us at an advanced stage in CSO's work on the HBI. Any limitations on the data stem from this fact and not from any deficiencies in the design of the Inquiry.

The British Ministry of Transport has been extremely helpful, and has provided data from its National Travel Survey 1965. An Foras Tal ntais has provided computer assistance. The Farm Management Division of An Foras Tal ntais generously made available the Farm Account Books from its Farm Management Survey 1966/67.

Any errors which remain are solely the writer's responsibility.

TRANSPORT IN THE DEVELOPING ECONOMY OF IRELAND

by

JOHN BLACKWELL*

INTRODUCTION

The purpose of this paper is to project inland transport demand in Ireland over the period 1967–1985, and in general to study the determinants of transport demand in the country. Certain aspects of road freight transport are also studied, with particular reference to road haulage licensing.

In recent years the economics of transport has attracted a considerable amount of interest. This has partly been a reflection of a general interest in cost-benefit analysis as applied to transport problems and partly a reaction to a number of specific problems. For example, the growth of private car ownership has focused attention on the problems of urban traffic congestion. Traffic congestion has in turn made more difficult the provision of satisfactory public transport services in cities. The growth of private car ownership has also undermined the former monopolistic position of the railways.

There has therefore been an increasing interest in the development of a “co-ordinated” transport policy which would cover both road and rail. There is scope for discussion about the impact of transport demand on the capacity of transport networks, and how this demand can be met with the least consumption of scarce resources. The general problem to be resolved is the provision of transport to the community at the lowest resource cost, taking into account social costs and benefits.

But as a first step it seems necessary to look at transport demand as it has evolved over a past number of years, and to examine the likely future demands on the transport infrastructure. For example, what are the factors determining car ownership and use, and how is car ownership likely to change over the next fifteen or twenty years? Projections of transport demand are best made over

a fairly long period of time, since transport infrastructure is characterised by its very long life and by an inevitably long time-lag between the decision to invest in infrastructure and the completion of this investment.

Since 1957, work on transport demand in Ireland has been done by O’Keeffe (1960–61), Treacy (1962–63), Reynolds (1962, 1963), CIE (1963), McCarthy (1963–64) and Sexton (1966–67). In the past two or three years a considerable volume of statistical information has become available which is relevant to the transport sector. This includes the Central Statistics Office’s *Sample Survey of Road Freight Transport 1964* (CSO, 1967). This gives us the opportunity to base our forecasts on recent statistical data.

At the time of writing the report *Regional Studies in Ireland* by Colin Buchanan and Partners had not been published. While the results of these regional studies could have considerable implications for transport policy, they would be unlikely to significantly change our projections.

In this study, no account is taken of the likely development of other forms of transport such as monorail or the hovercraft. It is likely that craft such as the hovercraft would compete with the railways and with other forms of public transport, rather than with the private car. The flexible service which the private car provides is, in any event, unlikely to be superseded. Internal waterways and internal air transport are unlikely to be significant carriers in the period under consideration.

We begin by making projections of the numbers of mechanically propelled vehicles over the period 1967–1985. The two most important types of vehicle (especially as regards likely pressure on road capacity) are the private car and the commercial goods vehicle. Much of this paper reflects the importance of the growth of private car ownership. The demand for vehicles is a derived demand.

*John Blackwell was an Assistant Research Officer with the Economic and Social Research Institute. The paper has been accepted for publication by the Institute. The author is responsible for the contents of the paper including the views expressed therein.

Private cars are needed to provide personal transport. Thus private car ownership tends to be a function of variables such as income. The demand for commercial goods vehicles reflects a demand for the movement of goods, and goods vehicle ownership tends to be a function of production and distribution patterns. We try to take account of these different influences when making the projections. The vehicle projections, which are made individually for each type of vehicle, are subsequently checked by a global projection applied to total vehicle ownership.

Information on vehicle mileage gives us an index of the changing utilisation of vehicles. We make estimates of the vehicle mileage on Irish roads, by type of vehicle, in a number of recent years. This enables us to see how usage per vehicle is changing over time.

Projections are also made of total passenger and freight traffic. We also examine certain aspects of road freight transport, and make some suggestions regarding future research work coming within the sphere of this paper.

1. PROJECTION OF PRIVATE CAR OWNERSHIP

1.1 Introduction

The projection of private car ownership is the most important element in the overall vehicle projection. Private cars accounted for 66 per cent. of all vehicles owned in Ireland in 1967, compared with 53 per cent. in 1957 (*Source*: Appendix C, Table C1).

In this section we examine the growth of private car ownership in Ireland over the period 1947-1967, and compare this with the ownership in Great Britain and the USA. Then the assumptions underlying the projection, together with methods used, are discussed. A number of different methods are used to build up the projection.

1.2 Growth of Private Car Ownership since 1947

The number of private cars in Ireland increased from 52,200 in 1947 to 135,000 in 1957 and 314,400 in 1967 (Appendix C, Table C1). In terms of cars *per capita*, ownership has increased from 0.018 in 1947 to 0.047 in 1957 and 0.109 in 1967 (Table 1; see also Chart 1). The only noticeable deviations from this trend of steady growth were in 1953 and 1957.

Here, as elsewhere in the text, we fit an exponential trend to time series data. This type of trend takes the form:

$$P = ab^t$$

where P is private cars *per capita*, a and b are constants and t is time. The trend is fitted by least squares regression of $\log P$ on t . This type of trend implies that P increases by a constant percentage annually.

The following are the trend rates of growth of private cars *per capita* in Ireland:

$$1947-1967: 8.8\% \text{ p.a. } (R^2 = .949)$$

$$1958-1967: 9.5\% \text{ p.a. } (R^2 = .994)$$

Comparative trend rates of growth of private car ownership in Great Britain are:

$$1947-1967: 8.8\% \text{ p.a. } (R^2 = .995)$$

$$1958-1967: 8.9\% \text{ p.a. } (R^2 = .995)$$

TABLE 1: PRIVATE CARS PER CAPITA: IRELAND, GREAT BRITAIN AND USA, 1947-1967

Year	Private cars <i>per capita</i> ^a			Annual percentage increase in private cars <i>per capita</i>		
	Ireland	Great Britain	USA ^b	Ireland	Great Britain	USA
1	2	3	4	5	6	7
				%	%	%
1947	0.018	0.040	0.214			
1948	0.020	0.040	0.227	11.1	0.0	6.1
1949	0.024	0.043	0.244	20.0	7.5	7.5
1950	0.029	0.046	0.266	20.8	7.0	9.0
1951	0.033	0.049	0.277	13.8	6.5	4.1
1952	0.036	0.051	0.280	9.1	4.1	1.1
1953	0.037	0.056	0.292	2.8	9.8	4.3
1954	0.040	0.063	0.300	8.1	12.5	2.7
1955	0.044	0.071	0.316	10.0	12.7	5.3
1956	0.047	0.078	0.323	6.8	9.9	2.2
1957	0.047	0.084	0.327	0.0	7.7	1.2
1958	0.050	0.091	0.327	6.4	8.3	0.0
1959	0.054	0.098	0.335	8.0	7.7	2.4
1960	0.060	0.108	0.341	11.1	10.2	1.8
1961	0.066	0.116	0.344	10.0	7.4	0.9
1962	0.073	0.126	0.353	10.6	8.6	2.6
1963	0.080	0.141	0.364	11.0	11.9	3.1
1964	0.089	0.157	0.374	9.9	11.3	2.7
1965	0.098	0.168	0.387	10.1	7.0	3.5
1966	0.103	0.179	0.398	5.1	6.5	2.8
1967	0.109	0.192	..	5.8	7.3	..

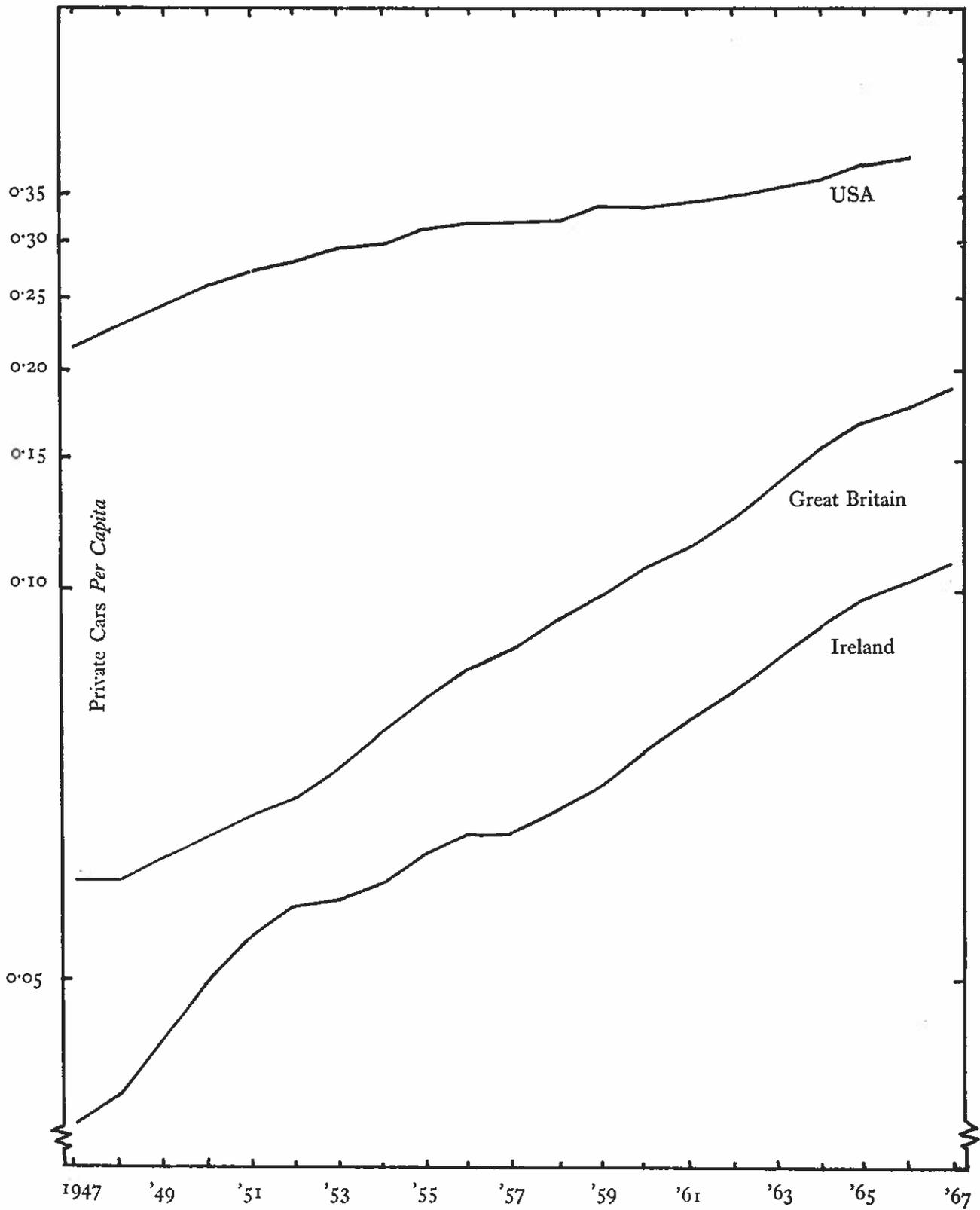
Note: a—Excluding State-owned vehicles

b—include taxis; from 1959 onwards include States of Alaska and Hawaii.

- Sources: Col. (2): SA; DLG Annual Vehicle Census
 Col. (3): British Road Federation, *Basic Road Statistics 1967*, pp. 4-5;
MDS April 1968, Tables 10, 118;
Annual Abstract of Statistics, 1938-1950, Table 6
 Col. (4): US Department of Commerce, *Highway Statistics, Summary to 1955*, Table MV-200,
 Bureau of Public Roads, *Highway Statistics (annual)*; Bureau of the Census, *Statistical Abstract of the United States (annual)*.

CHART 1: PRIVATE CAR OWNERSHIP 1947-1967: IRELAND, GREAT BRITAIN AND USA

(Semi-Logarithmic Scale)



Source: Table 1.

Since 1958 the growth of private car ownership in Ireland has been slightly higher than the British trend. The "gap" between car ownership in Ireland and in Great Britain is not very high. Ireland's level of ownership is constantly some six to seven years behind that of Great Britain: this can be seen from Table 1. On the other hand, there is a vast lag between ownership in Britain and in the USA. The 1967 car ownership level in Britain was exceeded in the United States in 1937.¹

As would be expected, over the 1947-1967 period the annual rate of growth of car ownership in the USA has been significantly lower than in Ireland or in Britain. Intuitively one would expect the US rate of growth, which is expressed on a much larger base, to be less.

1.3 Assumptions and Methods Used in Projecting Car Ownership

We begin with our general assumptions. No account is taken of possible changes in the methods by which road users pay for the use of congested roads, though it is possible that some form of direct pricing may be introduced in cities in order to charge road users for the costs of congestion which they cause.² Quite apart from doubts concerning the application of road pricing to Irish conditions, road pricing would be likely to affect car usage rather than car ownership. We also make the assumption that there is no restrictionist attitude adopted towards the growth of private car ownership.³

Four methods are used in building up a projection of car ownership. The first method tries to determine, by means of regression analysis, which explanatory variables would best project car ownership. Secondly, we fit a logistic curve to the car ownership data, assuming a certain saturation level of car ownership.

The third approach looks at car ownership at the household level, making use of data on the proportion of households owning cars, in a number of income groups.

Fourthly, a projection of new registrations (i.e. annual sales) of private cars is made. Using this projection, together with assumptions concerning

¹Source: US Department of Commerce (1957), Table MV-200.

²The Smeed Report (Ministry of Transport, 1964b, pp. 50-53) considered that a system of direct pricing for the use of roads would yield considerable economic benefits. Work on the technical feasibility of road pricing is in progress at the Road Research Laboratory (Ministry of Transport, 1966, p. 13).

³The welfare effects of unrestricted car ownership growth is outside our scope. This important subject is surely worth some future attention. Mishan (1967) provides an acute appraisal of the external diseconomies attached to the growth of private car ownership and use.

the scrapping of private cars, we can derive a projection of car ownership.

1.4 Use of explanatory variables

1.4.1 Introduction

This approach relies on the hypothesis that car ownership is related to explanatory variables such as income *per capita*. We test this hypothesis by regression analysis applied to time series data over the 1947-1966 period. Subsequently a cross-section of observations from a number of countries and from Irish counties is examined.

One of the independent variables which is used in the cross-sectional studies is population density. One would expect that, in density populated communities, high frequency public transport services would reduce the necessity for car ownership. The relation between car ownership and population density has been the subject of much recent discussion. Tanner (1965) plots data on car ownership in areas of Great Britain and the United States and says "It is clear that the number of cars per head tends to be lower in areas of high population density". Beesley and Kain (1964, p. 185) argue that car ownership is highly dependent on the density of work places and residences. Kain and Beesley (1965) in a further paper derive equations which express car ownership as a function of population density and median family income. They base the data on a sample of 45 US cities.

But given the dispersed pattern of population in Ireland, outside one or two cities, it is unlikely that population density would be a major factor influencing car ownership. We do not attempt to integrate this factor into our projections, apart from testing it in the cross-sectional studies.

1.4.2 Time series analysis Ireland, 1947-1966

A priori, we expect that private car ownership would be positively correlated with income *per capita*, and that it would be negatively correlated with the enforcement of hire purchase controls. We also expect that it would increase over time irrespective of the influence of income or the availability of hire purchase credit, i.e. we postulate an autonomous trend over time, which may be a reflection of factors such as consumers' acceptance and emulation effects.

The dependent variable in this analysis is the number of private cars *per capita*. Ideally, for the dependent variable one would like to construct a series of depreciated stocks of cars which would reflect the age distribution of the cars in use in each year. This has not been possible, since we have no information on this age distribution.

We would like to have included, as one of the independent variables, a price index for cars in use

(this would be even more appropriate if a depreciated stock of cars *per capita* had been the dependent variable). But no such index is available.⁴

Initially, the hypothesis is expressed in the following forms:

$$P = \alpha_0 + \alpha_1 D + \alpha_2 HP + \alpha_3 t + u$$

$$\log_e P = \beta_0 + \beta_1 \log_e D + \beta_2 HP + \beta_3 t + u$$

where P = private cars per 1,000 persons;
 D = disposable personal income *per capita* at constant prices (£);
 HP = hire purchase dummy variable,
 = 1 for 1957 and 1966 and
 = 0 for all other years;
 t = time = 0 at 1947;

and where u is an error term.

The following comments relate to the construction of independent variables D and HP .

Disposable personal income *per capita* at constant prices (D)

This is personal income (as defined in CSO, 1968) less taxes on personal income. The current values are deflated by the average value (1958 = 100) of consumers' personal expenditure on goods and services. This deflator is simply the quotient of the value of consumers' personal expenditure (at market prices) by its value at constant prices (CSO, 1968, p. 82, the quotient of row 51 by row 59). The figures are then expressed per head of population.

Hire purchase dummy variable (HP)

Once again we fall short of the ideal variable

⁴The CSO does compile information on new car prices, but for our purposes it would also be necessary to construct an index of second-hand cars. Then a composite index could be constructed. Information on the age distribution of cars in use would be needed in order to provide a weighting for this composite index. In any event, any price index for cars is vitiated by the difficulty of allowing for quality change in cars. For example, Cramer (1966) has shown that in the Netherlands over the 1950-1965 period, the rise in prices of motor cars has been just about offset by improvements in quality. The only attempt to quantify quality change with respect to car prices in Ireland (Geary and Pratschke, 1968, pp. 35-46) relies on a cross-section of observations, with somewhat disappointing results.

which would reflect hire purchase credit conditions. The ideal variable would reflect both the minimum percentage deposit and the maximum repayment period, for private car hire purchase agreements.

Only twice within the 1947-1966 period have there been government restrictions on hire purchase credit for private cars. The first was under the *Hiring, Hire-Purchase and Credit Sale Order*, 1956 (S.I. No. 46 of 1956) which laid down a minimum deposit of 25 per cent. and a maximum period of repayment of two years, effective from 13 March, 1956. This was later eased to 10 per cent. and three years respectively, on 15 February, 1957, and the restrictions were removed on 1 April, 1957. The second time was in 1965, when the *Hire-Purchase and Credit Sale Order* 1965 (S.I. No. 155 of 1965) prescribed a minimum deposit of 25 per cent. and a maximum period of repayment of three years, effective from 16 July, 1965. This was removed on 15 September 1967.

It is difficult to assess how hire purchase credit conditions vary in periods other than the above periods of Government restrictions. Not enough published information is available in order to construct reliable figures on the likely availability of hire purchase credit in each year. Therefore, rather than use a specific variable to reflect hire purchase credit conditions (e.g. by using the proportion of credit to be repaid in twelve months), we use a dummy variable. This dummy variable (HP) = 1 in 1957 and 1966, and = 0 in each other year. These seem to be the most appropriate years, since the vehicle counts (on which our car ownership figures are based) are taken at August each year.

The basic data for the regressions are contained in Table 1 and Table C2. Estimates of the coefficients are computed by least squares regression. In many cases the coefficients of HP and of t prove non-significant at the 5 per cent. level. In each of these cases we drop both HP and t and re-compute the regression. The following equations are derived.

	R^2	d
(1.1) $P = -79.98 + 0.6758 D + 3.788 HP + 1.251 t$ <div style="text-align: center; margin-left: 100px;"> $(0.1082)*** (2.651) (0.481)*$ </div>	$R^2 = 0.985$	$d = 0.91$
(1.2) $P = -78.05 + 0.6606 D + 1.372 t$ <div style="text-align: center; margin-left: 100px;"> $(0.1110)*** (0.4882)*$ </div>	$R^2 = 0.983$	$d = 1.01$
(1.3) $P = -118.3 + 0.9602 D$ <div style="text-align: center; margin-left: 100px;"> $(0.03619)***$ </div>	$R^2 = 0.975$	$d = 1.28$
(1.4) $\log P = -0.9304 + 0.8024 \log D - 0.01423 HP$ <div style="text-align: center; margin-left: 100px;"> $(0.4759) (0.95742)$ $+ 0.06592 t$ $(0.01169)***$ </div>	$R^2 = 0.982$	

$$(1.5) \log P = -1.015 + 0.8197 \log D + 0.06530t$$

$$(0.4576) \quad (0.01110)***$$

$$R^2 = 0.982$$

$$(1.6) \log P = -13.88 + 3.428 \log D$$

$$(0.1919)***$$

$$R^2 = 0.947 \quad d = 0.59$$

Throughout this paper *** signifies that the regression coefficient is significant at the 0.01 per cent. level on the basis of the *t* test. Significance at the 1 per cent. level is denoted by ** and significance at the 5 per cent. level by *.

One of the assumptions of our model is the serial independence of the error term. But in time series analysis, serial correlation may well exist between the errors in successive observations. The Durbin-Watson "d" statistic provides a test for the presence of serial correlation (in a few cases where equations are obviously unsatisfactory, this statistic is not computed).

In the first equation, containing all the variables, the dummy variable HP is non-significant at the 5 per cent. level. Its sign is positive, which is not what was expected. This variable is subsequently omitted.

Equation (1.2) contains both D and *t* as independent variables. The coefficients of both D and *t* are significant at the 5 per cent. level, and the equation as a whole is significant at the 5 per cent. level (using the F ratio test). But the "d" statistic indicates positive serial correlation of the error terms (at the 5 per cent. level). In addition, the equation is unsatisfactory because of multicollinearity—i.e. the

very high degree of correlation between variables D and *t* (the coefficient of correlation $r = 0.961$). Hence the estimates of the coefficients may be very unstable.

Equation (1.3) contains only D as the independent variable. The value of the "d" statistic lies in the indeterminate area. But the alternative test proposed by Theil and Nagar (1961) suggests the presence of positive serial correlation of the error terms, at the 5 per cent. level.

Similarly, the equations in the logs of both P and D are unsatisfactory, due either to non-significant coefficients, or to serial correlation of the error terms (evident in Equation (1.6)).

In an effort to overcome the problem of serial correlation, we try the following regressions. Firstly, we test a number of formulations using lagged disposable income, such as

$$P = a_0 + a_1 D_{-1} + u.$$

Secondly, we analyse the first differences of the observations. When one transforms to first differences, the serial correlation of the transformed errors is likely to be less than that of the original errors.

The following are the results of these regressions:

Original data	R^2	<i>d</i>
(1.7) $P = -84.88 + 0.7201D_{-1} + 1.283t$ (0.0865) (0.3741)**	0.990	1.22
(1.8) $P = -121.7 + 1.003D_{-1}$ (0.03300)***	0.982	1.43
(1.9) $P = -123.5 + 0.4081D + 0.5949D_{-1}$ (0.1289)** (0.1316)***	0.989	0.96
(1.10) $P = -124.9 + 1.047D_{-2}$ (0.0499)***	0.965	1.17
(1.11) $\log P = -2.959 + 1.225 \log D_{-1} + 0.0535t$ (0.3193)** (0.0077)***	0.990	0.57
(1.12) $\log P = -13.46 + 3.364 \log D_{-1}$ (0.1662)***	0.960	0.64
(1.13) $\log P = -12.88 + 3.269 \log D_{-2}$ (0.1810)***	0.953	0.89
First differences		
(1.14) $\Delta P = 3.745 + 0.1599 \Delta D$ (0.1107)	0.109	0.91
(1.15) $\Delta \log P = 0.03286 + 0.5547 \Delta \log D$ (0.4149)	0.0951	1.04

Table 2 shows the different slope coefficients for both 1947-1957 and 1958-1966, together with the R^2 and the d statistics. If one compares the coefficient over these two periods, the coefficients of both D and D_{-1} in the linear regressions are higher in the period in 1958-1966. The difference between the two coefficients of D is only marginal, but the difference between the coefficients of lagged income is more appreciable.

TABLE 2: CAR OWNERSHIP REGRESSIONS: SLOPE COEFFICIENTS, 1947-1957 AND 1958-1966

Variables in equation	1947-1957			1958-1966		
	Slope coefficient	R^2	d	Slope coefficient	R^2	d
P, D	0.9043	.889	1.28	0.9141	.942	1.08
P, D_{-1} ..	0.8455	.939	1.44	0.9214	.975	2.03
log P, log D ..	4.609	.920	1.45	2.461	.964	1.27
log P, log D_{-1}	4.048	.962	1.85	2.421	.977	2.35

A test of the equality between coefficients in two regressions is now used (cf. Johnston, 1963, pp. 136-138). It is found that there is not a significant difference between the 1947-57 and 1958-66 regressions, for either D or D_{-1} .

A final possibility remains. There may have been a change in the function relating car ownership to income, since 1958, whereby the slope coefficient remained the same in both 1947-57 and 1958-66, but the intercept changed. This can be tested by using the full 20 observations and by introducing a dummy variable, called S . This dummy variable = 0 for each year from 1947 to 1957, and = 1 for each year from 1958 to 1966.

Using this formulation, the hypothesis is that:

$$P = \alpha_0 + \alpha_1 D + \alpha_2 S + u$$

and similarly for lagged values of D and for log-log forms of the regressions.

The results of the regressions are as follows:

		R^2	d
(1.19)	$P = -111.0 + 0.9116D + 3.064S$ (0.0617)*** (3.147)	0.976	1.15
(1.20)	$P = -107.1 + 0.9036D_{-1} + 6.147S$ (0.0421)*** (1.998)**	0.989	1.94
(1.21)	$\log P = -12.95 + 3.242 \log D + 0.0644S$ (0.3330) (0.9036)	0.948	0.51
(1.22)	$\log P = -11.41 + 2.954 \log D_{-1} + 0.1402S$ (0.2359)*** (0.0624)*	0.970	0.72

Of these equations (1.20) seems highly satisfactory. The coefficients of both D_{-1} and S are highly significant and their signs are what we expect. The R^2 is extremely high. There is a certain amount of multicollinearity. D_{-1} and S are intercorrelated (the coefficient of correlation $r = 0.768$). However, this multicollinearity is not as serious as in the equations discussed earlier. There may be some slight doubt cast on the stability of (1.20) as a structural relationship but the intercorrelation present should not affect its usefulness in projecting car ownership. The coefficient of D_{-1} is somewhat smaller in Equation (1.20) than in Equation (1.8).

In summary, the most satisfactory equations seem to be (1.8) in which P is regressed on D_{-1} and (1.20) in which P is regressed on D_{-1} and on the dummy variable S .⁷

The elasticity of car ownership with respect to lagged disposable income from Equation (1.8) is 3.2, i.e. each 1 per cent. rise in GNP gives rise, on average, to a 3.2 per cent. rise in car ownership, with a one-year lag. This elasticity is calculated at the joint means, $\bar{P} = 54.2$, $\bar{D}_{-1} = 175.34$. The elasticity of car ownership with respect to disposable income, calculated from Equation (1.20), is 2.9.

These income elasticities can be compared with the results of other countries' studies, although these studies used dependent variables which were defined in a different way from ours. Chow (1960) in a US study takes as his dependent variable the number of "new car equivalents" *per capita* (older cars being regarded as equivalent to half a new car if their price were half that of new cars, etc.). He derives an income elasticity for the "weighted" car ownership with respect to real disposable personal income *per capita*. This elasticity is 1.46 (at mean

⁷One disconcerting feature of the time series analysis is that in many cases the highest R^2 of all is obtained from a simple regression on time t . This is true in the regression over 1947-66 of $\log P$ on t , and in the regression over 1958-66 of P on t and of $\log P$ on t . It could be argued that for projection purposes, such a regression of car ownership on time could be equally well used. This is not done, since our intention is to try to specify a model which is an intelligible structural relationship and which can also be useful for projection purposes.

car stock and mean income) for his linear relationship and 1.73 for his log-log relationship.

A British study (Dicks-Mireaux *et al.*, 1961) similar to Chow's, uses a depreciated stock of cars, taking cars in use adjusted for changes in age and size. It estimates, based on regression analysis over the period 1947-60, that the long term income-stock elasticity is equal to 2.4.

1.4.3 Variability of car ownership among countries

Having looked at time series data for Ireland, we now check the plausibility of our coefficients by examining two cross-sections. The first is a cross-section of countries.

A priori, we expect that private car ownership would be positively correlated with income, and negatively correlated with population density. This cross-section approach suffers from the inherent disadvantages of being based on aggregate data for countries. This aggregation is over regions within each country, of varying levels of development and levels of population density.

The following hypothesis is tested by regression analysis, using data for 58 countries, for which figures of *per capita* GDP are available:

$$P = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + u$$

where P = private cars per 1,000 persons, 1964;
 X_1 = *per capita* GDP at factor cost in US dollars, 1964;
 X_2 = population density (persons per square kilometre), 1964

and where u is an error term.

The variable X_1 (i.e. *per capita* GDP at factor cost in US dollars) is calculated at the parity rate.⁸ GDP at factor cost is a measure of a country's total production of goods and services. It is not equivalent to national income, since it excludes both depreciation and net factor income from abroad.⁹

The data on which the regressions are based are set out in Appendix C, Table C3, and the following are the results.

$$(1.23) \quad P = -16.3 + 0.1061X_1 + 0.002904X_2 \\ (0.03420)^{***} (0.1480) \\ R^2 = .896$$

The coefficient of population density in this equation is not significant at the 5 per cent. level. This is not altogether surprising since differences in

⁸Parity rates (as given in United Nations, 1966) are calculated by adjusting the official or free market exchange rates in 1938 by the relative change in the level of prices from 1938 to 1964 between the United States and each country.

⁹At the time when this section was being prepared, the *UN Yearbook of National Accounts Statistics*, 1966, which gives estimates of *per capita* national income, was not yet available. We use the *per capita* national income figures in Section 3, when discussing motor cycle ownership.

population density within each country are not reflected in the equation.

We now omit population density as an explanatory variable, and test the following formulations of the hypothesis:

Linear:

$$P = \alpha_0 + \alpha_1 X_1 + u$$

Double logarithmic:

$$\log_e P = \beta_0 + \beta_1 \log_e X_1 + u$$

or

$$P = \beta'_0 X_1 \beta_1 u$$

where β'_0 is the antilog of β_0 .

The following are the results:¹⁰

$$(1.24) \quad P = -16.2 + 0.1062X_1 \quad R^2 = .897 \\ (0.004819)^{***}$$

$$(1.25) \quad \log P = -2.107 + 1.320 \log X_1 \quad R^2 = .849 \\ (0.07430)^{***}$$

The log-log equation (1.25) has the advantage that the elasticity of Y with respect to X_1 is constant. The goodness of fit of Equation (1.25), as measured by R^2 , is slightly less than that of Equation (1.24), but the two equations are both equally significant at the .01 per cent. level (testing by means of the F ratio).

The elasticity of car ownership with respect to real GDP *per capita* is quite similar from both equations, i.e. 1.27 from the linear equation (calculated at the joint means $\bar{Y} = 60.6$, $\bar{X}_1 = 722.7$) and 1.32 from Equation (1.25). Therefore, based on this cross-section, a 1 per cent. increase in real GDP *per capita* results on average in an increase of about 1.3 per cent. in car ownership.

1.4.4 Variability of car ownership among Irish counties

The second cross-section is one of Irish counties. The basic analysis is provided in Appendix A. The elasticity of car ownership with respect to personal income *per capita* calculated from Equation (A.2) of Appendix A is 1.17 at the joint means ($\bar{P} = 57.6$, $\bar{X}_1 = 191.1$). This elasticity of 1.17 is reasonably close to the two elasticities calculated from the

¹⁰If private cars *per capita* are regressed on *per capita* GDP calculated at the exchange rate (for the 64 countries for which such data are available) the goodness of fit as measured by R^2 is .873, slightly lower. These *per capita* GDP figures were expressed (by United Nations, 1966) in national currency units, converted into US dollars using the prevailing exchange rate for each country with a minimum of adjustment.

58-country cross-section regression (i.e. 1.27 and 1.32).

The log-log equation for the Irish counties gives a higher elasticity of 1.46 with respect to personal income *per capita*. Both the linear and the log-log ownership elasticities are significantly lower than those derived from the Irish time series analysis.

1.4.5 Projection of car ownership using explanatory variables

In summary, the time series analysis has shown that the best equations explaining the growth of car ownership in Ireland are (1.8) and (1.20).

The cross-sectional analyses, whether across countries or across Irish counties, have given lower elasticities of car ownership with respect to income than have the time series analyses. This could be because of faulty specification of the time series model. This discrepancy in elasticities could also arise because of a difference between long and short period adjustment. The cross-section across a wide spectrum could reflect the long-term adjustment, with the time series reflecting the short-term adjustment.

On the question of population density, the cross-sectional regressions show that this variable is non-significant.

Equation (1.20) is used to project car ownership; this equation gives a slightly better fit to the past data than does (1.8). If alternative assumptions are made concerning the average growth of real disposable personal income *per capita* over the period 1967-1985 (ranging from 2.5 per cent. per annum to 4.0 per cent. per annum) the resulting alternative projections of car ownership are as in Table 3.

