TRAVEL BEHAVIOUR: RESPONSES TO DIRECT ROAD USER CHARGES

by

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ABSTRACT

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This thesis, submitted under the procedures for staff candidates, considers several aspects of driver behaviour in relation to the direct pricing of highway use by reference to a specific local example: Southampton's Itchen Toll Bridge. Although the case study example is an unusual component in the U.K. highway network, the issues considered in the thesis are fundamental, and are applicable to a wide range of circumstances.

Chapter 2 considers the effectiveness and equity of the Itchen Bridge tolls as a means of traffic restraint. In particular the responses to changes in toll price are considered, being compared with previous predictions, other examples and theoretical concepts. The particular funding arrangements of the Bridge are also briefly discussed.

Chapter 3 describes studies undertaken to measure the value of motorists' travel time savings by reference to their route choices between the Itchen Bridge and the untolled Northam Bridge. The case study location is particularly advantageous for such measurement and provides an opportunity to compare the transfer price method with the more traditional revealed preference approach.

Chapter 4 describes the differences in the reported travel habits of residents over a period of four months. Considerable variability was observed which has important implications in a wide range of transport research topics.

Chapter 5 puts forward an alternative idea to the principle of valuation implicit in Chapter 3. It is argued that in the context of current U.K. highway appraisal procedures the monetary valuation of travel time savings is not only difficult, but also unnecessary and possibly even unhelpful.

Traffic restraint by pricing, prediction of the response to changes in travel conditions, measuring the value of travel time savings, the variability of travel patterns and methods of highway appraisal are all important and topical issues in transport research. This thesis makes an original contribution in all these areas.

ACKNOWLEDGEMENTS

Chapter 2 draws extensively on data kindly made available by the City Engineer's Department of Southampton City Council (City Engineer, T. H. Nicholson, C.Eng., M.A., F.I.C.E.). In that connection I am grateful for the assistance of several officers of the City Engineer's Department including M. Coxon, R Powell and D Logan. I have also received data from the City Treasurer's Department and had useful conversations with the Itchen Bridge Manager, Mr K. Morgan.

The studies described in Chapter 3 were undertaken with a small amount of funds provided by the Committee for Advanced Studies of the University of Southampton and I would like to register my appreciation of their support.

Although the work in this thesis was undertaken entirely by myself, the content has undoubtedly been influenced by many colleagues and students. I am particularly grateful to the following who have assisted me in some respect: Jean Adam, Tim Holt, Cecilio Mar-Molinero, Richard Hall, Derek Clarke, several members of the Computer Advisory Service of Southampton University and the students of the 1981/82 M.Sc. course in Transportation Planning and Engineering. I am also grateful to colleagues in other institutions and to members of the collaborative Value of Time Study Team for the Department of Transport with whom I have had useful discussions.

In the Department of Civil Engineering, I acknowledge the advice and encouragement of Dr Mike McDonald and Professor Roy Butterfield. Thanks are also due to Joan Lake, Melanie Hallford and Anna Dabrowska who, at one time or another, have all processed the words contained in this thesis.

Finally, I would also like to thank Dr Sue Atkins for her encouragement and example.

CONTENTS

CHAPTER 1

INTRODUCTION

1.1 This thesis, which is submitted under the procedures for staff candidates, deals with four aspects of the research that I have undertaken since my appointment to the academic staff of the University in September 1979. The common theme is the study of the behaviour of drivers in relation to Southampton's Itchen Toll Bridge. Although the special local circumstances which led to the introduction of tolls are highly unusual, thus suggesting that the results of such research have little application elsewhere, the principles that are examined in this research are fundamental and have implications for the planning and operation of transport facilities everywhere.

1.2 The first topic studied is that of traffic restraint. The limitation by pricing of traffic volumes in cities to a level at which the existing infrastructure can cope efficiently has long been held to convey net economic benefits. However, practical tests of this idea are extremely few. The Southampton Corporation Act (1973) explicitly permits traffic restraint to be considered as one of the criteria for setting toll levels on the Itchen Bridge. This is the first example of deliberate restraint by pricing in the U.K. The effectiveness of the restraint measures and their fairness, particularly with respect to their impact on different income groups, are highlighted by this thesis. Both these issues have been prominent in the continuing debate on the merits of traffic restraint in general and road pricing in particular.

1.3 The second topic considered is raised in the context of the first: the response of drivers to a change in travel circumstances. The pattern of traffic flow before and after toll increases, as well as illustrating the effects of traffic restraint, also reveals the response of drivers to a change in the price of their selected transport option. In many circumstances transport planners and engineers seek to change travel habits either to those which are more

socially desirable (eg to prevent entry of through traffic to residential areas or to influence modal choice in order to reduce traffic congestion) or simply for commercial reasons (eg to maximise revenue). The study of the thresholds at which travellers are persuaded to make such changes is of both academic interest and practical importance:

> *"But by far the greatest need for an improved understanding of behaviour is related to the estimation of responses to major changes in the system which serve to significantly extend or restrict traveller's choices; 'threshold changes' which cause a major re-appraisal of travel related decisions. If we are to improve our understanding of behaviour, and thus responses to major change, we need to exploit to the fullest extent possible the research opportunities provided by any such changes." (Richards, 1980)*

Despite this vital interest, surprising little is known of these decision processes and this study contributes to the state of knowledge on this issue.

1.4 The third topic studied is the volatility or propensity to change of travel behaviour. Arising out of practical studies of the behaviour of users and non-users of the Itchen Bridge, it was possible to monitor the changes in travel habits of certain individuals over a period of four months. A surprising degree of variability was reported which, if confirmed, has implications across a wide range of transport research and applications. Such areas include the design of travel surveys, the deviation of origin-destination matrices from traffic counts and aspects of the dynamics of travel behaviour.

1.5 The fourth topic is the valuation of travel time savings. This is a vital measure, perhaps the single most important factor in the appraisal of transport proposals. The principal advantage accruing from most transport investments is a reduction in travel time for individuals and goods transported. For project appraisal purposes this must be weighed against the costs of the scheme and other effects, notably the environmental and social impacts. It has been conventional practice to convert travel time savings into a monetary value, to assist this appraisal process. The value placed on travel time savings

by consumers can be discerned from circumstances in which travellers make trade-offs between travel time and money. The route choices of drivers between the Itchen Bridge and the untolled Northam Bridge provide almost unrivalled conditions to measure such values.

1.6 A subsequent chapter calls into question that orthodox view. It asks whether in fact the monetary valuation of travel time savings does assist decision-makers or whether measurement in time units is sufficient.

1.7 This thesis is a completely revised work but, in compliance with the regulations governing Ph.D. submissions by staff candidates, does draw heavily on previously published material. Some of these publications were informal, in the sense that they were conference papers, rather than contributions to journals. The editing has attempted to eliminate repetition which was present in the original papers. Inevitably there is some correspondence of argument between Chapter 3 which describes work to establish a value of travel time savings and Chapter 5 which includes a section exploring the difficulties of doing this. Chapters 2, 3 and 4 contain substantial sections which have not been published before. The following paragraphs outline the contents of each chapter and explain their correspondence with those previous publications.

1.8 **Chapter 2** initially describes the location of the Itchen Bridge, the background to its construction and the development of the toll structure. It studies the influence of the tolls on the composition and flow of traffic, both using the Bridge and the radial corridor which it serves. In particular the change in flows resultant upon price increases are investigated by various estimation methods. Observed elasticities are compared with those predicted in studies undertaken before the bridge opened and with those observed on major U.S. toll facilities. The possible regressiveness of user charges is investigated. The Itchen Bridge derives its revenue from both tolls and rates. This arrangement is discussed in the context of similar proposals for mixed funding in the United States and the Government's desire to involve private capital in road construction.

1.9 The text of Chapter 2 incorporates material first given in a paper *"Impact of a Toll Increase on Itchen Bridge Traffic Flows"* (Atkins, 1981) presented to the 13th Annual Conference of the Universities Transport Studies Group (UTSG) at the University of Leeds in January 1981, and a revised version *"Traffic Restraint by Pricing: Experience from the Itchen Bridge, Southampton"* (Atkins, 1982b) presented to the Planning and Transportation, Research and Computation (PTRC) Summer Annual Conference at Warwick University in July 1982. It has received only minor editing from presentation to the Southern Section of the Chartered Institute of Transport at the Dolphin Hotel, Southampton in January 1985 as *"Traffic Control by Pricing: The Case of Southampton's Itchen Bridge"*.

1.10 **Chapter 3** describes the empirical work carried out to determine the value of travel time savings by reference to drivers' route choice between the tolled Itchen Bridge and other untolled river crossings. After a brief explanation of the importance of travel time valuation, the particular advantages of the Southampton location are reviewed. The design of the survey, its conduct and management are then described. The theoretical basis for the analysis is given and the results presented. The methods used and the results obtained are discussed. Comparisons are made with previous research work, with the figures currently recommended for use by the Department of Transport and with results from preliminary surveys forming a part of the work of the collaborative Value of Travel Time Study Team for the Department of Transport (MVA Consultancy, Institute for Transport Studies at the University of Leeds and the Transport Studies Unit at Oxford University, 1981-1985 continuing). The merits of the reported behaviour (revealed preference) and stated intention (transfer price) approaches are discussed.

1.11 The survey work described in Chapter 3 was supported by the Committee for Advanced Studies of Southampton University. A project report submitted to that Committee in January 1984 provided the basis for this chapter, although the work presented here considerably extends that document. Some early results were reported in *"The Value of*

Travel Time: An Empirical Study Using Route Choice" (Atkins, 1983b) presented at the PTRC Summer Annual Meeting at the University of Sussex in July 1983.

1.12 The first section of **Chapter 4** was presented to the 15th Annual UTSG Conference at Imperial College, London in January 1983 as *"Experience from a Repeated Travel Survey"* (Atkins, 1983a). The paper contains a comparison of responses given by the same households to interview surveys in February 1982 (as part of an M.Sc. student group project supervised by me) and in June 1982 (as a special component of the survey described in Chapter 3). From an admittedly small sample, a surprising pre-disposition to change was noted. The paper discusses possible reasons for this variability and, should this finding be confirmed more widely, some of the implications for transport studies. The second section of Chapter 4 was written in 1985 to place the earlier paper in context. Some correspondence with other empirical data is noted, and the issues raised in the original paper are shown to be of concern and interest across a wide range of current transport research.

1.13 **Chapter 5** is of a different nature. It is not descriptive but discursive, argumentative and iconolastic. At the PTRC Summer Annual Meeting at the University of Sussex in July 1983, following a series of technical presentation on the valuation of travel time savings, a debate was scheduled on "The Value of the Value of Time" Supposing, correctly in the event, that most persons present would favour the monetary valuation of travel time savings, I prepared some thoughts and presented a contribution to the debate, arguing against such orthodoxy. Although the debate was disappointing and indecisive, terminating in some disarray, I felt that the issue was worthy of further, more considered scrutiny. I therefore wrote a paper, expanding on my ideas, and submitted it to the Journal of the Institution of Highways and Transportation. As I had not received a decision from the editor by December 1983, I also offered the paper to PTRC for their 1984 Summer Annual Meeting. Both offers were accepted and the paper was published in the July 1984 edition of "Highways and

Transportation" (Atkins, 1984a) almost simultaneously with the presentation of a slightly shortened version at the PTRC Meeting (Atkins, 1984b).