TABLE 3: ALTERNATIVE PROJECTIONS OF PRIVATE CAR OWNERSHIP BASED ON DIFFERENT ASSUMPTIONS OF INCOME GROWTH

Year	Average Growth of Real Disposable Personal Income <i>Per Capita</i>	Private Cars <i>Per Capita</i>
1967 (actual)	% p.a.	0.109
1970	2.5	0.117
	3.0	0.120
	3.5	0.123
	4.0	0.126
1975	2.5	0.145
	3.0	0.155
	3.5	0.165
	4.0	0.176
1980	2.5	0.177
	3.0	0.196
	3.5	0.215
	4.0	0.235
1985	2.5	0.214
	3.0	0.243
	3.5	0.274
	4.0	0.308

It is now necessary to postulate a growth rate of disposable income over the projection period. The higher growth rate in income since 1958 has already been discussed. The trend rate of growth of real disposable personal income *per capita* was 3.75 per cent. in 1958-66.

Between 1967 and 1970 the favourable effects of the Anglo-Irish Free Trade Agreement should be significant. It seems reasonable to assume a growth rate of 4 per cent. per annum in real disposable personal income *per capita* in the 1967-1970 period. It is assumed that subsequently the growth rate will be 3.5 per cent. per annum, in the 1970-1980 period and 3.0 per cent. per annum in the 1980-1985 period. This falling-off in the growth rate is assumed partly because incomes would be continually increasing on a larger base. The resulting projections of car ownership are given in Table 4.

There are a number of reservations concerning this projection of car ownership. Firstly the projection assumes that the specification of our regression model is reasonably correct. Secondly, it assumes that the parameters of the regression equation remain unchanged over the projection period. Thirdly, it is dependent on a certain projection of disposable income *per capita*.

TABLE 4: PROJECTION OF PRIVATE CAR OWNERSHIP BASED ON REGRESSION RESULTS

Year	Private Cars <i>per Capita</i>
1967 (actual)	0.109
1970	0.126
1975	0.170
1980	0.221
1985	0.274

1.5 Logistic Curve Projection

1.5.1 The Logistic Curve

It has been found that the growth of certain living organisms can be represented by the logistic curve (see Pearl, 1926, p. 125). This obviously need not be the case with car ownership, but there is a certain plausibility in trying to fit a logistic curve to the available data on car ownership, in order to estimate future long-term movements its ownership (for an example of this approach, see Tanner, 1965).

We firstly discuss the general form of the logistic curve. A form of this curve is derived which basically reduces the projection process to one of selecting a saturation level of car ownership. There follows an estimate of a likely saturation level of car ownership for Ireland. The logistic curve is then fitted.

The logistic curve¹¹ is S-shaped, is asymptotic to the t axis at large negative t and to the abscissa $= a$ (i.e. on the vertical axis) for large positive t . The curve grows slowly, gathers speed, and finally ceases to grow at an upper asymptote.

Equation (1.28) in footnote 11 shows that the rate of growth of y at any time t is proportional to the product of the existing value of y and the distance of y from its upper asymptote at a . Therefore the rate of increase of y increases as the existing value of y increases, and decreases as the distance of y from its upper asymptote decreases.

Given a sufficient number of observations, one could fit a logistic curve to data, through estimating the parameters a and c by least squares regression. This is not so in the case of Ireland, where one is a considerable period away from saturation (i.e. the upper asymptote a). We therefore adopt a similar approach to that used by Tanner in his British studies (see for example, Tanner, 1965). In footnote

¹¹The general form of the logistic curve is as follows:

$$(1.26) \quad y = \frac{a}{1 + be^{-ct}}$$

where b , e and c are parameters to be determined from the data and t is time. Differentiating (1.26) with respect to t , one obtains:

$$(1.27) \quad \frac{1}{y} \frac{dy}{dt} = c - (c/a)y$$

Therefore

$$(1.28) \quad \frac{dy}{dt} = \frac{c}{a}y(a-y)$$

We now assume that the current number of private cars *per capita* is Y and that the current rate of growth of Y is 100 r per cent. per annum. The saturation level of cars *per capita* is the constant a . Time t is equal to 0 at the present time, while b and c are constants determined from the equation.

Inserting these values in Equation (1.28) we have

$$\frac{dY}{dt} = \frac{c}{a}Y(a-Y)$$

$$rY = \frac{c}{a}Y(a-Y)$$

Therefore:

$$(1.29) \quad c = \frac{ar}{a-Y}$$

When $t = 0$, from Equation (1.26) we have $Y = \frac{a}{1+b}$. Therefore

$$(1.30) \quad b = \frac{a-Y}{Y}$$

If we insert the values of c and b as given in Equations (1.29) and (1.30), into Equation (1.26), we can derive the following function for y :

$$(1.31) \quad y = \frac{aY}{Y + (a-Y)\exp(-art/a - Y)}$$

11, we derive Equation (1.31) which enables us to solve for y (car ownership at any time t). The only unknown in this equation is the saturation level a . Therefore, once the saturation level a is fixed, the logistic curve is determined.

This is a useful means of projecting car ownership by means of the logistic curve, for a country such as Ireland which is a considerable period away from possible saturation. This method of projection has at least two distinct advantages. Firstly, one is not dependent on the ability to project explanatory variables in order to project car ownership. Secondly, it seems suited to forecasting over such a long time period as we have in mind.

As a test of the general relevance of the logistic curve, three modified exponential trends are fitted to long-term data on USA and Swedish car ownership. These two countries should be much nearer possible saturation than is Ireland or Britain, and a large number of observations is available for each country. Each of these three modified exponential trends approaches an upper asymptote.

The three curves are derived from the modified exponential function $y' = a + br^t$. The curves are the simple modified exponential where y' = car ownership y ; the Gompertz where $y' = \log y$; and the logistic, where $y' = \frac{1}{y}$. In these formulae

a , b and r are constants and t is a set of integers representing time.

The USA data cover the period 1920-1966, and the Swedish data the period 1923-1966 (excluding the years 1940-1946 for Sweden due to the effects of the war).

If we wish to compare these curves, it is necessary to weight the squared deviations of y' , according to our assumptions about variations in y . Two common assumptions are:

(a) Uniform error, i.e. $var(y)$ is constant.

(b) Proportional error, i.e. standard error (y) is proportional to y , i.e. $var(y)$ is proportional to y^2 .

The curves are fitted, making each of these assumptions in turn. Appendix Table C5 gives the actual and calculated values of car ownership for USA and Sweden derived by fitting these curves (the Gompertz calculations are not shown).

The calculated values given by the logistic curve give quite a good fit to the data for both USA and Sweden. The simple modified exponential curve does not fit the data, for either the USA or Sweden. For the USA the logistic curve gives a better fit than the Gompertz, whether we assume uniform or proportional error. For Sweden, the logistic curve

gives a better fit than the Gompertz, although if we assume uniform error the difference is marginal.

It is possible to compare the extent to which the different curves fit the data. If we let the difference between actual and calculated ownership in any year be equal to u , then $\sum u^2$ is given in Table 5.

These results lead us to believe that, *a priori*, the logistic curve can represent the growth of car ownership.

TABLE 5: FITTING OF EXPONENTIAL CURVES TO USA AND SWEDISH CARS PER 1,000 PERSONS: SUM OF SQUARED DEVIATIONS

Type of Curve	Assumptions Concerning Variations in y			
	USA		Sweden	
	Uniform	Proportional	Uniform	Proportional
Gompertz ..	No Fit	20,167	3,030	No Fit
Logistic ..	19,519	17,457	2,955	6,114

1.5.2 Estimation of saturation level—general

The levels of private car ownership in Ireland and in Great Britain are not yet approaching saturation level. This can be seen from Table 1, which shows annual rates of increase of ownership. The annual rate of growth of car ownership does not decline gradually in the period examined.

More significantly, there is not yet much evidence of an approaching saturation level for the United States as a whole. However, in those US States with a high level of car ownership there has been a fairly low rate of growth of ownership in recent years. The eleven US States with more than 0.410 private cars *per capita* in 1965 had an average compound rate of growth of ownership over the 1960–65 period of 1.93 per cent. per annum compared with an overall US average of 2.52 per cent. per annum in the same period (Table C5).

It may be slightly misleading to compare Ireland with countries such as Great Britain and the United States in this way. The United States is a much less densely populated country than Great Britain, and one would need to examine in much greater detail the relationship between car ownership, income level and population density in order to derive more meaningful conclusions regarding saturation levels. It may be that different saturation levels would apply to countries such as Ireland, Britain and the US. One would also need to take account of the influence of differing family sizes between these countries. The higher family size in Ireland might mean that its hypothetical saturation level would be lower than that of Great Britain.

We therefore base our estimates of the saturation level in Ireland on two other methods. The first is

based on an examination of the pattern of car ownership growth in Irish counties. The second method is based on the Irish age distribution.

1.5.3 "Intercept" method

The first method has been developed by Tanner (see for example, Tanner, 1965). One examines a set of administrative districts over successive time periods. Appendix Table C4 shows that administrative districts in Ireland with the highest rate of car ownership tend to have the lowest rate of increase in car ownership, in each time period examined. There is therefore the possibility of establishing a significant relationship between these two variables and thereby estimating the level of car ownership which relates to a nil rate of growth in ownership—i.e. the saturation level.

We therefore postulate that the annual average percentage increase in car ownership over a certain period is a function of the actual level of car ownership in this period. A cross-section of observations from Irish counties and county boroughs is taken and this hypothesis is tested by least squares regression.

Firstly, the Irish data are examined; the basic data are in Table C4. Since population figures for counties and county boroughs (necessary for calculating private cars *per capita*) are available only once every five years, the analysis is limited to a number of five-year periods. The periods chosen are 1951–56, 1956–61 and 1961–66, and we have 29 observations in each of these periods.¹²

The variables used are as follows:

Annual average percentage increase in car ownership (Y):

This is calculated over each five year period by the following method. If P_i = number of cars *per capita* at year i ($i = 1, 2, \dots, 6$), then:

$$Y = 100 (P_6/P_1)^{1/5} - 100$$

Car ownership (X):

This is the geometric mean of car ownership in year 1 and year 6, i.e.

$$X = (P_1 P_6)^{1/2}$$

The regression equations for each of the three periods examined are as follows:

1951–1956 :

$$Y = 14.25 - 145.4X \quad R^2 = .306$$

(42.18)**

F ratio = 11.9 significant at 1 per cent. level.

¹²Due to a boundary change, it is not possible to calculate separate figures for Cork County Council and Cork County Borough areas. There are also boundary changes which affect a comparison of cars *per capita* in 1961 with earlier years (see CP 1961, footnotes to Table 3), but these are ignored for our analysis.

1956-1961:

$$Y = 12.35 - 90.72X \quad R^2 = .338$$

(24.45)***

F ratio = 13.8 significant at 0.1 per cent. level.

1961-1966:

$$Y = 14.42 - 61.66X \quad R^2 = .160$$

(27.18)*

F ratio = 5.14 significant at 5 per cent. level.

In each of the above cases the overall significance of the regression is tested by means of the F ratio test. The regression for 1956-1961 is highly significant, and each of the other regressions is significant at the 5 per cent. level at least.

If similar regressions are run for the county districts, the R^2 are higher (.436, .560 and .214).

In calculating a car ownership saturation level based on a British cross-section, Tanner (1965, Appendix 3) assumes that the data conform to the model:

$$Y = a + \beta X + u$$

where u is an error term and where X is an independent variable not subject to error. Given this assumption he tries to determine the value of X for which the average value of Y is zero (one is unable to calculate the average value of X when Y is zero, since it is assumed that the X values are given).

Tanner also derived a sampling variance for the required intercept, the value of X for which Y is zero. He calls this the "obvious" estimate, implying that it is a commonsense quantity to use. It is not necessarily an unbiased estimator, but one requires only an approximate estimate of the saturation level. Tanner's formula for the sampling variance of the intercept is used in calculating confidence limits. (The formula for estimated variance of the intercept is given in Tanner, 1965, Appendix 3.)

We calculate the values of the intercept at $Y = 0$ from the above regression equations. This gives a calculated saturation level for X (cars *per capita*) for each of the periods; in addition, 95 per cent. confidence limits for the intercepts are calculated.¹³ The calculated saturation levels (cars *per capita*) are as follows (with 95 per cent. confidence limits in brackets):

$$1951-1956: 0.098 (0.060 - 0.136)$$

$$1956-1961: 0.136 (0.072 - 0.165)$$

$$1961-1966: 0.234 (0.120 - 0.355)$$

¹³Another possible application of these cross-sectional regressions, which has not been attempted, is that of projecting car ownership levels in the counties. The "intercept" approach might be a help in this regard.

The increase in the calculated saturation level between 1956-61 and 1961-66 is over double the increase between 1951-56 and 1956-61—this is partly a reflection of the abnormally depressed economic conditions during much of the 1956-61 period.

1.5.4 Demographic age distribution

This method of estimating the saturation level is based on an examination of the age distribution of the demographic population. We estimate the proportion of the population which is likely to hold driving licences, and then postulate that one car per licence-holder is a reasonable upper limit.

The Irish car-driving population comprises those aged 17 and over, and it is assumed that the minimum age of a licence-holder will not change. In 1966, 54 per cent. of the population was in the 17-64 age group.

It is now necessary to project this 17-64 age group. The most recently published population projections made by CSO are contained in an NIEC Report (NIEC, 1967). These projections are based on different assumptions concerning net emigration (i.e. on whether it would fall to 5,000 per annum by 1976, 1981 or 1986). We choose the projection which assumes that net emigration would fall to 5,000 per annum by 1976 (NIEC, 1967, Table 4).

From Table 4 of NIEC (1967) we calculate the projected numbers of persons in the 15-64 age group. The likely future proportions in the 17-64 age group are obtained by assuming that the relativity between the number of persons in the 15-17 age group and those in the 15-64 age group remains constant. Based on these assumptions, we estimate that the proportion of population in age group 17-64 would increase from 53.7 per cent. in 1966 (CP 1966, Table 10) to 53.1 per cent. in 1976, 51.0 per cent. in 1986 and 50.5 per cent. in 1991.

It is now arbitrarily assumed that, for health and other reasons, 10 per cent. of the population aged 17-64 would not be able to drive or would not be willing to drive, and that 50 per cent. of the population aged 65 or over would not drive. When estimating the proportion of the projected population which is aged 65 or over, we rely on the population projections contained in ISB, June 1965, since NIEC (1967) does not have this information. Based on these assumptions, it is calculated that the proportion of the population which is capable and willing to drive would change from 53.9 per cent. in 1966 to 53.3 per cent. in 1976, 51.4 per cent. in 1986 and 50.9 per cent. in 1991.

Assuming that one car per potential driver is a reasonable limit, these figures suggest that 0.50 cars

per head of total population would be an approximate saturation level.

1.5.5 Conclusions on saturation level

There is no evidence of an imminent saturation level of car ownership from aggregate Irish, British or even US data over the 1947-67 period. We have, however, tried to estimate the Irish saturation level both by using the "intercept" method based on a cross-section of Irish administrative districts, and by using data on the Irish age distribution.

The calculated Irish saturation level based on "intercept" data is 0.23 private cars *per capita*, based on Irish county and county borough data covering the 1956-61 period. However, the Irish "intercept" has increased quite rapidly over the three five-year periods which have been examined. In 1967 the level of private car ownership in Ireland (0.109 cars *per capita*) had already exceeded the calculated "intercept" for the 1951-56 period. The calculated Irish saturation level of 0.234, based on data relating to the period 1961-1966, is below the level of car ownership reached in Australia, Canada and the USA in 1964. It would be reasonable to assume that the Irish level of ownership would at some future date approach the level at present achieved in the above-mentioned countries.

It is very likely that the calculated "intercept" will continue to increase in future periods. This changing value of the "intercept" does not mean that the saturation level is changing. The saturation level is a constant, which we are trying to estimate. The changing value of the "intercept" does mean that the "intercept" method is of very limited use in estimating the saturation level.

These considerations lead to the tentative conclusion that the demographic age-distribution data give a more realistic estimate of an Irish saturation level. Nevertheless we place some credence on the "intercept" method. We reduce the 0.50 level (given by the age-distribution method) and accept a saturation level of 0.45 private cars *per capita* for calculation purposes.

1.5.6 Logistic Curve Projection

Equation (1.31) in footnote 11 is used to project car ownership. When inserting values in Equation (1.23) one problem concerns the current value of r , where the current rate of growth of private cars *per capita* equals 100 per cent. In normal circumstances, one would insert the 1967 value, i.e. 0.058. However, as can be seen from Table 1, the 1966 and 1967 values of 100 are abnormally low compared with recent years, due to the marked slowing down of economic growth which occurred in 1965 and 1966. The average rate of growth of cars *per capita* in the period 1962-67 was 8.4 per cent. per annum, and

this was used for calculating r , giving a value of 0.084. The other values inserted in Equation (1.31) are:

$$a = 0.450.$$

$$Y = 0.109 \text{ (i.e. cars } per \text{ capita in 1967).}$$

Based on these calculations, the projected car ownership rates in the period 1967-1985 are given in Table 6.

TABLE 6: PROJECTION OF CAR OWNERSHIP, 1967-1985 USING LOGISTIC CURVE

Year	Private Cars <i>per capita</i>
1967 (actual)	0.109
1970	0.139
1975	0.188
1980	0.258
1985	0.316

How sensitive are the above projections to different assumptions concerning the saturation level? If we were to work with a saturation level of 0.40 cars *per capita*, the projected ownership in 1980 would be 0.251, compared with the 0.258 figure in Table 4. If a saturation level of 0.500 were used, the projected ownership in 1980 would be 0.265. Therefore in the period up to 1980, the projections are not unduly sensitive to changing assumptions concerning saturation level.

1.6 Household Car Ownership

Up to recently there has been a lack of information on the relationship between household car ownership and household income levels. The HBI 1951-52 (CSO, 1954) provides information concerning household expenditure on motor cars (including running costs). These data are not used since they are out of date and lack sufficient detail.

No time series data are available on car ownership at the household level. Instead, we have information from two recent analyses: the HBI 1965-66 and the sample of farms used by An Foras Talúntais for its Farm Management Survey 1966/67. These two sources complement one another to a certain extent since the HBI is confined to urban areas. We use information from these sources in order to determine the proportions of private households in certain income groups who own cars.

Firstly, we make some simple calculations on the extent of car ownership at the household level, based on CP data. It is necessary to exclude non-private households from these calculations (among the main categories of non-private household are boarding house, hospital, boarding school and religious institution). We estimate that the number of private cars per private household in 1966 was 0.42; this is based on an estimated 693,000 private households in 1965; in making this estimate we

deduct an estimated 10,000 cars which are attached to non-private households.¹⁴

But even after correcting for non-private households, this figure of 0.42 is an over-estimate, since private cars are held by car-hire firms, by the motor trade and also in business fleets. These cars inflate the numerator ("private cars") and they do not correspond to the denominator ("private households").

The extent of this over-estimate, and a general check on the above household ownership figures, may be obtained from HBI 1965-66 and from FMS data. The HBI data are based on 4,759 returns from private urban households. Any household co-operating in the HBI which showed expenditure on motor car insurance is regarded as owning a car or cars. This information was specially provided by CSO on request.

The following reservations need to be borne in mind. Firstly, some of the households who register expenditure on motor car insurance possibly own more than one car. We do not know what is the proportion of these multi-car households. Therefore we cannot determine the exact number of private cars per household from the HBI.

Secondly, when the car was used entirely for business purposes it was not summarised in the HBI. If used partially for business it was summarised in the HBI. Therefore, our data do not reflect the varying use made of private cars for business purposes.

The FMS sample is a stratified random sample, the farms being stratified by size groups. The original sample consisted of 1,412 farms, but after excluding farms under 5 acres, estates and certain unsatisfactory record books, we are left with a sample of 1,396 farms.

It is possible to derive a very approximate overall weighted average of household car ownership, using HBI and FMS data. The HBI data are based on a larger sample and should be relatively more accurate than the FMS data. An estimated 30 per cent of urban households in 1965-66 owned a car or cars (HBI 1965-66). Of the FMS sample, relating to rural households, 43 per cent. owned a car or cars. But this FMS figure is likely to be biased upwards since (a) there was a high rate of substitution in the

sample and (b) holdings under 5 acres are excluded. Suppose that the "true" figure for all rural households is 38 per cent. Using the numbers of rural and non-rural households as weights¹⁵ the overall average proportion of car-owning households is estimated at 34 per cent.

It is now necessary to allow for multi-car ownership. Very little information is available on this question in relation to Ireland. We make use of two sources on multi-car households. Firstly, an analysis from the Limerick Traffic Survey relating to 1967 shows that 45 per cent. of the households are car-owning, of which 2 per cent. own more than one car.¹⁶ This estimate is subject to a fairly wide margin of error.

Secondly, we look at data for Scotland. This is the British region which most resembles Ireland in its economic characteristics. Also, Scotland has the lowest car ownership of all the British New Standard Regions.¹⁷ The 0.139 cars *per capita* in Scotland in 1966 compare with the 0.179 average for all Great Britain and the 0.103 average for Ireland. In Scotland in 1966, 35.6 per cent. of the households owned cars, of which 31.6 per cent. owned one car and 3.9 per cent. owned two or more cars.¹⁸ This car owning proportion is quite near the Irish figure. If one strikes a balance between the Limerick and the Scottish data, a figure of 3 per cent. of households owning more than one car in 1966 seems a reasonable estimate. We estimate, therefore, based on HBI and FMS data, that 36 per cent. of Irish households owned cars in 1966, of which 33 per cent. owned one car and 3 per cent. owned more than one car.

Using these figures, we obtain an estimated 0.39 cars per household in 1966. This can be compared with the earlier estimate of 0.42 cars per household. The difference between the two figures is equivalent to 20,800 cars. We assume that this difference amounts to the number of cars held by the motor trade, and in business fleets (although more strictly, some portion of the difference is probably due to errors of estimation).

1.7 Conclusions on Projection of Private Car Ownership

In Appendix A, Section A.2, we look at the relationship between car ownership and household

¹⁴There were 3.97 persons per private household in 1961, excluding those living in non-private households (CP 1961). The number of persons in non-private households in 1961 was 132,040. We assume that household size, and the number of persons in non-private households, remain the same in 1966. This leads to an estimate of 693,000 in private households in 1966 (compared with 676,000 in 1961). Having estimated the number of private households in 1966, it only remains to estimate the number of cars attached to non-private households in that year. This is done by arbitrarily assuming an average of about 1.5 cars per non-private household. By arbitrarily assuming that the average non-private household size is 20 persons, we estimate that there were 6,600 non-private households in 1966.

¹⁵The weights are 365,800 (the number of households included in the HBI) and 310,600 (total private households in 1961 less 365,800). The data relate to 1961 since the HBI was based on household data from CP of that year. This should not have too distorting an effect since it is relativities which are important.

¹⁶This estimate is based on unpublished data, obtained specially from the Limerick Traffic Survey by ESRI and An Foras Forbartha.

¹⁷This information relates to 1965. *Source*: Central Statistical Office (1967), Table 31.

¹⁸*Source*: General Register Office, *Sample Census 1966: Summary Tables*.

variables, based on HBI data. An attempt is made to project car ownership, based on these data. A further approach to car ownership projection is made in Section A.3 of Appendix A which is based on trends in new registrations per annum. Of the different approaches which have been made it is felt that the projections based on both HBI data, and on new registrations are unreliable. This is possibly because of a number of unrealistic assumptions underlying these two projections. Their estimates of future car ownership seem to be, respectively, an underestimate (HBI) and an overestimate (new registrations) of likely future trends.

We concentrate on the two other methods. The logistic curve projections (assuming a saturation level of 0.45 cars *per capita*) are consistently higher than those made on the basis of regression analysis. The logistic curve projections, with the "regression" projections in brackets, are 0.139 (0.126) cars *per capita* in 1970, 0.188 (0.170) in 1975, 0.258 (0.221) in 1980 and 0.316 (0.274) in 1985. The differences between the logistic and the "regression" estimates could be due to the margin of error in the estimates. Another possible reason for the discrepancy may be our use of a linear regression equation which may underestimate the likely future growth of car ownership.¹⁹ We have little evidence on which method may be more reliable. As a purely empirical rule, we choose a projection midway between the two. This projection is given in Table 7, which also converts

¹⁹In this regard, for the period 1958-66, the regressions of both log P on log D and of log P on log D₋₁ give very high R² (as can be seen from Table 2). Nevertheless it would not seem justifiable to use a log-log relationship, established over such a relatively short period, for projection.

the cars *per capita* into car numbers by using estimates of the future demographic population.

TABLE 7: PROJECTION OF PRIVATE CAR NUMBERS, 1967-1985

Year	Private Cars <i>per capita</i>	Population	Private Car Numbers
1967 (actual)	0.109	'000 2,892	314,400
1970 ..	0.133	2,950	392,000
1975 ..	0.179	3,084	552,000
1980 ..	0.240	3,287	789,000
1985 ..	0.295	3,566	1,052,000

When estimating the demographic population, the CSO projection published in Table 4 of NIEC (1967) is chosen, as was done when assessing the likely future demographic age distribution. This CSO projection is adjusted upwards by 3,000 in each year (since the 1966 out-turn was higher by 3,000 than the 1966 projection). The population projections in the table are obtained by linear extrapolation from the adjusted NIEC projections (which do not relate exactly to the years we have chosen).

Our projection of cars *per capita* implies an annual average rate of growth of 6.85 per cent. per annum in the 1967-1970 period; of 6.05 per cent. per annum in the 1970-1980 period, and 4.23 per cent. per annum in the 1980-1985 period. This compares with the trend rates of growth of 8.8 per cent. per annum in the 1947-1967 period, and 9.5 per cent. per annum in the 1958-1967 period. The element of uncertainty, inherent in any forecast, becomes very large when we look beyond 1975.

2. PROJECTION OF GOODS VEHICLE OWNERSHIP

2.1 Introduction

Since 1957 the growth rate of total commercial goods vehicles has been very moderate; between 1957 and 1967 the total stock of these vehicles increased by only 5.6 per cent. A more significant change has occurred in the distribution of goods vehicles by unladen weight, which is shown in Table C8. There is one difficulty with regard to the interpretation of Table C8. In 1960 the regulations relating to the licensing of commercial goods vehicles changed the definition of unladen weight for licensing purposes. The *Finance (Excise Duties) (Vehicles) (Amendment) Act 1960* defined unladen weight for the purpose of motor vehicle duty as being inclusive of all additions (e.g. containers and cattle bodies). This means that in a table such as

Table C8, many goods vehicles "moved" to a higher unladen weight class between 1959 and 1960. Therefore comparison between the distribution of vehicles by unladen weight before and after 1960 is somewhat distorted.

Since 1960, there has been a marked change in fleet composition. There has been a considerable increase in the number of vehicles over 4 tons. This gradual switch to vehicles of larger unladen weight, and hence larger carrying capacity, is due to the greater productivity of these vehicles. These vehicles give significantly lower costs per ton-mile.

As with the projection of private car ownership, it is necessary to make some basic assumptions which underlie the projection of goods vehicle ownership. The projections are made in the context

of the present licensing system for road haulage, and the present CIE rail network. Any change in the regulations governing road haulage licensing would alter the "mix" of traffic between rail and road. However, it is quite possible, particularly in the short run, that any change in road haulage licensing arrangements would not significantly affect the overall number of goods vehicles. Any liberalisation of the licensing regulations would be likely to result in a shift of traffic from rail to road. Theoretically this could mean an increase in the number of goods vehicles required to handle this traffic. But this would be very problematic since (a) the likely shift in traffic is a marginal one in the context of total ton mileage;²⁰ (b) there must exist a certain "surplus capacity" among the "own account" fleet at the moment. Under a liberalised framework, this capacity might be taken up by, for example, the filling of back-hauls.

In these projections no account is taken of the possible impact of containerisation developments. It is rather difficult to say whether the undoubted increase of containerisation will affect goods vehicle numbers. Theoretically, insofar as this development would increase turn-around times for vehicles, there would be savings in vehicle fleets. One is uncertain whether this would happen in practice, on a significant scale.

2.2 Method of Projecting Goods Vehicles

The total numbers of goods vehicles in past years are of limited use for projections, since the significant factor has been the changing structure of the goods vehicle fleet. This changing structure can be measured in terms of unladen weight or can be estimated in terms of carrying capacity (although no accurate figures are available from year to year for carrying capacity).

A projection of goods vehicle numbers should, if possible, be consistent with likely future trends in road ton-mileage (from the demand side) and carrying capacity (from the supply side). The basic method is an iterative one, which depends on a search for such consistency. We begin therefore by estimating both ton-mileage and carrying capacity for a number of recent years. These figures, together with projections, are contained in Sections 2.3 and 2.4 respectively.

One source of difficulty is the conversion of the projected goods vehicle numbers into ton-mileage demand, and carrying capacity respectively. The ton-mileage check is based on a simple identity: annual ton-mileage equals the product of the number of vehicles by the product of weighted average load carried per mile (abbreviated to average load,

²⁰The relative road-rail shares of total ton-mileage are discussed in Section 7.

and measured in tons) and average annual mileage per vehicle. The conversion of vehicle numbers into carrying capacity is done simply by multiplying vehicle numbers by average carrying capacity. Rather than perform these conversions for all goods vehicles taken together, there are separate calculations for each unladen weight class. This should make the calculations more accurate. An obvious difficulty is the selection of the two ton-mileage parameters—average load and average mileage, together with average carrying capacity, for future years. This is discussed in Section 2.5.

The goods vehicle projections are discussed in Section 2.6. Firstly, based on the trends since 1960, a modified extrapolation is made of the number of goods vehicles in each unladen weight class. Then we check if this projection is consistent with (a) the projected ton-mileage demand for road freight and (b) the projected carrying capacity of the goods vehicles.

This procedure leads to a modification of the initial extrapolation and once again the implications of the second extrapolation for ton-mileage demand and for carrying capacity are assessed. This iterative process is continued until the extrapolation of goods vehicle numbers is reasonably consistent with both projected ton-mileage demand and projected carrying capacity.²¹ We also examine whether the projected pattern of light goods vehicles is consistent with the cross-sectional results of Appendix B.

This iterative procedure is open to the criticism that the projection of ton-mileage and of carrying capacity is taken as "fixed" and that the extrapolations of goods vehicle numbers are checked against these projections. Admittedly the projections of ton-mileage and of carrying capacity rest on fairly tenuous foundations. It has only been possible to use observations from 1960 onwards for the regression analysis, and have made highly simplified assumptions concerning the future growth of GDP. In addition, the actual "observations" of ton-mileage and carrying capacity in each year since 1960 are no more than very approximate estimates.

But in the circumstances it seems best to check against ton-mileage and carrying capacity; at the least the two projections, one from the demand side and the other from the supply side, provide an independent check on the goods vehicle numbers.

A final test of consistency concerns the light goods vehicles. These vehicles tend to be engaged in

²¹There is one particular weakness in this approach. In any one iteration, if for example a lower volume of ton-mileage is required, there are many combinations of vehicle numbers in the different unladen weight classes, which would generate this ton-mileage given our parameters such as average load. A large number of light vehicles or a small number of heavy vehicles would generate the same ton-mileage. Therefore, in each iteration we have tried to spread the possible changes in vehicle numbers as evenly as possible over the unladen weight classes.

certain distinctive types of activity and their projection is evaluated separately.

2.3 Estimation and Projection of Ton-mileage Demand

In this section the ton-mileage of road freight transport in each year since 1960 is estimated. This ton-mileage is then projected forward. Estimates of ton-mileage for the 1960-1967 period must be based on SSRF data for 1964. We assume that in each year since 1960 ton-mileage per vehicle (within each of five unladen weight groups) is equal to the 1964 estimate calculated from SSRF. An estimate of total ton-mileage by road follows, by using the numbers of vehicles in these unladen weight groups. This method is used by Sexton (1966-67). Table 8 shows Sexton's estimates for 1960-65, and our estimates for 1966 and 1967.

Table 8 shows that estimated ton-mileage by road increased from 722 million in 1960 to 1,222 million in 1967. These figures are obviously imprecise; we are limited by lack of suitable data on this matter.

We now wish to build up projections of ton-mileage. Ideally, for this one would use projections of the growth rates of specific sectors in the economy. This approach is not possible since no long term

projections of sectoral output are available. Instead, some regressions of ton-mileage (T) on a number of explanatory variables are tested.

A priori it is difficult to conceive of an ideal explanatory variable. GDP is not wholly ideal, since it is a measure of net output and excludes raw materials and other intermediate goods. We test a formulation with GDP plus imports as a composite explanatory variable. Imports at constant prices are added on to GDP in this composite variable. Imports should generate a certain amount of ton-mileage by road. We also test a formulation with GDP alone as explanatory variable.²² Also we test a multiple regression, with volume of production of transportable goods industries and the gross output of agriculture as explanatory variables.

Both linear and log-log formulations of the regressions are tested. The variables included are as follows (their values in the 1960-67 period are given in Table 8):

²²Another possibility open to us was to construct a "transport weighted" index of output of sectors in the economy, the weights comprising the "sectoral" shares in total ton-mileage. (A "transport weighted" index of production was constructed for Britain by Glover, 1960.) This was not attempted, partly due to the difficulty of including the agricultural and distributive sectors in the "weighted index".

TABLE 8: TON-MILEAGE AND CERTAIN ECONOMIC INDICATORS, 1960-1967

Year	Ton-mileage	GDP at constant (1958) factor cost X_1	GDP at constant (1958) factor cost plus imports (at 1958 prices) X_2	Index Number of Volume of Production in transportable goods industries (1953=100) X_3	Index of Volume of Gross Output in Agriculture, excluding value of changes in livestock, including turf (1953=100) X_4
(1)	(2)	(3)	(4)	(5)	(6)
	million	£ million	£ million		
1960	721.85	538.1	765.2	126.0	112.6
1961	852.97	560.0	819.6	137.4	119.8
1962	947.92	579.9	852.0	146.2	120.1
1963	1011.78	597.7	898.8	153.5	121.0
1964	1048.60	630.8	969.3	165.3	122.7
1965	1110.64	638.5	990.8	174.2	120.1
1966	1111.69	650.0	1003.0	182.1	125.7
1967	1222.07	680.0	1052.0	198.4	135.2

Source: Col. (2) Sexton (1966-67), p. 113 for 1960-1965; own estimates for other years.
 " (3) NIE 1966, Table A.4 for 1960-1966; own estimate for 1967 based on *Review of 1967 and Outlook for 1968* (Pr. 9992) Table 3 (b) and based on data on taxes and subsidies contained in NIE 1966, Table A.4.
 " (4) for imports: *Trade Statistics of Ireland*.
 " (5) ISB, September 1967, p. 195; data from CSO.
 " (6) ISB, June 1967, p. 71; data from CSO.

T=ton-mileage
 X_1 =GDP at constant factor cost
 X_2 =GDP at constant factor cost plus imports at constant prices
 X_3 =index number of volume of production in

transportable goods industries
 X_4 =index of volume of gross output in agriculture, excluding livestock numbers, including turf.

The following equations are derived:

		R^2	d
(2.1)	$T = -956.4 + 3.216X_1$ (0.2806)***	.956	1.59
(2.2)	$T = -422.3 + 1.552X_2$ (0.133)***	.958	1.58
(2.3)	$T = -8.959 + 6.459X_3 - 0.1922X_4$ (1.513)*** (5.686)	.945	0.93
(2.4)	$T = -25.15 + 6.413X_3$ (0.6344)***	.945	0.93
(2.5)	$\log T = -6.160 + 2.037 \log X_1$ (0.2114)***	.939	1.36
(2.6)	$\log T = -3.135 + 1.472 \log X_2$ (0.1391)***	.949	1.39
(2.7)	$\log T = 1.469 + 1.078 \log X_3 - 0.00717 \log X_4$ (0.2614)* (0.7649)	.939	0.92
(2.8)	$\log T = 1.446 + 1.076 \log X_3$ (0.1126)***	.938	0.92

Of these equations, (2.2) seems to be the most satisfactory. This equation has a higher R^2 than any other, and is free from serial correlation of the error terms (this seems a reasonable deduction at the 5 per cent. level, although the Durbin-Watson table does not tabulate d values for less than 15 observations).

Equation (2.2) is used to project ton-mileage. The assumptions which are necessary concerning the future values of the explanatory variable must concern both GDP and imports. The share of imports in this variable X_2 has risen from 29.7 per cent. in 1960 to 35.4 per cent. in 1967. The average compound rate of increase of real GDP in the 1960-67 period was 3.4 per cent. per annum, and the average compound rate of increase of real imports in the same period was 7.4 per cent. per annum.

The following assumptions are made: for real GDP, average increase of 4.0 per cent. per annum in 1967-70, of 3.5 per cent. per annum in 1970-80, of 3.0 per cent. per annum in 1980-85; for real imports, average increase of 7 per cent. per annum in 1967-70, of 6 per cent. per annum in 1970-80, of 5 per cent. per annum in 1980-85. On this basis, the projection of ton-mileage is given in Table 9.

TABLE 9: PROJECTED TON-MILEAGE, 1967-1985

Year	Ton-miles (millions)
1967 (estimated)	1,222.07
1970	1,472
1975	1,934
1980	2,519
1985	3,135

These projections are equivalent to an average compound rate of growth of 5.9 per cent. per annum in the period 1967-1975, and 4.9 per cent. per annum over 1975-1985. This compares with a trend rate of growth of 6.8 per cent. per annum in the 1960-1967 period (calculated by fitting an exponential curve to the data, $R^2 = .913$).

2.4 Estimation and Projection of Carrying Capacity

2.4.1 Estimation of carrying capacity in past years

The only information which is available on the carrying capacity of commercial goods vehicles relates to 1964, the year of the SSRF.²³ From SSRF (Table 45), based on the relationship between carrying capacity and unladen weight, the total carrying capacity of the goods vehicle fleet in 1964 can be calculated for each unladen weight class.²⁴ The average carrying capacity per goods vehicle is given in Appendix C, Table C11.

As would be expected, the amount of carrying capacity in relation to unladen weight increases

²³There is one reservation here—the carrying capacity figures are subject to a wider margin of error than are other figures in SSRF.

²⁴Table 45 of SSRF gives a two-way frequency distribution, unladen weight \times carrying capacity. The number of vehicles in each unladen weight class is multiplied by the estimated average carrying capacity of each carrying capacity class. This average is usually assumed to be the mid-point of the class interval. But in some cases, the average carrying capacity is more likely to lie towards the upper limit of the class interval. The averages chosen (based on information from CSO) are as follows: 0.5, 1.5, 3.0, 4.0, 5.0, 6.5, 9.0, 13.0 (for unladen weights up to and including 5 tons) and 14.5 (for over 5 tons unladen weight). These correspond to the class intervals under 1, 1-2, 2-3, 3-4, 4-5, 5-7, 7-10, and over 10, respectively.

markedly once the 2-3 ton unladen weight category is exceeded.

This tabulation is now used to estimate total carrying capacity in each year since 1960. This is done by multiplying the number of vehicles in each unladen weight group by the appropriate average capacity, from the tabulation. The results are given in Table 10.

TABLE 10: ESTIMATED CARRYING CAPACITY OF COMMERCIAL GOODS VEHICLES IN IRELAND, 1960-1967

Year	Total Carrying Capacity (tons)	Average Carrying Capacity per Commercial Goods Vehicle (tons)
1960	91,400	2.10
1961	102,300	2.33
1962	110,200	2.46
1963	115,900	2.55
1964	120,000	2.56
1965	125,900	2.61
1966	125,200	2.67
1967	133,200	2.90

The data in Table 10 are only approximate figures, since (a) the basic 1964 figures are themselves estimates, and (b) there is a margin of error due to the application of the 1964 averages to produce figures for other years. Over time there are technical changes in the types of goods vehicles made. It is likely that the goods vehicles being produced in 1967, of a given unladen weight, have a higher carrying capacity than their counterparts in 1960. If this is so, this table over-estimates carrying capacity for the years prior to 1964, and under-estimates it for subsequent years.

The estimated average carrying capacity per goods vehicle, given in Table 10, has increased steadily over this 1960-1967 period. Between 1960 and 1967, the estimated average carrying capacity has increased by 38 per cent. This is to be expected. It is a reflection of the shift towards heavier goods vehicles which was discussed earlier.

2.4.2 Projection of carrying capacity

Least squares regression is now used to try to explain the growth of carrying capacity (C) in terms of variables such as GDP. The independent variables (together with their algebraic symbols) which were used in the ton-mileage regressions, are used again here. Due to the multicollinearity which became evident from the ton-mileage regressions, multiple regression is not attempted on X_3 and X_4 (gross output in industry and in agriculture, respectively). Both linear and log-log regressions are attempted. The results are as follows:

		R^2	d
(2.9)	$C = -53470 + 277.3X_1$ (23.14)***	.960	1.57
(2.10)	$C = -7821 + 134.2X_2$ (10.00)***	.968	1.63
(2.11)	$C = 27106 + 551.3X_3$ (55.73)***	.943	1.20
(2.12)	$C = -107638 + 1826X_4$ (457.4)**	.726	
(2.13)	$\log C = 1.998 + 1.506 \log X_1$ (0.1379)***	.952	1.41
(2.14)	$\log C = 4.224 + 1.089 \log X_2$ (0.08513)***	.965	1.50
(2.15)	$\log C = 7.627 + 0.07940 \log X_3$ (0.07601)***	.949	1.22
(2.16)	$\log C = 1.845 + 2.041 \log X_4$ (0.5118)**	.726	

The most satisfactory results are in the regressions on X_1 and on X_2 as independent variables. The linear regressions on these variables give marginally better results than the log-log regressions.

Equation (2.10), incorporating GDP plus imports as explanatory variable (X_2), seems to be the most satisfactory one; this equation explains the highest proportion of the variance in carrying capacity.

Equation (2.10) is used to project carrying capacity. The same assumptions are made concerning X_2 in future years, as were made when discussing the ton-mileage projections. The projections are in Table 11.

TABLE 11: PROJECTED CARRYING CAPACITY, 1967-1985

Year	Carrying Capacity (tons)
1967 (estimated)	133,200
1970	156,000
1975	196,000
1980	247,000
1985	300,000

These projections are equivalent to an average compound rate of growth of 4.9 per cent. per annum in the period 1967-1975, and 4.3 per cent. per annum over 1975-1985. This compares with a trend rate of growth of 5.0 per cent. per annum in the 1960-67 period (calculated by fitting an exponential curve to the data, $R^2 = .926$).

2.5 Estimation of Parameters

The estimation of future average annual mileage and average load is quite difficult. There are a number of obvious cross-sections which help us here: the Irish SSRF of 1964 and the three British surveys since 1952. This approach, though inevit-

able, is not ideal. One would like to have more observations than the four available from these surveys and one would like to avoid the application of British figures to Irish conditions.

Appendix C, Table C9, compares average mileage per goods vehicle in Britain and in Ireland. This table shows that there is a reasonable similarity between the Irish and the British patterns of average annual mileage for the 2-3, 3-5 and over 5 weight classes. There is a divergence between mileage in the two countries for the under 1, and 1-2 classes.

The British figures show that annual average vehicle mileage among all classes of goods vehicle declined between 1958 and 1962. An independent time series is also available which provides data of annual mileage in Britain in each year since 1960. This shows that average vehicle mileage has been increasing steadily since 1962: from 12,700 in 1962 to 13,700 in 1967.²⁵

On the basis of the information on average mileage, it seems best to simply apply the Irish 1964 figures over the projection period. There are not enough data to justify assumptions of increasing or decreasing vehicle mileage for vehicles of varying unladen weights. The apparent increase in annual mileage per goods vehicle in Britain has only occurred since 1963, and this does not give enough data for our purposes. Therefore in estimating the future annual average mileage parameters, we apply the 1964 values (in each unladen weight group) throughout the projection period.

The data on average load are now examined. Appendix C, Table C10, compares Irish and British figures. If one compares the 1964 Irish figures with the 1962 British figures there is a reasonably close similarity between their patterns of average load, in corresponding unladen weight classes. The British figures show no marked trend over time, in average load, in any of the unladen weight groups.

We assume that average load will increase in future; this would be partly a reflection of the likely increasing proportions of goods vehicles in the heavier unladen weight classes. For unladen weights up to 3 tons, the 1964 average loads are presumed to hold. For the unladen weights of over 3 tons, the 1964 values are accepted in the period 1967-1975. Values of 4.2 tons (for the 3-5 ton unladen weight class) and 6.7 tons (for the over 5 ton class) are presumed to hold in the 1976-1985 period.

Finally the data on carrying capacity per goods vehicle are examined. Appendix C, Table C11 gives this information for Ireland and for Great Britain. This table shows very little tendency for average

²⁵Highway Statistics 1967, Table 21. There is a discrepancy between the estimate of vehicle mileage for 1962 of 9,900, derived from the British Ministry of Transport Survey, and the figure in Highway Statistics 1967 of 12,700 for 1962. This could be due to a difference in definition.

carrying capacity to change markedly over time in Britain. It is likely that average carrying capacity per vehicle in Ireland will continue to increase in future. This will be a reflection of the increasing proportion of heavy vehicles in the goods vehicle fleet. This likely increase in average carrying capacity should be most pronounced in the higher unladen weight groups where the class intervals are larger.

The following assumptions are therefore made concerning the future course of average carrying capacity: no change for unladen weights up to 3 tons; for vehicles of 3-5 tons unladen weight, an increase of 10 per cent. between 1964 and 1970, of 10 per cent. between 1970 and 1980 and of 5 per cent. between 1980 and 1985; for vehicles of over 5 tons unladen weight, an increase of 20 per cent. between 1964 and 1970; of 20 per cent. between 1970 and 1980, and of 10 per cent. between 1980 and 1985.²⁶

2.6 Projection of Goods Vehicles, and Tests for Consistency

Firstly, we examine how, over the period 1960-67, the number of goods vehicles in each of a number of unladen weight groups has been changing. This period is chosen because of the change in the definition of unladen weight for licensing purposes, already referred to. Initially the period 1960-67 is examined, and the mean percentage change in the number of goods vehicles in each unladen weight class is calculated.²⁷ For comparative purposes, and despite the 1960 legislative change, the mean percentage changes for the 1950-67 period are also calculated. The results of these calculations are given in Table 12.

TABLE 12: PERCENTAGE CHANGES IN GOODS VEHICLE NUMBERS, BY UNLADEN WEIGHT 1950-1967

Unladen Weight Class (tons)	Mean Percentage Change in Goods Vehicle Numbers	
	1950-1967	1960-1967
(1)	(2)	(3)
	%	%
Under 1	+3.80	-3.80
1-2	+3.72	+11.38
2-3	-3.73	-3.40
3-4	+12.90	+3.02
4-5	+15.41	+18.29
5-7	+13.10	+14.60
Over 7	+18.65	+10.15

Source: Table C9.

²⁶To aid computation, the 1970-80 percentage increases are halved in order to derive estimates for 1975.

²⁷These are calculated according to the usual compound rate of growth formula based on the end points (i.e. 1960 and 1967) only: i.e. if amount A_i grows from A_0 at r per cent. per annum, then

$$r = n \sqrt[n]{A_i/A_0} - 1$$

There are very high rates of growth for vehicles of 1-2 tons unladen weight, and of over 4 tons unladen weight, during the 1960-1967 period. But it is unlikely that these high rates of growth could be maintained very far into the future. Initially, when we extrapolate the goods vehicle numbers, the 1960-67 percentage rates of growth are chosen for the 1967-70 period, with the exception of a scaling down for the 4-5 unladen weight group. When projecting beyond 1970, the rates chosen for 1967-70 are scaled down somewhat.

These rates of growth result in certain projections of goods vehicle numbers which, when combined with the values of the parameters (average load and average mileage) for each unladen weight class which were discussed earlier, imply a certain ton-mileage in each year. But although these growth rates of vehicle numbers yield a total ton-mileage for 1970 which is not remarkably higher than that projected, the ensuing ton-mileage for 1980 is excessively high when compared with our previous projection. There are similar implications for future carrying capacity—an excessively high carrying capacity in 1980 when compared with the previous projection.

The percentage rates of growth are therefore scaled down and, after a number of attempts, the combination of rates of growth in Table 13 is arrived at, which gives satisfactory results.

TABLE 13: POSTULATED ANNUAL AVERAGE PERCENTAGE CHANGES IN GOODS VEHICLES BY UNLADEN WEIGHT, 1967-1985

Unladen Weight (tons)	Average Annual Percentage Change		
	1967-1970	1970-1980	1980-1985
Under 1	% -4	% -3	% -3
1-2	+7	+5	+4
2-3	-3	-2	-2
3-4	+3	+2	+2
4-5	+10	+5	+4
5-7	+10	+5	+4
Over 7	+8	+5	+4

On the basis of Table 13 (using our average load and average mileage parameters), ton-mileage would be 1,480 million in 1970, 1,780 million in 1975, 2,340 million in 1980 and 2,760 million in 1985.

These figures are reasonably close to our projected figures of ton-mileage. The 1970 ton-mileage is practically identical with the earlier projection, and the 1975 figure is 8 per cent. lower. The above 1980 and 1985 figures are, respectively, 7 per cent. and 12 per cent. lower than in our earlier projection. The implications for future carrying capacity are also satisfactory—i.e. 9 per cent. higher in 1970 than in our earlier projection, 8 per cent. higher in

1975 and 1980 and 10 per cent. higher in 1985. Given the margin of error inherent in the calculations, these discrepancies seem reasonable enough.

If one applies the rates of growth in Table 13 the projection of goods vehicles given in Table 14 is obtained. In this table an estimate of the future number of steam-driven, electrically-propelled vehicles and dumpers is added.

TABLE 14: PROJECTION OF GOODS VEHICLE NUMBERS, 1967-1985^a

Unladen Weight (tons)	1967 (actual)	1970	1975	1980	1985
Under 1	21,100	18,600	16,000	13,700	11,800
1-2	8,500	10,500	13,400	17,100	20,700
2-3	4,000	3,600	3,300	3,000	2,700
3-4	5,200	5,700	6,300	7,000	7,700
4-5	3,700	5,000	6,400	8,100	9,900
5-7	1,800	2,300	3,000	3,800	4,600
Over 7	700	900	1,200	1,500	1,800
Total	45,000	46,700	49,500	54,100	59,200
Steam-driven electrically-propelled vehicles and dumpers ..	900	1,100	1,600	2,000	2,300
Grand Total ..	46,000	47,800	51,100	56,100	61,500

Note: a—Column entries do not always add up to totals due to rounding.

This projection does not constitute a large increase in goods vehicle numbers. But it is dependent on the continuance of the swing towards heavier vehicles.

As a final check on the consistency of these projections, we consider the light goods vehicles. The dividing line between "light vans" and other goods vehicles is, to a certain extent, an arbitrary one. We regard goods vehicles of 1½ tons unladen weight or under as being "light vans".

In Appendix B, there is an analysis of the ownership of light commercial vehicles in Irish counties. In this Appendix, the ownership of goods vehicles of 1 ton unladen weight or under is also examined. The regressions in Appendix B use characteristics of the retail trade and of service industry in general, and also car ownership among a number of explanatory variables. This is done since many light commercial goods vehicles are engaged in distribution or are used as substitutes for private cars. In 1964, 29 per cent. of the registered goods vehicles of 1 ton unladen weight or under were engaged in distribution (retail and wholesale), a further 25 per cent. were not used for transporting goods during the relevant survey week.^{27a} These latter vehicles—i.e. those which did not carry goods—were in fact passenger cars (e.g. station wagons) in many cases.²⁸

^{27a}SSRF, Table 52.

²⁸See SSRF, p. 25.

Fifty-four per cent. of the goods vehicles of 1–2 tons unladen weight were engaged in distribution and 11 per cent. of these vehicles were not used for transporting goods. Much of the work of these “light vans” is of a short-haul nature. Over 70 per cent. of the tonnage carried by vehicles of under 2 tons unladen weight is carried on lengths of haul of 15 miles or under.²⁹ This short-haul pattern is consistent with the tendency to use many of these vehicles for distribution and service industry work.

The results of the analysis in Appendix B are fairly inconclusive, in terms of our *a priori* hypotheses.³⁰ The ownership of “light vans” of 1½ tons unladen weight or under is negatively correlated with personal income *per capita* and positively correlated with both private car ownership and with urbanisation.

²⁹SSRF, Table 5.

³⁰There are also weaknesses in the choice of variables in this Appendix. There is no explanatory variable which relates to the wholesale sector of distribution.

It is possible to argue that the number of “light vans” needed for distribution will not grow very much in future years. This is because of the likely economies of scale resulting from the operation of a single combined fleet of “light vans” in certain areas of distribution, especially in chain stores and supermarkets. These economies of scale would be accentuated by any trends towards vertical integration in these areas.³¹

In summary, it is difficult to integrate the results of the analysis of Appendix B with the projections given in Table 14. The projection of the lighter goods vehicles in Table 14 shows that vehicle numbers of under 1 ton would decrease while those of 1–2 tons would increase. This projection is not necessarily disproved by Appendix B, and is accepted, in the absence of more detailed information on the determinants of “light vans” ownership.

³¹This line of reasoning is due to R. J. Tarling.

3. PROJECTION OF OTHER VEHICLE OWNERSHIP

3.1 Motor Cycles

3.1.1 Introduction

The number of motor cycles in Ireland increased from 4,600 in 1950 to a peak of 52,200 in 1964 and then declined to 45,700 in 1967 (Appendix Table C1). While motor cycle ownership in Great Britain increased steadily from 1950 to 1960, there has been a pronounced decline in ownership since 1960. The Irish pattern has been one of steady growth between 1950 and 1964 but of decline since 1965 (Table 15).

TABLE 15: MOTOR CYCLES *PER CAPITA*: IRELAND AND GREAT BRITAIN, 1947–1967

Year	Ireland	Great Britain
(1)	(2)	(3)
1947	·0016	·0096
1948	·0017	·0115
1949	·0018	·0133
1950	·0020	·0153
1951	·0022	·0173
1952	·0027	·0193
1953	·0038	·0211
1954	·0051	·0231
1955	·0073	·0253
1956	·0092	·0266
1957	·0099	·0294
1958	·0107	·0302
1959	·0120	·0343
1960	·0146	·0365
1961	·0162	·0364
1962	·0171	·0359
1963	·0174	·0354
1964	·0183	·0349
1965	·0181	·0322
1966	·0163	·0281
1967	·0158	·0269

Source: Col. (2)—SA; DLG Annual Census. Col. (3)—British Road Federation, *Basic Road Stats.* 1967; MDS, May 1968.

3.1.2 Projection of motor cycle ownership: general discussion

Motor cycle ownership must depend to a considerable extent on taste factors, and on patterns of cross-substitution between motor cycles and private cars. Also, the relationship between motor cycle ownership and income is, most likely, a complex one. It is possible that there is a “threshold” effect: i.e. until a country reaches a certain level of income *per capita* motor cycle ownership increases, but once this income level is reached durables such as private cars are substituted for motor cycles. Some data given in Maizels (1959) indicate that in countries with a high income *per capita*, motor cycle ownership tends to decrease with income. This implies that a motor cycle is an “inferior good” in these countries. Maizels’s data also indicate that in less-developed countries, ownership tends to increase with income.

A different approach is provided by Tanner (1965) who argues—based on a cross-section of countries, but without any precise statistical testing—that motor cycle ownership tends to be greatest in countries with about 0·1 other vehicles *per capita*. This implies that when the ownership of other vehicles exceeds this figure motor cycle ownership tends to decline. This hypothesis seems to be approximately borne out by the Irish experience. Motor cycle ownership reached a peak in 1964 and has been declining since that year, and the number of other vehicles *per capita* exceeded 0·1 for the first time in 1962.

A certain amount of hypothesis testing with

regard to motor cycle ownership is attempted in this paper. We look at three cross-sections. The first is a cross-section of countries, the second a cross-section of Irish counties, and the third draws on HBI data.

3.1.3 Cross-section of countries

One of the difficulties concerning international comparisons of motor cycle ownership is the paucity of data. Some information on ownership is available in the *Annual Bulletin of Transport Statistics for Europe 1965*, but this would not provide us with very many observations.

Table C12 gives information on motor cycle ownership in a cross-section of 29 countries. *A priori*,

we expect that motor cycle ownership is negatively correlated with income, and that it is positively correlated with population density. A positive correlation with population density is the opposite to what was expected in the car ownership regressions; it is a reflection of the advantages, such as mobility, of a motor cycle in urban conditions.

A number of equations are tested by least squares regression, where:

MC = Motor cycles per 1,000 persons in 1965.

X_1 = National income *per capita* (£) in 1965.

X_2 = Population density (persons per square kilometre) in 1965.

The following are the results of the regressions:

		R ²
(3.1)	$MC = 2.598 + 0.005156X_1 + 0.03261X_2$ (0.002812) (0.02133)	.197
(3.2)	$MC = 5.224 + 0.005625X_1$ (0.002864)	.125
(3.3)	$\log MC = -4.584 + 0.8584 \log X_1 + 0.2319 \log X_2$ (0.0923)*** (0.07943)**	.765
(3.4)	$\log MC = -3.624 + 0.8463 \log X_1$ (0.1098)***	.687

The most satisfactory equation in the statistical sense is Equation (3.3). There is quite a high R² for a cross-section, and the coefficients of both national income *per capita* and of population density are significant. But the sign of national income *per capita* is positive, which is not what was expected. The sign of population density is positive which is what was expected.

3.1.4 Cross-section of Irish counties

The basic analysis is contained in Appendix A. In general, the results of that analysis show that motor cycle ownership is positively correlated with income *per capita* (contrary to expectations). The signs of other significant variables agree with our *a priori* expectations—the proportion of non-agricultural population in a high social group (negative sign), population density (positive) and urbanisation (positive).

3.1.5 Motor cycle ownership in Irish households

From HBI 1965–66, it is estimated that 6.2 per cent. of households in Ireland own motor cycles. Table 16 shows motor cycle ownership in Irish households by disposable income group. There is no regular pattern of decreasing or increasing ownership as income increases.

There are at least two main reasons why this table may be misleading. Firstly, the reservations made in

Appendix A concerning the interpretation of a table such as this need to be borne in mind—i.e. the difficulties with regard to understatement of income. Secondly, one needs to study household size, since this can influence patterns of motor cycle ownership independently of the influence of income.

TABLE 16: MOTOR CYCLE OWNERSHIP IN HOUSEHOLDS, 1965–1966: HBI DATA

Disposable Household Income per week	Percentage of Households Which Own a Motor Cycle ^a
£	%
Under 4	0.9
4–7	2.1
7–10	3.1
10–15	6.7
15–20	7.1
20–25	6.8
25–30	5.9
30–40	10.6
40–50	10.1
Over 50	8.5

Note: a—It is not known what proportion of these households own more than one motor cycle.
Source: HBI 1965–66.

We now test regressions based on HBI data contained in Appendix C, Table C6, similar to the car ownership regressions tested in Appendix A. The dependent variable is now the proportion of households which own a motor cycle. The regression

analysis is based only on the grouping by Disposable Household Income \times Household Size. All the results are not presented (although are available on request), and the following equation is the most satisfactory:

$$(3.5) \quad Y = 2.005 + 0.009X_1 + 0.637X_2$$

$$\quad \quad \quad (0.002)^{**} \quad (0.250)^*$$

$$\quad \quad \quad R^2 = .653$$

where: Y = proportion of households which own a motor cycle (%);

X₁ = average income per household (shillings per week);

X₂ = average number of persons per household.

In equation (3.5) both coefficients are significant and there is a reasonably good R². There is a positive coefficient for household size: this is what we had expected. But the sign of the income variable X₁ is the opposite to what we had expected, being positive.

3.1.6 Summary of empirical analysis and derivation of projection

It has not been possible to deduce that a motor cycle is an "inferior good" from either the cross-sectional regressions or from Table 16 (based on HBI data). The empirical evidence seems to point to a contrary conclusion: the income coefficient is positive and significant in the cross-country regression, the Irish counties cross-section, and in the Irish household cross-section.

The following *a priori* hypotheses are, however, borne out by our analysis. From the cross-section across countries there is a positive relationship between motor cycle ownership and population density. From the Irish counties cross-section there seems to be a positive relationship between motor cycle ownership and both population density and urbanisation. There is also a significant, and positive coefficient of household size in the Irish households' regression.

It is therefore difficult to relate these findings to the theoretical case that the motor cycle is an "inferior good", or to the fact that motor cycle ownership has been declining in Ireland since 1964, and in Britain since 1960. There are likely to be conflicting tendencies at work. The relationship between motor cycle ownership and income may depend on the actual income level of the country in question. If motor cycle ownership is positively correlated with population density and with urbanisation, then increasing urbanisation could serve as a counterbalance to possible effects of the "inferior good" hypothesis.

The other hypothesis mentioned in the text

(derived from Tanner 1965) is based on the number of vehicles other than motor cycles, *per capita*. If this hypothesis is accepted then one could project a decrease in motor cycle ownership.

The final choice is a subjective one, to an extent. We assume that the decline in ownership since 1964 will continue, at a relatively mild rate. It is assumed that ownership will decline to the levels shown in Table 17. In deriving the motor cycle numbers, the population projections used at the end of Section 1 are again accepted.

TABLE 17: PROJECTION OF MOTOR CYCLES, 1967-1985

Year	Motor Cycles <i>per capita</i>	Motor Cycle Numbers
1967 (actual) ..	0.0158	45,700
1970	0.015	44,000
1975	0.014	43,000
1980	0.012	39,000
1985	0.011	39,000

3.2 Agricultural Tractors

The number of licensed agricultural tractors increased from 5,700 in 1947 to 34,400 in 1957 and 55,900 in 1967³² (Table C1). This growth is a reflection of the substitution of capital for labour in Irish agriculture. The number of agricultural tractors per head of persons at work in agriculture (including forestry and fishing) increased from 0.049 in 1954 to 0.117 in 1962 and 0.168 in 1966.³³

Over the period 1950-1966, the number of agricultural tractors has risen by 44,200 while the number of persons engaged in agriculture has decreased by 185,000.³⁴ The trend rate of growth of agricultural tractor numbers in this period is 9.7 per cent. per annum (R² = .943).

We assume that the number of agricultural tractors will continue to grow, but at a reduced proportional rate (since the expansion will be on a continually widening base). We assume for the projection that the growth of agricultural tractors will average 6 per cent. per annum in the period 1966-1970, 4 per cent. per annum in the period 1971-1975 and will gradually stabilise after 1975. On this basis we estimate that the number of agricultural tractors will increase from 55,900 in 1967 to 79,000 in 1970, 92,000 in 1975, 100,000 in 1980 and 110,000 in 1985.

³²In June 1966 the total number of tractors on Irish farms (Source: CSO) was 64,200 compared with the figure of 55,500 at August of that year given in Table C1. The reason for this discrepancy is that tractors for use entirely on the farm are not licensed. We make use only of the data on licensed tractors.

³³Source: Appendix C1; *Economic Statistics issued prior to the Budget*.

³⁴CSO, *The Trend of Employment and Unemployment; Economic statistics issued prior to the Budget*.

3.3 Other Vehicles

The projection of these vehicles is shown in Table 18. These vehicles are in the following categories:

3.3.1 Public service vehicles (six seats and under)

Public service vehicles of six seats and under are taxis, and their number declined steadily between 1957 and 1965, but increased again in both 1966 and 1967. The decline presumably occurred outside the cities, due to the competition of private transport. We assume that taxi numbers will remain stable in future.

3.3.2 Public service vehicles (over six seats)

These are omnibuses. Their numbers have gradually increased from 800 in 1947 to 1,400 in 1957 and 1,800 in 1967. Most of these omnibuses are owned by CIE. The future numbers of these vehicle depends partly on public policy (e.g. attitudes to road pricing or to the curbing of private car usage in cities). The gradual increase in omnibus

numbers should continue. Allowance has also been made for the increased number of CIE 'buses required to operate the free school 'bus plan from 1967 onwards—i.e. 230 special school 'buses.³⁵

3.3.3 General haulage tractors

These tractors have been increasing steadily in recent years (from 420 in 1958 to 830 in 1967). An approximate linear extrapolation of these figures is used to obtain the projection.

3.3.4 Exempt and miscellaneous vehicles

The vehicles exempt from Road Tax include vehicles owned by diplomats, vehicles owned by the State, ambulances, road rollers and fire-engines. For these exempt vehicles and the "miscellaneous" vehicles (which include hearses and excavators) an approximate linear extrapolation of past trends is used for the projection.

³⁵Deputy General Manager of CIE, quoted in *Irish Times*, 29 November, 1967.

TABLE 18: PROJECTION OF OTHER VEHICLES 1967-1985

Year	Public Service Vehicles		General Haulage Tractors	Exempt from Road Tax	Miscellaneous Vehicles	Total
	6 Seats or under	Over 6 Seats				
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1967	4,100	1,800	800	5,600	1,700	14,100
1970	4,000	2,200	1,000	6,000	1,900	15,100
1975	4,000	2,400	1,300	7,000	2,400	17,100
1980	4,000	2,500	1,500	8,000	2,900	18,900
1985	4,000	2,700	1,800	9,000	3,400	20,900

4. PROJECTION OF TOTAL VEHICLE OWNERSHIP

In this section an independent projection of total vehicle ownership is made based on explanatory variables. This is compared with the global projection derived from summing the earlier projections for various types of vehicle.

The total number of vehicles in Ireland has increased from 253,100 in 1947 to 476,000 in 1967 (Table C1). We postulate that total vehicle ownership is related to GNP *per capita*. The latter variable is a general indicator of economic activity. As in the regressions explaining private car ownership, a time trend is also introduced.