1.14 Chapter 5 is an amended version of the PTRC paper, re-introducing some of the excluded material and cross-referencing to other chapters of this thesis. It is argued that, in the context of current U.K. highway appraisal procedures, the monetary valuation of travel time savings is unnecessary, since the majority of other factors remain measured in non-monetary units. Valuation is, in any case, difficult from a practical perspective, a view given credence by the substantial effort currently being devoted to the issues by the Department of Transport through their collaborative consultancy team. Finally it is argued that investment decisions must take into account the interests of society as a whole, and these are not necessarily the summation of individual valuations. Any process which gave greater weight to the preferences of those with greatest wealth could be questioned on moral grounds. By confusing political values with technical facts, the monetary valuation of travel time may compromise the traditional neutrality of planners and engineers.

1.15 Thus despite focussing on the subject of a specific, local and highly unusual piece of infrastructure and its management, this thesis contains examination of fundamental issues in transport.

CHAPTER 2

TRAFFIC CONTROL THROUGH PRICING: THE CASE OF SOUTHAMPTON'S ITCHEN BRIDGE

2.1 INTRODUCTION

2.1.2 The construction, maintenance and renewal of highways is an expensive business. In terms of equity or social justice it seems only fair that most of these costs should be paid by those who use the roads. However, our current system of charging motorists through taxation, by excise licence and fuel tax is relatively insensitive to use and, in particular, fails to consider the costs that one user causes for another, the congestion costs. Thus, in the early 1960's, as the growth in road traffic accelerated, the idea of direct charging for the use of roads was strongly advocated as a means of controlling the growing levels of congestion in cities. The economic theory of road pricing is most fully expounded by Walters (1968), and the practical issues were examined by the Smeed Committee (Ministry of Transport, 1964). The most accessible summary of the arguments is given by Roth (1967).

2.1.2 Briefly, these theories show that economic efficiency would be improved by charging according to the costs of use, these being related to both the damage caused to the highway infrastructure and the congestion costs imposed on other road users. Trips for which the users were not prepared to pay the "true" price would be removed, thus reducing congestion and speeding the journeys of those who were willing to pay. Revenue gained would not only cover appropriate maintenance costs but also signal the requirement for further investment to increase capacity. Provided they could be quantified, environmental costs could, in theory, also be covered in this way.

2.1.3 Such schemes have appealed to both ends of the political spectrum having been given active consideration by the G.L.C. under both Conservative and Labour administrations, and given great emphasis in the recent "Omega" Transport report from the "right-wing" Adam Smith

Institute (Adam Smith Institute, 1983). Although road pricing was shown to be technically feasible two decades ago, and technological advance has made such systems easier and cheaper in that period, there is still a marked reluctance to proceed towards that goal of near-optimal pricing. There are many reasons for this, not only the large scale of operation that would be required to implement any scheme but also the political considerations. These clearly include fears of short-term loss of political popularity but also more intrinsic concerns about harm to businesses, the need to maintain the economic vitality of the city centre in competition with suburban locations and possible discrimination against poorer motorists (Higgins 1979, May 1983).

2.1.4 Indeed, only the strong City/State Government of Singapore has so far managed to introduce a direct pricing strategy. Their so-called area licensing scheme (in fact a cordon pricing scheme as it is passage through a cordon, not presence in an area which requires the licence) was introduced in 1975 and is apparently highly successful (Holland and Watson, 1978). Hong Kong is currently investigating the feasibility of a road pricing scheme using electronic number plates (Dawson, 1983) which, if implemented, will come closest to the concepts of the Smeed Report.

2.1.5 In the U.K., London (twice), York and Bristol have considered direct pricing proposals but generally various sub-optimal methods (some involving an element of pricing but more commonly using non-pricing strategies) have been used to control the levels of traffic flow in cities. These include policies such as car parking controls (availability, price, duration of stay, opening times), physical restraints (cell systems, traffic mazes, pedestrian streets, banned turns) and measures either to increase travel times by private vehicles (zones and collar experiment, queue transfers through signal timings) or to reduce travel times or costs for preferred vehicles (bus lanes, bus priority schemes, fares subsidies). A review of most of these policies is given by Thomson (1978) and case-studies of several of the techniques in various world cities are contained in "Managing Transport" (OECD, 1979). However, there is one U.K. location in which

direct pricing is used as an element in traffic control strategy, complementary to the more usual techniques mentioned above. It is Southampton's Itchen Bridge. Although this scheme involves unusual circumstances unlikely to be replicated elsewhere, it is worthy of close scrutiny for two principal reasons. First, it permits some practical investigation of the levels of charges necessary to deter traffic and the sensitivity of users' responses, and secondly, it provides an example to test some of the arguments put forward against pricing as a means of traffic control.

2.1.6 It has been stated that "our ability to decide, both technically and politically, whether restraint is needed" requires "an increased willingness by both analysts and decision makers to experiment with restraint mechanisms and to learn from our experience" (May, 1981). The Itchen Bridge case can provide some evidence to aid this process.

2.1.7 This Chapter therefore examines the Itchen Bridge as a case study but with particular reference to the restraint aspects of the scheme. The background, location and unusual nature of the toll structure are firstly described. The influence of the tolls on the vehicular composition of traffic using the bridge and its radial corridor are then presented. The effect of pricing on the volume of traffic using the bridge is considered next, with particular attention being focussed on the response to toll price changes. Various methods for estimating the effects of price changes are considered, including some evidence on the "stated intention" response from a home-interview survey of users and non-users. The observed elasticities are compared with those initially forecast and with those observed at major toll facilities in the United States.

2.1.8 The possible regressiveness of user charges is also considered with some evidence being provided from the home-interview survey.

2.1.9 An additional and topical stimulus to the study of direct pricing of road use is the Government's wish to involve private capital in road construction projects. Although specific proposals have

recently been rejected by the Secretary of State for Transport this decision was clearly taken reluctantly. Tolls represent one way to transfer payment from road user to road provider but have usually received scant attention in such debates. For a variety of reasons there is current American interest in a "mixed-funding" approach for roads including both public (tax-supported) finance and toll revenue. The Itchen Bridge is financed in precisely this way, deriving revenue from both rates and tolls, and once again its example can provide some useful factual insights.

2.2 THE ITCHEN BRIDGE: BACKGROUND, LOCATION AND TOLL STRUCTURE

2.2.1 LOCATION AND BACKGROUND

The River Itchen divides Southampton into two unequal parts. In the larger western section are the City Centre (the principal business, commercial and entertainment centre for the whole region), the Docks, and most other major employers such as the Ordnance Survey, the General Hospital and the University. The smaller eastern section is principally residential with the notable exceptions of the Vosper Thorneycroft Shipyard at Woolston and the district centres at Woolston and Bitterne (See Figure 2.1). This distribution of land uses, especially homes and workplaces, gives rise to a substantial demand for travel across the river, particularly at peak hours.

2.2.2 Northam Bridge, a conventional untolled facility, allows Southampton's main traffic route to the east through Bitterne to pass over the river. In 1977 the Itchen Bridge was opened approximately 1½ miles to the south. This replaced the former chain ferry or floating bridge which had limited capacity in terms of both the quantity and size of vehicles which could be transported.

2.2.3 Prior to 1977 residents of the south-eastern part of the city (principally the districts of Woolston, Sholing and Weston) had an unenviable choice of routes to gain access to the City Centre. They could use the chain ferry which accommodated pedestrians, cyclists, motorcyclists and a limited number of light vehicles but no heavy commercial vehicles (HCV's) or buses. Bus users were required to use two services, crossing the river as foot passengers. Alternatively travellers could make a diversion to the north to use Northam Bridge. However, the Northam Bridge route is heavily used and in the morning peak access is limited by the side roads control of the Bitterne Traffic Management Scheme (Earp, 1973). Hence these districts, although geographically very close to the City Centre, were deprived of easy access to most of the City's principal activities.

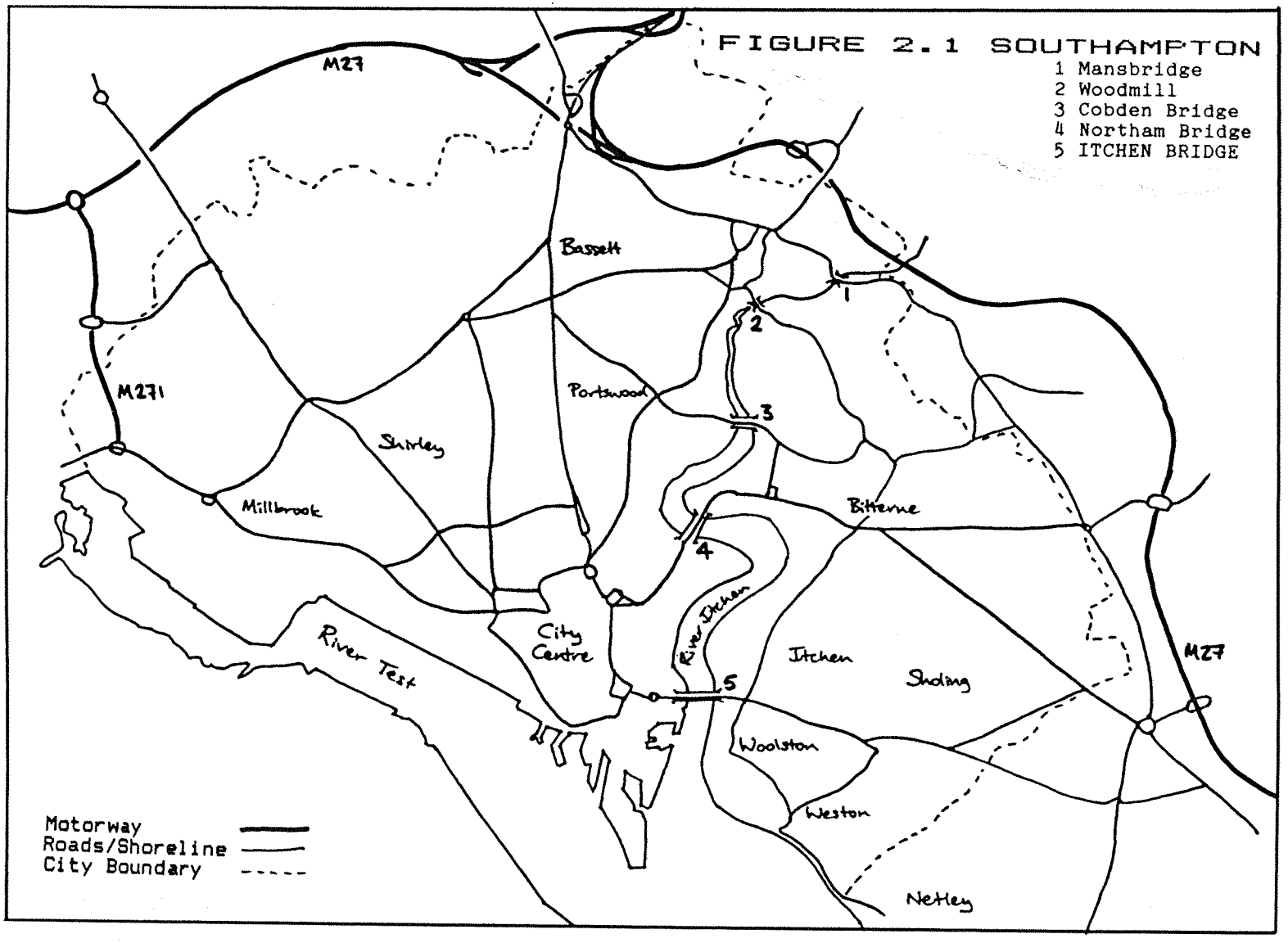


FIGURE 2.1 SOUTHAMPTON
1 Mansbridge
2 Woodmill
3 Cobden Bridge
4 Northam Bridge
5 ITCHEN BRIDGE
M27
M271
Bassett
Portswood
Shirley
Millbrook
Bitterne
City Centre
River Test
River Itchen
Itchen
Shoing
Woolston
Weston
Netley
M27
Motorway
Roads/Shoreline
City Boundary

2.2.4 There had been a long-held desire in the city for a bridge at the ferry site; an Itchen Bridge Company had been established in 1833. In the early 1970's however, the likely need to replace the floating bridge vessels and the impending demise of the City Council's powers in the 1974 Local Government re-organisation finally ensured that a bridge would be constructed (Adams, 1977).

2.2.5 TOLLS

A bridge at the Woolston site, however, had little strategic merit for the national highway network and would not be supported by Central Government funding. The only realistic way of financing the project was through tolls, and this required a special Act of Parliament. The background and administrative procedures necessary for the Southampton Corporation Act (1973) to gain Parliamentary legislative approval have been described by the former City Engineer. (Robertson, 1976).

2.2.6 This Act has now been consolidated with minor amendments into the Hampshire Act 1983. This latter Act refers to the powers of the County Council as the highway authority. However, Southampton City Council manage and operate the bridge under an agency agreement. The Hampshire Act 1983 prescribes the conditions for determining the level of tolls to be charged as follows:-

> "In exercising their powers under this section the County Council shall have regard to:
> first, the financial position and future prospects of the bridge scheme;
> secondly, the need to control the composition and flow of traffic over the bridge so as to avoid causing traffic congestion in areas adjacent to the bridge and so as to preserve the character and amenities of those areas; and
> thirdly, whether to allow any class of traffic to use the bridge without payment of tolls or on payment of tolls at a reduced rate, either generally or during specified hours or on specified occasions:-

(a) Where the grant of any such concession would assist the disabled or aged;

(b) Where, in the opinion of the County Council, the grant of any such concession for a limited period would be desirable in the interests of assisting the establishment of industry or commerce in the city;

(c) Where the traffic is of a local character."(Hampshire Act 1983).

2.2.7 These toll-setting criteria will now be considered individually. First the initial costs of land acquisition and construction were such that financial considerations naturally predominated: revenue maximisation was certainly an early priority. Although the bridge account continues in deficit the tolls are now an important source of revenue to the City, being independent of central government controls.

2.2.8 The second criterion is the one of most relevance to this Chapter. It permits tolls to be used to control the flow and composition of traffic using the bridge in order to protect the environment of adjacent areas. This represents the first deliberate introduction of restraint by price on vehicle movement in the U.K. The reasons why such controls were necessary can be seen by reference to the location of the bridge illustrated in Figure 2.1.

2.2.9 On the eastern side of the bridge the road network is of limited capacity, in both traffic and environmental terms, to well beyond the city boundary; the roads are all single carriageway and have mainly residential frontages. Before 1977 traffic volumes were relatively light, the floating bridge capacity being approximately 200 vehicles per hour. HCV use was also low as the floating bridge could not accommodate heavy vehicles. Although the bridge was intended primarily as a local facility there were many reasons why it would be an attractive choice for longer-distance trips also. Firstly the existing bridges were already congested at peak periods and some trips would naturally be attracted to the new route. Secondly, in combination with the Western Approach scheme (through Millbrook, just

to the west of the City Centre) it would form a quick route for through traffic, at least prior to the completion of the M27 motorway around the north of Southampton. Thirdly, it would provide easy access from the east to and from the commercial docks, and this traffic would be likely to include a high proportion of large and heavy vehicles.

2.2.10 It was feared that there would be a large influx of extraneous traffic, including many heavy commercial vehicles, into the Woolston and Sholing areas. This would clearly have been detrimental to the environment in precisely the geographical areas that the bridge was intended to benefit. A toll structure was therefore developed with deterrence in mind including a punitive toll for heavy commercial vehicles. Buses were exempt from tolls and services were re-organised to include through routes between Woolston and the City Centre.

2.2.11 The simple application of high toll levels, however, would not only deter long distance traffic but also inhibit local use. The third criterion of the Act, therefore, permits certain exclusions or concessions to be made, including geographic discrimination. In practice, concessionary tolls for commercial vehicles are limited to businesses based in a specified area of Woolston, Sholing and Weston, approximately that part of the natural catchment area for the bridge within the City boundary. All City residents are eligible for concessionary tolls for cars, partly for administrative ease and partly for reasons for fairness as all residents contribute to bridge costs through the household rates.

2.2.12 The toll structure, shown in Figure 2.2, therefore exhibits a fine balance between financial expediency, environmental protection and the promotion of local interests.

2.2.13 In order to restrain vehicle flow in the surrounding areas at peak periods but avoid excessive deterrence at other times it was thought necessary to vary the toll charged. The peak hour "surcharge", however, applies only to category 3 vehicles. Peak hours are very broadly defined, from 0600 to 0930 hours and from 1600 to 1830 hours. Until November 1980 the concessionary rate for local vehicles of

FIGURE 2.2 ITCHEN BRIDGE TOLLS (Concessions bracketed)

CATEGORY	DESCRIPTION	JUNE 1977	DEC. 1979	NOV. 1980
1	Public Service Vehicles, bicycles	Zero	Zero	Zero
2	Motorcycles, Mopeds	5p	5p	10p
3	Cars, Vans, Taxis PEAK OFF-PEAK	15p 10p(8.3p)	20p 15p(11.1p)	30p(25p) 20p(15p)
4	Commercial Vehicles < 3 tons Coaches	25p(20p)	30p(25p)	40p(30p)
5	H.C.V. > 3 ton with 2 axles	£1.00(35p)	£1.20(45p)	£1.60(60p)
6	H.C.V. > 3 ton with 3+ axles	£10.00(35p)	£10.00(45p)	£15.00(60p)

category 3 could only be claimed at off-peak times. From November 1980 two types of tokens (peak and off-peak) were offered at a discount to local residents.

2.2.14 Also in November 1980 the hours of toll collection were altered. Previously between midnight and 6 a.m. no tolls were charged but a prohibition on use by HCV's was effected under Traffic Regulation Orders (TRO). Since November 1980 24 hour toll collection operates and the TRO has been abandoned. It is considered that this is economically worthwhile, as well as inhibiting vandalism.

2.3 THE EFFECTS OF PRICING

2.3.1 INTRODUCTION

2.3.1.1 The influence of pricing can be seen in two of the characteristics of traffic using the bridge: composition and volume.

2.3.1.2 The degree to which the toll structure favours or discriminates against a particular class of user is revealed by the composition of bridge traffic relative to that found on similar roads in the Southampton area.

2.3.1.3 It is not possible to see the direct effect of pricing on the traffic volume using the bridge as a toll has been present since the bridge was first open to traffic. However, some measure of the influence of pricing can be gained in three ways. The best indication is provided by the changes in traffic volumes that resulted from the two toll increases which took place in December 1979 and November 1980. The November 1980 toll increase also featured a change from 18 hour to 24 hour toll collection and the change in flow in the period just prior to 0600 which was free, but became subject to toll, provides a second indication of sensitivity. Finally in the Summer of 1982, in connection with a survey for another purpose, the author was able to investigate the "stated response" of car drivers to hypothetical changes in the toll level. Although clearly subject to bias, the response to such questions can provide further evidence of the effects of pricing.

2.3.2 EFFECTS OF PRICING ON TRAFFIC FLOW COMPOSITION

2.3.2.1 Discrimination in the toll structure is present to the extent that the ratio of toll charge to normal operating costs for a particular class of vehicle is greater or less than the average ratio for all vehicles. Clearly cyclists and buses receive positive advantage by total avoidance of toll payment; it is the comparative positions of motorcycles, cars and commercial vehicles that is of most interest here.

2.3.2.2 Estimates of the marginal vehicle operating costs (excluding the value of occupants' time) for cars and HCV's were obtained from the formulae in the COBA 9 Manual (Department of Transport, 1981a). At 40kph and ignoring the hilliness and bendiness factors, costs of 4p per kilometre for cars and 22p per kilometre for the heaviest commercial vehicles were obtained (1979 prices). The ratios of operating costs of mopeds and motorcyles to cars were estimated by reference to the University's rates of reimbursement to staff using their own vehicles for travel on University business.

2.3.2.3 An alternative "official" weighting of costs between vehicle types is revealed by the annual licence fees. From March 1983 these were: Cars £85; Mopeds £8.50: Motorcyles (250cc and above) £34; Heavy Commercial Vehicles (12½ tons unladen weight - c.38 tons gross vehicle weight) £2940 (British Road Federation, 1983). These charges partially reflect the relative damage inflicted to the highway infrastructure by vehicles of different weight, best known as the "fourth power law" (see for example Currer and O'Conner, 1979).

FIGURE 2.3: DISCRIMINATION IN PRICING BY VEHICLE CLASS

Ratios of Costs Relative to Private Cars

	Estimated Marginal Operating Costs	Licence Fees	Itchen Bridge Tolls	
			Peak	Off-Peak
Mopeds	0.26	0.1	0.33	0.5
Motorcycles (over 250cc)	0.52	0.4	0.33	0.5
Cars	1	1	1	1
HCV's	5.5	35	50	75

2.3.2.4 Figure 2.3 shows the relative weights of these charging systems compared to the Itchen Bridge toll structure. It can be seen that in relation to marginal operating costs the toll structure heavily penalises HCV's. The bias is less marked in relation to annual licence fees which take some account of the relative damaging factors of different axle weights, although this criterion is probably inappropriate here. The Figure also suggests that the balance between the tolls paid by cars and motorcyclists is approximately correct although it could be argued that on this basis moped riders, for example, are paying too much with riders of larger machines being favoured.

2.3.2.5 These calculations simply emphasise the common public perception that while a toll of 20p or 30p for a car or 10p for a motorcycle is not unreasonable, a charge of £15 when an alternative route is readily available would indeed be prohibitive for any class of vehicle.

FIGURE 2.4:COMPOSITION OF VEHICULAR FLOW (excluding buses and cycles)

(Percentages)	Motorcycles	Cars	Light Goods	Heavy Goods
Itchen Bridge	7.8	89.8	2.2	0.11
Average of 9 Radial Routes	3.8	78.7	9.7	7.9
Average of 6 Radial Routes (excluding Itchen alternatives)	4.0	78.7	9.7	7.5
Portsmouth Road	5.2	82.7	9.1	3.0

Notes: Itchen Bridge : Working Day 24hr Average May 83 - June 84

Other Flows : Single 12 hr Classified Counts in 1984.

2.3.2.6 The effect of the toll structure on the composition of vehicular flow over the bridge is illustrated in Figure 2.4. The composition is contrasted with that observed in 12 hour counts at nine points on other radial routes in the City. A second comparison is with a subset of six of these counts, excluding points on radials just to the north which might be a substitute for the Itchen Bridge route. A further comparison is with Portsmouth Road, the principal radial serving the Itchen Bridge.

2.3.2.7 It should be noted that the vehicle categorisations, principally between cars and light goods, varies between the sources and hence those figures are not directly comparable. Additionally, 12hr counts would have higher percentages of commecial vehicles (and probably motorcycles) than 24hr records.