The hypothesis takes the following forms:

$$V = a_0 + a_1 NP + a_2 t + u$$

$$\log_e V = \beta_0 + \beta_1 \log_e NP + \beta_2 t + u$$

where: V = total vehicles per 1,000 persons;

NP = gross national product *per capita* at constant (1958) market price (£);

t = time = 0 at 1947.

The basic data for the regressions are given in Appendix C, Tables C2 and C13; the following are the results of the regressions (in a few cases where regression coefficients are quite insignificant, "d" statistics are not computed).

		R ²	d
(4.1)	$V = -71.28 + 0.5728NP + 3.643t$ (0.09678)*** (0.5406)***	.996	0.91
(4.2)	$V = -176.6 + 1.211NP$ (0.03660)***	.984	0.75
(4.3)	$\log V = 4.875 - 0.2511 \log NP + 0.08979t$ (0.6712) (0.01689)***	.981	
(4.4)	$\log V = -13.20 + 3.268 \log NP$ (0.1766)***	.950	0.29

The equation which has both NP and t as independent variables gives a very good fit and both coefficients are highly significant. But the "d" statistic indicates positive serial correlation of the error terms, at the 5 per cent. level. The equation is also likely to be unstable, since there is high intercorrelation between NP and t (coefficient of correlation $r = .979$). Serial correlation is also present in the equation which incorporates V and NP.

In Equation (4.3), the coefficient of log NP is non-significant (this is consistent with the high intercorrelation between log NP and t). Equation (4.4) gives a good fit to the data but again there is strong evidence of positive serial correlation.

Some formulations using lagged NP and using first difference transformations are now attempted. The following are the results of these regressions:

Original data

		R ²	d
(4.5)	$V = -72.90 + 0.5915NP_{-1} + 3.702t$ (0.0868)*** (0.4763)***	.996	0.91
(4.6)	$V = -178.1 + 1.250NP_{-1}$ (0.03988)***	.983	0.71
(4.7)	$V = -183.5 + 1.309NP_{-2}$ (0.05264)***	.975	0.89
(4.8)	$V = -179.5 + 0.5755NP + 0.6652NP_{-1}$ (0.2724)* (0.2792)*	.987	0.42
(4.9)	$\log V = 3.408 + 0.0424 \log NP_{-1} + 0.793t$ (0.5157) (0.0129)***	.987	0.33
(4.10)	$\log V = -12.53 + 3.160 \log NP_{-1}$ (0.1642)***	.956	0.32
(4.11)	$\log V = -12.21 + 3.118 \log NP_{-2}$ (0.1644)***	.957	0.48

First differences

(4.12)	$\Delta V = 5.264 + 0.2659 \Delta NP$ (0.1272)	.205	1.45
(4.13)	$\Delta \log V = 0.03089 + 0.6335 \Delta \log NP$ (0.4655)	.0982	0.69

Equation (4.6), in which NP_{-1} is the independent variable, has a very high R². But there is evidence of positive serial correlation of the errors at the 1 per cent. level. All the other equations using original

data have serially correlated error terms (at the 5 per cent. level). In addition, Equation (4.8) is unsatisfactory because of high intercorrelation between NP and NP_{-1} (coefficient of correlation $r = .991$).

In the first difference equation incorporating ΔV and ΔNP , the coefficient of ΔNP is all but significant at the 5 per cent. level—although this coefficient is changed markedly from that of NP in Equation (4.2). But the R^2 is quite unsatisfactory.

As in the section on car ownership we now use transformations which try to overcome the serially correlated errors.³⁶ The following equations are obtained for the transformed variables:

$$(4.14) \quad V' = -67.50 + 1.176NP' \\ (0.0720)^{***} \quad .940 \quad 1.52$$

$$(4.15) \quad (\log V)' = -1.099 + 1.869(\log NP)' \\ (0.2783)^{***} \quad .726 \quad 1.48$$

³⁶Each transformation again assumes a first order autoregressive system. For the linear regression V on NP , the estimate of ρ the autoregressive coefficient is $\hat{\rho} = 0.618$. For the regression of $\log V$ on $\log NP$, $\hat{\rho} = 0.827$. Values of 0.6 and 0.8 respectively are used for the transformations.

Equation (4.14) has a satisfactory R^2 of .940. The coefficient of NP is changed slightly from its value in (4.2). As one would expect, the main effect of the transformation has been to alter the standard error of NP , which is almost doubled compared with (4.2).

Since the constant -67.50 in Equation (4.14) is an estimate of $(1-\rho)$, the equation may be restated in terms of the original variables as follows:

$$(4.16) \quad V = -168.8 + 1.176NP \\ (0.0720)^{***}$$

As was done in the case of private car ownership, we now examine the case for taking account of a possible structural change in the economy since 1958 which may have led to an upward shift in our relationships. Once again the original twenty-year observation period is divided into two periods—1947–1957 and 1958–1966. The slope coefficients for these periods are in Table 19, together with R^2 and d statistics.

TABLE 19: VEHICLE OWNERSHIP REGRESSIONS SLOPE COEFFICIENTS 1947-1957 AND 1958-1966

Variables in Equation	1947-1957			1958-1966		
	Slope Coefficient	R^2	d	Slope Coefficient	R^2	d
V, NP	1.287	.941	0.71	1.037	.978	1.01
V, NP_{-1}	1.229	.958	1.05	1.039	.988	1.96
$\log V, \log NP$	4.535	.977	1.40	2.059	.986	1.37
$\log V, \log NP_{-1}$	3.998	.983	1.74	2.017	.985	2.01

Table 19 shows that the coefficients of both NP and of NP_{-1} have decreased in the second of these periods. Therefore, we do not accept that there has been an upward shift in the relationships.

Finally, similarly to our procedure in the car ownership regressions, we test whether there has been a change in the intercept, in the function relating vehicle ownership to national product, with the slope coefficient remaining the same. This is tested by again introducing a dummy variable,

called S . This variable equals zero for each year from 1947 to 1957 and equals 1 for each year from 1958 to 1966.

The hypothesis now is that:

$$V = a_0 + a_1NP + a_2S + w$$

and similarly for lagged values of NP and for log-log forms of the regressions. The results of the regressions are as follows:

$$(4.17) \quad V = -159.8 + 1.120NP + 7.148S \\ (0.0615)^{***} (3.980) \quad .986 \quad 0.68$$

$$(4.18) \quad V = -150.2 + 1.095NP_{-1} + 11.70S \\ (0.0478)^{***} (2.875)^{***} \quad .992 \quad 1.49$$

$$(4.19) \quad \log V = -12.66 + 3.165 \log NP + 0.0365S \\ (0.3222)^{***} (0.0939) \quad .951 \quad 0.26$$

$$(4.20) \quad \log V = -10.71 + 2.810(\log NP)_{-1} + 0.1201S \\ (0.2612)^{***} (0.0717) \quad .963 \quad 0.38$$

Equation (4.18) gives a very good fit to the data. The “*d*” statistic lies in the indeterminate region at the 5 per cent. level (though near the upper bound of this region).³⁷ There is also intercorrelation between NP_{-1} and *S* (coefficient of correlation $r = .797$).

The choice lies between the use of Equation (4.16), i.e. the equation obtained by means of the transformation, and Equation (4.18) in which the dummy variable *S* is incorporated. Equation (4.16) is chosen, both because of its satisfactory “*d*” statistic and because it is free from the slight problem of multicollinearity evident in Equation (4.18).

The assumptions concerning the future growth of GNP *per capita* are in line with those already made for real disposable personal income *per capita* and GDP—i.e. 4 per cent. per annum in the 1967–1970 period, 3.5 per cent. per annum over 1970–1980 and 3.0 per cent. per annum over 1980–1985. As a basis of comparison, in the 1958–1966 period, the trend

³⁷The Durbin-Watson upper bound coincides in this case with the exact bound given by Theil and Nagar (1961).

rate of growth of real GNP *per capita* was 3.5 per cent. per annum ($R^2 = .972$).

The resulting projection of vehicles *per capita* is given in Table 20, together with the corresponding vehicle numbers, making the usual assumptions regarding the future population levels. In this table it is compared with the “global” projection obtained simply by adding the projections already made for each type of vehicle. This global projection is illustrated in Chart 5 for the main vehicle categories.

The projection of total vehicles obtained from the regression model is consistently higher than the “global” projection. The discrepancy increases over time: the proportionate difference is one of 9 per cent. in 1970, for example, compared with 16 per cent. in 1975. Thus the two methods are in reasonable accord with one another. The “global” projection should be more accurate, since when deriving it we took account of the factors influencing the ownership of each type of vehicle. Part of the difference between the projections is due to the margin of error inherent in these calculations.

TABLE 20: PROJECTION OF VEHICLES, CLASSIFIED BY TYPE OF VEHICLES, 1967-1985, TOGETHER WITH PROJECTION USING REGRESSION ANALYSIS.

Year	Private Cars	Commercial Goods Vehicles	Motor Cycles	Agricultural Tractors	Other Vehicles	Total	Projection Regression	Using Analysis
							Total Vehicles <i>per capita</i>	Total Vehicle Numbers
1967 (actual)	'000 314	'000 46	'000 46	'000 56	'000 14	'000 476		'000 476
1970	392	48	44	79	15	578	0.165	628
1975	552	51	43	92	17	755	0.284	876
1980	789	56	39	100	19	1,003	0.369	1,213
1985	1,052	62	39	110	21	1,284	0.455	1,623

5. VEHICLE MILEAGE ON IRISH ROADS

5.1 Introduction

This section estimates the total vehicle mileage on Irish roads in a number of recent years, estimated separately for each type of vehicle. This information will show how the utilisation of vehicles (as measured by average mileage performed per annum) is changing over time, and it will also serve as a basis for estimates of road passenger mileage (to be made in Section 6).

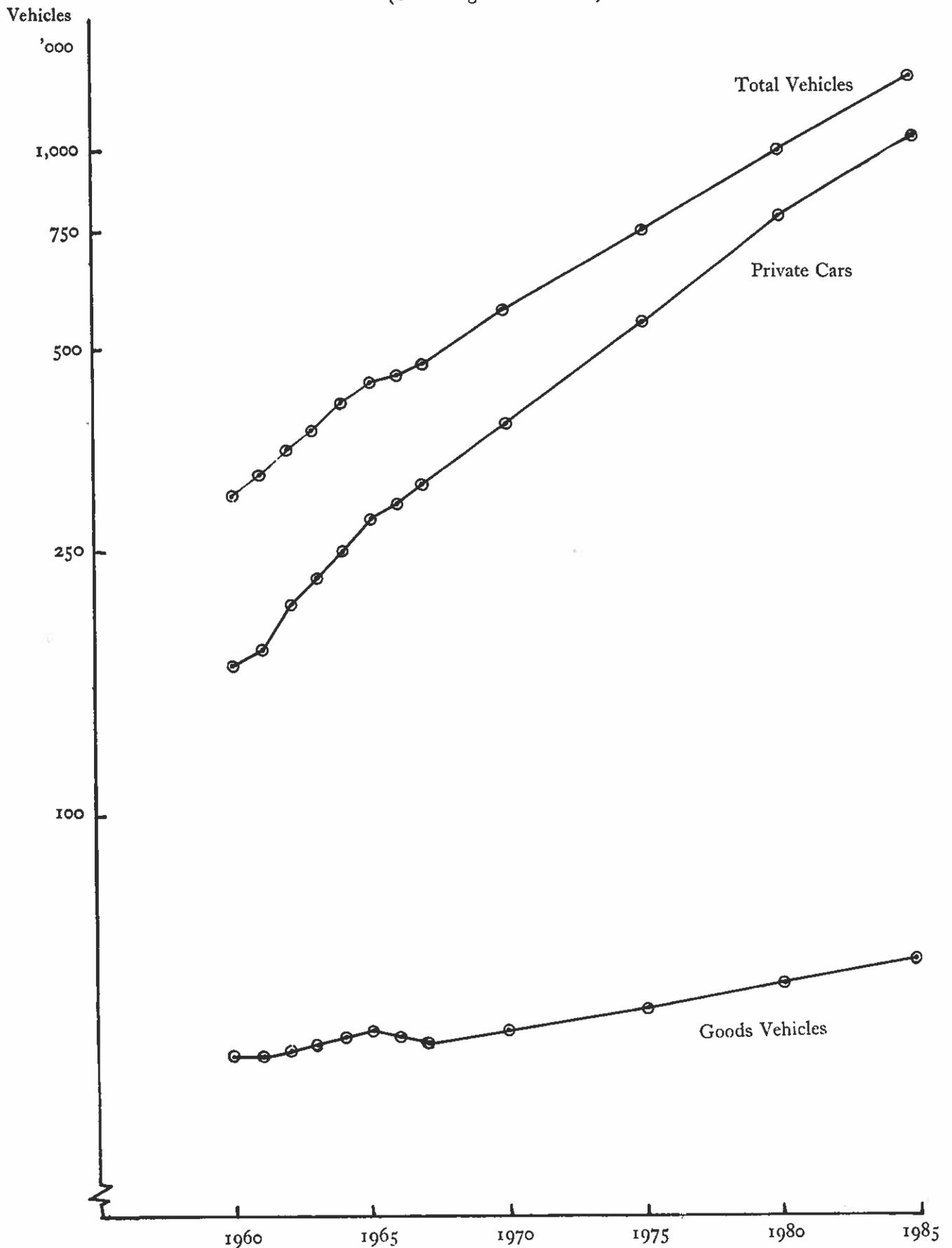
The most satisfactory method of estimating

vehicle mileage is to use data from traffic counts at points which are scientifically located on the road network. Such traffic count data have not until recently been collected in Ireland. From the beginning of 1968 a system of sample counts with mechanical counters operates which will eventually provide an estimate of vehicle mileage on 3,000 miles of arterial and through routes.

Some data on vehicle mileage in Ireland in 1964, based on traffic censuses, are given in O'Keefe

CHART 2: TOTAL VEHICLES BY MAIN CATEGORY OF VEHICLE, 1960-1985

(Semi-Logarithmic Scale)



Source: Table 28; Table C1

(1965a). These data³⁸ show that the total estimated vehicle mileage on Irish roads in 1964 was 4,775 million. This estimate excludes the four County Boroughs of Dublin, Limerick, Waterford and Cork. One can deduct 650 million vehicle miles from O'Keeffe's figure, as an estimate of pedal cycles' vehicle mileage, and 50 million as an estimate of tractors' vehicle mileage (source for adjustments: draft report for An Foras Forbartha by R. Hearne). This leaves 4,075 million as an estimate of vehicle mileage.

The data in O'Keeffe (1965a) show that vehicle mileage per mile of road in Ireland varies considerably among counties. The counties with the higher vehicle mileage per mile of road are Dublin (which has over three times the national average), Louth, Kildare and Laoighis; those with the lowest vehicle mileage are Sligo, Leitrim, Mayo and Roscommon.

5.2 Utilisation of Fuel Consumption Data

In the following sections we use data on fuel consumption, supplemented by direct information concerning vehicle mileage of goods vehicles and omnibus passenger services, to estimate total vehicle mileage on Irish roads in a number of years since 1958. The years chosen are 1958, 1961, 1964 and 1966. In these estimates, both general haulage tractors and agricultural tractors are excluded, as are steam-driven, electrically-propelled vehicles and dumpers, vehicles exempt from Road Tax, "miscellaneous vehicles" (as defined in Section 3.3), and motor coach services.

The fuel consumption method is based on a simple identity: if V = number of vehicles, c = average fuel consumption per vehicle (gallons per mile), M = annual average mileage travelled per vehicle and F = total fuel consumption by vehicles per annum, then:

$$VcM = F.$$

Values of V (for each category of vehicle) and F are available, and it is possible to estimate values of c for various classes of vehicle. It is therefore possible to estimate M , the unknown in the identity.

The fuel consumption method is necessarily approximate, since one must utilise average figures of fuel consumption for various classes of vehicle, and since the average fuel consumption of any one category of vehicle (classed for example by cubic capacity) can change over a number of years. There may also be a "leakage" of fuel due to its being used other than in propelling vehicles.

³⁸The data of O'Keeffe (1965a) are partly based on a census in 1963 which was taken at 1,200 points on the 9,000 mile existing main road network. O'Keeffe uses this census for data on 3,000 miles of arterial and other through routes. He supplements it with information from a 1965 census which covers the remaining 48,000 miles of the rural road network. The 1965 census was a 10 per cent. sample of all the 22,000 individual sections in the 48,000 mile network (see O'Keeffe 1965a).

This method is a highly simplified one and the absolute estimates of vehicle mileage are subject to a wide margin of error. The estimates should be more reliable in providing an indication of how mileage per vehicle changes from one year to another, than in giving an accurate absolute mileage figure.

5.3 Vehicle Mileage in 1964

5.3.1 Introduction

We begin by making estimates of vehicle mileage for 1964. These estimates are more accurate than those for any other year, since 1964 is the reference year of SSRF which gives an accurate estimate of the vehicle mileage of goods vehicles.

In this analysis we ignore some practical difficulties:

- (a) A problem is created by traffic across the Border. Travellers from the Six Counties purchase petrol in the Republic, and the converse also holds. There may not be an exact correspondence between petrol purchased, and vehicle mileage performed, in the Republic.
- (b) There may be some petrol consumed by omnibuses or by agricultural tractors.

5.3.2 Petrol consumption of cars and motor cycles, 1964

The first step in estimating vehicle mileage via fuel consumption data is to estimate the average fuel consumption of the vehicles in question. Table 21 outlines the number of private cars and taxis, distributed according to cubic capacity, in 1964, together with the average petrol consumption relating to each category of car.³⁹

TABLE 21: FUEL CONSUMPTION BY PRIVATE CARS AND TAXIS 1964

Type of Vehicle	Number of Vehicles	Average Petrol Consumption (gallons per mile)
(1)	(2)	(3)
<i>Private Cars :</i>		
<i>Horse Power</i>		
<i>Over</i>	<i>Not Over</i>	
8	8	0.025
10	10	0.031
12	12	0.039
14	14	0.040
16	16	0.041
20	20	0.046
24	24	0.052
	801	0.067
<i>Taxis</i>	3,426	0.05 ^a
<i>Private Cars and Taxis</i>	257,920	

Note: a—This is an arbitrary estimate.

Source: Col. (2): DLG, Annual Vehicle Census.

³⁹The assumptions concerning the average petrol consumption of taxis follow Chandler and Tanner (1958) and Reynolds (1962).

It is necessary to make allowance for the fact that utilisation (in terms of annual mileage per annum) varies for cars of differing size. No Irish data are available on this question, but some recent British data are given in Table 22. As one would expect in general the larger the car the greater its annual usage. Two groups of vehicles run counter to this trend—the 1,201–1,400 and the 2,001–2,500 c.c. groups. This is puzzling; it may be due to these two size groups in Britain having a higher than average proportion of old cars and/or a lower proportion of employer-owned cars (which are relatively more intensively used than are privately-owned cars).

TABLE 22: ANNUAL VEHICLE MILEAGE BY ENGINE SIZE OF CAR IN GREAT BRITAIN 1965

Engine Size (c.c.)	Annual Vehicle Mileage (weighted average)
Up to 1,000	7,318
1,001–1,200	8,246
1,201–1,400	6,972
1,401–1,600	8,333
1,601–2,000	9,172
2,001–2,500	6,847
2,501–3,000	9,155
3,001 or over	10,696
All Cars	8,022

Source: NTS 1965.

Although the cubic capacity class intervals in Table 22 do not exactly correspond in all cases with the class intervals in Table 21 (using the standard conversion factor: 125 c.c. equals one horse power), they are broadly comparable. The data in Table 22 are used to weight the figures of average petrol

consumption given in Table 21, in order to calculate a weighted average petrol consumption per vehicle. This weighting pattern is obviously not an ideal one for Irish conditions. But although the annual usage of vehicles in each size group must differ between Ireland and Britain, the relative average usage between each size group should be fairly similar in each country.

A weighting for taxis is also used; following Booth⁴⁰ the arbitrary assumption is made that taxis run three times as many miles each year as other cars.

Based on Table 21, the weighted average petrol consumption of private cars and taxis in 1964 is 0.0315 gallons per mile. A final adjustment is necessary to correct for the likely over-estimation of fuel consumption. The figures quoted are unlikely to be achieved in practice, due to the decreasing fuel economy of older cars, and due to varying driving techniques, for example. The average fuel consumption is therefore increased by an arbitrary 10 per cent.—i.e. to 0.035 gallons per mile.

Table 23 gives data on fuel consumption of motor cycles in 1964. It is assumed that the larger the capacity of a motor cycle, the greater is its utilisation in terms of annual mileage. Consequently an additional parameter w is introduced, in order to calculate a weighted figure for petrol consumption. The choice of weights is to a certain extent arbitrary. Figures of average petrol consumption for various categories of motor cycle are Road Research Laboratory estimates quoted in Chandler and Tanner (1958).

⁴⁰Booth, J. L. (1967), p.34.

TABLE 23. FUEL CONSUMPTION BY MOTOR CYCLES 1964.

Cubic Capacity	Number of Motor Cycles	Average Petrol Consumption (gallons per mile)	Weighting Factor	Total Petrol Consumed per Mile by Motor Cycles (gallons)
(1)	(2)	(3)	(4)	(5)
150 and under	43,320	0.0083	1	360
151–250	7,410	0.0111	1 + w	82 (1 + w)
Over 250	950	0.0154	1 + 2 w	15 (1 + 2 w)
Total	51,680 ^a			457 + 112 w

Note: a—The slight discrepancy between this total of motor cycles and the figure given in Table C1 for 1964 is accounted for by a certain number of tricycles and other miscellaneous cycles.

Source: Information from CSO; Chandler and Tanner (1958).

Based on Table 23 the average petrol consumption of motor cycles in 1964 is:

$$\frac{457 + 112w}{51,680 + 9,310w} \text{ gallons per mile.}$$

The denominator in the above expression is the sum of the figures in Col. (2), each being multiplied by its appropriate weighting factor. For various values of w , the average petrol consumption of motor cycles in 1964 varies from 0.0088 (when $w = 0$) to 0.0091 (when $w = 0.4$). An average

consumption of 0.0090 gallons per mile is assumed for motor cycles in these calculations.

To summarise, we have estimated the average petrol consumption (gallons per mile) achieved by private cars (including taxis) and by motor cycles in 1964. It is now possible to estimate the vehicle mileage of cars and motor cycles by combining this information with figures on the total gallons of petrol consumed by cars and taxis in that year. Total petrol consumption by all vehicles in the year ended March 1965 was 115.99 million gallons (Revenue Commissioners, 1966, Table 18), and this figure is used as an estimate of 1964 calendar year consumption. This figure includes petrol consumed by certain vehicles which do not meet our definition of "private car and motor cycle". Therefore the following adjustments to this figure are necessary:

- (a) An estimate of goods vehicles' petrol consumption is deducted from the total. The basic data on goods vehicles' petrol consumption are given in Table 24. This table shows that an estimated 13.28 million gallons of petrol were consumed by petrol fuelled goods vehicles in 1964.

TABLE 24: PETROL CONSUMPTION DATA FOR THE ROAD FREIGHT FLEET 1964

Unladen Weight (tons)	Number of Petrol-Fuelled Vehicles	Total Annual Fuel Consumption (millions of gallons)
0-1	24,840	8.11
1-2	5,280	3.07
2-3	1,620	1.30
3-5	660	0.66
Over 5	40	0.14
Total	32,430	13.28

Source: Information from CSO (based on SSRF).

- (b) An estimate of exempt vehicles' petrol consumption is deducted from the total. In order to simplify the calculations, the following assumptions are made. Firstly, it is assumed that the use of these vehicles is relatively intensive—an average of 15,000 miles per annum is assumed. Secondly, their fuel consumption is assumed to be 0.040 gallons per mile. Using these assumptions, we estimate that the amount of petrol consumed by the exempt vehicles in 1964 was 2.87 million gallons.
- (c) An estimate of petrol consumed by tourists who travel with their cars is deducted from the total. In 1964, tourists brought 30,214 cars directly into the Twenty-Six Counties by sea and air. The estimated average mileage of these cars in the Twenty-Six Counties is 1,092. In

addition, cars are brought directly into the Six Counties. Some 66 per cent. of Six-County visitor bednights are spent in the Twenty-Six Counties. This factor of 66 per cent. is combined with the above mileage figure of 1,092 in order to derive an approximate estimate of these visitors' annual mileage. In 1964 there were 41,256 accompanied cars brought directly into the Six Counties.⁴¹ The resulting estimate of vehicle mileage of all tourists' cars is 62.73 million for 1964. We assume that the average petrol consumption of these vehicles is equal to the overall average of 0.035 gallons per mile which was already derived for Irish cars and taxis. The estimated petrol consumption of tourists' cars was therefore 2.20 million gallons in 1964.

Taking into account the deductions under (a), (b) and (c), the estimate of petrol consumed by private cars and taxis and motor cycles in 1964 is 97.64 million gallons.

5.3.3 Derivation of vehicle mileage from fuel consumption and other data

Finally, we estimate the ratio between private cars' (including taxis) and motor-cycles' average annual mileage since, for example, a relatively high or low utilisation of motor cycles would affect total fuel consumption. No Irish data exist on this question.

It is necessary to look to other countries for comparative data on this matter: the ratio of private cars' average annual mileage to motor cycles' average annual mileage in a number of European countries is as follows: (definitions of "private cars" and of "motor cycles" vary slightly in these data, but they are adequate as an approximation):⁴²

Great Britain	3.3:1
Denmark	2.9:1
West Germany	3.2:1
Norway	3.0:1

Such a small number of countries is of limited help to us. In the above countries, average car usage is between 2.9 and 3.3 times motor cycle usage. The two most densely-populated countries, Great Britain and West Germany, have the highest ratios. A ratio of 3.0:1 is accepted for our purposes.

All the information is now available with which to solve a series of equations relating vehicle usage to petrol consumption. The basic identity mentioned in Section 5.2, i.e. $VcM \equiv F$ is applied to both private cars (including taxis) and motor cycles.

⁴¹All the tourist information in these paragraphs is due to Bord Fáilte Éireann.

⁴²Source: for Britain—*Highway Statistics 1967*, Table 21; Danmarks Statistik, *Danish Statistical Yearbook 1968*; *Statistisches Bundesamt*; Central Bureau of Statistics of Norway.

The resulting vehicle mileage estimates of private cars and taxis, and of motor cycles (in terms of annual mileage per vehicle) for 1964 are given in Table 25, Col. (4). Information on the vehicle mileage of omnibuses and goods vehicles is directly available from published sources, and is also given in Table 25.

5.4 Vehicle Mileage in Years Other than 1964

An estimate is now made of vehicle mileage in three other years: 1958, 1961 and 1966. Once again fuel consumption data are used. One difficulty is that there is no direct source of goods vehicles' mileage as there was in 1964, due to SSRF. There seem to be two alternative ways of estimating goods vehicles' mileage for these years. The simplest method is to assume that, for each of the five unladen weight classes for which data are in SSRF, average mileage in these years is equal to average mileage in 1964. This is consistent with the assumption made, when projecting goods vehicle numbers, that average mileage per vehicle, in each unladen weight group, remains constant in future years.

The alternative method would estimate goods vehicles' diesel fuel consumption in each of these years and add this to the total petrol consumption figure in each year. There would be an additional identity of the $V_c M = F$ form, due to the estimate of goods vehicles' mileage.

The former of these two methods is used, both in order to simplify the calculations required and also because it would seem to give estimates which are equally as good as those derived from the second method.⁴³

In estimating the vehicle mileage of cars and motor cycles in these years, we use almost exactly the same method as for 1964, and tables analogous to Tables 21 and 23 are drawn up,⁴⁴ but since there is no direct

⁴³The vehicle mileage estimate of goods vehicles for 1958 is biased. This is because, as has already been discussed, goods vehicle numbers by unladen weight before and after 1960 are not strictly comparable. It is hoped that errors are, to an extent, self-cancelling.

⁴⁴The basic data on the number of private cars in each horse power class are in Table C14.

For taxis and for the private cars up to 14 horse power the same fuel consumption figures are used as in 1964. Slightly different figures are used for the other horse power categories, i.e.

Horse Power		1960	1962	1966
<i>Over</i>	<i>Not Over</i>			
14	16	0.037	0.040	0.042
16	20	0.042	0.045	0.048
20	24	0.047	0.050	0.053
24		0.059	0.067	0.067

The 1964 weighting pattern, which takes account of differing utilisation patterns among cars of different sizes, is used. This leads to a weighted average fuel consumption (gallons per mile) for private cars and taxis of 0.036 in 1958 and 0.035 in both 1961 and 1966. For the motor cycles, the same petrol consumption figure is used as for 1964.

information on petrol consumption by goods vehicles in these years we use the 1964 figures for such consumption.

In the calculations we assume initially that the proportion of petrol fuelled vehicles in each unladen weight group in these years is as in 1964. It is likely that there is a gradual substitution, within unladen weight classes, of diesel fuelled for petrol fuelled vehicles. A comparison of data in Booth, 1967, p. 32 with SSRF p. 24 confirms this. Therefore the following somewhat arbitrary adjustments to the estimated petrol consumed by goods vehicles are made: additions of 6% to 1961 and 12% to 1958 figures, deduction of 5% from 1966 figure.

Once again it is assumed that on average, private cars are utilised 3 times more intensively than are motor cycles. The same assumptions are made concerning the average mileage of tourists who travel to Ireland with their cars.

The vehicle mileage estimates for the three years 1958, 1961 and 1966 are given in Table 25.⁴⁵

TABLE 25: ESTIMATED MILEAGE PER VEHICLE ON IRISH ROADS, 1958, 1961, 1964 AND 1966

Type of Vehicle	Annual Average Mileage per Vehicle			
	1958	1961	1964	1966
(1)	(2)	(3)	(4)	(5)
Private car and taxi ^a	11,100	11,100	10,600	10,800
Motor cycle ..	3,700	3,700	3,500	3,600
Goods vehicle ^b ..	7,100	8,400	9,000	9,400
Omnibus ^c ..	34,800	32,900	31,800	31,300
Total ..	9,500	9,700	9,500	9,800

Notes: a—Excludes mileage of cars brought into the Twenty-Six Counties by tourists.

b—Excludes steam-driven and electrically-propelled vehicles.

c—Excludes motor coach services.

Source: For goods vehicle: Table C8; SSRF Table 2
For omnibus: SA; ISB.

⁴⁵The following are the details of the estimated petrol consumed by goods vehicles, exempt vehicles and tourists in each of these years (in millions of gallons), with comparative figures for 1964.

Type of Vehicle	1958	1961	1964	1966
Goods vehicle ..	14.61	12.89	13.28	11.78
Exempt vehicle ..	2.56	2.60	2.87	3.20
Tourist's car ..	0.66	1.12	2.20	3.12

The values for F (fuel consumption) in the equations are (in millions) 1958: 60.49, 1961: 75.96, 1964: 97.64, 1966: 114.8. The numbers of tourists who accompanied their cars were as follows:

Year	To Republic	To Six Counties
1958	8,570	12,292
1961	15,511	20,893
1964	30,214	41,256
1966	47,200	52,300

Source: Information from Bord Fáilte Éireann.

5.5 Discussion of Vehicle Mileage Figures

Table 26 gives the estimated vehicle miles travelled on Irish roads in 1964.

TABLE 26: TOTAL VEHICLE MILEAGE 1964

Type of Vehicle	Vehicle Mileage (millions)
Private car and taxi	2,742.21
Motor cycle	184.90
Goods vehicle ^a	416.54
Omnibus ^b	49.90
Private car brought in by tourist ..	62.73
Total	3,456.27

^a—Excludes steam-driven and electrically-propelled vehicles.
^b—Excludes motor coach services.

In this table the vehicle mileage travelled by tourists, who accompany their cars, is included. The estimated vehicle mileage on Irish roads in 1964 was 3,456 million. This figure can be compared with the estimate made by O'Keeffe (1965) for 1964, which was described at the beginning of this section. O'Keeffe's estimate of 4.1 million vehicle miles (adjusted) in 1964 is significantly higher than ours. It has been suggested (by Hearne *op. cit.*) that the factor used by O'Keeffe in converting from 1965 count date to the 1964 vehicle mileage estimate may be too high, leading to an over-estimate of 1964 mileage. This could account for the discrepancy between O'Keeffe's 1964 estimate and our estimate.

Annual average utilisation of vehicles as given in Table 25 seems to be reasonably static, if not decreasing, over time. The estimated average mileage per private car (including taxis) has declined since 1958 and has been fairly static in recent years.

The average vehicle mileage of motor cycles has remained fairly constant over time. Average annual mileage of goods vehicles has steadily increased between 1958 and 1966. This is because the heavy goods vehicles continue to form a larger proportion of the goods vehicle fleet and these heavy vehicles perform more miles per annum.