2.3.2.8 It can be seen that the HCV traffic using the bridge is abnormally low, clearly a result of the punitive toll. This has some effect on the main feeder route, Portsmouth Road, where just 3.0% of the flow is heavy vehicles compared to an average of 7.9% elsewhere. Even when the routes that might receive the heavy vehicles discouraged from using the Itchen Bridge are excluded (for example, at 9.5% the percentage of heavies using Northam Bridge is the highest in this sample) the average is still 7.5% with the next lowest figure being 4.2% for Shirley Road. The figure of 3.0% HCV's in Portsmouth Road gives some indication of the environmental protection afforded to Woolston by the toll structure. In a traffic census taken in 1977 before the bridge was opened, when no heavy vehicles could cross the Itchen at this point, 2.2% HCV's were recorded. The total flow has increased, however, as discussed later.

2.3.2.9 The other noticeable feature of Figure 2.4 is the comparatively high use of motorcycles on the bridge (7.8%). It is suggested that this is related to two factors. Firstly the former floating bridge was relatively convenient for two-wheelers and this may still exert some influence on travel habits. Secondly many large industrial sites in the U.K. attract extensive use of two-wheeled

vehicles by their workforce, for example the Royal Naval Dockyard at Portsmouth and Rolls Royce at Derby. The Vosper Thorneycroft Shipyard similarly influences traffic composition in Woolston. In this context it is interesting to note that the highest percentage use of motorcycles in this sample (7.9%) arises in Wide Lane where the Ford Motor Company has its works.

2.3.2.10 The main conclusions of this section are that the high level of tolls on HCV's is clearly an effective deterrent and that this has a beneficial influence on the environment in Woolston. Most of the 20 or so category 5 and 6 vehicles crossing the bridge on working days are using local concessionary tickets. If passage over the bridge by token-using vehicles is regarded as "legitimate" then there remain only some 2 or 3 heavy vehicles per day whose presence may be due to the bridge as a through traffic route.

2.3.3 EFFECTS OF PRICING ON TRAFFIC FLOW VOLUME

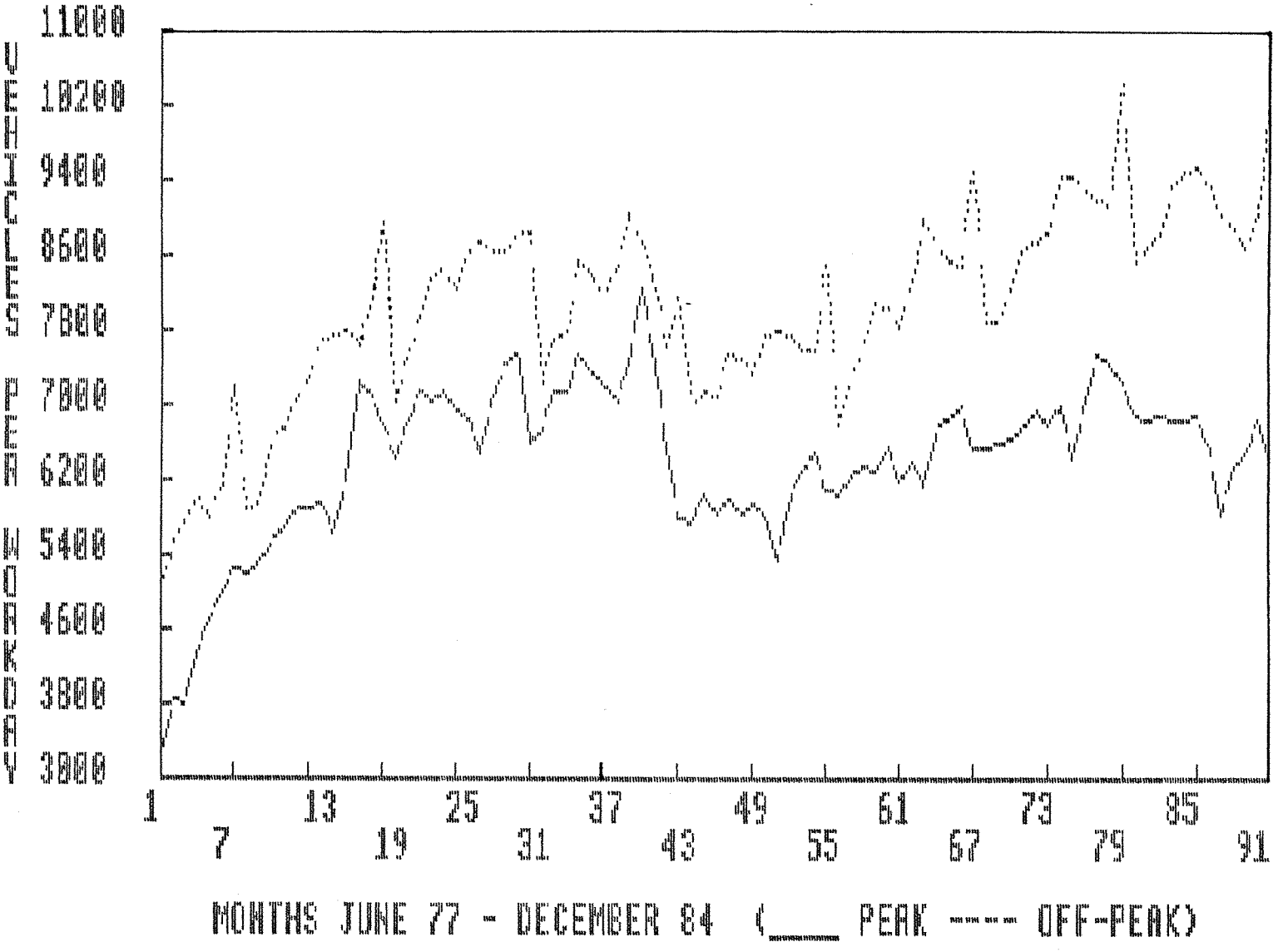
2.3.3.1 The pattern of traffic volume using the bridge since its opening is shown in Figure 2.5. The Figure shows the monthly average workday flows for category 3 vehicles in both peak and off-peak periods.

2.3.3.2 Workdays are normal working days, that is Monday to Friday inclusive but excluding public holidays like Christmas and Bank Holidays. Traditionally transport planners have concentrated their attention on these "typical" days, somewhat to the neglect of weekend travel and other special events (see also comments in Chapter 4). This perhaps reflects concern with "normal" peak hour travel, usually associated with journeys to and from work, as opposed to "leisure" trips at other times which tend to be viewed as being of less importance (see Chapter 5 for a discussion on the value of travel time savings). These workdays certainly exhibit more regular, and hence predictable, traffic flows than other days.

2.3.3.3 Only category 3 vehicles are recorded in Figure 2.5. However, this is not thought to be misleading for two reasons. Firstly category 3 vehicles represent some 90% of the total traffic flow (see Figure 2.4) and hence little accuracy is lost by excluding other categories. Secondly the pricing differential between peak and off-peak periods exists only for category 3 vehicles. This temporal variation in tolls is particularly useful in the subsequent analysis. Hence, the focus of attention for the rest of this section is category 3 workday flows.

2.3.3.4 Figure 2.5 shows several interesting trends. The seasonal variation in flows is markedly different from that given by National Statistics. It is possible to identify an initial "learning curve" as travellers became aware of the bridge. There are December off-peak maxima (perhaps associated with Christmas shopping in Southampton), August peak minima (holiday period for workers) and other special effects like particularly bad winter weather conditions (January 1979).

FIGURE 2.5 MONTHLY AVERAGE WORKDAY FLOWS



2.3.3.5 The influence of pricing on traffic volume using the bridge can only be shown indirectly. Other than on exceptional days, like Christmas Day and Boxing Day, tolls have always been charged and hence the effect of introducing pricing cannot be identified. However, the changes in tolls that took effect on 3 December 1979 and 17 November 1980 do provide an opportunity to study the reaction of drivers to price changes. Hence the sensitivity of response can be investigated. However, this exercise is hampered by the fact that there have been only 2 price changes in the 7½ years of bridge operation; obviously more changes would improve the sources of information available for study. A further difficulty is presented by the timing of the toll changes; both were implemented just before Christmas when traffic flows tend to change rapidly (see Figure 2.5).

2.3.3.6 The principal problem in attempting to study the response to toll changes is the prediction of what traffic flows would have been in the absence of any change (Weustefeld and Regan, 1981; Smart and Ramsey, 1982). A very wide range of factors affect traffic volume using the bridge and even the following is probably an incomplete list:

(i) Toll price. The value of a fixed price toll is gradually eroded by the influence of inflation.

(ii) Land use changes. For example, the opening of a new hypermarket at Bursledon on the eastern fringe of Southampton, may have affected the pattern of shopping trips in this corridor.

(iii) Economic and Social factors. The general recession in the U.K. will influence the amount of travel undertaken. Industrial action at major employers (e.g. Docks) may affect traffic volume and its temporal distribution.

(iv) Time of year. Seasonal changes in activity patterns affect traffic flow.

(v) Weather conditions. For example, severe winter conditions significantly reduce traffic flow.

(vi) Motoring costs. Changes in petrol prices might be thought to influence flow levels, although Itchen Bridge data shows very little evidence of response to the large and varied changes experienced in recent years.

(vii) Road Network changes. Either permanent changes such as the completion of the M27, or temporary differences such as the presence of road works on a parallel route, could affect traffic flows.

(viii) Other Modes. Changes in bus service fares or frequencies might contribute to alterations in car use of the bridge.

All these factors modify the regular cyclical daily and weekly traffic patterns commonly observed in most cities, and contribute to a traffic level which varies considerably with time.

2.3.3.7 A second problem for analysis is that it might reasonably be expected that the data would exhibit a response "lag" as travellers, particularly infrequent users, encounter the new tolls and consider or try out alternative choices before re-establishing a regular travel pattern (Clarke, Dix and Goodwin, 1981). This would suggest that the period immediately following a toll change should not be used as an "after" period.

2.3.3.8 Three ways of estimating the impact of the toll changes on traffic flows are now presented. The merits of each approach and a discussion on the results are considered later.

2.3.3.9 (i) "Simple" Before and After Comparison

The selection of a suitable time period for analysis is of particular importance here. A sufficiently lengthy period must be considered to allow reasonable statistical confidence to be established, avoiding excessive bias from the inherent daily fluctuations in traffic flow. Too lengthy a period, however, means increased liklihood of inclusion of changes in other factors such as those listed above. In particular the proximity of the toll changes to Christmas meant that a relatively short period must be used to avoid the influence of seasonal trends.

2.3.3.10 A two week period before and after the toll changes was therefore adopted. Indeed, for the 1979 increase this was the only practical possibility. It is interesting to note a complete lack of evidence to support the "lag" phenomenon as outlined above. For both toll increases there was an immediate change in traffic volume which appeared highly stable. The toll increases were well publicised, both at the toll plaza and elsewhere, in order to minimise difficulties at the toll booths. On the assumption that the "before" flows represent what would have occurred in the "after" period without the toll increase, the following results (Figure 2.6) were obtained, as previously reported (Atkins, 1982).

2.3.3.11 The percentage toll change figures shown reflect the changes in use of the concessionary toll opportunities. Only a very small proportion of car drivers use concessionary tokens. Each toll increase, however, has caused an increase in token use and hence the average price rise experienced by users is slightly less than the full increase. For example, for the December 1979 increase, use of off-peak tokens increased from 2.4% use of a 17% discount to 5.6% use of a 26% discount. The average price increase was therefore 48.4%, not the full 50% that might have been expected.

FIGURE 2.6: TOLL PRICE CHANGES: SIMPLE BEFORE AND AFTER MODEL

	3 December, 1979	17 November, 1980
Peak		
Basic Toll Increase	15p – 20p	20p – 30p
Percentage Toll Change	+33.3%	+47.7%
Percentage Flow Change	–4.0%	–17.9%
Elasticity	–0.12	–0.37
Off–Peak		
Basic Toll Increase	10p – 15p	15p – 20p
Percentage Toll Change	+48.4%	+32.5%
Percentage Flow Change	–5.0%	–14.3%
Elasticity	–0.10	–0.44

2.3.3.12 (ii) "Corrected" Before and After Comparison

When the above results were first compiled there was insufficient data to study in detail the weekly pattern of flows in the period before Christmas. For 1977 the data is still dominated by the learning curve effect and the toll changes affect the data in 1979 and 1980. However it is now possible to consider data from 4 unaffected years: (1978, 1981, 1982 and 1983) and also the November data from 1979 before the toll was changed.

2.3.3.13 Pre–Christmas weekly traffic flow data for the peak period is inconsistent, except for the week immediately prior to Christmas when a drop is noted in all years. In 1978 and 1983 an increasing trend is

noticed; in 1981 and 1982 a steady or marginally declining trend is present. Thus the peak period results shown above have not been modified.

2.3.3.14 For the off-peak, however, there are consistent trends in all years with a small decline in mid-November but then steady increases before a dramatic rise in the week just prior to Christmas. Thus in 1979 off-peak flows reduced due to the toll change when in all other years at this time an increase was noted. Hence, the simple B+A method underestimates response. In 1980 the decline due to the toll increase occurred at a time when a small decline occurred in other years. Hence the simple model slightly overestimates the toll sensitivity here. Using the average percentage weekly change observed in neutral years as a correction device the following modified results were obtained for the off-peak period (Figure 2.7). Further study recently has shown that inclusion of pre-Christmas data for 1984 would not significantly affect these results.

FIGURE 2.7: TOLL PRICE CHANGES: "CORRECTED" BEFORE AND AFTER MODEL

	3 December 1979	17 November 1980
Off-Peak		
Basic Toll Increase	10p - 15p	15p - 20p
Percentage Toll Change	+48.4%	+32.5%
Percentage Flow Change	-8.31%	-12.1%
Elasticity	-0.17	-0.37

2.3.3.15 (iii) Trend Extrapolation

While there are many statistical techniques for studying time series data (for some examples in transport see Smart and Ramsay, 1982 or Nihan and Holmesland, 1980), the simplest way to remove the effect of

seasonal variations is to calculate the 12-monthly moving average. The results for both peak and off-peak data are shown graphically in Figure 2.8. This diagram is probably the most succinct expression of trends in vehicle usage of the Itchen Bridge. The "learning curve" effect shows particularly clearly with increasing flows but a declining rate of growth. The first downturns on the graphs show at the time of the first toll increase. The off-peak trend then stabilises, with the peak still increasing but at a lower rate of increase than previously. After the second toll increase both trends decline until the influence of the toll changes drops out from the averaging process. Both curves then show virtually linear trends with the off-peak increasing at a greater rate. The peak flows have still not recovered to their pre-increase levels, when congestion was presenting a problem in Porstmouth Road in the morning peak. Interestingly both lines show a decline since July 1984 when the M27 Motorway to the north of Southampton was completed.

2.3.3.16 From these longer term trend graphs it is possible to predict by extrapolation what the moving average might have been without a toll increase. Hence the monthly average flows can be estimated and the influence of the toll change identified. Extrapolation can either be done "by eye" or by curve-fitting. Some compromise was achieved here by seeking a curve which provided not only good statistical fit but also identified a "reasonable" future trend. Estimates of the response to toll changes by this method are shown in Figure 2.9.

FIGURE 2.8 12-MONTHLY MOVING AVERAGE OF MONTHLY AV. FLOWS

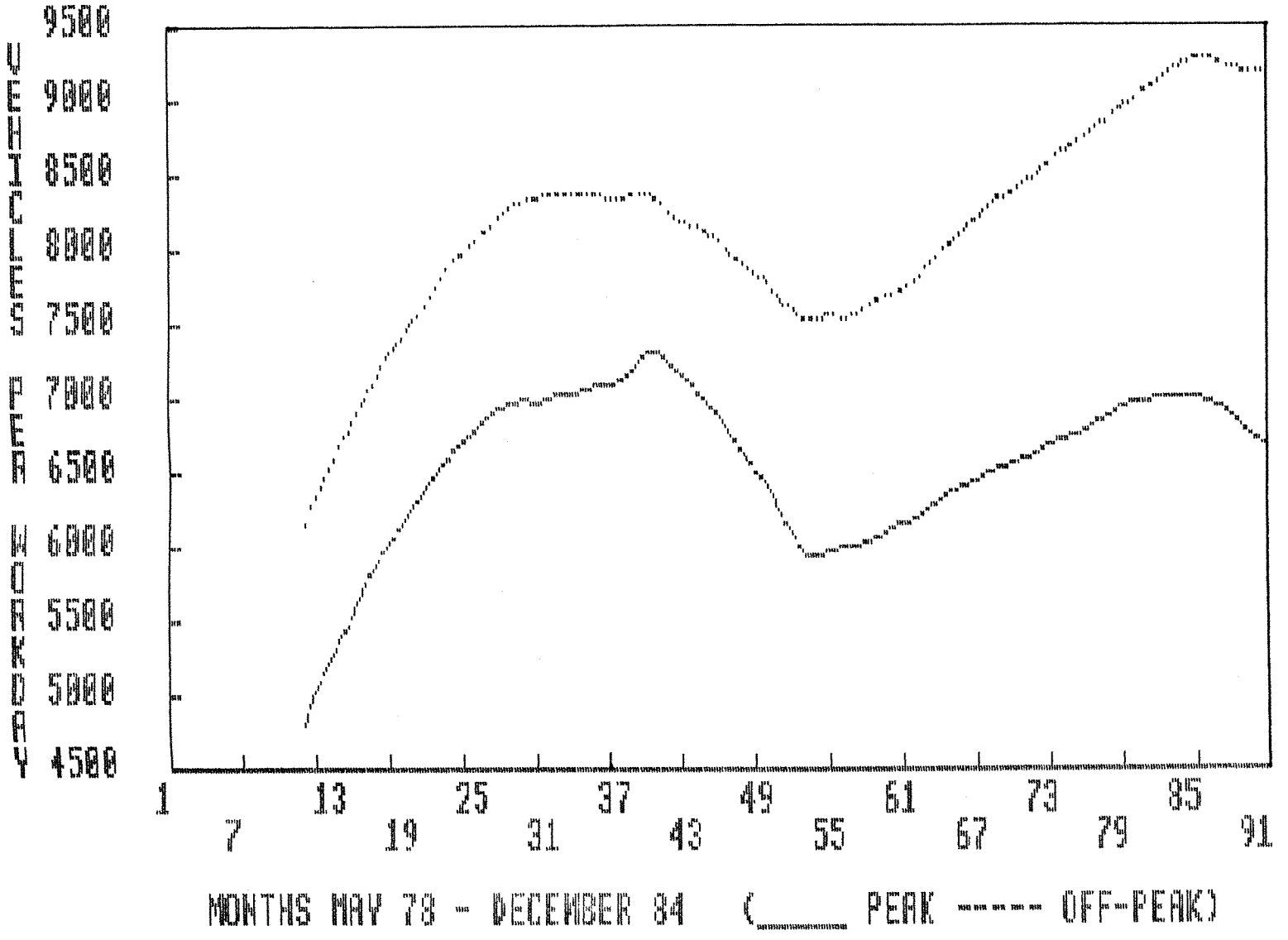


FIGURE 2.9: TOLL PRICE CHANGES : TREND EXTRAPOLATION METHOD

	3 December 1979	17 November 1980
Peak		
Basic Toll Increase	15p - 20p	20p - 30p
Percentage Toll Change	+33.3%	+47.7%
Percentage Flow Change	-7.4%	-11.9%
Elasticity	-0.22	-0.25
Off-Peak		
Basic Toll Increase	10p - 15p	15p - 20p
Percentage Toll Change	+48.4%	+32.5%
Percentage Flow Change	-8.1%	-15.3%
Elasticity	-0.17	-0.47

2.3.3.17 Discussion of Analysis Techniques

In the absence of additional data sources the simple "Before and After" method clearly provides an acceptable first approximation of the impact of the toll increases. The strength of this technique is given added emphasis by the particular data sets used here. These exhibited not only sudden and dramatic changes in flows coincident with the toll changes but also apparently stable flow levels within each of the before or after periods. However, it is clear that the proximity to Christmas of the toll changes does demand more detailed investigation of the patterns of flows during this period. While a greater number of years in which to study the weekly pattern of flows would be highly desirable, the "modified" before and after model for off-peak flows is an obvious improvement.

2.3.3.18 Effective time series analysis of this data by a more complex method such as Holt-Winters smoothing or a Box-Jenkins model technique is only now becoming possible as relatively large data sets are necessary to ensure adequate model specification. The author is currently undertaking such work, seeking to fit appropriate time series models to the Itchen Bridge data. However, the analysis accomplished to date has indicated that a simple time series approach can add little explanation to the moving average technique already employed. Further studies, perhaps including deflated toll price as a variable, are anticipated. The simple 12-monthly moving average used here is, I believe, valuable in visualising the longer term trends, but does require careful interpretation. The influence of data from a specific month is exerted over a long time period through the averaging process. Despite the apparent stability illustrated in Figure 2.8, using such trends to infer individual monthly values is vulnerable to considerable error propøgation. For example the 12-monthly moving average for off-peak flows throughout 1980 is relatively stable, and extrapolation infers a monthly average workday flow for November 1980 of a little above 9,000 vehicles per day. However, in the first half of November 1980 and still prior to the toll increase, an average of only 8,000 vehicles was observed. The influence of the previous toll change must be considered to avoid this problem.

2.3.3.19 Thus, it is suggested that the "before and after" figures, adjusted for off-peak periods, remain the best estimates of the influence of the toll increases.

2.3.3.20 **Flows Midnight – 6 a.m.**

A further way of demonstrating the response to price changes is to examine the data on traffic-flows in the period midnight to 6 a.m. before and after the November 1980 toll change. Before 17 November 1980 no tolls were charged in this period but after this date 24 hour toll collection operated. The number of vehicles using the bridge in this period changed from an average of 661 before the toll change to 384 after, a 42% reduction.

2.3.3.21 Clearly this change now includes some travellers who altered the timing of their journey. Although after 17 November, 1980 there was still a toll price change at 0600 hours (from 20p to 30p), some persons may have previously made efforts to use the bridge after midnight or before 6 a.m. in order to avoid the toll altogether. For example, there is anecdotal evidence that vehicles queued just prior to midnight, only passing through the toll plaza once the collectors had gone off duty! Furthermore, not too much confidence should be placed on small changes in small numbers. However, if this change were to be interpreted as the likely response of drivers to changes in toll level close to zero it indicates that an untolled bridge would experience a substantial increase in travel demand.

2.3.3.22 Stated Intention (Transfer Price)

A further indication of the likely reaction to changes in pricing can be gained from the "stated intention" responses of travellers when interviewed.