When compared with British figures on average mileage (given in Appendix C, Table C15), the Irish

figures of annual mileage per private car are significantly higher. The British figures in this Appendix relate to "privately taxed cars and vans" rather than "cars"; calculations from NTS indicate an annual mileage 3 per cent. higher for "cars". The Irish figures of annual mileage per private car are significantly higher than the British figures. For example, estimated average mileage per private car in Ireland was 10,800 in 1966 compared with 8,100 in Britain in the same year.

The data in Appendix C, Table C16, on average mileage per private car in a number of other countries provide further comparisons. When compared with these countries, the Irish average annual car mileage is not unreasonably high. For example, the Netherlands' average car mileage of 11,200 (although itself probably an over-estimate—see note to the table) is higher than the Irish estimate. The Danish figure of 9,800 miles is also relatively near the Irish estimate.

We now wish to examine what are the likely reasons for this discrepancy between annual mileage per private car in Ireland and in Britain. This may help us to estimate future patterns of car usage. This examination is done in a relatively impressionistic manner, mainly by looking at NTS data.

Three possible reasons for the disparity are examined:

- (a) the greater urbanisation in Britain;
- (b) the higher family size in Ireland;
- (c) the higher proportion of multi-car owning households in Britain.

The first possibility is that the greater urbanisation of Britain discourages private car usage there, leading to a greater use of public transport. This hypothesis implies that there is a considerable suppressed demand for car usage in Britain. This can roughly be tested by looking at the data in Table 27.

TABLE 27. AVERAGE WEEKLY VEHICLE MILEAGE PER VEHICLE BY TYPE OF VEHICLE AND SIZE OF AREA,^a 1965

Type of Vehicle	Size of Area (i.e. Population)					Rural
	Four large Conurbations ^b	Urban Areas 1-1 million	Urban Areas 100-250 thous.	Urban Areas 25-100 thous.	Urban Areas 3-25 thous.	
Unclassified Car	153	143	136	140	160	137
Ordinary Saloon Car	129	124	111	137	128	127

Notes: ^a—London built up area is excluded.

^b—Birmingham, Manchester, Glasgow and Liverpool.

Source: NTS 1965.

The "urbanisation" hypothesis is not borne out by this table. There is generally a higher average mileage in the urban areas than in the rural areas in Britain. Also, in the case of the "ordinary saloon car", the average mileage in the urban areas of 3-25 thousand population is not markedly lower than that in more densely populated areas.

The second possibility is that the higher family size in Ireland might also explain different patterns of usage.⁴⁶ Again the NTS cross-section gives some information on the effects of household composition on vehicle usage. This information is given in Appendix C, Table C17. This table gives a household income \times household composition classification. One must be cautious in interpreting this table, since the figures in some of the "cells" may not be highly significant. Nevertheless, the general pattern which emerges is that large households do not generate higher mileage per vehicle. Single-person households in fact generate a higher average mileage per vehicle than do other types of household.⁴⁷

The third possibility which we examine is the likely effect of Britain's higher proportion of multi-car owning households. From Table 28, it seems that average car usage does not decline in multi-car owning households. In these households, a higher than average usage of the principal car is offset by lower than average usage of the subsidiary car. The one case where there may be lower average vehicle usage is when the household also has van(s) or lorry(s).

The three possible explanations which we have

⁴⁶Average family size in Ireland (i.e. average number of children born per family) is 3.53 (CP 1961 Vol. VIII Table 7A). The average for England and Wales is 1.87 (General Register Office (1966), *Census 1961: England and Wales: Fertility Tables*, Table 2(i)).

⁴⁷Table C17 relates to all vehicles and includes motor cycles and vans. Although the average annual mileage of motor cycles is lower than that of private cars, this should not affect the relativities which we are interested in.

examined do not cover all possible reasons for the differing level of car usage between Ireland and Britain. Possibly the level of car ownership in each country is a factor. For example, Tanner (1966) shows, based on data from US States supplemented by British data, that a rising level of vehicle ownership tends to reduce miles per vehicle. This might seem to conflict with the NTS evidence on the influence of multi-car ownership on usage. But it is possible to reconcile these two trends: only a certain amount of the increase in vehicle ownership is due to increased multi-car ownership.

TABLE 28: AVERAGE WEEKLY MILEAGE PER VEHICLE FOR VEHICLES IN HOUSEHOLDS, 1965

Status of Car	Average Weekly Vehicle Mileage
Sole household car	134
Sole household car, but where household also has van(s) or lorry(s)	101
Main household car—where household has at least two cars	158
Other household car—where household has at least two cars	119
Hired/Borrowed car	356
Total ..	134

Source: NTS 1965.

Tanner (1966) also argues (although not presenting empirical evidence on this point) that an improved quality of the road system would probably tend to increase miles per vehicle. He defines "quality" to mean "the average speed which can be maintained in the actual journeys undertaken in the traffic conditions actually obtaining" (Tanner 1966, p. 7). It is quite possible that, on the basis of this definition, the road system in Ireland is of a higher "quality" than that in Britain, thereby contributing to the higher car usage.

6. PASSENGER TRAFFIC BY ROAD AND RAIL

6.1 Introduction

In this section we look at trends in passenger traffic by road and rail in recent years. Since published figures on omnibus passenger mileage are available only for CIE passenger traffic, a time series of all omnibus passenger mileage is constructed. Also, for 1966 an estimate is made of passenger mileage on all modes of transport.

Table 29 shows that vehicle mileage on omnibus passenger services has risen since 1955, while the number of passengers carried has declined slightly. The great majority of these passengers are carried on

CIE services, and Dublin City and suburban services carry most of the traffic.⁴⁸ This table also contains our estimate of all omnibus passenger mileage which has fluctuated from year to year but remained at about 700 million throughout the period.⁴⁹ This estimate includes the passenger

⁴⁸For example in 1964 these services carried 78 per cent of all CIE passengers (Source: SA).

⁴⁹The passenger mileage figures are constructed by the following method. Based on the CIE *Annual Reports*, the average receipts per passenger mile from road passenger services (excluding tours and private hire) are calculated. Data on gross receipts from passenger fares for all omnibus services (excluding cross-Border services) are available in SA.

mileage performed on private omnibuses, which is a small proportion of the total.

Table 30 shows the trend in CIE rail passenger traffic in the period 1958/59 to 1966/67. This period is examined, since it dates from the acquisition by CIE of GNR in October 1958. Annual rail passenger traffic has decreased from 11.7 million in 1958/59 to 9.3 million in 1966/67, but the increase in average length of journey (from 28 miles in 1958/59 to 37 miles in 1966/67) has resulted in an increase in the number of rail passenger-miles over this period.

TABLE 29: VEHICLE MILES AND PASSENGERS CARRIED ON OMNIBUS PASSENGER ROAD SERVICES (EXCLUDING CROSS-BORDER SERVICES) 1955-1966

Year	Vehicle Miles	Passengers	Passenger Miles
(1)	(2)	(3)	(4)
	'000	'000	million
1955	45,900	306,087	b
1956	47,098	305,325	700
1957	47,703	308,866	752
1958	48,304	297,654	762
1959	49,117	294,070	773
1960	49,021	299,285	774
1961	48,212	292,081	743
1962	48,741	294,425	686
1963 ^a	44,770	268,925	633
1964	49,895	304,506	751
1965	49,012	294,395	735
1966	49,119	285,965	667

Notes: a—Affected by a 'bus strike.

b—Data not available at time of writing.

Source: Cols. (2) and (3): SA; ISB, June 1967.

Col. (4): CIE Annual Report; SA.

TABLE 30: RAILWAY PASSENGER TRAFFIC, 1958/59—1966/67

Year Ended March	Passengers	Passenger Miles
	'000	'000
1958/59	11,714 ^a	325,973 ^a
1959/60	12,276	344,085
1960/61	11,053	352,142
1961/62	10,157	344,348
1962/63	9,833	336,634
1963/64	9,846	330,991
1964/65	9,304	333,146
1965/66	8,981	336,633
1966/67	9,294	345,658

Notes: a—Adjusted to include Great Northern Railway traffic from 1 April 1958.

Source: SA; CIE Annual Report, 1966/67.

6.2 Passenger Mileage by Mode of Transport in 1966

It is now possible to draw up a table which shows the distribution of passenger mileage in Ireland, according to mode of transport, making use of our previous calculations on vehicle mileage. We take no account of those vehicles which were excluded from the vehicle mileage estimates of the previous section. This estimate excludes passenger mileage performed in goods vehicles. The passenger mileage estimates are derived as follows, for the calendar year 1966.

Private cars (including taxis)

Our estimate of vehicle mileage performed by private cars and taxis in 1966 is used (Table 25). In the absence of any Irish data on vehicle occupancy, we apply the occupancy of 1.8 persons per private car which holds for Britain (Ministry of Transport, 1967^a, Table 4C) to the vehicle mileage figure, to obtain an estimate of passenger mileage.

Motor cycles

Our estimate of vehicle mileage by motor cycles in 1966 is used (Table 25). An occupancy of 1.07 persons per motor cycle is arbitrarily assumed in order to estimate passenger mileage.

Omnibus

The information is contained in Table 29.

Rail

Rail passenger mileage was 346,000 in 1966/67 (CIE 1967). This will approximate to a calendar year figure for 1966.

All these estimates of passenger mileage, by mode of transport, are brought together in Table 31. Private cars (including taxis) accounted for 83 per cent. of all passenger miles in 1966.

TABLE 31: ESTIMATED PASSENGER MILEAGE, 1966

Mode of Transport	Passenger Miles	Proportion of Total Passenger Mileage
	million	%
Private cars (including taxis)	5,827	83.0
Motor cycles	181	2.6
Omnibuses	667	9.5
Rail	346	4.9
Total	7,021	100.0

6.3 Projection of passenger mileage

The assumption is made that average annual mileage of private cars (including taxis) and of motor cycles remain at their levels in 1966. We use our projection of the number of private cars and motor cycles in 1970 and 1975. This gives a projected vehicle mileage of these modes of transport, and we apply the same occupancy factors as in the building up of 1966 estimates, in deriving a projection of passenger mileage in 1970 and 1975. The projection for private cars (including taxis) is 7,610 million passenger miles in 1970 and 10,540 million in 1975. The projection for motor cycles is 169 million in 1970 and 165 million in 1975.

It is difficult to obtain a basis for projecting passenger mileage on omnibus and rail services. This is an area where policy decisions (e.g. on road pricing, or on the pattern of the rail network) could have a significant impact. Even given a "no change" policy situation, one would need to know something

about patterns of cross-substitution between public and private transport.

Given a situation where omnibus and rail passenger mileage remained at their 1966 levels, then private cars (including taxis) would account for 87

per cent. of passenger mileage in 1970, omnibuses for 8 per cent. and the railways for 4 per cent. The 1975 proportions, making the same assumptions, would be 90 per cent., and 6 per cent. and 3 per cent. respectively.

7. FREIGHT TRAFFIC BY ROAD AND RAIL

7.1 Introduction

In this section trends in freight traffic by road and rail for a past number of years are examined. Firstly, the freight traffic by road is analysed.

7.2 Freight Traffic by Road

No accurate information is regularly available on the volume of freight traffic by road, whether this is measured in terms of tons or ton-mileage. The only possible estimates are based on SSRF data for 1964. Such estimates inevitably must be subject to a wide margin of error. Sexton (1966-67) gives estimates of tonnage by road in the period 1960-65. We follow his method, and derive further estimates of this freight traffic for 1966 and 1967. These estimates are built up in the same way as the ton-mileage estimates given in Table 8. The estimates are based on the average tonnage carried per vehicle in 1964. These averages are calculated (from SSRF) for each of five unladen weight classes and are applied to the numbers of vehicles in these unladen weight classes in years other than 1964.

The figures given in Sexton (1966-67, Table A9) show that tonnage by road increased steadily from 38.22 million tons in 1960 to 57.51 million tons in 1965. Our tonnage estimates are 57.43 million tons in 1966 and 62.03 million tons in 1967. Information on ton-mileage has been given in Table 8. The estimated ton-mileage by road increased from 721.85 million in 1960 to 1,222.07 million in 1967. Average load carried per vehicle has probably increased since 1960 (due to the greater proportions of goods vehicles in the heavier unladen weight classes). Therefore these estimates of tonnage and of ton-mileage probably over-estimate goods traffic in the period 1960-1963, and underestimate it in the period since 1965.

7.3 Rail Freight Traffic

Tables 32 and 33 give details of rail freight traffic carried by CIE in the period 1958/59-1966/67. In this period, the overall tonnage of freight carried on the rail network has increased by 13 per cent.—from 2.4 million tons in 1958/59 to 2.7 million tons in 1966/67. In this period, the average length of haul for all rail goods traffic has increased from 83 miles in 1958/59 to 98 miles in 1966/67.

Table 32 shows that coal and coke traffic has declined markedly since 1958/59; the tonnage of

other minerals has declined but an increased average length of haul has resulted in ton-mileage remaining steady, while livestock tonnage has decreased by 27 per cent. but livestock ton-miles have declined by only 7 per cent. General merchandise traffic is the only type of traffic to record a pronounced increase in both tonnage (from 1,500 in 1958/59 to 2,100 in 1966/67) and ton-miles. The average length of haul of general merchandise traffic has increased from 88 miles in 1958/59 to 102 miles in 1966/67.

7.4 Rail/Road Division of Traffic and Projection

Since figures have been given of both road and rail traffic since 1960, it is now possible to estimate the rail share of the total freight traffic. It is assumed that rail traffic in the financial year 1966/67 approximates to traffic in the calendar year 1966, and similarly for other years. The rail share for the period 1960/65 is given in Sexton (1966-67); it is therefore only necessary to compute the 1966 figure, which is 4.57 per cent. of tonnage and 18.14 per cent. of ton-mileage.⁵⁰ In 1966, there was an estimated total ton mileage of 1,358.08 million, of which an estimated 1,111.70 million ton-miles were on the road system, and 746.38 million on the rail system. The estimated rail share of total ton-mileage rose in 1966 to a proportion approaching its 1962 figure. The estimated rail proportion of ton-mileage had fallen in each year from 1960 to 1965. The estimated rail share of total tonnage was at its highest since 1963.

A projection of ton-mileage by road has already been made for the period 1967-1985. A similar projection of rail ton-mileage is a difficult exercise. We assume that there are no major changes in policy towards the retention of rail services, or the pricing of road-rail services. Average length of haul should still continue to increase steadily, leading to probable increased ton-mileage on the railways. While it would be theoretically desirable to build up projections of rail traffic for separate types of commodities, this is hardly worthwhile especially in view of the declining rail traffic in certain commodities.

⁵⁰The ton-mileage figures given in Sexton (1966-67) differ somewhat from the figures in Table 33, since they exclude certain ton-mileage performed in the Six Counties. In our estimate of the 1966 rail share we follow this practice and use an adjusted ton-mileage of 246.384 million (source for adjustment: information from CIE).

TABLE 32: RAILWAY FREIGHT TRAFFIC (TONS), 1958/59-1966/67.

Year ended March	General merchandise	Coal, coke and patent fuel	Other minerals	Livestock	Total
	'000	'000	'000	'000	'000
1958/59 ^a	1,666	59	520	177	2,422
1959/60	1,748	33	581	156	2,518
1960/61	1,872	49	590	179	2,690
1961/62	1,868	40	463	192	2,563
1962/63	1,943	37	482	132	2,594
1963/64	1,971	35	465	133	2,604
1964/65	1,910	17	433	101	2,461
1965/66	1,968	9	422	98	2,497
1966/67	2,131	11	474	129	2,745

Notes: a—Adjusted to include Great Northern Railway traffic from 1 April, 1958.

Source: SA; CIE Annual Report 1966/67.

TABLE 33. RAILWAY FREIGHT TRAFFIC (TON-MILES), 1958/59-1966/67.

Year ended March	General merchandise	Coal, coke and patent fuel	Other minerals	Livestock	Total
	'000	'000	'000	'000	'000
1958/59 ^a	147,235	5,478	33,915	14,241	200,869
1959/60	155,895	1,298	36,982	13,591	207,766
1960/61	165,556	2,306	39,083	15,952	222,897
1961/62	167,481	1,947	33,041	17,641	220,110
1962/63	169,149	1,917	34,438	12,811	218,315
1963/64	171,638	1,591	34,796	13,158	221,183
1964/65	170,943	853	32,563	9,995	214,354
1965/66	197,782	385	32,058	9,779	240,004
1966/67	216,864	513	34,634	13,286	268,047

Notes: a—Adjusted to include Great Northern Railway traffic from 1 April, 1958.

Source: SA; CIE Annual Report 1966/67.

Our earlier projections of ton-mileage by road were 1,472 million tons in 1970 and 1,934 million tons in 1975 (Table 9). Assume that there is 300 million ton-mileage by rail in 1970 and 360 million by 1975 (this seems a reasonable, if possibly over-generous assumption on the basis of past trends as given in Table 33). Then, on the basis of our projection of ton-mileage by road,⁵¹ the rail share would be 16.9 per cent. in 1970 and 15.7 per cent. in 1975.

This is a simplified approach, and does not allow for the possibility of shifts in traffic from road to rail, which would reduce our earlier road ton-mileage projection. Given these assumptions, which seem relatively favourable towards the railways, the proportion of ton-mileage carried by rail would decline slightly in future years.

⁵¹We also assume that the rail ton-mileage in the Six Counties remains at its 1966/67 level of 21.7 million.

8. ASPECTS OF ROAD FREIGHT TRANSPORT

8.1 Introduction

When considering the projection of goods vehicles, it was necessary to make some assumptions concerning the future pattern of road haulage licensing. In this section we wish to examine some aspects of road freight transport, with particular reference to road haulage licensing. This section points out some features of road freight transport (with special reference to the data available in SSRF) which have implications for road haulage licensing. We have not had an opportunity to examine many fundamental questions which relate to the licensing system.

8.2 Historical Background

The basic legislation is contained in the *Road*

Transport Act 1933 and the *Transport Act 1944*. The transport of merchandise by road was restricted to licence-holders or to carriage taking place within certain exempted areas. Any person who already operated a merchandise road service or his successor in title was entitled to receive a licence. This licence was granted in respect of his previous area of operation, and the class of goods which he was carrying. In the licence the maximum unladen weight of the licensee's vehicles was specified. This stipulation in effect limited the number of vehicles which each licensee was allowed to use.

Apart from hauliers operating within the exempted areas, certain other classes of operators are not required to hold merchandise licences, such as turf hauliers and operators engaged in the haulage

of whole milk and separated milk to and from creameries. There has been a recent relaxation in licensing provisions. It has been announced that licences authorising the carriage of livestock in a restricted area would be extended in scope, on application, to permit the carriage of livestock under licence anywhere in the State.

There are therefore three main sectors in the licensed hauliers: the own account hauliers (who are exempt from licensing), the licensed hauliers and CIE which is not subject to licensing provisions.

The Act of 1933 was introduced because of fears of price-cutting, and in order to protect the position of the railways. Entry into the road haulage industry requires little capital, and fears of price-cutting were understandable in the depressed economic conditions of the 1930's, as road hauliers tried to keep their business. It was also thought that private traders running their own lorries occasionally took goods for hire and quoted low rates for this. Similar fears in Britain led to the British licensing system of the 1930's.

It was intended that the railway be made the most economical means of carrying goods traffic.⁵² The existence of competition as it existed prior to the Act threatened the railways' position. The railways' "natural monopoly" was also being threatened by the growth of private car usage.

8.3 Structure of Road Haulage Industry

The number of merchandise licences has varied very little over time. The total number of licences held was 950 in 1951, and 977 in both 1964 and 1965.⁵³ In 1965, 66 concerns furnished "nil" returns (i.e. evidence of no goods traffic activity) and of the remaining concerns, 884 were classed as small operators and 24 as large operators (excluding the rail companies).⁵⁴ Three railway companies hold merchandise licences.

In 1965 the small operators owned 1,059 goods vehicles, the large operators 103 and the railway companies 1,065.⁵⁵ Thus the distribution of goods vehicles among hauliers is extremely skewed. Most concerns own only one lorry, the average number of vehicles per small concern being 1.2. There is one large concern, i.e. CIE (which owned 950 goods and parcels vehicles at March 1966).⁵⁶ The

⁵²The reasoning behind the 1933 Act was that:

"for a considerable time to come the most economical method of transportation for a variety of classes of goods and in several parts of the country will be the railways". (Minister for Industry and Commerce, (1933), *Dail Eireann*, Vol. 46, Col. 384).

⁵³ISB December 1953, December 1966.

⁵⁴ISB December 1966.

⁵⁵ISB December 1966.

⁵⁶CIE *Annual Report 1965/66*.

non-rail large operators average little more than 4 lorries per concern.

8.4 Pattern of Road Freight Transport

A remarkably high proportion of road freight in Ireland is carried by own account transport—80.4 per cent. of tonnage and 82.9 per cent. of ton-mileage (SSRF Table 1). CIE's proportion of tonnage is 8 per cent. and other licensed hauliers' proportion of tonnage is 12 per cent. In making these comparisons, it needs to be kept in mind that the carriers are engaged in very different types of activity. Not all the short-haul "own account" traffic could be carried economically by licensed hauliers.

The Irish proportion of freight traffic carried by "own account" transport can be compared with the data in Table 34 on the importance of the "own account" sector in certain European countries (where data are available, this proportion is given for both tonnage and ton-mileage).

The Irish proportion of transport activity carried on own account transport is higher than in any of the countries in Table 34. A comparison with Britain is complicated by the different licensing provisions in that country (all these remarks relate

TABLE 34: PROPORTION OF 'OWN ACCOUNT' ROAD FREIGHT TRAFFIC IN A NUMBER OF EUROPEAN COUNTRIES, 1966

Country	Proportion of 'Own Account' Road Freight Traffic	
	Proportion of Tonnage	Proportion of Ton-Mileage
	%	%
Belgium ^a	67	56
France ^b	64	...
Netherlands ^c ..	42	...
Norway	48

Notes: a—Excludes freight carried by vehicles under 1 ton carrying capacity.

b—For vehicles weighing over 1 ton.

c—Excludes transport by delivery vans of up to 1 ton carrying capacity.

Source: Institut National de Statistique, Bruxelles; *Annuaire Statistique 1966 du Ministère de l'Équipement et du Logement et du Ministère des Transports*, 1967; Netherlands Central Bureau of Statistics; Central Bureau of Statistics of Norway.

to the British licensing system prior to the *Transport Act 1968*). The British "A" licence vehicles correspond to the Irish 'hire or reward' sector, while "C" licence vehicles correspond to the Irish private sector. But there are no Irish licences like the British "Contract A" (whereby vehicles can be used, under a contract, for the exclusive carriage of a person's goods) or "B" licence (whereby vehicles may be used in connection with the trade of licensee or for hire or reward). Most of the work of the "B" licence vehicles is for hire.⁵⁷

⁵⁷Ministry of Transport (1964a), Table 29.

We therefore regard the "public haulage" sector in Britain as comprising "A", "Contract A" and "B" licence vehicles. Given this assumption, the proportion of goods traffic activity carried by "own account" transport in 1962 was 59.2 per cent. of tons and 48.5 per cent. of ton-miles.⁵⁸ This British proportion on "own account" is relatively near the proportions for the European countries which we have examined. It is significantly lower than the Irish proportion.

The information on road freight tonnage by length of haul in Ireland is rather surprising, with particular reference to the "own account" sector's share of tonnage. One would expect that the "own account" sector's share of traffic would decrease as the length of haul increased. This happens in Britain, where "C" licence vehicles accounted for 56 per cent. of tonnage moved on end-to-end journeys under 50 miles, 46 per cent. of tonnage on journeys of 50-99 miles and 27 per cent. of tonnage on journeys of 100 miles or over.⁵⁹

In Ireland the "own account" sector maintains its large share of tonnage carried, over the long lengths of haul (*source*: Sexton, 1966-67, Table 7). This may be partly due to the licensing regulations, whereby many licensed hauliers must confine their activities within certain areas.

⁵⁸Ministry of Transport, *Survey of Road Goods Transport 1962, Final Results, Part I*, Table 29.

⁵⁹Ministry of Transport (1964a), Table (iv).

We now wish to make some estimates of utilisation of goods vehicles. One way of estimating this is to calculate the proportion of carrying capacity actually loaded, and this information is given in Table 35. This is not an ideal method. The proportion of carrying capacity actually loaded will to a certain extent depend on the type of good. If goods are light in weight in relation to the space occupied the carrying capacity (in terms of tonnage) may not be filled yet it may not be possible to put any more quantities of the good on the vehicle. There may be an awkward load, or a fragile load and consequently only part of the volume capacity may be filled.

In addition, the carrying capacity figures in Table 35 do not cover trailer capacity but all tonnage and ton-mileage data in SSRF do in fact cover loads carried in trailers. This affects the comparison between tonnage and carrying capacity data, since a higher proportion of trailers existed in the CIE and licensed hauliers fleets than in the "own account" fleet.⁶⁰ In addition, the carrying capacity figures supplied for SSRF were the vehicle owners' own estimates and it is thought that they may be subject to a wider margin of error than other data collected in the Road Freight Survey.

Bearing in mind these reservations, the data in Table 35 can be interpreted. The best basis for comparison is provided on end-to-end journeys. End-to-end journeys concern the transport of single

⁶⁰Information from CSO.

TABLE 35. UTILISATION OF CARRYING CAPACITY IN 1964.

Unladen weight ^a	Average load ^b per end-to-end journey	Average load ^b per intermediate journey	Estimated carrying capacity per vehicle ^c	Proportion of carrying capacity loaded on end-to-end journeys	Proportion of carrying capacity loaded on intermediate journeys
	tons			%	
<i>Own account</i> :					
1 ton and over	0.3	0.4	0.5	60	80
1 to 2 tons	1.0	0.9	1.1	91	82
2 to 3 tons	3.5	2.7	4.0	88	68
3 to 5 tons	7.2	5.5	7.4	97	74
Over 5 tons	12.5	9.8	11.9	105	82
All vehicles			2.4		
<i>CIE</i> :					
2 to 3 tons	2.0	3.0	3.5	67	86
3 to 5 tons	6.6	6.0	8.6	77	70
Over 5 tons	9.8	6.0	9.4	105	65
All vehicles			8.4		
<i>Other licensed hauliers</i> :					
2 to 3 tons	4.0	2.0	4.9	83	42
3 to 5 tons	8.3	6.5	8.5	98	76
Over 5 tons	8.8	—	10.4	85	—
All vehicles			8.4		

Note: a—All vehicles under 2 tons unladen weight have been classed as own account.

b—Quotient of tonnage by number of loaded journeys.

c—These figures do not cover trailer capacity.

Source: SSRF, Table 3; information from CSO.

loads from one origin to one destination, whereas intermediate journeys cover trips where loads are collected or delivered at a number of points. Table 35 shows that the utilisation of the "own account" sector seems to be higher than that of the other sectors: this comparison applies to vehicles of over 2 tons unladen weight.

A further method of examining the utilisation of vehicles is to look at the proportion of empty mileage. *A priori* one might expect that the "own account" sector would show up less favourably in this comparison. This sector is, for example, inhibited from filling return loads due to licensing provisions. It may also have grown more than is economically justifiable, due to the limitations placed on licensed hauliers' operation.

Nevertheless, the "own account" sector has a lower proportion of empty mileage than either of the "hire or reward" sectors: 30.4 per cent. compared with 35.7 per cent. for CIE and 42.4 per cent. for other licensed hauliers (SSRF Table 4). The proportion of empty mileage on "hire or reward" is surprisingly high. An *ex post* rationalisation for this might be the limitations placed on licensed hauliers (regarding area of operation, type of good carried etc.) and the nature of much of Irish transport activity—e.g. short-haul freight for the building industry.

These explanations may also account for the general poor showing of road freight operators, i.e. 31.3 per cent. of the mileage of all road freight operators is empty mileage (SSRF Table 4). Sexton (1966–67, Appendix Table B) shows that the proportion of empty mileage in Ireland for all journeys is much higher than in Britain—this discrepancy is especially marked for the "hire or reward" sector using vehicles of over 3 tons unladen weight.

8.5 Some General Considerations

Theoretically, a case can be made against a road haulage licensing system, other than a system which provides for conditions of work and fitness of vehicles. This case has been fully developed by Munby (1965).

Under certain circumstances, e.g. if there was pressure on road capacity, and spare capacity in the rail system, there would be a *prima facie* case for a diversion of traffic from road to rail. This is one of the justifications for the changes in the British

licensing regulations (*Transport Act 1968*). In Ireland, however, there is no evidence of considerable pressure on road capacity on most inter-urban routes. The railway system could hardly hope to be an economic carrier for much of the traffic shifted from road. There is a shortage of the heavy bulk long-distance flows which are inherently suited to rail transport. Examples of this type of traffic are coal, iron and steel, and extractive materials. Most of CIE's rail ton-mileage is general merchandise traffic—this accounts for 81 per cent. of total ton-mileage in 1966/67 (CIE, 1967).

One theoretical argument in favour of the liberalisation of road freight is that it could improve the utilisation of vehicles through the filling of capacity on return journeys. Under the present licensing system it is likely that vehicles carrying goods in one direction return empty in the opposite direction.

This argument gains force the longer the length of haul in question. The escapable costs directly attributable to the return load are little more than the extra cost of seeking out traffic, the cost of documentation and of extra mileage. They are of less relative importance, as a proportion of total round-trip costs, the longer the average length of haul.

The fact that much road transport in Ireland is short-haul diminishes the force of this argument. Excluding the activity of vehicles over 5 tons unladen weight, 59 per cent. of road freight tonnage is carried on journeys of up to 10 miles. Vehicles of over 5 tons unladen weight carry 41 per cent. of their tonnage on journeys of up to 10 miles.⁶¹ Where the length of haul is short, it may not be worth the lorry's effort to seek out return loads.

Also, the data given in the tables have shown that the utilisation of the capacity of the "own account" sector compares more than favourably with that of other sectors. This might further lessen the applicability of the back-haul factor.

Such comparisons as we have presented, and examination of vehicles performance based on the 1964 Survey are of limited usefulness in the road freight licensing debate. The Irish environment is likely to have special features which are absent in other countries, and there is no substitute for a comprehensive weighing up of costs and benefits due to our present licensing system.

⁶¹SSRF Table 5.

9. SUMMARY

The main findings of this paper are as follows, by section:

Section 1

In 1967 there were 0.109 private cars *per capita*

in Ireland. It is estimated that 36 per cent. of all households in 1966 owned cars, of which 33 per cent. owned one car and 3 per cent. owned more than one car.

The rate of growth of private car ownership in

Ireland has accelerated since 1958. The trend rate of growth of car ownership in the whole 1947-1967 period was 8.8 per cent. per annum, but since 1958 the trend rate of growth has been 9.5 per cent.

We project car ownership over the 1967-1985 period, taking no account of effects of possible changes in the methods by which road users pay for the use of congested roads. One of our main methods of projection is to relate the growth of car ownership to factors such as disposable income *per capita* and subsequently to make an estimate of the likely future rate of growth of disposable income. Car ownership is regressed on disposable income and on other variables over the 1947-1966 period. This time series work shows that, on average, each percentage increase in disposable personal income *per capita* is accompanied by an increase of about 3 per cent. in car ownership.

Regression analysis is also used taking observations from a number of countries and from Irish counties. This work confirms the relationship between car ownership and income which was established in the Irish time series, but gives lower elasticities of car ownership with respect to income than did the time series analysis.

The second main method is based on fitting a long term time trend to car ownership. One particular type of exponential curve, the logistic curve, is used. Our "logistic" method depends on the assumption of a saturation level of car ownership—i.e. a level beyond which cars *per capita* would cease to increase. The best estimate of a saturation level, although this is subject to quite a margin of error, is about 0.45 cars *per capita*.

The other methods which are used to project car ownership do not give very satisfactory results. One of these entails a study of the relationship between car ownership and variables such as income and family size, at the household level. Information from two different sources (i.e. Household Budget Inquiry and Farm Management Survey) is available on the relationship between car ownership and income at the household level, but it is not possible to combine these two sources because of the different income concepts used. Regression analysis based on Household Budget Inquiry data alone uses two independent variables—household income (significant coefficient with a positive sign) and household size (significant coefficient with a negative sign). The elasticity of car ownership with respect to household income, calculated from these equations, is 1.4 which is relatively near that derived from all the earlier cross-sectional analysis.

We try to derive a very approximate projection of car ownership, taking HBI data to represent the whole economy. This is based on an assumption of unchanged income distribution among Irish house-

holds. Disposable household income in 1965-66 is lognormally distributed. Using this distribution, we estimate the likely number of car-owning households in each income group. But this method seems to lead to a considerable underestimation of car ownership in future years.

In a purely empirical manner, for the projection, we accept one midway between the "regression" estimate and the "logistic" estimate. Our projection is of an increase in ownership from 0.109 cars *per capita* in 1967 to 0.179 in 1975 and 0.295 in 1985.