2.3.3.23 In June 1982 the University conducted a household interview survey in eastern Southampton concerning travel over the Itchen and Northam Bridges. The principal aim of the study was to determine a value of travel time from drivers' perception of the time and cost differences between routes using Northam and Itchen bridges and their actual route selection. The survey and its results are fully described in Chapter 3. Although the study focussed primarily on reported current behaviour the opportunity was taken to ask drivers how they would respond to a change in toll price. Despite the fact that stated intention can sometimes bear little resemblance to subsequent actual behaviour (e.g. Gensch, 1980; Bonsall, 1981), the results are still of interest.

2.3.3.24 The toll price change question was phrased as: "Assuming the travel times remain as you have stated, would you change route if the Itchen Bridge toll were X?". X was determined from the toll currently faced for the journey (either peak or off-peak rate and with toll concession if appropriate) adjusted by either a 5p increase for Itchen

users or a 5p decrease for Northam users. Successively larger toll changes were offered until the respondent stated that their route choice would change. A minimum of a zero toll was suggested to Northam users, and a £1 maximum for Itchen users, but even at these rates some persons would not alter their choice. From the responses Figure 2.10 was compiled.

2.3.3.25 Several qualifications are appropriate before interpreting Figure 2.10. First, responses to hypothetical questions are notoriously biassed. In this case there would be a "natural" tendency to exaggerate the sensitivity to toll increases with the aim of discouraging such increases from being implemented. This has been termed "policy response bias" (Bonsall, 1983). Secondly, the survey area was located within the City boundary and therefore the sample contained mostly short distance trips. These might be expected to be more sensitive to toll changes than longer distance trips where the toll represents a much lower proportion of total journey costs. The City's own survey in Summer 1980 showed that during peak periods 40% of the bridge users trips came from beyond the City boundary. These factors suggest that the results might indicate an upper bound to the likely general reaction to a toll increase. Thirdly, the question mentioned only route-switching effects and hence the results may not take account of changes in the total level of demand for travel (e.g. by changes in destination choice) which would occur as the price alters.

2.3.3.26 Figure 2.10 does show the anticipated exaggerated response to toll increases. For small price rises, where route switching is perhaps likely to be the major effect, elasticities of -2.0 for the peak and -0.8 for the off-peak are obtained. However, it is interesting to note that the elasticities for small toll decreases (peak -0.32, off-peak -0.53) are more reasonable. Indeed some manipulation to select the percentage changes in vehicular flow from the same toll price changes as occurred in December 1980 gives elasticities of -0.46 for the peak and -0.39 for the off-peak, very close to the observed figures of -0.37 for both time periods. The

FIGURE 2.10: STATED INTENTION RESPONSES OF DRIVERS TO TOLL CHANGES

Percentage Use of Itchen Bridge	Peak	Off-Peak
Toll change: -30p	91	-
-25p	84	-
-20p	82	92
-15p	73	86
-10p	65	84
-5p	56	71
0	53	63
+5p	34	50
+10p	18	37
+15p	11	21
+20p	5	10
+25p	5	7
+30p	4	4
+35p	4	3
+40p	4	2
+45p	3	2
would never change	3	2
Sample size	770	760

Source: Home Interview Survey of Regular Travellers, June 1982

positive induction to change that is inferred by the question phrasing (termed "affirmation bias" by Bonsall, it infers that route-switching is a likely, reasonable reaction, sought by the interviewer; the earlier the "yes" response the sooner the questioning ceases) is counteracted by the habit or inertia effect, perhaps called "brand loyalty" in other contexts, which may also have been enhanced by a previous overstatement of the advantages ("rationalisation" bias) of the chosen route. Nevertheless this balancing of these bias effects clearly does provide a better estimate of the likely reaction than the response to the question in its original form! (For further elaboration on response bias, see the discussion of the transfer price method in Chapter 3.)

2.3.3.27 Traffic Flows in Areas Adjacent to the Bridge

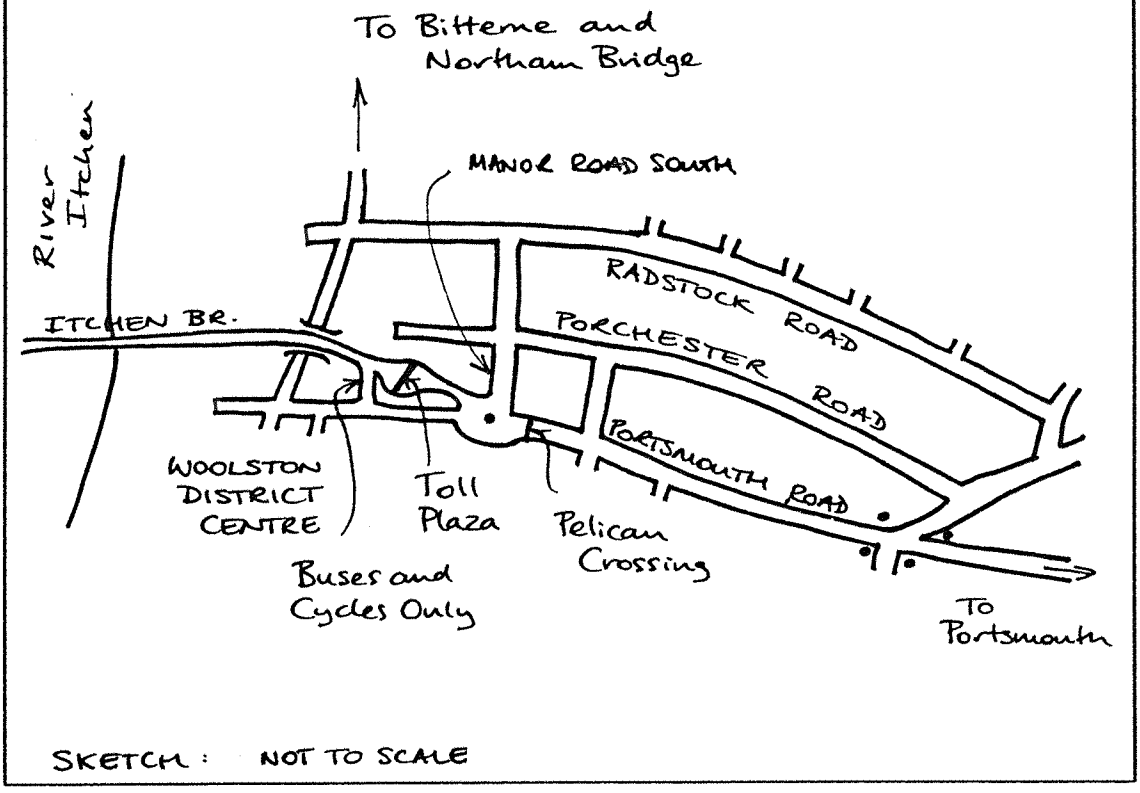
The aim of traffic restraint on the Itchen Bridge is to avoid congestion and to protect the environment in areas adjacent to the bridge. There is unfortunately little evidence to test the success of this policy. Annual one-day traffic counts on Portsmouth Road, the main approach road to the east, show a near doubling of flow when the bridge was first opened. This increase of traffic may have been compensated by reduction elsewhere as less traffic would need to move north/south through the area to gain access to the Northam Bridge routes. While traffic use of the Itchen Bridge has subsequently grown appreciably, flows on Portsmouth Road have increased at a lesser rate, indistinguishably from the general small traffic growth experienced throughout the City.

2.3.3.28 Congestion has at times caused problems. In 1980 the morning peak flows regularly queued back from the toll booths to the mini-roundabout controlling the bridge approach and from there back along Portsmouth Road, sometimes for a considerable distance. This slow-moving traffic was further aggravated by delays at a pelican crossing just prior to the roundabout and several wily motorists re-routed via Porchester and Radstock Roads (principally residential

streets) to gain prior access at the mini-roundabout from Manor Road South (see Figure 2.11). Since the 1980 toll increase, however, this problem has virtually disappeared.

2.3.3.29 Congestion occasionally occurs now in the morning peaks on the bridge but this is due to delays for bridge traffic at the roundabout at the western end of the bridge rather than excessive demand for use of the bridge itself.

FIGURE 2.11: LOCAL ROAD NETWORK ON EASTERN SIDE OF ITCHEN BRIDGE



SKETCH: NOT TO SCALE

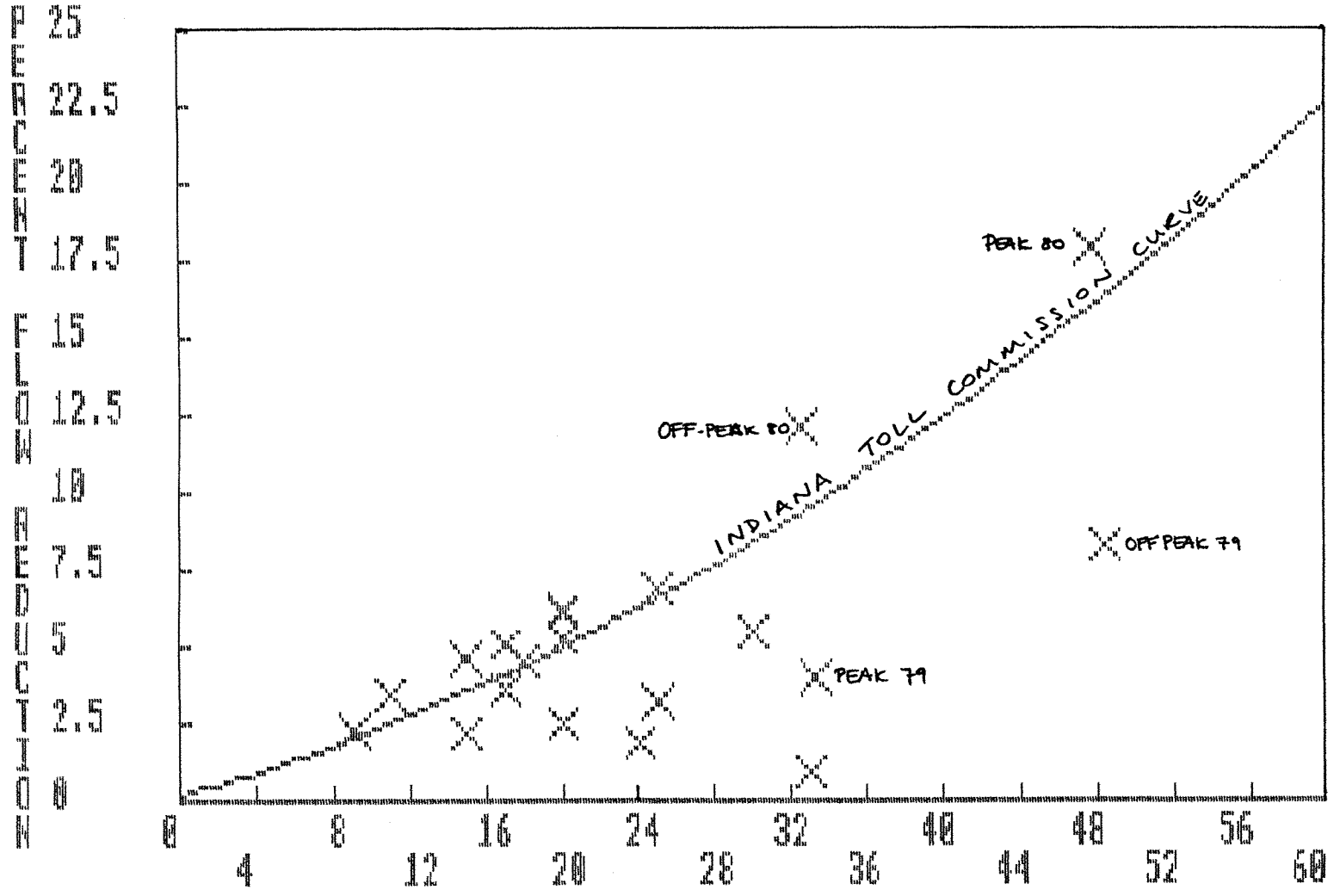
2.3.4 DISCUSSION ON THE EFFECTS OF PRICING

2.3.4.1 Prior to the opening of the bridge to traffic, consultants were appointed to advise on the initial level of tolls to be charged. From complex modelling exercises a very high sensitivity to toll level was predicted; for the price changes of the 1979 increase implied elasticities of -0.88 for the peak and -1.51 for the off-peak are obtained. These figures have been shown to be erroneous. Fortunately the initial traffic levels proved to be very close to the forecast values, although early growth was rapid (see Figure 2.5) and these predicted levels were soon exceeded. Reasons for the large errors in predicted sensitivity are hard to pinpoint, but it does reflect a general lack of useful quantified information on travel behaviour despite the vast sums spent on transportation planning models in the 1960's and 1970's.

2.3.4.2 It is interesting to compare the Itchen Bridge results with those for various American toll facilities including bridges, tunnels and roads. Figure 2.12 presents the Itchen results superimposed on U.S. data including a "toll sensitivity curve" developed by the Indiana Toll Road Commission (Weustefeld and Regan, 1981). It can be seen that the Itchen results are in broad agreement with the American experience, in sharp contrast to the consultants estimates mentioned above. This agreement is all the more surprising if the widely different nature of the locations is considered. In particular the Itchen Bridge does have a closely available alternative route and perhaps greater sensitivity to toll changes might have been anticipated.

2.3.4.3 In economic theory the response to price changes is determined by the demand curve which is usually presented as a smooth curve convex to the origin. However, there are recent developments which suggest that an S-shaped curve may be a more realistic representation of consumer behaviour. There may exist a "threshold level" for transport price changes (White, 1984). For price changes below the threshold relatively little reaction is observed, however, when stimulated by a "significant" price change travellers will actively seek journey

FIGURE 2.12 ITCHEN TOLL SENSITIVITY c.f. U.S. TOLL RESULTS



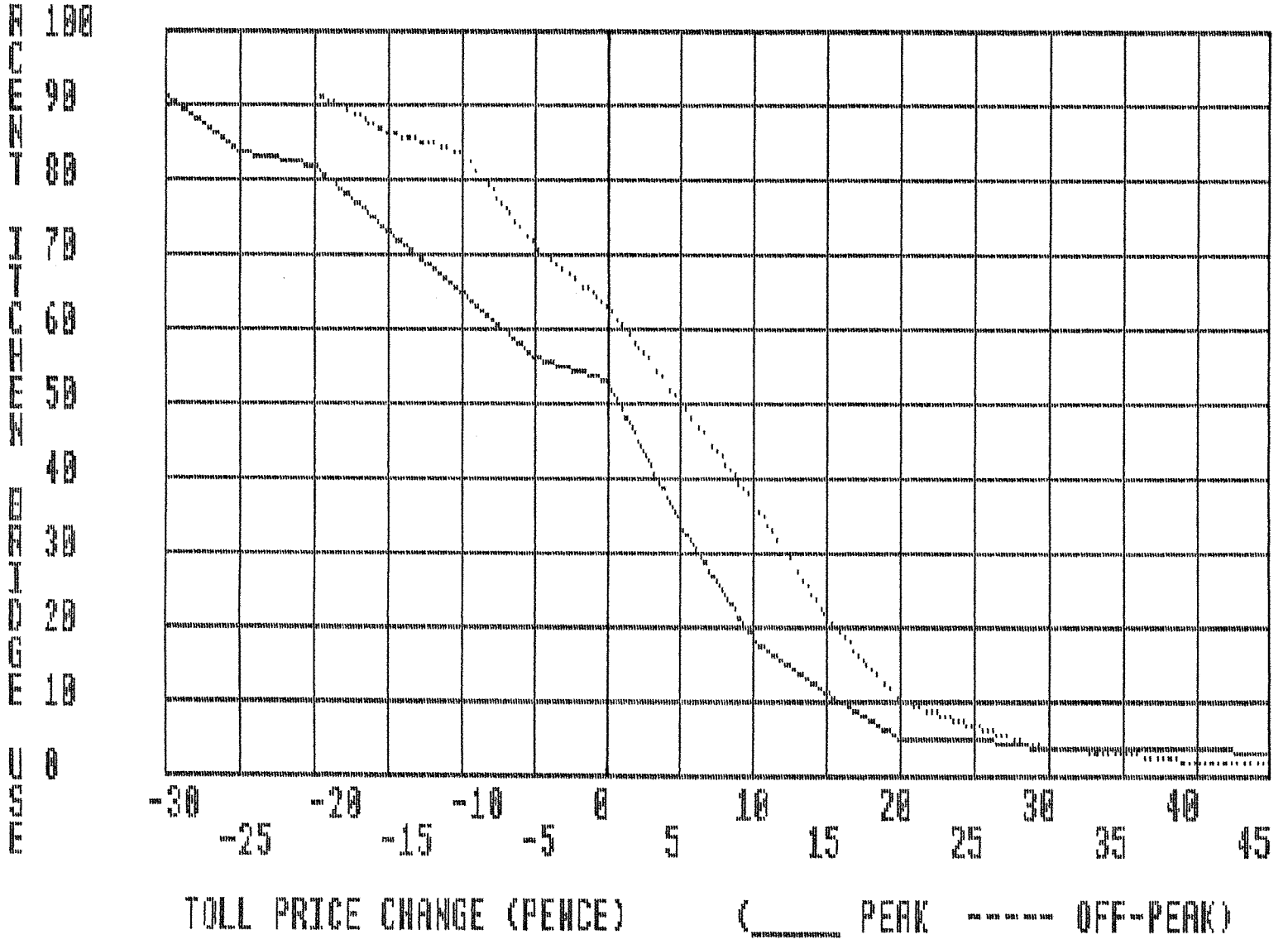
alternatives which may then result in large changes in traffic volumes. Such S-shaped curves also arise from most currently accepted theories of transport choice behaviour such as logit or probit models.

2.3.4.4 S-shaped curves, being single monotonic functions, are not in fact inconsistent with the smooth demand curve of classical economics, but have assisted the appreciation that the conventional diagrams are but one representation of reality. While the results from the Itchen Bridge price rises give only limited support for this threshold idea, the "stated response" curve does resemble the (reversed) S-shape in its central and lower sections (see Figure 2.13).

2.3.4.5 The threshold concept, which draws some features from catastrophe theory (Thom, 1972), also appears in theories of habit and hysteresis (Goodwin, 1977). Goodwin's suggestion of different demand curves dependent upon the past history of cost changes implies a greater response to a second price rise than to the first, which concurs with the Itchen results. It is also interesting to note the American experience: "public reaction may be more negative to a series of repeated increases" (Weustefeld and Regan, 1981).

2.3.4.6 While elasticity is a simple and appealing measure of response to price changes it is clear from both theory and practice that a constant elasticity is unlikely. The Indiana Toll Commission curve suggests elasticity is a function of the percentage price rise, the threshold concept suggests a divergence of response while Goodwin's theories suggest it is partially dependent on the past history and frequency of toll changes. Elasticity is also highly dependent upon the next best course of action available to the consumer. If an alternative is convenient and cheap then response will be elastic. If not, consumers may be regarded as "captive" and response inelastic. Elasticity therefore measures the availability and quality of alternative courses of action as much as consumer aversion to the changed variable. For the Itchen Bridge the completion of the M27 to the north of Southampton has clearly affected the pattern of demand for river-crossing trips and may well have increased the elasticities also.

FIGURE 2.13 STATED INTENTION RESPONSES TO TOLL PRICE CHANGES



2.3.4.7 While the level of toll clearly exerts some influence on traffic flows in areas adjacent to the bridge there is insufficient data available to explore this relationship in detail. Pricing may be a useful tool to control traffic flow levels generally but it cannot limit flows to within a pre-determined figure (e.g. below the onset of congestion). The sensitivity necessary to effectively restrain traffic to some specified level would require toll changes to be made very frequently, clearly an undesirable practice.

2.3.5 Conclusions on the Effects of Pricing on Traffic Volume

2.3.5.1 It is concluded that the first toll increase produced only a small reduction in flow whereas the second increase, a year later, did cause a much greater proportionate effect. Elasticities for peak and off-peak seem consistent for each price change. The imposition of a toll for the period midnight to 6 a.m. did have a major influence on flow, but some of these travellers may have altered only the timing of their journey. Asking drivers what their reaction to toll increases would be, produced the expected exaggerated response. However, the stated response to toll reductions may provide some guidance to actual response to toll increases.

2.3.5.2 Estimates of sensitivity to the tolls made before the bridge opened were highly erroneous. The observed elasticities are more akin to U.S. experience for major facilities where, in most cases, alternative routes are not readily available. Predictions of response to future price changes would need to take account of the change in alternative routes offered by the opening of the M27 as well as the proposed price change, whether this exceeds some threshold value (below which it might be generally viewed as just a normal price rise to be expected in inflationary times) and the time elasped since the last increase.

2.3.5.3 While tolls provide a general control on flow levels this cannot be sensitive or precise in the sense of limiting flows to below some maximum level.

2.4 PRICING AND EQUITY

2.4.1 OBJECTIONS TO DIRECT PRICING OF ROAD USE

2.4.1.1 A list of reasons for rejection of road pricing strategies for cities has been compiled by May (1983), drawn principally from his own earlier reference (May, 1979) and from Higgins (1979). The list is:-

1. The restraint would be unworkable (administratively or from the standpoint of enforcement).
2. The restraint would be ineffective (in that the net response to the penalty imposed would be insignificant).
3. The restraint would have adverse effects on transportation (by diverting traffic or overloading public transportation).
4. The restraint would cause economic activity to relocate.
5. The restraint would be unfair to certain groups in society (the poor, essential users, and others).
6. The restraint would involve an unacceptable restriction on freedom of movement.
7. The restraint would be unnecessary.

2.4.1.2 Some of these have only limited relevance to the Itchen Bridge case study as the fact that the bridge created a new transport link clearly outweighs the effects of price as a deterrent to some potential users (e.g. Nos. 3, 4 and 6). The need for restraint (Number 7) was clearly anticipated in setting up the toll structure and would appear to have been justified by the extensive queues that have occurred at times on the bridge approach; inevitably these would have been longer and more frequent without the toll. The administration and enforcement aspects (Number 1) have been shown to a be practical success, but the principle of toll collection for bridge crossings was already well established in public consciousness. As demonstrated above, the toll has been effective (Number 2) and the sensitivity of the response would permit much greater control on traffic flows if this was thought desirable. The remaining objection of discrimination (Number 5) will now be considered in more depth.

2.4.1.3 Firstly it should be noted that the toll structure is deliberately discriminatory, positively favouring Southampton residents (concessionary tokens), business in the Woolston Area (commercial vehicle concessions), certain vehicle types (e.g. cycles and buses free), times of day (e.g. off-peak c.f. peak tolls) and so on. However, unintentional discrimination, particularly between income groups is the principal concern of this objection. There is a considerable literature on the regressiveness of road pricing from both theoretical and practical perspectives (see for example Richardson (1974), Foster (1975), Button & Pearman (1983)). While this is understandable, similar arguments are rarely heard with reference to other discriminatory traffic management schemes, for example, car parking charges.