Section 2

In past years, the increase in goods vehicle numbers has not been striking. The carrying capacity of the goods vehicle fleet has however increased markedly (we estimate that it has increased by almost 50 per cent. since 1960). This increased capacity has been due to a big increase in the number of heavy goods vehicles being used (since 1960 the number of goods vehicles of over 5 tons unladen weight has more than doubled). This movement to larger vehicles means a big increase in effective capacity: not alone can these vehicles carry heavier loads but they also perform more miles per annum than the average. Our projections try to take account of this factor by firstly projecting both ton-mileage and carrying capacity; then we try to derive, through an iterative procedure, a projection of goods vehicles which would be consistent with these ton-mileage and carrying capacity estimates.

Our projections of ton-mileage and of carrying capacity are both based on a relationship over time with Gross Domestic Product plus imports. These projections are summarised in this tabulation:

Projections of Ton-Mileage and of Carrying Capacity

Year	Ton-Mileage (million)	Carrying Capacity (tons)
1967 (estimated)	1,222	133,200
1975	1,934	196,000
1985	3,135	300,000

Quite a marked increase in ton-mileage and in carrying capacity is projected, increases which are in line with trends since 1960. But since there is likely to be a continually increasing proportion of heavy goods vehicles in the fleet, our projected increase in vehicle numbers is not very large. The replacement of goods vehicles by heavier vehicles should account for a significant proportion of the increased ton-mileage.

Sections 3 and 4

The projection of motor cycle ownership assumes that the recent fall in ownership will continue, al-

though not at a very rapid rate. The projections of other vehicle numbers mainly rely on the extrapolation of past trends.

If we sum the projections made for each class of vehicle, they imply that total vehicles would increase from 476,000 in 1967 to 755,000 in 1975 and 1,003,000 in 1980. A summary of the projections is given in the following tabulation:

Projection of Vehicles 1967-1985

Year	Private Cars	Commercial goods vehicles	All vehicles
	'000	'000	'000
1967 (actual)	314	46	476
1970 ..	392	48	578
1975 ..	552	51	755
1980 ..	789	56	1,003
1985 ..	1,052	62	1,284

We estimate that the number of private cars will increase by 70 per cent. by 1975—i.e. from 314,000 to 552,000. Private car numbers would more than double, according to this projection, by 1980. The projection of private cars is based on a steady increase in population over the period (e.g. to 3.3 million in 1980).

Section 5

This section contains estimates of vehicle mileage on Irish roads over the period 1958-1966, based on fuel consumption data, coupled with direct information available from CSO's work. The estimates are summarised in the following tabulation, for 1958 and 1966:

Estimated Annual Mileage per Vehicle

	1958	1966
Private cars (incl. taxis) ..	11,100	10,800
Goods vehicles ..	7,100	9,400
All vehicles	9,500	9,800

The estimated average annual mileage by private cars has declined since 1958 and has been fairly static in recent years. It seems reasonable to assume, both from the Irish data and from data on other countries, that this average mileage should remain reasonably stable in future years. Although the proportion of Irish households owning more than one car should increase considerably in future years, on the evidence of British data this would not necessarily lead to a higher average mileage per private car.

The average annual mileage of private cars in Ireland is significantly higher than that in Britain. But the Irish estimate of average car usage is not unreasonably high when compared with certain other European countries, particularly the Nether-

lands and Denmark. One possible explanation for the discrepancy between Irish and British levels of usage may lie in a higher quality road system in Ireland (in terms of average speeds which can be maintained).

Goods vehicles' usage has been increasing in past years, and this trend should continue. This is a reflection of the increasing proportion of heavy vehicles in the goods vehicle fleet, which are more intensively used.

Section 6

This section concerns passenger traffic trends by road and rail. The number of passengers carried on omnibuses has declined slightly since 1955; omnibus passenger mileage has fluctuated within a range of about 650-760 million during most of these years.

On the rail sector, the number of passengers carried has decreased between 1958/59 and 1966/67, but due to an increase in average length of journey there has been an increase in passenger miles from 326 million in 1958/59 to 346 million in 1966/67.

In 1966 we estimate that private cars (including taxis) accounted for 83 per cent. of total passenger mileage, compared with 10 per cent. for omnibuses and 5 per cent. for the railways. The private car's share of passenger mileage is likely to increase in future years.

Section 7

This section deals with freight traffic by road and rail. The estimated ton-mileage carried by road transport has increased by 69 per cent. in the period 1960-1967.

On the rail system, the average length of haul of freight traffic has increased. The estimated rail share of total ton-mileage was 18 per cent. in 1966, its highest share since 1962. This share will probably decline, at least slightly, in future years.

Section 8

Some features of road transport are examined, with particular reference to road haulage licensing. With regard to the structure of the road haulage industry, the distribution of goods vehicles among hauliers is extremely skewed; most concerns own only one lorry, and there is one large concern (CIE).

The share of the "own account" sector in total freight activity is particularly high in Ireland, when compared with a number of European countries. Contrary to expectations, the "own account" sector's share of traffic does not decrease as the length of haul increases. These two features of road freight activity may be a reflection of the restrictions on haulage for hire or reward.

The utilisation of "own account" vehicles com-

compares more than favourably with other sectors—whether measured in terms of the proportion of carrying capacity filled, or in terms of the proportion of empty mileage travelled.

Some theoretical arguments with reference to road haulage licensing are also considered. Our comparative data may be of some help in the evaluation of road haulage licensing (and there is a con-

siderable amount of comparative data on Irish/British road freight patterns in Sexton, 1966/67). But comparative data are, of their nature, limited in their scope. There are circumstances peculiar to the Irish situation. Any thorough examination of road haulage licensing would of necessity be a complex benefit/cost exercise, which would need to take into account the implications for the rail system.

10. POSSIBLE FUTURE RESEARCH WORK

Already in this paper there have been a number of questions on which our knowledge is scanty and on which future work would be desirable. Here we bring together a number of these points, together with other suggestions regarding future research work which evolved from the work on this paper.

The results of the time series and cross-sectional analyses of private car ownership leave much to be desired. A promising approach might be one which makes use of the depreciated stock of cars concept (already referred to in Section 1.4) as a dependent variable in time series analysis, and uses a price index of all cars in use as one of the explanatory variables (if possible, taking account of the quality change factor which could be particularly relevant for private cars). It would also be desirable to integrate more satisfactorily the cross-sectional with the time series data, than we have done.

On the question of basic data which would help analyses of car ownership, the basic needs seem to be for information at the household level on ownership (including details on multi-car-owning households) and use; and their relationship with variables such as household income.

When projecting ton-mileage and carrying capacity, which projections were integrated with our projections of goods vehicle numbers, it was necessary to make many rather arbitrary assumptions. This was partly because there is only one cross-section, relating to 1964, which gives information on goods vehicle activities. More accurate information in future on trends in ton-mileage, vehicle mileage and average load would be of interest in itself and also as a means of estimating future goods vehicle numbers.

Even if one knew accurately the total ton-mileage in each year, projections of ton-mileage would ideally require some further information. This could, for example, take the form of projections of the value of sectoral outputs at constant prices which could be converted into tonnage by using certain factors, and the tonnage further converted into ton-mileage by making assumptions regarding the average

mileage of the goods. No information is available on the nature of firms' demand for road freight transport. Any survey data on, for example, the demand for freight transport by different types of industry, would help the projection of goods vehicles.

In the section on vehicle mileage we did not discuss the possible future levels of tourist traffic, with its pronounced seasonal pattern. This is a subject worth some attention.

We have not had an opportunity to build up any projections of passenger mileage. This could be done by either of two methods. Firstly, one could take the public transport passenger mileage figures and add estimates of private car and other passenger mileage. The resulting total could then be projected, possibly by using explanatory variables such as income *per capita*.

The second approach would be a more disaggregated one. Information from a travel survey would be necessary. This approach is based on an analysis of journeys by purpose—e.g. whether to/from work, to/from school, personal business, holiday travel. One could integrate into this study future assumptions concerning the rate of growth of the labour force (which influences commuter journeys) and assumptions concerning the numbers of school-going age. Certain types of journey (typically non-commuter and non-business journeys) should be more sensitive than others to the ownership of a car by the household, and assumptions concerning the future proportion of car owning households could also be integrated into this study. One of the most interesting features of this second approach is that it would give the opportunity to integrate a considerable number of assumptions concerning the future trend of factors such as working population.

The above disaggregated approach to the projection of passenger mileage illustrates one of the possible uses of a general travel survey. Such a survey at the household level, covering all types of travel by household members, could provide much valuable information on present patterns of transport demand.

The usefulness of survey data on the nature of firms' demand for road freight transport has already been mentioned in the context of goods vehicles' projections. Such information would be equally helpful in evaluating road haulage licensing. Such a survey could find the reasons for choice between various forms of road transport, and measure the relative importance of factors such as speed and reliability in road transport.

On the question of road haulage licensing, there are a number of specific problems which we did not have an opportunity to tackle, for example:

- (a) The case for a specific licensing system tailored to specific routes;
- (b) What are the extent of economies of scale in road haulage? This could be related to the skewed distribution of road hauliers in the country, already referred to, in which one concern has a relatively large share of the goods vehicles;

(c) The desirability of making a distinction between short and long distance haulage;⁶²

(d) The implications of changes in licensing arrangements for the rail system. This could involve an estimation of marginal costs on the rail system and a comparison of these with marginal costs of road haulage (possibly as reflected in road haulage charges);

(e) The difficult problems created by the creation of congestion costs on the roads (e.g. by heavy lorries). One possible justification for the maintenance of a road haulage licensing system is the existence of these congestion costs. The licensing system could be regarded as a type of control over road use.⁶³

⁶²In Belgium, France and Germany, a distinction is made between short and long distance road haulage, and the short distance haulage is free of many of the restrictions placed on long distance haulage. In these countries, an objective of the licensing system is to protect the railways, and it seems that short-distance road freight traffic is not thought to compete with the railways (see Bayliss, Brian J. 1965, pp. 66 ff.).

⁶³This point is discussed in Munby (1965).

APPENDIX A

ANALYSES CONCERNING CAR AND MOTOR CYCLE OWNERSHIP

A.1 Variability of Car Ownership and Motor Cycle Ownership among Irish Counties

Car ownership rates differ considerably among Irish counties (Table A1). The number of private cars *per capita* in 1966 ranges from .126 (Meath) and .123 (Tipperary N.R.) to .063 (Mayo) and .077 (Leitrim).

Multiple regression analysis is used in relating car ownership in these counties to certain economic variables. The hypothesis is that car ownership varies directly with income *per capita* and the proportion of population in a "high" social group, and inversely with population density and degree of urbanisation.

We test this hypothesis by least squares regression in the following ways:

linear :

$$P = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \dots + \alpha_n X_n + u$$

double logarithmic :

$$\log P = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \dots + \beta_n \log X_n + u$$

where: P = private cars per 1,000 persons in 1960;

X_1 = income *per capita* (£) in 1960;

X_2 = population density (persons per 1,000 acres) in 1961;

X_3 = percentage of population in urban districts in 1961;

X_4 = percentage of non-agricultural population in a high social group in 1961;

X_5 = percentage of total population in a "high" social group in 1961;

and where u is an error term.

Either personal income or income *per capita* can be used as an income variable. We use the regressions with firstly personal income *per capita* (X'_1) and secondly income arising *per capita* (X''_1) included as the income variable.

The year 1960 is chosen as the basis for the variables since it is close to the Census of Population of 1961 and is also the year to which our only county income figures relate (Attwood and Geary, 1963).

The following comments relate to the construction of the independent variables. Personal income is

income receivable by households from all sources, earned or not. It includes social security and other transfer payments, emigrants' remittances and dividends receivable.

In calculating X_4 we exclude the two social groups "farmers, farmers' relatives and farm managers", and "other agricultural occupations and fishermen".⁶⁴ Of the remaining population, those over fourteen years of age and in the following social groups are expressed as a proportion of the total: higher professional, lower professional, employers and managers, salaried employees. This calculation is limited to males (whether gainfully or not gainfully occupied) and females who are gainfully occupied.

In calculating X_5 we add in the agricultural sector. Since there are only two social groups covering this sector, we must use a proxy for social group. Two such proxies suggest themselves—an indicator of acreage or of rateable valuation. The latter is chosen, since an acreage classification might conceal great differences in productivity between farms of different sizes. The number of male and female farmers whose farms have a rateable valuation of £30 or over is added to the "high social group non-agricultural population" in variable X_5 and expressed as a proportion of total non-agricultural (male and female gainfully employed) plus agricultural (male and female farmer) population. This £30 dividing line is an arbitrary assumption.

It would have been desirable to test these regressions with Counties Cork, Limerick and Waterford divided into County Borough and County Council areas, and Tipperary divided into North and South Ridings. Such an approach is not possible since no published income figures are available for County Boroughs or other administrative areas which are smaller than counties.

The basic data on which the regressions are based are given in Table A1. A step-wise regression programme is used. Any independent variable for which the regression coefficient does not differ significantly from zero at the 10 per cent. significance level (by the t test) is dropped, and the regression is recalculated. But if the F ratio decreases significantly after the dropping of a certain variable, then this variable

⁶⁴For a list of the social groups and of the occupations assigned to them see CSO (1963, Appendix C).

TABLE A1: PRIVATE CAR OWNERSHIP AND OTHER ECONOMIC VARIABLES, IRISH COUNTIES, 1960

County	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	
	Private Cars per 1,000 persons	Y ₁	Motor Cycles per 1,000 persons	Y ₂	Personal Income per capita X ₁ '	Income Arising per capita X ₁ ''	Population density (persons per '000 acres) X ₂	Percentage of population in Urban Districts X ₃	Percentage of Non-Agricultural population in a "high" social group X ₄	Percentage of Total population in a "high" social group X ₅
					£	£		%	%	%
Carlow	..	67.7	14.9	215	172	151	23	23	15	24
Cavan	..	50.4	8.2	164	128	121	6	6	17	19
Clare	..	44.5	7.3	167	129	94	12	12	17	19
Cork	..	65.7	14.7	199	184	179	33	33	16	20
Donegal	..	41.7	11.0	153	119	95	0	0	6	14
Dublin	..	68.9	23.5	231	259	3,154	12	12	17	17
Galway	..	43.0	5.3	178	136	102	55	55	21	18
Kerry	..	47.0	7.1	174	135	100	18	18	16	16
Kildare	..	68.8	18.0	227	193	154	12	12	13	18
Kilkenny	..	69.2	12.9	219	177	121	16	16	16	28
Laoighis	..	71.4	10.9	204	164	106	0	0	15	24
Leitrim	..	52.7	7.7	167	120	89	0	0	22	13
Limerick	..	59.6	12.8	204	172	201	38	38	16	22
Longford	..	56.8	7.7	170	116	119	12	12	17	21
Louth	..	58.7	18.9	180	186	332	55	55	13	16
Mayo	..	35.2	6.9	153	113	92	12	12	20	12
Meath	..	72.8	15.0	222	174	113	12	12	14	28
Monaghan	..	50.9	8.7	175	134	148	22	22	18	23
Offaly	..	61.0	14.6	200	163	104	18	18	14	23
Roscommon	..	43.8	5.6	170	128	97	0	0	21	19
Sligo	..	44.7	9.8	174	139	121	25	25	19	17
Tipperary	..	74.4	9.9	212	170	118	28	28	16	26
Waterford	..	64.4	17.8	218	187	157	47	47	16	22
Westmeath	..	62.1	13.4	204	154	121	6	6	17	25
Wexford	..	60.2	15.5	185	148	143	26	26	16	25
Wicklow	..	61.7	10.4	203	158	117	35	35	17	22

Source: Cols. (2) and (3): SA 1961; CP 1961, Vol. I, Table 3.

Cols. (6) and (7): CP 1961, Vol. I, Table 9.

Cols. (8) and (9): CP 1961, Vol. III, Table 7; information from CSO.

TABLE A2: REGRESSION OF CAR OWNERSHIP (P) ON SETS OF INDEPENDENT VARIABLES: IRISH COUNTIES: LINEAR EQUATIONS

Equation Number	Constant Term	Coefficient					R ²	
		X ₁	X ₁	X ₂	X ₃	X ₄		X ₅
A1	-14.04	0.3515 (0.06751)***		-0.00009307 (0.002072)	-0.04139 (0.06229)	-0.3892 (0.3156)	0.5709 (0.3291)	.852
A2	-21.98	0.3533 (0.05066)***					0.5907 (0.2729)*	.836
A3	-22.91	0.4213 (0.04268)***						.802
A4	-8.633		0.3226 (0.05789)***	-0.006771 (0.002859)*	-0.1540 (0.06782)*	0.02848 (0.3263)	0.9879 (0.2623)**	.863
A5	-7.957		0.3205 (0.05132)***	-0.006683 (0.002613)*	-0.1524 (0.06382)*		0.9912 (0.2534)***	.863
A6	-1.317		0.2020 (0.03287)***				1.341 (0.2427)***	.806
A7	17.8		0.2553 (0.0472)***					.545

is reinserted into the equation. This procedure is repeated at each subsequent significance level.

In general the linear equations fit the data slightly better, as measured by R², and of the linear equations those incorporating income arising *per capita* give better results in almost all cases. Table A2 shows the results of linear equations only (log-log results are available on request). The log-log equations point to the same significant independent variables as do the linear equations.

With personal income *per capita* included instead of income arising *per capita* in the regressions, the R² are only slightly lower, but the coefficients not so significant. The one exception is the simple regression of car ownership on personal income in Equation (A.3), which shows a high R² (80 per cent. of the variability in car ownership being explained) and a highly significant coefficient. The data for this simple regression are shown in Chart A1.

In summary, either Equation (A.2), (A.3) or (A.5) would seem to represent the most satisfactory fit to the data of the linear equations, the latter two equations yielding coefficients which are very highly significant.

Equation (A.2) shows that car ownership is positively correlated with both personal income *per*

capita and the proportion of total population in a "high" social group. Equation (A.5) shows that car ownership is positively correlated with both income arising *per capita* and the proportion of total population in a "high" social group, and negatively correlated with both population density and urbanisation.

Motor cycle ownership

A similar cross-section regression is applied to motor cycles per 1,000 persons (MC), in Irish counties in 1960. Although the same independent variables are used as in the car ownership regressions, the hypothesis is different. We expect that motor cycle ownership is negatively correlated with income *per capita* and with the proportion of the population in a "high" social group, and positively correlated with population density and urbanisation. These *a priori* expectations are consistent with the discussion of motor cycle ownership in Section 3.

The basic data are given in Table A1. Full results are not given (although are available on request). Once again the linear equations give more significant results. The following equation seems to be the best from the statistical point of view:

$$(A.13) \quad MC = -0.1227 + 0.1168X''_1 - 0.3679X_4 \quad R^2 \\ (0.01338)*** (0.1384)* \quad .814$$

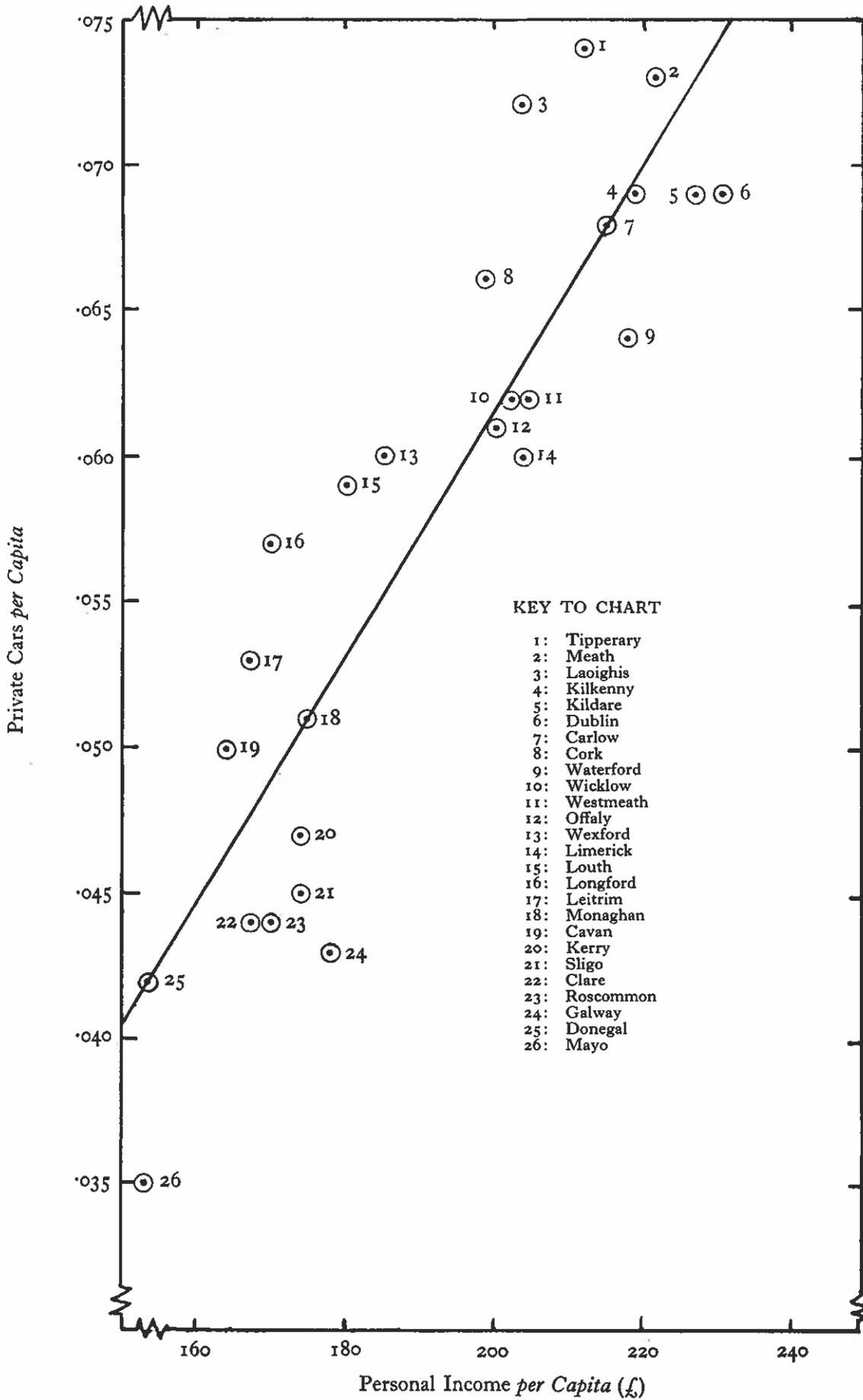
This equation has significant coefficients of X''₁ (income arising *per capita*) and X₄ (proportion of non-agricultural population in a "high" social group). But the coefficient of X''₁ is positive, which is contrary to our expectations. The sign of the

coefficient of X₄ is negative, which is what was expected.

The only other interesting equation is the following:

$$(A.7b) \quad MC = 0.9103 + 0.09474X'_1 + 0.003032X_2 \quad R^2 \\ (0.02283)*** (0.0008728)** \\ + 0.06417X_3 - 0.5481X_4 \quad .782 \\ (0.03072)* (0.1569)**$$

CHART A1: PRIVATE CAR OWNERSHIP AND PERSONAL INCOME *PER CAPITA*: IRISH COUNTIES, 1960



Source: Table A1.

In this equation the sign of the income variable (personal income *per capita*) is again positive. Once again the sign of X_4 is significant and negative. The two other coefficients in this equation are both significant, i.e. X_2 (population density) and X_3 (urbanisation). Both X_2 and X_3 are positive in sign, as was expected.

A.2 Household Car Ownership

A.2.1 Relationship between car ownership and household variables based on HBI

In this section we try to establish a relatively simple relationship between car ownership and variables such as household income, using the HBI results. We do not test the possibility of using discriminant analysis applied to the household cross-section.⁶⁵ Neither did we have an opportunity to test whether a useful relationship could be established between expenditure on car purchase (taking the net expenditure, i.e. selling price less trade-in value) and household income.⁶⁶

Firstly, we look at Table A3 which shows car ownership among households in various disposable household income groups. Disposable income is equal to gross household income (i.e. direct income

plus transfer payments) less direct taxation. It is, therefore, not unlike the disposable personal income variable which we used in the Irish time series analysis.

Households with a disposable income exceeding £20 per week have a much higher car ownership than those below this income level. This might at first seem to confirm the "threshold" hypothesis (which Reynolds 1963 discusses), i.e. that once a certain income level is exceeded, the propensity to own cars increases markedly.

But the data in Table A3 are suspect for the following reason: Income is understated in the HBI (see report on HBI 1965-66). Total expenditure from HBI is greater than total income (this can be seen from Table C6). In addition, the degree of understatement of income may not be uniform between income classes (see report on HBI 1965-66 for a reference to this point).

Therefore, for these reasons, when analysing the HBI data, we follow the usual procedure and take total household expenditure as a proxy for income in regression analysis. The best solution is to group the households according to stated income, and to take total expenditure as the independent variable in the regression analysis. The regression coefficients may still be slightly biased, even after this procedure.

In Table C6 the data are grouped by Disposable Household Income and Household Size. There are four household size groups within each of the four disposable income groups. This gives 16 "cells", i.e. 16 observations. Table C6, and all other tables based on HBI in this paper which give data based on disposable household income, do not appear in the CSO's Report on HBI. These data were, on request, specially compiled by CSO for use by ESRI.

Chart A2 is based on Table C6 and shows the relationship between ownership of cars and average household income (taking average total household expenditure as a proxy for income). This chart shows no evidence of the "threshold" effect.

Regression analysis is now used. From now on, all references to regression analysis in relation to "income" relate in fact to the "expenditure" data contained in the last two Columns of Table C6. We test two different formulations. In the first formulation household size⁶⁷ is introduced as an explicit variable. In the second formulation, the independent variable is income *per capita*. Household size appears implicitly in this latter form.

⁶⁷When calculating household size, each member of the household, of whatever age, is regarded as equivalent. It would have been possible to use equivalent adults (as used by Leser, 1962 in his analysis of HBI 1951-52, for example). But we have throughout the paper counted all age groups as equivalent in calculating *per capita* figures; also equivalent adults seems more suited to discussion of expenditure patterns rather than of consumer durable ownership.

TABLE A3: CAR OWNERSHIP IN HOUSEHOLDS: HBI DATA

Disposable Household Income per week	Percentage of Households Which Own a Car ^a
Under £4	0.3
£4 but under £7	3.3
£7 " " £10	7.4
£10 " " £15	18.2
£15 " " £20	32.4
£20 " " £25	44.1
£25 " " £30	47.9
£30 " " £40	53.6
£40 " " £50	67.6
Over £50	73.4

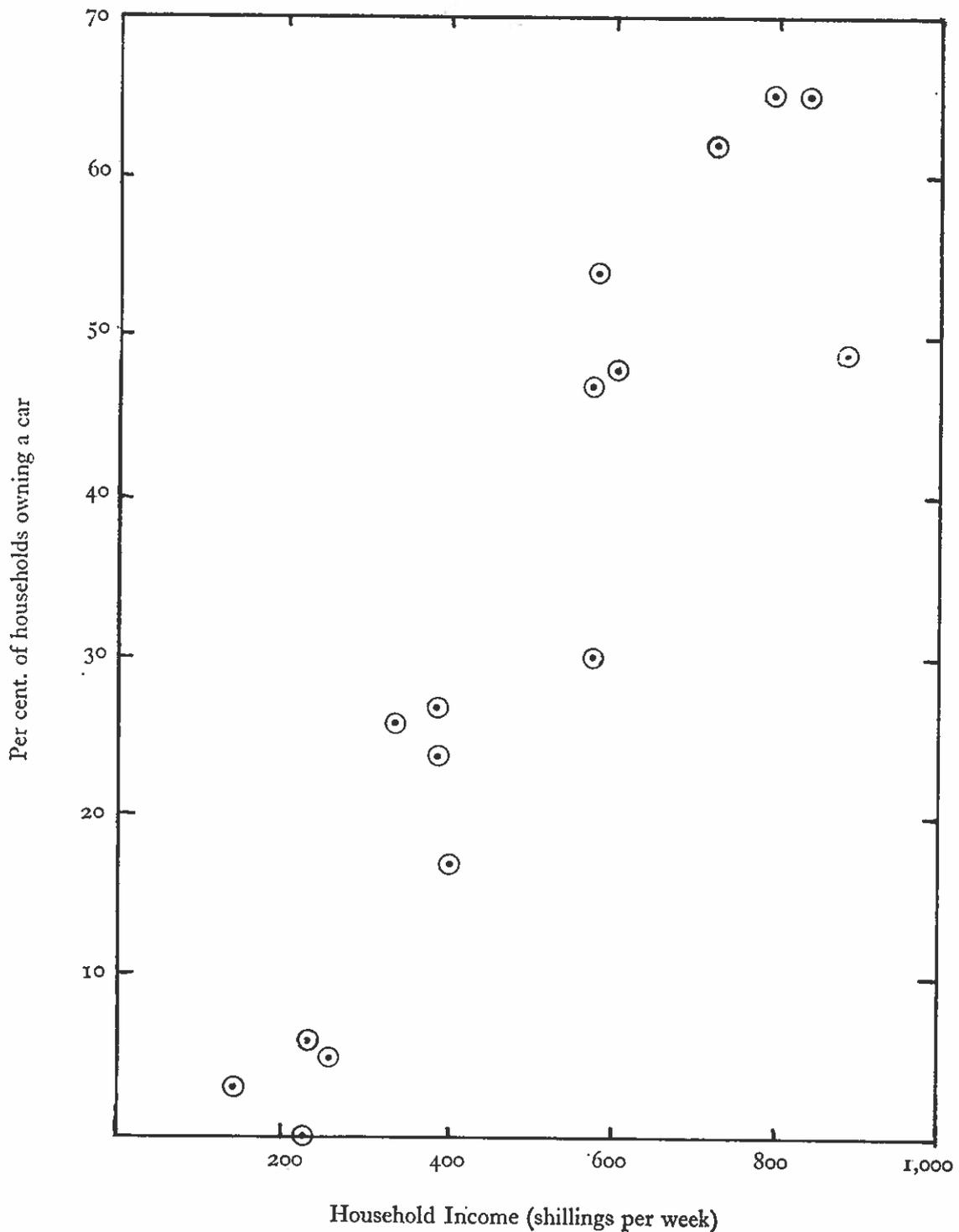
Note a—It is not known what proportion of these households own more than one car.

Source: HBI 1965-66.

⁶⁵An interesting application of discriminant analysis as applied to car ownership data is available in Meron's work (Meron, 1967a, 1967b). This method assigns an "index" Z which enables every observation to be allotted to either the car-owning or the non-car-owning household population. Variables such as population density and household income can be selected to determine the "index".

⁶⁶A useful illustration of this approach is provided by the work of Mogridge (1967). He determines the expenditure on car purchase at each income level, and derives a function which states, for each income level, an average expenditure on car purchase. He then examines the relationship between this function of stock value, car ownership level and the structure of the car population.

CHART A2: CAR OWNERSHIP^a IN IRELAND, COMPARED WITH HOUSEHOLD INCOME^b



NOTES: *a*—The figures take no account of multiple car ownership.

b—Average total household expenditure is used as a proxy for household income.

Source: Table C6.

The first formulation tested is as follows:

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + u$$

where: Y = proportion of households which own a car (%);

X₁ = average income per household (shillings per week);

X₂ = average number of persons per household.

The second formulation is:

$$Y = \beta_0 + \beta_1 X_3 + u$$

where: Y = proportion of households which own a car (%);

X₃ = income *per capita* (shillings per week).

As well as the above linear formulations, we test log-log formulations, where all the variables are in logs, including persons per household.

Most of the regression analysis is based on the grouping by Disposable Household Income and Household Size, since Disposable Income seems to be a more realistic variable for our purposes. As a check, a limited number of regressions are based on the grouping by Gross Household Income and Household Size.

The following are the results of the regressions, when the data are grouped by Disposable Household Income × Household Size (basic data for the regressions are in Table C6):

	R^2
(A.8) $Y = -1.177 + 0.095X_1 - 2.761X_2$ (0.005)*** (0.557)***	.953
(A.9) $Y = -11.52 + 0.090X_1$ (0.009)***	.863
(A.10) $Y = 11.53 + 0.158X_3$ (0.044)**	.475
(A.11) $\log Y = -15.54 + 2.468 \log X_1 - 0.7916 \log X_2$ (0.3734)*** (0.3414)*	.773
(A.12) $\log Y = -15.37 + 2.257 \log X_1$ (0.4149)***	.679
(A.13) $\log Y = -8.813 + 1.531 \log X_3$ (0.3936)**	.519

When the data grouped according to Gross Household Income × Household Size are used, the results are not markedly different, whether for the linear or the log-log regressions. Therefore we concentrate on the above results.

Equation (A.8)—in which household size is introduced as an explicit variable—gives a much better fit than does Equation (A.9). The two coefficients in (A.8) are highly significant, and the R² of .953 is very high for a cross-section. The signs of the coefficients in this equation are what we expect: car ownership positively correlated with household income and negatively correlated with household size. The coefficient of household size means that, leaving aside the influence of household income, households with a higher family size tend to have a lower car ownership.

If we ignore for the moment the problems created by multi-car households, the Y values in the above regressions comprise the number of cars per 100 households.⁶⁸ Accepting this approximation, the

ownership elasticity of cars per household, with respect to household income is 1.4. This is calculated from Equation (A.8) at the joint means ($\bar{Y} = 33$, $\bar{X}_1 = 494.1$). This elasticity is quite near the cross-sectional elasticities already calculated from data on Irish counties—i.e. 1.17 in the linear equation and 1.46 in the log-log equations (both with respect to personal income *per capita*).

A.2.2 Relationship between car ownership and farm income, based on FMS

Table A4 shows car ownership on Irish farms by acreage, and Table A5 car ownership on Irish farms by family farm income.

Family farm income is gross output less net expenses. It is the return to the farm labour, managerial input and capital investment. It excludes income derived from non-farm activities, and is therefore not an ideal measure of income.

In a relatively small number of cases, family farm income is a negative quantity. In such a case the farm is running at a loss, and can only exist for a certain amount of time, e.g. by selling off stock (leaving out of account its possible sources of non-farm income).

⁶⁸If there were a significant number of multi-car households in the HBI sample, then the correct number of cars per 100 households would be somewhat higher.

TABLE A4: CAR OWNERSHIP ON IRISH FARMS BY ACREAGE 1966/67

Unadjusted Acreage ^a	Proportion of Farms Owning a car
5-15	8
15-30	18
30-50	26
50-100	55
100-150	70
150-200	74
200-300	84
Over 300	72

Note: a—This acreage is not adjusted—i.e. it is not strictly equivalent to the total effective acreage farmed.

Source: FMS 1966/67.

TABLE A5: CAR OWNERSHIP ON IRISH FARMS BY FAMILY FARM INCOME, 1966/67

Annual Family Farm Income	Proportion of Farms Owning a Car
	%
Less than £0	38
£0 to £199	17
£200 to £399	24
£400 to £599	44
£600 to £799	59
£800 to £999	67
£1,000 to £1,299	78
£1,300 to £1,599	94
£1,600 to £1,999	93
£2,000 to £2,599	97
Over £2,600	87

Source: FMS 1966/67.

These tables show that the proportion of farms which are car-owners becomes very large in the higher acreage groups and the higher income groups. There is a very high proportion of car-owning farms in the income groups exceeding £800 per annum.

Since the FMS does not provide data on all sources of income from farms, it is not possible to integrate the car ownership data from the HBI and the FMS.

A.2.3 Projection of car ownership based on household car ownership data

An attempt was made to project car ownership by using ownership data related to household income.⁶⁹ This method gave unrealistically low estimates of future car ownership, and on further examination seemed to be basically unstable. A summary of this approach, rather than the results, is presented here. The basic assumptions are that:

- (a) the distribution of household income remains the same in future years;
- (b) the proportion of car-owning households in each income group remains the same in future years.

⁶⁹This method, though much less sophisticated, owes much to the work of Faure (1959), and of Vermetten (1964).

Therefore if assumptions are made concerning the future level of household incomes, one can calculate the future proportion of households in each income group. One can thereby estimate the overall proportion of car-owning households.

A common assumption with regard to income distributions is that of lognormality. It is possible to use an approximate graphic method to check the Irish household income distribution for lognormality (see Aitchison and Brown, 1957, pp. 31-33). The cumulative distribution of disposable household income given in Table A6 is used.

TABLE A6: CUMULATIVE DISTRIBUTION OF DISPOSABLE HOUSEHOLD INCOME, 1965-66

Disposable Household Income per Week	Proportion of Families with Incomes less than this income
£	%
4	6.40
7	14.50
10	22.23
15	43.54
20	63.50
25	75.61
30	84.11
40	93.84
50	97.37

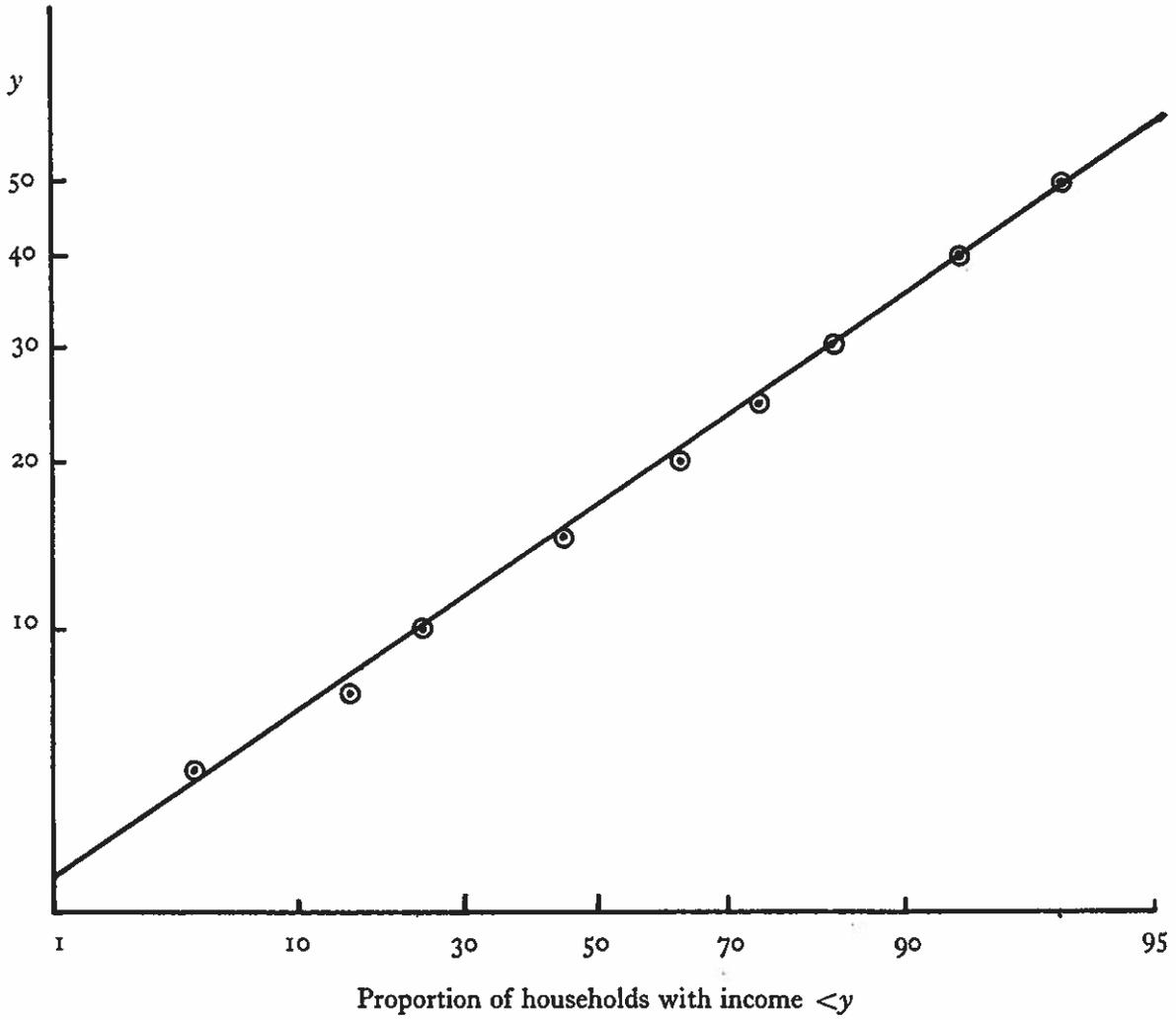
Source: HBI 1965-66.

The values from Table A6 are plotted on logarithmic probability paper—i.e. in Chart A3. In this chart the scale of ordinates is graduated logarithmically and on the abscissa the proportions are plotted as their equivalent normal deviates. Clearly the points on this chart lie very close to a straight line. The straight line in Chart A3 is fitted by eye to the points. Although this method is not a rigorous test of lognormality, the approximation to a straight line is so close that we deduce that household income is lognormally distributed. It is also possible to estimate the mean and standard deviation of the distribution, with reasonable accuracy, from Chart A3 (see Aitchison and Brown, 1957, p. 32). The estimated mean of the distribution, $\mu = \log_e 16.5$.

Based on the income distribution in Chart A3 it is possible to estimate the likely future distribution of household income. The resulting estimate of the proportion of car-owning households is integrated with an estimate for “non-HBI” areas which is in proportion to the estimated increase in “HBI” ownership.

The resulting unrealistically low projection of car ownership is probably due to the highly simplified approach, the tenuous assumptions made and the use of HBI data to represent the country as a whole. Also, car ownership is likely to increase “autonomously” over time (i.e. independently of income changes).

CHART A3: DISTRIBUTION OF HOUSEHOLD DISPOSABLE INCOME, 1965-66



Source: HBI 1965-66.

A.3 Data on New Registrations and Scrappage

This method of projecting car ownership is based on a simple identity. The addition to cars in use each year equals new registrations less the number of cars scrapped. Therefore, if we can project new registrations, and deduct our projection of the number of cars scrapped, we can derive a projection of net annual additions to cars in use.

It is rather difficult to project the number of new registrations particularly over the fairly long period which we have in mind. There is no discernible trend over time in the level of new car registrations per 1,000 persons, as can be seen from Table C13. Since 1960, new registrations per 1,000 persons have fluctuated between 9.9 and a "high" of 15.1. The amount of new registrations per annum is highly susceptible to fluctuations in economic activity. A model which would satisfactorily explain new registrations would most likely be a set of simultaneous equations. It would use the relationship between new registrations (R) and the level of car ownership (P) or possibly lagged car ownership, and

the relationship between each of these variables and explanatory variables such as disposable income. We simply test single equation formulations.

We use time series analysis relating to the 1947-1966 period.⁷⁰ Our hypothesis takes the following forms:

$$R = \alpha_0 + \alpha_1 D + \alpha_2 HP + \alpha_3 t + u$$

$$\log R = \beta_0 + \beta_1 \log D + \beta_2 HP + \beta_3 t + u$$

where: R = new registrations per 1,000 persons;

D = disposable personal income *per capita* at constant prices (£);

HP = hire purchase dummy variable = 1 for 1957 and 1966, but 0 for all other years;

t = time = 0 at 1947.

The results of the regressions are given in Table C7. Of these regression equations, the following gives the most satisfactory result:

$$(A.14) R = -17.94 + 0.1468D - 1.767HP$$

(0.007835)*** (0.6625)*

R^2	d
.955	1.75

In this equation, the coefficient of both D and HP are significant at the 5 per cent. level and each has the sign we expected. The equation which incorporates both D and the time trend has a significant coefficient for D but a non-significant coefficient for t.

The simple regression of R or D is also satisfactory in terms of goodness-of-fit, but the above equation is chosen for projection purposes, due to its higher R^2 .

In addition to projecting new registrations, it is necessary to deduce the likely future pattern of car scrappage. The scrappage rate of private cars is estimated as follows: Let the number of private cars at August in year t (August being the month in which the annual count of vehicles is made) be P_t and let the number of new registrations in the twelve months ending July of year t be R_t . Then the number of cars scrapped is equal to $R_t - (P_t - P_{t-1})$. Table A7 and Chart A4 show the new registrations and scrappage of private cars in each year ended July, since 1950.

If the number of cars scrapped in the twelve months ending July of year t is taken as a function of P_{t-1} , it is possible to calculate scrappage rates. These calculations are shown in Table A7. Over the past twelve years the scrappage rates have remained reasonably constant, at around 7-8 per cent. per annum.

TABLE A7: PRIVATE CARS IRELAND: NEW REGISTRATIONS AND SCRAPPAGE, 1950-1967

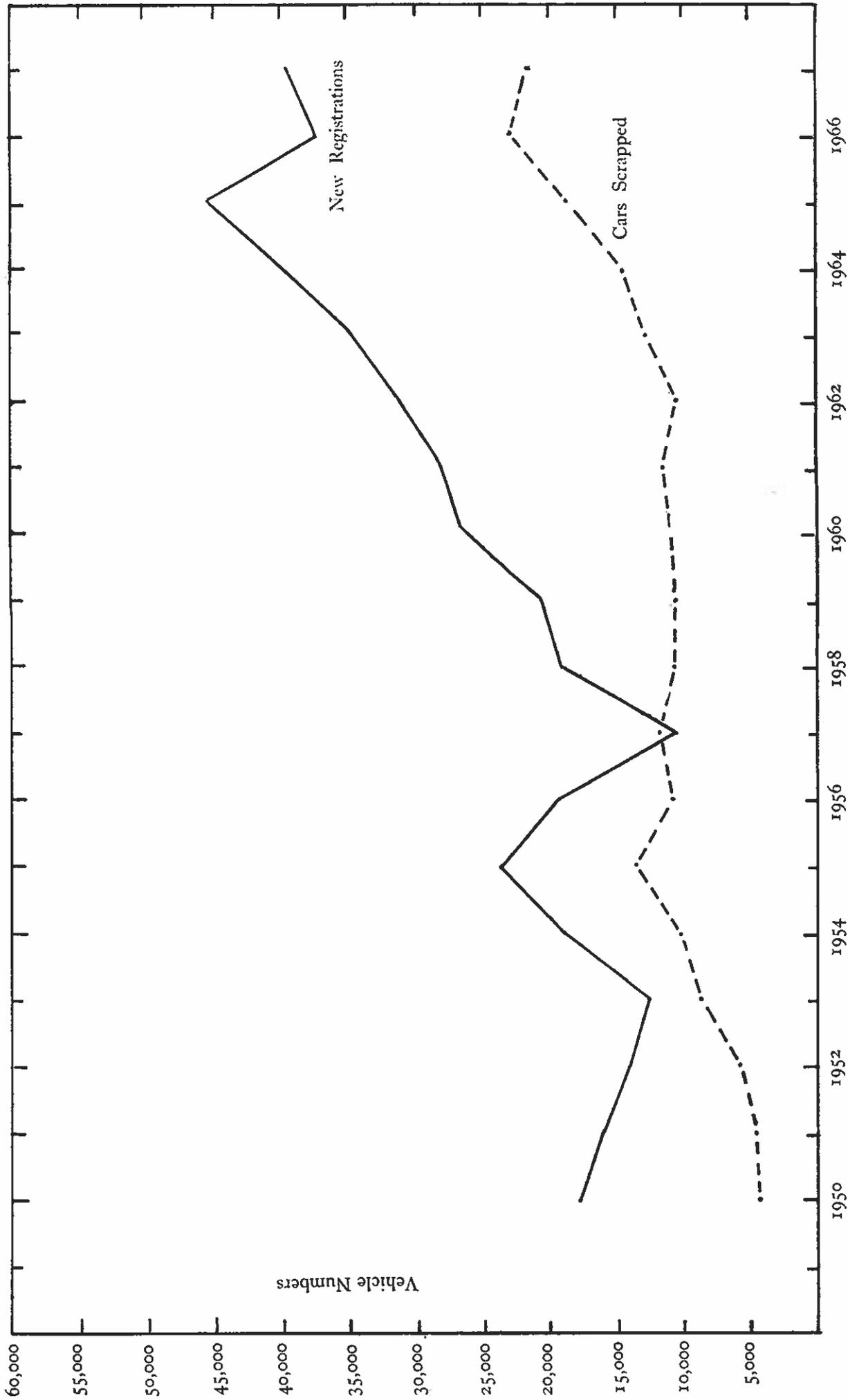
Year	New Registrations year ended July	No. of Cars Scrapped year ended July	Scrappage Rates %
1950 ..	17,695	4,466	6.21
1951 ..	16,087	4,513	5.30
1952 ..	14,005	5,819	6.02
1953 ..	12,404	8,499	8.10
1954 ..	18,764	10,109	9.29
1955 ..	23,688	13,637	11.61
1956 ..	19,302	10,852	8.51
1957 ..	10,709	11,657	8.57
1958 ..	19,041	10,686	7.91
1959 ..	21,455	10,769	7.51
1960 ..	26,534	10,907	7.08
1961 ..	28,102	11,481	6.77
1962 ..	31,177	10,313	5.54
1963 ..	34,775	12,816	6.19
1964 ..	40,056	14,687	6.41
1965 ..	45,562	18,608	7.31
1966 ..	37,497	22,573	8.02
1967 ..	39,763	21,701	7.32

Source: SA: DLG Annual Census.

Equation (A.14) is used to project new registrations *per capita*. This projection is combined with assumptions concerning scrappage rates and a projection of car ownership results.

⁷⁰We have concentrated on relatively simple formulations, using parameters estimated over the 1947-1966 period. No attempt has been made (as in the section on private car ownership) to study the 1947-57 and 1958-66 periods or to examine the hypothesis that a structural change in the economy since 1958 would have affected the relationship established.

CHART A4: PRIVATE CARS, IRELAND, NEW REGISTRATIONS AND SCRAPPAGE, 1950-1966



Years ended July

Source: Table A7

Taking Equation (A.14) as the basis, Table A8 shows the levels of new registrations associated with alternative growth rates of disposable income. Table A8 is drawn up on the assumption of no hire purchase restrictions (and therefore variable $HP=0$).

TABLE A8: PROJECTION OF NEW REGISTRATIONS PER 1,000 PERSONS, ASSUMING ALTERNATIVE GROWTH RATES OF INCOME

Year	Average Growth of Real Disposable Personal Income (per cent per annum)			
	2.5	3.0	3.5	4.0
1967 (actual)	14	14	14	14
1970 ..	18	19	20	20
1975 ..	23	25	27	29
1980 ..	28	32	35	39
1985 ..	35	40	45	51

As was done in the section on projected car ownership, the following assumptions are made concerning the average growth of real disposable personal income: 4.0 per cent. per annum 1966-

1970; 3.5 per cent. per annum 1970-1980; 3.0 per cent. per annum 1980-1985. It is also assumed, based on Table A7 that the average scrappage rate in the future will be 7 per cent. per annum. The projection of new registrations, and of car ownership given in Table A9 is then obtained.

The outcome of this projection is a car ownership of .206 *per capita* in 1975 and .380 *per capita* in 1985. This projection is considerably higher than those which we have made earlier. It is felt to be unreliable, partly because of the number of assumptions which have been necessary to derive it.

TABLE A9: PROJECTION OF NEW CAR REGISTRATIONS AND OF CAR OWNERSHIP, 1967-85

Year	New Registrations per 1,000 persons	Private Cars <i>per capita</i>
1967 (actual) ..	14	0.109
1970	21	0.141
1975	28	0.206
1980	36	0.287
1985	45	0.380

APPENDIX B

VARIABILITY OF LIGHT GOODS VEHICLE OWNERSHIP AMONG IRISH COUNTIES

A cross-section of observations is taken from the Irish counties in 1962,⁷¹ and we try to explain their ownership in terms of explanatory variables such as income *per capita* and characteristics of the retail trade. Information was not yet available at the time of writing from the *Census of Distribution and Services 1966*, and it is necessary to rely on information from the *Census of Distribution 1956*.

We test whether there is any cross-substitution between light commercial vehicle ownership and car ownership, by including car ownership as an

⁷¹The year 1960 (for which county income figures are available) or the Census of Population year of 1961 would have been more appropriate years. This was the earliest year for which information on the ownership, by county, of light commercial vehicles was available.

independent variable. We also test, as in the passenger cars regressions, whether ownership of "light vans" is related to either population density or urbanisation (proportion of population in urban districts).

The dependent variable is the number of light commercial vehicles per 1,000 persons⁷² owned in each county (Y). This is taken as either the number of commercial vehicles of 1 ton unladen weight or under per 1,000 persons (Y_1), or the number of commercial vehicles of $1\frac{1}{2}$ tons unladen weight or under per 1,000 persons (Y_2).

⁷²Each county's population in 1962 is estimated by linear extrapolation from CP 1961 and CP 1966.

TABLE B1: OWNERSHIP OF LIGHT COMMERCIAL VEHICLES, AND CERTAIN ECONOMIC VARIABLES, IRISH COUNTIES 1962

County	Commercial goods vehicles per 1,000 persons, 1962		Private cars per 1,000 persons 1962 X_2	Sales per retail trade establishment 1956 £'000	Percentage at work in tertiary sector 1961 X_8
	1 ton unladen weight or under Y_1	$1\frac{1}{2}$ tons unladen weight or under Y_2			
(1)	(2)	(3)	(4)	(5)	(6)
Carlow	8.1	9.1	80.7	7.6	35.0
Cavan	9.8	10.9	62.7	5.3	25.1
Clare	9.6	10.3	58.4	3.0	26.5
Cork	12.4	14.3	80.2	5.9	40.3
Donegal	6.7	8.1	52.7	4.8	29.1
Dublin	9.0	11.0	83.2	15.4	60.5
Galway	6.5	7.1	52.6	5.4	28.0
Kerry	6.6	7.8	59.2	3.9	30.6
Kildare	7.8	8.8	82.3	7.3	41.4
Kilkenny	6.1	6.9	78.6	6.0	31.7
Laoighis	6.0	7.1	85.7	6.2	29.4
Leitrim	7.6	8.3	68.2	3.9	20.8
Limerick	8.2	9.8	73.3	5.7	42.6
Longford	5.6	10.1	73.1	5.3	27.1
Louth	9.8	11.1	73.1	8.2	41.0
Mayo	4.9	6.0	45.1	4.1	23.1
Meath	11.4	12.6	87.4	5.6	30.1
Monaghan	11.2	12.7	64.3	6.4	29.4
Offaly	6.4	7.7	71.0	6.3	27.3
Roscommon	5.6	6.3	51.7	4.0	21.6
Sligo	9.8	10.7	54.7	5.0	30.4
Tipperary	8.1	9.2	88.2	5.1	32.3
Waterford	9.0	10.9	76.6	7.2	42.7
Westmeath	6.9	7.8	74.9	5.9	39.9
Wexford	11.4	12.6	75.8	7.3	36.3
Wicklow	13.0	14.2	76.8	7.3	43.9

Source: cols. (2), (3): Information from DLG; CP 1966 Vol. I Table III.
 col. (4): SA.
 col. (5): *Census of Distribution 1956*, Table 2B.
 col. (6): CP 1961 Vol. IV Table 4.

The hypothesis takes the following forms:

linear:

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \dots + \alpha_n X_n + u$$

double logarithmic:

$$\log Y = \beta_0 + \beta_1 \log X_1 + \beta_2 \log X_2 + \dots + \beta_n \log X_n + u$$

where: Y = number of light commercial vehicles per 1,000 persons in 1962.

X₁ = income *per capita* (£) in 1960.

X₂ = private cars per 1,000 persons in 1962.

X₃ = population density (persons per 1,000 acres) in 1962.

X₄ = percentage of population in urban districts in 1961.

X₅ = total sales (£'000) per retail trade establishment in 1956.

X₆ = percentage of persons at work in the tertiary sector (building and construction are excluded but commerce and other services are included) in 1961.

and where *u* is an error term.

Once again it is possible to use personal income or income arising as our income measure. The regressions are tested with firstly personal income *per capita* (X'₁) and secondly income arising *per capita* (X''₁) included as the income variable.

The data (except for values of explanatory variables already given in Table A1) are outlined in Table B1, and the results of the regressions are given in Tables B2 and B3. The step-wise regression programme described in Appendix A is again used.

In the regressions which have Y₁ as dependent variable, the results are quite poor: no coefficient is significant at the 5 per cent level, and only 29 per cent. of the variability in light commercial vehicle ownership is explained. Equation (B.2) is similarly unsatisfactory.

The regressions with Y₂ as dependent variable are more satisfactory. The best overall equations are (B.4) and (B.9). Equation (B.9) explains 46 per cent. of the variability in light commercial vehicle ownership and all the coefficients are significant at the 5 per cent. level. This equation shows that "light vans" ownership is negatively correlated with personal income *per capita*, and positively correlated with both private car ownership and urbanisation. The coefficient of car ownership (i.e. the cross-substitution term) is the opposite to what had been expected.

In summary, the results do not conform very well with our expectations. It had been expected that the ownership of light commercial vehicles would be positively correlated with variables such as retail sales, and that it would be negatively correlated with car ownership. Neither of these postulates is confirmed by the regressions.

TABLE B2: REGRESSION OF LIGHT COMMERCIAL VEHICLE OWNERSHIP ON SETS OF INDEPENDENT VARIABLES: IRISH COUNTIES: LINEAR EQUATIONS

Equation Number	Dependent Variable	Constant Term	Coefficient						R ²	
			X' ₁	X'' ₁	X ₂	X ₃	X ₄	X ₅		X ₆
B.1 ..	Y ₁	7.414	-0.06136 (0.03781)		0.1083 (0.06868)	-0.0006388 (0.001722)	0.03027 (0.03415)	-0.005473 (0.5294)	0.1390 (0.1056)	0.344
B.2 ..		4.010		-0.03900 (0.03778)	0.07183 (0.06512)	0.0001147 (0.001920)	0.04005 (0.03696)	0.01058 (0.5507)	0.1347 (0.1130)	0.293
B.3 ..	Y ₂	10.02	-0.09011 (0.03569)*		0.1579 (0.06483)*	-0.0003861 (0.001625)	0.03376 (0.03223)	-0.00009529 (0.4997)	0.1549 (0.09071)	0.466
B.4 ..		10.50	-0.08913 (0.03507)*		0.1527 (0.05948)*				0.1035 (0.05983)*	0.402
B.5 ..		5.403		-0.07153 (0.03613)	0.1202 (0.06229)	0.0009843 (0.001836)	0.05206 (0.03535)	0.03721 (0.5268)	0.1635 (0.1081)	0.408

TABLE B3: REGRESSION OF LIGHT COMMERCIAL VEHICLE OWNERSHIP ON SETS OF INDEPENDENT VARIABLES: IRISH COUNTIES: LOG-LOG EQUATIONS

Equation Number	Dependent Variable	Constant Term	Coefficient						R ²	
			log X' ₁	log X'' ₁	log X ₂	log X ₃	log X ₄	log X ₅		log X ₆
B.6 ..	log Y ₁	4.053	-1.436 (0.8267)		0.9016 (0.4970)	-0.02712 (0.1270)	0.01342 (0.01057)	-0.0490 (0.3304)	0.5627 (0.3990)	0.379
B.7 ..		0.5865		-0.4569 (0.6464)	0.4873 (0.4644)	0.03467 (0.1438)	0.01173 (0.01118)	-0.1083 (0.3488)	0.5023 (0.4437)	0.298
B.8 ..	log Y ₂	5.779	-1.952 (0.6333)		1.187 (0.3807)**	0.00290 (0.09727)	0.01595 (0.008100)	0.0007486 (0.2531)	0.4806 (0.3056)	0.561
B.9 ..		4.556	-1.448 (0.6009)*		1.241 (0.3867)**		0.02213 (0.007705)			0.456
B.10 ..		1.901		-1.072 (0.5149)	0.8155 (0.3699)*	0.1174 (0.1145)	0.01397 (0.008903)	0.06533 (0.2778)	0.5183 (0.3534)	0.464
B.11 ..		1.230		-0.8594 (0.4570)	0.6243 (0.3302)				0.7737 (0.2998)*	0.375
B.12 ..		0.5549							0.4850 (0.1739)*	0.245

APPENDIX C

STATISTICAL TABLES

TABLE C1: NUMBER OF MECHANICALLY-PROPELLED VEHICLES IN IRELAND 1947-1967 (AT 10 AUGUST EACH YEAR)

Year	Private cars	Public Service Vehicles		Commercial Goods Vehicles including dumpers	Road Locomotives, Motor Tractors, etc.		Motor Cycles	Exempt from Road Tax	Other Vehicles	Total Vehicles
		6 seats or under	over 6 seats		General Haulage	Agricultural Haulage				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1947	52,187	5,399	816	18,838	311	5,682	4,645	2,496	—	90,374
1948	60,453	6,753	933	22,806	786	8,425	5,004	2,842	—	108,002
1949	71,911	7,013	1,174	23,698	689	9,714	5,291	3,046	—	122,536
1950	85,140	6,759	1,231	24,726	515	11,255	5,801	2,707	—	138,134
1951	96,714	6,885	1,229	26,721	524	14,165	6,405	3,339	—	155,982
1952	104,900	6,710	1,230	28,315	500	15,956	7,980	2,198	—	167,798
1953	108,805	5,688	1,224	33,196	495	18,426	11,317	3,466	536	183,153
1954	117,460	5,343	1,245	37,090	654	22,755	15,052	3,880	553	204,032
1955	127,511	5,013	1,301	40,175	631	26,448	21,436	3,858	625	226,998
1956	135,961	4,472	1,372	41,880	653	27,887	26,539	3,643	637	243,044
1957	135,013	5,188	1,377	43,233	472	34,397	28,571	3,970	857	253,078
1958	143,368	4,841	1,388	43,433	423	33,547	30,568	4,264	843	262,675
1959	154,054	4,367	1,426	43,634	506	35,295	34,059	4,183	945	278,469
1960	169,681	4,096	1,436	43,530	520	36,970	41,467	4,180	878	302,767
1961	186,302	3,868	1,466	43,838	582	39,723	45,594	4,337	931	326,641
1962	207,166	3,823	1,478	44,874	658	43,123	48,268	4,563	952	354,905
1963	229,125	3,649	1,514	45,433	675	46,253	49,529	4,741	1,119	382,038
1964	254,494	3,426	1,562	46,928	736	49,890	52,173	4,791	1,263	415,263
1965	281,448	3,411	1,608	48,276	815	52,998	51,968	5,157	1,448	447,129
1966	296,372	3,562	1,636	46,922	821	55,503	47,091	5,327	1,545	458,779
1967	314,434	4,134	1,777	45,980	834	55,908	45,668	5,645	1,666	476,046

Source: SA: DLG, Annual Census.

TABLE C.2: MACRO-ECONOMIC DATA FOR IRELAND 1947-1966

Year	Real Disposable personal income per capita	GNP per capita at constant (1958) market prices
(1)	(2)	(3)
	£	£
1947	137.0	168.4
1948	144.1	176.1
1949	155.4	185.4
1950	158.5	187.6
1951	157.9	190.6
1952	158.5	196.4
1953	164.5	202.8
1954	164.7	205.3
1955	171.3	210.9
1956	168.9	209.9
1957	170.2	212.1
1958	167.3	210.7
1959	177.9	222.3
1960	186.0	232.5
1961	197.6	244.5
1962	202.3	250.1
1963	206.6	256.6
1964	221.1	269.6
1965	221.7	273.8
1966	223.6	277.4

Source: col. (2) NIE 1966 Tables A7, B7; RVS 1965 Table 1; CP 1966, Table III.
col. (3) NIE 1966 Tables A4, B6; RVS 1965 Table 1; CP 1966, Table III.

TABLE C3: CAR OWNERSHIP, *PER CAPITA* GDP
AND POPULATION DENSITY IN 58 COUNTRIES,
1964

Country	Private cars per '000 population 1964	<i>Per capita</i> GDP at factor cost ^a 1964 \$	Population density (persons per square kilometre) 1964
Austria	97	1,033	86
Belgium	124	1,462	307
Cyprus	60	591	63
Denmark	143	1,684	110
Finland	82	923	14
France	182	1,579	88
Germany (F.R.)	143	1,766	226
Greece	9	450	65
Ireland	91	895	41
Italy	91	1,032	170
Luxembourg ..	170	1,737	127
Malta & Gozo ..	63	388	1,024
Netherlands ..	87	1,431	361
Norway	112	1,882	11
Portugal	21	418	99
Spain	20	545	62
Sweden	217	2,095	17
Switzerland ..	143	2,071	142
Turkey	3	299	39
United Kingdom	156	1,698	222
Australia	243	1,807	1
Canada	261	2,106	2
U.S.A.	373	3,002	21
Argentina	33	612	8
Barbados	45	371	563
British Guiana	14	327	3
Chile	11	456	11
Costa Rica	14	270	27
Dominican Republic	8	206	72
Ecuador	3	194	17
Guatemala	6	295	40
Jamaica	29	528	159
Mexico	17	428	20
Nicaragua	8	229	11
Panama	21	483	16
Peru	11	240	9
Puerto Rica ..	87	963	290
Trinidad and Tobago	54	617	185
Venezuela	42	792	9
Ceylon	8	142	167
Japan	17	718	262
Korea, Rep. of	—	143	281
Philippines ..	4	129	104
Vietnam, Republic of	2	74	92
Congo, Dem. Republic of ..	3	73	7
Ghana	4	204	32
Ivory Coast ..	7	142	12
Kenya	7	95	16
Libya	22	199	1
Mauritius	17	216	387
Morocco	12	153	29
Senegal	8	124	17
South Africa ..	58	700	14
Southern Rhodesia	23	268	11
Tanzania ^b	3	82	11
Tunisia	11	209	28
Uganda	4	78	31
Zambia	10	264	5

Notes: a—In U.S. dollars calculated at parity rate.
b—Data for former Tanganyika only are available.

Source: U.N. Statistical Yearbook 1965, Table 154;
U.N. Demographic Yearbook 1965, Table 2;
U.N. Yearbook of National Accounts Statistics
1965, Table 9B.

TABLE C4: CAR OWNERSHIP IN IRISH COUNTIES AND COUNTY BOROUGHS, 1951-1966

Administrative Area	Private cars <i>per capita</i> , average in each period ^a			Private cars <i>per capita</i> 1966 ^a	Growth rate of private cars <i>per capita</i> , average in each period		
	1951— 1956	1956— 1961	1961— 1966		1951— 1956	1956— 1961	1961— 1966
					%	%	%
Carlow	·044	·063	·090	·109	7·5	6·9	8·0
Cavan	·028	·043	·075	·099	7·5	11·6	11·7
Clare	·024	·040	·068	·090	10·3	10·5	12·0
Cork C.C. and C.B. ..	·042	·060	·089	·110	7·4	7·6	8·8
Donegal	·023	·038	·061	·078	12·0	9·4	10·7
Dublin C.C. and C.B.	·052	·066	·092	·112	3·9	5·9	8·1
Galway	·026	·040	·061	·078	10·5	7·8	10·2
Kerry	·024	·041	·067	·087	12·9	9·5	10·8
Kildare	·046	·067	·093	·113	10·4	5·2	8·3
Kilkenny	·044	·062	·089	·110	8·4	5·9	8·8
Laoghis	·044	·067	·093	·111	10·9	6·5	7·3
Leitrim	·026	·046	·068	·077	13·6	10·8	5·1
Limerick C.C.	·037	·059	·088	·111	12·30	6·97	9·7
Limerick C.B.	·036	·048	·068	·086	6·26	5·16	9·8
Longford	·035	·053	·083	·106	9·0	8·6	10·3
Louth	·041	·057	·086	·111	6·5	6·9	10·6
Mayo	·020	·032	·060	·068	11·6	8·4	11·8
Meath	·052	·068	·099	·126	5·9	5·4	10·1
Monaghan	·034	·049	·074	·094	7·2	7·2	10·2
Offaly	·038	·056	·081	·099	9·4	7·0	8·4
Roscommon	·026	·040	·065	·087	11·2	7·2	12·6
Sligo	·028	·041	·066	·086	8·1	8·0	11·5
Tipperary N.R.	·049	·072	·101	·123	10·64	5·67	8·2
Tipperary S.R.	·047	·068	·094	·113	9·19	5·74	7·7
Waterford C.C.	·045	·063	·090	·112	7·29	6·21	8·9
Waterford C.B.	·037	·053	·076	·086	4·94	9·80	5·1
Westmeath	·042	·059	·084	·100	7·4	7·0	7·4
Wexford	·040	·057	·086	·112	8·9	6·2	11·2
Wicklow	·041	·057	·088	·114	6·5	7·2	10·9

Notes: a—Data exclude government-owned cars.

C.C.=County Council.

C.B.=County Borough.

Source: Information from CSO;

CP 1956 Table 6;

CP 1961 Vol. 1 Table 111;

CP 1966 Preliminary Report.

TABLE C5: CAR OWNERSHIP IN USA AND IN SWEDEN 1920-1966, TOGETHER WITH CALCULATED OWNERSHIP DERIVED FROM FITTED LOGISTIC CURVES

Year	USA: cars per 1,000 persons			Sweden: cars per 1,000 persons		
	Actual ownership	Calculated ownership		Actual ownership	Calculated ownership	
		Assuming uniform error	Assuming proportional error		Assuming uniform error	Assuming proportional error
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1920 ..	76	135	122			
1921 ..	85	138	125			
1922 ..	97	141	128			
1923 ..	118	143	132	6	4	8
1924 ..	135	146	135	8	5	9
1925 ..	151	149	139	10	5	9
1926 ..	164	153	143	12	6	10
1927 ..	169	156	147	13	7	11
1928 ..	177	159	150	15	8	12
1929 ..	189	163	154	16	10	13
1930 ..	187	166	159	17	11	14
1931 ..	180	170	163	17	12	16
1932 ..	167	173	167	16	14	17
1933 ..	164	177	171	16	16	19
1934 ..	170	181	176	16	18	21
1935 ..	177	185	181	18	21	22
1936 ..	188	189	185	19	24	25
1937 ..	197	193	190	21	27	27
1938 ..	194	198	195	25	30	30
1939 ..	200	202	200	29	34	32
1940 ..	207	207	205			
1941 ..	221	212	211			
1942 ..	207	216	216			
1943 ..	192	222	222			
1944 ..	190	227	227			
1945 ..	193	232	233			
1946 ..	200	238	239			
1947 ..	214	243	245	24	38	36
1948 ..	227	249	252	26	43	39
1949 ..	244	256	258	28	48	43
1950 ..	266	262	265	36	53	47
1951 ..	277	268	271	43	60	52
1952 ..	280	275	278	50	66	57
1953 ..	292	282	285	59	74	64
1954 ..	300	290	292	77	82	70
1955 ..	316	297	300	91	91	78
1956 ..	323	305	307	100	101	87
1957 ..	327	313	315	116	112	97
1958 ..	327	322	322	132	123	108
1959 ..	335	330	330	145	136	122
1960 ..	341	339	338	159	150	137
1961 ..	344	349	347	172	165	155
1962 ..	353	359	355	189	181	177
1963 ..	364	369	364	204	198	203
1964 ..	374	380	372	217	217	234
1965 ..	387	391	381	233	238	273
1966 ..	398	403	391	244	260	323

Source: Col. (2)—U.S. Department of Commerce, *Highway Statistics Summary to 1955* Table MV-200; Bureau of Public Roads, *Highway Statistics* (annual); Bureau of the Census, *Statistical Abstract of the United States* (annual).

Col. (5)—The Association of Swedish Automobile Manufacturers and Wholesalers, *Motor Traffic in Sweden* 1967, p. 19.

TABLE C6: CAR AND MOTOR CYCLE OWNERSHIP, INCOME AND OTHER VARIABLES IN IRISH HOUSEHOLDS: DATA GROUPED ACCORDING TO DISPOSABLE HOUSEHOLD INCOME × HOUSEHOLD SIZE^a

Income (shillings per week)			Household Size (average number of persons)		Proportion of households which own cars	Proportion of households which own motor cycles	Household Expenditure (shillings per week)		
Disposable		Gross	Group	Average			Average household	per capita	
Group	Average	Average							
Under 200	105.91	108.07	1 or 2	1.44	%	%	140.08	97.28	
	142.29	144.81		3.29	3	2		224.71	68.30
	155.83	158.35		5.29	6	2		253.89	47.99
	156.34	157.68		7.40	5	2		219.82	29.71
					0	0			
200 but under 400	281.72	305.37	3 or 4	1.82	26	5	326.67	179.49	
	301.94	314.60		3.48	27	8	380.82	109.43	
	304.35	311.41		5.46	24	6	382.70	70.09	
	312.97	319.72		8.37	17	9	396.18	47.33	
400 but under 600	473.89	549.66	5 or 6	1.84	48	3	600.68	326.46	
	485.48	525.80		3.58	54	5	579.39	161.84	
	491.38	512.65		5.42	47	6	577.93	106.63	
	495.23	509.90		8.77	30	10	575.05	65.57	
600 and over	944.74	1,135.19	7 or more	1.92	62	4	723.92	377.04	
	821.15	956.48		3.62	65	7	795.84	219.85	
	793.14	873.39		5.46	65	11	839.40	153.74	
	846.16	902.72		8.74	49	14	888.56	101.67	

Note: a—The 16 observations given are obtained from the 4 × 4 grouping Disposable Household Income × Household Size.

Source: HBI 1965-66.

TABLE C7: REGRESSIONS OF NEW CAR REGISTRATIONS (R) ON SETS OF INDEPENDENT VARIABLES

	R ²	d
$R = -17.94 + 0.1468D - 1.767HP$ (0.007835)*** (0.6625)*	.955	1.75
$R = -22.01 + 0.1775D - 0.1646I$ (0.03128)*** (0.1376)	.940	1.85
$R = -17.18 + 0.1415D$ (0.00877)***	.935	1.60
$\log R = -15.23 + 3.331 \log D - 0.2537HP$ (0.2236)*** (0.1043)*	.929	1.89
$\log R = -14.56 + 3.197 \log D$ (0.2446)***	.904	1.76
$R = -16.65 + 0.1421D_{-1}$ (0.01336)***	.869	1.16
$R = -16.91 + 0.1469D_{-2}$ (0.01928)***	.783	1.09
$\log R = -13.10 + 2.930 \log D_{-1}$ (0.3405)***	.814	1.18
$\log R = -12.74 + 2.875 \log D_{-2}$ (0.4691)***	.701	1.08
$\Delta R = 0.1084 + 0.1021 \Delta D$ (0.05985)	.146	1.97
$\Delta \log R = -0.01537 + 3.576 \Delta \log D$ (2.136)	.142	1.88

TABLE C8: GOODS VEHICLES IN IRELAND CLASSIFIED BY UNLADEN WEIGHT 1947-1967

Year	1 ton and under	1-2 tons	2-3 tons	3-4 tons	4-5 tons	5-7 tons ^b	over 7 tons ^b	Total
1947 ..	5,987	5,213	6,809	441	236	42	8	18,735
1948 ..	8,770	5,444	7,477	535	313	102	21	22,662
1949 ..	10,132	4,976	7,316	614	317	139	28	23,522
1950 ..	11,167	4,591	7,611	665	327	152	31	24,544
1951 ..	12,185	4,376	8,409	856	385	257	52	26,520
1952 ..	13,168	4,062	8,307	1,023	361	277	56	27,254
1953 ..	18,598	3,757	8,329	1,538	408	179	144	32,953
1954 ..	21,168	4,357	8,518	1,847	509	264	166	36,829
1955 ..	24,418	3,637	8,731	2,104	540	265	171	39,866
1956 ..	26,409	3,437	8,293	2,364	602	308	184	41,597
1957 ..	28,180	3,376	7,772	2,465	693	314	173	42,973
1958 ..	28,563	3,225	7,256	2,879	538	358	235	43,054
1959 ..	28,725	3,352	6,764	3,289	556	350	206	43,242
1960 ..	27,611	4,016	5,078	4,246	1,154	676	370	43,151
1961 ..	25,233	5,750	4,472	4,958	1,729	851	441	43,434
1962 ..	24,836	6,203	4,331	5,389	1,983	1,071	489	44,302
1963 ..	24,386	6,494	4,239	5,516	2,407	1,198	503	44,743
1964 ..	24,835	7,167	4,161	5,483	2,768	1,243	520	46,177
1965 ..	25,008	7,641	4,215	5,527	3,088	1,410	541	47,430
1966 ..	23,308	8,037	4,133	5,393	3,176	1,436	550	46,033
1967 ..	21,058	8,545	3,985	5,232	3,739	1,754	728	45,041

Notes: a—Exclude steam-driven and electrically-propelled vehicles.

b—Estimated figures for period 1947-1951.

Source: DLG Annual Census.

TABLE C9: ESTIMATED AVERAGE ANNUAL MILEAGE PER GOODS VEHICLE: IRELAND (1964) AND GREAT BRITAIN (1952, 1958 AND 1962)

Unladen Weight (tons)	Average Annual Mileage (to nearest hundred)			
	Ireland 1964	Great Britain		
		1952	1958	1962
(1)	(2)	(3)	(4)	(5)
<i>Over Not Over</i>				
1 ..	3,800	9,100	8,500	5,800
2 ..	9,100	9,900	10,200	7,400
3 ..	11,900	15,800	19,200	10,500
5 ..	19,200	21,500	23,300	18,500
TOTAL ..	27,400	28,000	31,500	25,400
	9,000	12,700	12,500	9,900

Note: The figures given in col. (2) differ slightly from the corresponding figures in Sexton (1966-67) where the divisor was the total number of "relevant" vehicles, i.e. where vehicles not included in the transport of goods had been excluded without making any difference to the total vehicle miles involved.

Source: Col. (2): SSRF Table 2.

Col. (3): Glover and Miller (1954), Tables 1, 10.

Col. (4): Ministry of Transport and Civil Aviation (1959), Tables 1, 6.

Col. (5): Ministry of Transport (1964a), Tables 3, 18.

TABLE C10: ESTIMATED AVERAGE LOAD PER GOODS VEHICLE: IRELAND (1964) AND GREAT BRITAIN (1952, 1958 AND 1962)

Unladen Weight (tons)	Average Load (tons)			
	Ireland 1964	Great Britain		
		1952	1958	1962
(1)	(2)	(3)	(4)	(5)
<i>Over Not Over</i>				
1 ..	0.24	0.22
2 ..	0.50	0.45	0.37	0.47
3 ..	1.65	2.13	1.59	1.88
5 ..	3.89	3.64	3.65	3.69
TOTAL ..	6.10	7.05	7.22	6.85
	2.52	2.64	3.12	2.39

Source: Col. (2): SSRF, Table 2.

Col. (3): Glover and Miller (1954), Tables 1, 10, 20.

Col. (4): Ministry of Transport and Civil Aviation (1959), Tables 1, 6, 8.

Col. (5): Ministry of Transport (1964a), Tables 3, 18, 20.

TABLE C11: ESTIMATED AVERAGE CARRYING CAPACITY PER GOODS VEHICLE: IRELAND (1964) AND GREAT BRITAIN (1952, 1958 AND 1962)

Unladen Weight (tons)	Average Carrying Capacity (tons)			
	Ireland 1964	Great Britain		
		1952	1958	1962
(1)	(2)	(3)	(4)	(5)
Under 1	0.54	0.45	0.43	0.52
1 - 2	1.08	1.35	1.13	0.78
2 - 3	3.96	3.45	4.12	3.18
3 - 4	7.15	6.58	6.68	5.73
4 - 5	8.46			7.46
5 - 7	10.22	11.06	12.10	10.48
Over 7	13.50			13.67

Source: Col. (2): SSRF, Table 45.
Col. (3): Glover and Miller (1954), Tables 1, 3.
Col. (4): Ministry of Transport and Civil Aviation (1959), Tables 1, 2.
Col. (5): Ministry of Transport (1964a), Tables 3, 5.

TABLE C12: MOTOR CYCLE OWNERSHIP, NATIONAL INCOME PER CAPITA AND POPULATION DENSITY IN 29 COUNTRIES 1965

Country	Motor cycles per 1,000 persons 1965	National income per capita 1965	Population Density (persons per square kilometre) 1964
(1)	(2)	(3)	(4)
Austria	28	970	87
Belgium	15	1,406	310
Finland	16	1,390	14
France	8	1,436	89
Germany	10	1,447	229
Great Britain ..	21	1,451	231
Greece	6	566	65
Ireland	18	783	41
Italy	55	883	171
Luxembourg ..	26	1,498	128
Netherlands ..	11	1,265	366
Norway	16	1,453	11
Portugal	3	351	100
Switzerland ..	16	1,928	144
Ivory Coast ^a ..	0	188	12
Malawi	0	38	33
Morocco	1	174	30
South Africa ..	6	509	15
Uganda ^b	1	77	32
Brazil	3	217	10
Canada	4	1,825	2
U.S.A.	7	2,893	21
Ceylon	2	130	171
India	0	86	159
Iraq ^a	1	193	18
Israel	15	1,067	124
Pakistan ^a	1	89	109
Australia	6	1,620	1
New Zealand ..	11	1,706	10

Notes: a—1964.
b—1966 for motor cycle stock.

Source: Col. (2): International Road Federation, Statistical Data 1965, Table IV.
Col. (3): U.N. Yearbook of National Accounts Statistics 1966.
Col. (4): U.N. Demographic Yearbook 1966.

TABLE C13: OTHER DATA ON VEHICLES IN IRELAND 1947-1967:

(a) NEW PRIVATE CAR REGISTRATIONS
(b) TOTAL VEHICLE OWNERSHIP

Year	Private Cars: New Registrations per 1,000 Persons	Total Vehicles per capita
(1)	(2)	(3)
1947	2.8	0.30
1948	4.3	0.36
1949	5.1	0.41
1950	5.9	0.47
1951	5.2	0.53
1952	4.2	0.57
1953	4.8	0.62
1954	7.1	0.69
1955	8.1	0.78
1956	5.1	0.84
1957	4.7	0.88
1958	6.7	0.92
1959	8.1	0.98
1960	9.9	1.07
1961	10.1	1.16
1962	11.3	1.25
1963	13.0	1.34
1964	14.4	1.45
1965	15.1	1.56
1966	13.7	1.59
1967	13.6	1.65

Source: Col. (2): SA; Information from CSO.
Col. (3): SA; DLG, Annual Census.

TABLE C14: PRIVATE CARS CLASSIFIED BY HORSE POWER: 1958, 1961 AND 1966

Horse power		1958	1961	1966
Over	Not over			
	8	47,583	76,625	114,895
8	10	68,153	74,410	117,598
10	12	20,461	24,785	31,471
12	14	1,827	5,365	25,080
14	16	862	1,211	2,979
16	20	2,346	1,687	1,592
20	24	819	1,326	1,924
24		1,317	893	833
TOTAL ..		143,368	186,302	296,372

Source: DLG, Annual Census.

TABLE C15: ESTIMATED AVERAGE ANNUAL MILEAGE FOR EACH CLASS OF VEHICLE IN GREAT BRITAIN, 1960, 1963 AND 1967

Class of Vehicle	Annual Mileage per Vehicle		
	1960	1963	1967
Private cars and private vans	7,500	7,600	8,000
All motor cycles ..	3,500	2,700	2,400
Buses and coaches ..	30,500	29,600	30,500
All goods vehicles ..	12,700	12,800	13,700
All Motor Vehicles ..	7,800	7,700	8,300

Source: Highway Statistics 1967, Table 21.

TABLE C16: ESTIMATED AVERAGE ANNUAL MILEAGE PER PRIVATE CAR IN CERTAIN COUNTRIES

Country	Year	Average Annual Mileage
Belgium	1966	8,100
Denmark ^a	1966	9,800
France	1965/66	6,200
West Germany ^b	1966	9,800
The Netherlands ^c	1965	11,200
Norway ^b	1966	7,100
U.S.A.	1965	9,300

Notes: a—Includes taxis.

b—Includes the mileage performed outside the country concerned.

c—This figure probably overestimates the actual annual average mileage, since the mileage of cars which are in use for less than one year is grossed up to a yearly average. This figure also includes the mileage performed outside the Netherlands.

Source: Institut National de Statistique, Bruxelles; Denmark's Statistik; Danish Statistical Yearbook 1968; Annuaire Statistique de la France, 1966; Statistisches Bundesamt; Netherlands Central Bureau of Statistics; Central Bureau of Statistics of Norway; U.S. Department of Transportation (1967), *Highway Statistics* 1965.

TABLE C.17: WEEKLY MILEAGE PER VEHICLE IN FULLY PRODUCTIVE HOUSEHOLDS IN BRITAIN, 1965^a

Household Income Per Week	Type of Household ^b						
	Single-person	Two-person	Three-person with one or more under age 16	Three-person all being 16 years or older	Four-person	Five or more persons	All Households
Under £17 ..	106	77	96	94	80	77	84
£18-£27 ..	155	113	127	112	112	105	114
£28-£37 ..	208	146	154	150	140	128	144
£38-£47 ..	88	151	147	159	167	144	153
£48 or more	346	143	157	140	132	140	143
All Incomes ..	143	115	128	129	121	114	121

Notes: a—This table includes vehicles which are household registered (whether or not they are used regularly in course of work), employer registered, registered by other household, and hired or borrowed for whole week of recording period. It includes cars, vans and motorcycles.

b—Households with unknown gross income are excluded.

Source: NTS, 1965.

REFERENCES

- Aitchison, J., and Brown, J. A. C. (1957), *The Lognormal Distribution*. Cambridge University Press.
- Attwood, E. A. and Geary, R. C. (1963), *Irish County Incomes in 1960*, ERI Paper No. 16. Dublin: ERI.
- Bayliss, Brian J. (1965), *European Transport*. London: Kenneth Mason.
- Beesley, M. E., and Kain, J. F. (1964), "Urban Form, Car Ownership and Public Policy: An Appraisal of Traffic in Towns", *Urban Studies*, Vol. I, No. 2, 174-203.
- Booth, J. L. (1967), *Fuel and Power in Ireland: Part IV: Sources and Uses of Energy*, ESRI Paper No. 37. Dublin: ESRI.
- British Road Federation (1967), *Basic Road Statistics*. London: British Road Federation.
- CSO (1954), *Household Budget Inquiry 1951-52*. Dublin: Stationery Office.
- CSO (1963), *Census of Population of Ireland 1961*, Vol. I. Dublin: Stationery Office.
- CSO (1964), *Census of Population of Ireland 1961*, Vol. VI. Dublin: Stationery Office.
- CSO (1967), *Sample Survey of Road Freight Transport 1964, Final Report*, Dublin: Stationery Office.
- CSO (1968), *National Income and Expenditure 1966*, Pr. 9975. Dublin: Stationery Office.
- Central Statistical Office (1967), *Abstract of Regional Statistics*, No. 2, 1966. London: HMSO.
- Chandler, K. N., and Tanner, J. C. (1958), "Estimates of the Total Miles Run by Road Vehicles in Great Britain in 1952 and 1956", *J. R. Statist. Soc.*, Series A, Vol. 121, No. 4, 420-437.
- Chow, Gregory C. (1960), "Statistical Demand Functions for Automobiles and their Use in Forecasting", in *The Demand for Durable Goods*, edited by Arnold C. Harberger. Chicago: The University of Chicago Press.
- CIE (1963), *Report on Internal Public Transport*. Dublin: CIE.
- CIE (1967), *Annual Report 1966/67*. Dublin: CIE.
- Cramer, J. S. (1965), "Een Prijnsindex Van Nieuwe Personeauto's, 1950-1965", *Statistica Neerlandica*, Vol. 20, No. 2, 215-224.
- Dicks-Mireaux, L. A., OHerlihy, C. St. J., Major, R. L., Blackaby, F. T., and Freeman, C. (1961), "Prospects for the British Car Industry", *National Institute Economic Review*, No. 17, 15-47.
- Faure (1959), "Une Modèle Prospectif du Marché de l'Automobile", *Consommation*, Oct.-Dec. 1959.
- Geary, R. C., and Pratschke, J. L. (1968), *Some Aspects of Price Inflation in Ireland*, ESRI Paper No. 40. Dublin: ESRI.
- General Register Office (1966), *Census 1961, England and Wales, Fertility Tables*. London: HMSO.
- Glover and Miller (1954), "The Outlines of the Road Goods Transport Industry", *J. Roy. Statist. Soc.*, Series A, Vol. 117, No. 3.
- Glover, K. F. (1960), "Statistics of the Transport of Goods by Road", *J. Roy. Statist. Soc.*, Series A, Vol. 123, No. 2, 107-131.
- Johnston, J. (1963), *Econometric Methods*. New York: McGraw-Hill.
- Kain, J. F., and Beesley, M. E. (1965), "Forecasting Car Ownership and Use", *Urban Studies*, Vol. 2, No. 2, 163-185.
- Leser, C. E. V. (1962), *Demand Relationships for Ireland*. ERI Paper No. 4. Dublin: ERI.
- McCarthy, P. F. (1963/64), "Traffic Census for Main Road System", *Trans. Instn. civ. Engrs. Ire.*, Vol. 90, 151-184.
- Maizels, A. (1959), "Trends in World Trade in Durable Consumer Goods", *National Institute Economic Review*, No. 6, 15-36.
- Meron, R. (1967a), *Discriminant Analysis of Factors Affecting Car Ownership by Households*, Paper presented to the Conference of the General Application Section of The Royal Statistical Society on Statistical Theory and Practice at the University of Sussex.
- Meron, R. (1967b), *Forecasts of Car Ownership*. (Unpublished.)
- Ministry of Transport and Civil Aviation (1959), *The Transport of Goods by Road: Report of a Sample Survey made in April 1958*. London: HMSO.
- Ministry of Transport (1964a), *Survey of Road Goods Transport 1962, Final Results*, Part I.
- Ministry of Transport (1964b), *Road Pricing: The Economic and Technical Possibilities*. London: HMSO.
- Ministry of Transport (1966), *Transport Policy*, Cmnd. 3057. London: HMSO.
- Ministry of Transport (1967a), *National Travel Survey—1964 (Preliminary Report), Part I—Household Vehicle Ownership and Use*. London: Ministry of Transport.
- Ministry of Transport (1967b), *Highway Statistics 1966*. London: HMSO.
- Ministry of Transport (1968), *Highway Statistics 1967*. London: HMSO.
- Mishan, E. J. (1967), *The Costs of Economic Growth*. London: Staples Press.
- Mogridge, M. J. H. (1967), "The Prediction of Car Ownership", *Journal of Transport Economics and Policy*, Vol. I, No. 1, 52-74.
- Munby, D. L. (1965), "The Economics of Road Haulage Licensing", *Oxford Econ. Pap.*, Vol. 17, No. 1, 111-129.
- NIEC (1967), *Report on Full Employment*, Pr. 9188. Dublin: Stationery Office.
- O'Keeffe, Peter J. (1960-61), "Economic Aspects of Road Improvements in Ireland", *Trans. Instn. civ. Engrs. Ire.*, Vol. 87, 153-198.
- O'Keeffe, P. J. (1965a), Conference on Road Safety (Dublin, December 1965), *Report on Proceedings*, pp. 47-56.
- O'Keeffe, P. J. (1965b), *Studies on Rural Roads Problems*, Paper read at 1966 Spring Show Conference. (Unpublished.)
- Pearl, R. (1926), *The Biology of Population Growth*. London: Williams and Norgate.
- Revenue Commissioners (1966), *Annual Report year ended March 1965*. Dublin: Stationery Office.
- Reynolds, D. J. (1962), *Inland Transport in Ireland: A Factual Survey*, ERI Paper No. 10. Dublin: ERI.
- Reynolds, D. J. (1963), *Road Transport: The Problems and Prospects in Ireland*, ERI Paper No. 13. Dublin: ERI.
- Sexton, J. (1966-67), "Road Freight Transport in Ireland", *Journal of SSISI*, Vol. XXI, Part V, 96-124.
- Tanner, J. C. (1965), "Forecasts of Vehicle Ownership in Great Britain", *Rds. Rd. Constr.*, Vol. 43, 314-317, 371-376.
- Tanner, J. C. (1966), *Vehicle-Mileage in the United States and in Britain*, RRL Report No. 31. Harmondsworth: Road Research Laboratory.
- Theil, H., and Nagar, A. L. (1961), "Testing the Independence of Regression Disturbances", *J. Amer. Statist. Ass.*, Vol. 56, 793-806.
- Treacy, P. J. (1962-63), "A Precursory Review of Traffic Counting in Rural Areas", *Trans. Instn. civ. Engrs. Ire.*, Vol. 89, 49-88.
- United Nations (1966), *Yearbook of National Accounts Statistics 1965*, New York: United Nations.
- U.S. Department of Commerce (1957), *Highway Statistics, Summary to 1955*. Washington: U.S. Government Printing Office.
- U.S. Department of Transportation (1967), *Highway Statistics 1965*. Washington: U.S. Government Printing Office.
- Vermetten, J. B. (1964), "Prognose van het Autopark Met Behulp van een 'Diffusion' Model", *Statistica Neerlandica*, Vol. 18, No. 4, 463-471.

THE ECONOMIC AND SOCIAL RESEARCH INSTITUTE

Reprint Series :

1. *Commentary on "Europe's Future in Figures"* R. C. Geary
2. *Forms of Engel Functions* C. E. V. Leser
3. *The Cost Structure of British Manufacturing, 1948-61*
E. T. Nevin
4. *The Life of Capital Assets: An Empirical Approach* E. T. Nevin
5. *Estimation of Quasi-linear Trend and Seasonal Variation*
C. E. V. Leser
6. *The Pattern of Personal Expenditure in Ireland* C. E. V. Leser
7. *Some Remarks about Relations between Stochastic Variables:
A Discussion Document* R. C. Geary
8. *Towards An Input-Output Decision Model for Ireland*
R. C. Geary
9. *Do-It-Yourself Economics of the Firm; First Draft of a Statistical
Scheme* R. C. Geary
10. *Recent Demographic Developments in Ireland* C. E. V. Leser
11. *The Average Critical Value Method for Adjudging Relative
Efficiency of Statistical Tests in Time Series Regression
Analysis* R. C. Geary
12. *A Note on Residual Heterovariance and Estimation Efficiency
in Regression* R. C. Geary
13. *Direct Estimation of Seasonal Variation* C. E. V. Leser
14. *Ex post Determination of Significance in Multivariate Regression
when the Independent Variables are Orthogonal* R. C. Geary
15. *The Economics Of An Off-Shore Island* G. G. Firth
16. *The Role of Macroeconomic Models in Short-Term Forecasting*
C. E. V. Leser
17. *A Dublin Schools Smoking Survey*
Angus O'Rourke, Noellie O'Sullivan, Keith Wilson-Davis
18. *Significance Tests in Multiple Regression*
R. C. Geary, C. E. V. Leser

Geary Lecture:

1. *A Simple Approach to Macro-economic Dynamics*
R. G. D. Allen
2. *Computers, Statistics and Planning—Systems or Chaos?*
F. G. Foster

Publication Series:

1. *The Ownership of Personal Property in Ireland* Edward Nevin
2. *Short Term Economic Forecasting and its Application in Ireland*
Alfred Kuehn
3. *The Irish Tariff and The E.E.C.: A Factual Survey*
Edward Nevin
4. *Demand Relationships for Ireland* C. E. V. Leser
5. *Local Government Finance in Ireland: A Preliminary Survey*
David Walker
6. *Prospects of the Irish Economy in 1962* Alfred Kuehn

THE ECONOMIC AND SOCIAL RESEARCH INSTITUTE

Publication Series:—continued.

7. *The Irish Woollen and Worsted Industry, 1946–59: A Study in Statistical Method* R. C. Geary
8. *The Allocation of Public Funds for Social Development* David Walker
9. *The Irish Price Level: A Comparative Study* Edward Nevin
10. *Inland Transport in Ireland: A Factual Survey* D. J. Reynolds
11. *Public Debt and Economic Development* Edward Nevin
12. *Wages in Ireland, 1946–62* Edward Nevin
13. *Road Transport: The Problems and Prospects in Ireland* D. J. Reynolds
14. *Imports and Economic Growth in Ireland, 1947–61* C. E. V. Leser
15. *The Irish Economy in 1962 and 1963* C. E. V. Leser
16. *Irish County Incomes in 1960* E. A. Attwood and R. C. Geary
17. *The Capital Stock of Irish Industry* Edward Nevin
18. *Local Government Finance and County Incomes* David Walker
19. *Industrial Relations in Ireland: The Background* David O'Mahony
20. *Social Security in Ireland and Western Europe* P. R. Kaim-Caudle
21. *The Irish Economy in 1963 and 1964* C. E. V. Leser
22. *The Cost Structure of Irish Industry, 1950–60* Edward Nevin
23. *A Further Analysis of Irish Household Budget Data, 1951–1952* C. E. V. Leser
24. *Economic Aspects of Industrial Relations* David O'Mahony
25. *Psychological Barriers to Economic Achievement* P. Pentony
26. *Seasonality in Irish Economic Statistics* C. E. V. Leser
27. *The Irish Economy in 1964 and 1965* C. E. V. Leser
28. *Housing in Ireland; Some Economic Aspects* P. R. Kaim-Caudle
29. *A Statistical Study of Wages, Prices and Employment in the Irish Manufacturing Sector* C. St.J. O'Herlihy
30. *Fuel and Power in Ireland: Part I. Energy Consumption in 1970* J. L. Booth
31. *Determinants of Wage Inflation in Ireland* Keith Cowling
32. *Regional Employment Patterns in the Republic of Ireland* T. J. Baker
33. *The Irish Economy in 1966* The Staff of The Economic and Social Research Institute
34. *Fuel and Power in Ireland: Part II. Electricity and Turf* J. L. Booth
35. *Fuel and Power in Ireland: Part III. International and Temporal Aspects of Energy Consumption* J. L. Booth
36. *Institutional Aspects of Commercial and Central Banking in Ireland* John Hein
37. *Fuel and Power in Ireland; Part IV, Sources and Uses of Energy* J. L. Booth
38. *A Study of Imports* C. E. V. Leser
39. *The Irish Economy in 1967* The Staff of The Economic and Social Research Institute
40. *Some Aspects of Price Inflation in Ireland* R. C. Geary and J. L. Pratschke
41. *A Medium Term Planning Model for Ireland* David Simpson
42. *Some Irish Population Problems Reconsidered* Brendan M. Walsh
43. *The Irish Brain Drain* Richard Lynn
44. *A Method of Estimating the Stock Capital in Northern Ireland Industry; Limitations and Applications* C. W. Jefferson
45. *An Input-Output Analysis of the Agricultural Sector of the Irish Economy in 1964* R. O'Connor with M. Breslin
46. *The Implications for Cattle Producers of Seasonal Price Fluctuations* R. O'Connor