2.4.1.4 It has been argued (Foster, 1974) that road pricing would be generally progressive in its impact. This argument is based on the fact that poorer groups in society generally do not own cars and therefore would not pay this tax. They might benefit, either as bus users through service improvements resulting from reduced congestion, or from the way in which government might choose to spend the revenue from road pricing (a cross-subsidy to public transport has been suggested as some compensation to those "tolled-off" from car use). In contrast richer groups in society are likely to make more trips and longer trips probably on more congested streets and at peak times and would therefore be likely to pay more.

2.4.1.5 However, Richardson suggests that road pricing would not be progressive in the strict sense, and particularly, in relation to richer and poorer motorists (Richardson, 1974). Although low income groups might benefit, as outlined above, wealthier motorists would also benefit as the price charged for road use would not be proportional to income. Their "willingness-to-pay" could be much greater than the price charged and hence a consumer surplus benefit would be achieved. Whether gains at the extreme ends of the income spectrum but losses in the middle-income groups is intrisincally progressive or regressive is impossible to assess (Button and Pearman, 1983). An irony of the

situation is that congestion may be an equitable allocative instrument (i.e. willingness to queue and equality of time resources) despite its intrinsic inefficiency aspects.

2.4.1.6 Regardless of whether road pricing is either progressive or regressive it is certainly true that the issue is one of concern for implementation (Higgins, 1979 and response by May).

2.4.2 REGRESSIVENESS OF ITCHEN BRIDGE TOLLS

2.4.2.1 Some evidence on how the response to pricing varies between income groups can be obtained from the data collected by Southampton University in 1982 (see Chapter 3 for full details of this survey). This home interview survey was conducted in an area of Southampton where drivers' route choice between the Itchen toll bridge and the untolled Northam Bridge was likely to be marginal. Given certain perceived time and cost differences between the routes, were low income drivers more likely to choose the cheaper alternative? In other words, was the value of travel time revealed by their route choices related to income level?

2.4.2.2 As a part of the survey respondents were asked to indicate which range contained their total household income. Although there can be no guarantee of the accuracy of individual responses it is generally thought that reported incomes would be closely correlated to actual incomes. From the results shown in Figure 2.14 it can be seen that 90% answered this question and that a reasonable distribution across the groups was achieved. It was found that disaggregating the full data set into reported income groups was statistically justified; a slightly better model fit was obtained. However, the values of travel time obtained for each group showed no discernable pattern and certainly no relationship to the reported income levels. Having regard also to the standard errors for the values of travel time of each group it can only be stated that no relationship was found between reported income and travel time values.

2.4.2.3 Thus it seems that there is no discernable trend to the willingness-to-pay tolls between different income groups. It is interesting to note that this agrees with experience in Singapore as reported by Watson and Holland (1978). Clearly the Southampton finding must be seen in the context of relatively low toll charges even taking account of the highly "visible" nature of the tolls, being a direct out-of-pocket cost. Similarly the toll levels are low in comparison to prices suggested for traffic restraint schemes and hence caution should be exercised in drawing inferences from this result.

FIGURE 2.14 : TRAVEL TIME VALUES BY REPORTED INCOME GROUP

Group No.	Reported Annual Income	No. of Respondents	Value of Travel Time (p/min)	Standard Error
0	Unknown, refused	122	2.27	0.85
1	< £5000	275	5.01	1.59
2	£5000 - £7500	340	6.29	2.16
3	£7500 - £10000	289	3.63	0.99
4	£10000 - £12500	141	2.32	0.57
5	> £12500	74	4.04	1.04

2.4.2.4 However, although no income-related relationship was observed, this does not necessarily imply that pricing is not regressive. What it does indicate is that tolls were not influencing the spending patterns of households with differing financial resources. Thus those who object to pricing for reasons of equity can draw no support from these results, but this evidence alone does not render their attitude untenable.

2.5 PRIVATE FINANCING OF ROADS

2.5.1 In the United States, after a period when publicly financed road construction (the so-called "tax-supported" facilities) predominated, toll roads are again receiving attention (Weustefeld, 1984). There are several reasons for this. First several major toll facilities have either reached or are nearing the time when their total debt will be repaid. Federal law anticipates these roads becoming toll-free but many are approaching the end of their design life and large maintenance and renovation costs may then fall on State authorities without financial resources to undertake such work. Continuation of tolls on many of these roads is being sought, but has been successfully opposed in Connecticut, for example. Secondly toll facilities constructed more recently are failing to generate sufficient income to repay debts and support from other sources is generally necessary. This certainly parallels U.K. experience where most estuarial crossings have increasing debt burdens (FTA, 1982; Tuckwell et al, 1985). Thirdly many U.S. commentators see a "deferred maintenance" problem for their country's road network; one estimate of refurbishment is $230 billion (Pooley, 1984). This is thought to arise from public agencies not spending enough on routine maintenance due to competition for funds from more politically attractive schemes, often outside the transport sector altogether. (Again this experience may sound familiar to some U.K. engineers.) With little hope of additional tax revenues, tolls are seen as a possible source of salvation, and some States are even investigating the introduction of tolls on formerly toll-free facilities (Weustefeld, 1984). This is perhaps the principal justification for current U.K. interest to involve private capital in road construction; "the private financing proposal ..... could mean better roads sooner" (Butler, 1982).

2.5.2 However, unlike U.S. developments, tolls have not received much attention in U.K. debates on this topic. For example, in 1982 the then Secretary of State for Transport wrote "There are other problems with tolls. There are a few tolled estuarial crossings, but the remainder of the major road network is almost entirely toll-free. So unless drivers can see a real advantage in using a tolled road the

price charged (and the delay involved in collecting it) is likely to discourage them from using it whenever there is a reasonably convenient alternative. Except in the case of estuarial crossings our road system is now so well developed that there usually will be such an alternative. This ease of diversion would make it difficult to finance a new road from toll revenue." (Howell, 1982). Such a view is not borne out by the Itchen Bridge experience where even in conditions closely competitive with an alternative route some 17,000 vehicles per day paying over £1.3 million per annum use the toll facility.

2.5.3 Most major new roads are constructed to meet an anticipated demand for travel. This forecast use is because the proposal would become the preferred route for many individual travellers. These travellers would perceive significant advantages for their chosen route over other alternatives. It therefore seems obvious that some payment could be extracted, and probably without excessive deterrence, to produce an excess of revenue over operational cost. This may not totally finance a new road, but could certainly make a substantial contribution. While this clearly could be done, whether it should be is, of course, a political question. The "Roads Lobby" would be likely to organise some vigorous opposition as evidenced by their response to the 1985 Budget Statement in the form of whole-page adverts in the quality National newspapers.

2.6 DISCUSSION

2.6.1 As indicated by the toll setting criteria quoted earlier pricing was necessary for Southampton's Itchen Bridge first to make a contribution to costs and secondly to control some of the disbenefits that might have occurred with unfettered use of the facility by all traffic. These two aspects of pricing will now be discussed.

2.6.2 The presence of user charges on one particular link in the transport network inevitably causes a considerable distortion in the pattern of costs and benefits that might be expected under conventional financing arrangements. The principal benefit from the bridge is improved accessibility for a particular geographical area of the city. Under the normal financing arrangements for road construction since 1974, the costs would have been spread over taxpayers nationally and ratepayers in Hampshire. Toll pricing was necessary to enable construction of a link that would otherwise not have been built. Thus improved accessibility for the Woolston district has been achieved but at some cost to both the bridge users (and those deterred from using it) and Southampton ratepayers. The justice of this arrangement depends upon one's perspective. Many Woolston area residents are clearly angered that they should have to pay to use the bridge when other areas of the City have good accessibility without user charges. However, at least Woolston residents receive a benefit, whereas residents in other parts of Southampton (say Lordshill, for example) pay a contribution to the bridge through the City rates for very little benefit. Such inequities are not, of course, unusual as unequal access to other public facilities (e.g. swimming pools) is inevitable. It could perhaps be argued that some proportion of construction costs should have been paid by Central Government. Even if the route served was not one of national significance, Central Government still have some responsibility for the local welfare of its citizens, as recognised by the general rate support grant arrangements. A relatively small contribution from Central Government would transform the Itchen Bridge into a self-financing (i.e. totally user charged) facility. However, whether tolls should ever be abolished is questionable because of their traffic flow control function.

2.6.3 The toll structure achieves two control or management objectives. One is to avoid certain undesirable consequences of general toll payment and the other to achieve traffic restraint.

2.6.4 The presence of tolls inhibits use of the bridge which inevitably reduces accessibility. This is particularly undesirable for certain groups in society and thus the toll structure grants concessions to the disabled, to cyclists and to bus users. The punitive toll for heavy commercial vehicles could adversely affect local industry, or influence future industrial location decisions in an unintended way, and thus local concessions are available for these vehicles. The toll level is also likely to deter more shorter trips than longer ones, as it represents a larger proportion of total journey costs. Therefore a local concession, available to all City residents, also operates for category 3 vehicles. In this way some of the worst consequences of toll payment are limited.

2.6.5 Traffic restraint has been the main focus of this Chapter. It has been demonstrated that for HCV's a very high toll does exclude virtually all through trips. For category 3 vehicles, flows are clearly sensitive to toll level although a precise specification of the relationship, particularly with respect to flows on other roads near the bridge, is very difficult. In many ways the crude title of "traffic restraint" is simply not appropriate for the subtle and selective way in which the toll structure influences travel behaviour.

2.6.6 Traffic restraint has been defined as measures which "impose a restriction on vehicle use in order to achieve a significant modification in the mode, time, route or destination of journeys" (May, 1983). This definition is said to exclude both traffic management and measures to improve alternative modes of travel such as fares subsidies. May debates whether cell systems fall into this definition, excluding them from the remainder of his paper. Thomson uses traffic limitation as a generic term to include traffic restriction (physical or legal barriers including traffic management and cell systems), traffic restraint (methods to alter the balance between private car use

and other alternatives) and traffic avoidance (longer term actions to modify travel demand) (Thomson, 1978). May's definition of traffic restraint is clearly more in line with current professional usage. However, it does seem inconsistent in that cell systems and other physical restraints clearly do impose a restriction on vehicle use and almost all traffic management schemes do so to a more limited extent. The definition of "significant" is clearly problematical in that while any local alteration in traffic control may not in itself appear to involve "restraint" it may be just the change which pushes the traveller over his or her threshold of acceptability of their current travel conditions, provoking a change in travel behaviour. Whether such a response was intended is almost irrelevant. Indeed it could be argued that "traffic restraint" should encompass both of Thomson's categories "restriction" and "restraint".

2.6.7 It is regrettable that all three words (restraint, restriction and limitation) have negative connotations. More neutral phrases like traffic control or traffic management have been appropriated for narrower, more specific meanings. It is hard to persuade public opinion that actions with these negative titles could be of general benefit (Hills, 1979). Yet the techniques that might be termed "traffic restraint" under either definition have the aim of producing an overall improvement in conditions for society as a whole; for both travellers and non-travellers, in both economic and environmental terms. Recently the phrase "travel management" has been used (Browning, 1984) a term which better reflects the overall benefits from such measures, and which seems particularly suitable for application to the Itchen Bridge.

2.6.8 A list of criteria by which to judge the merits of proposals aimed at "travel management" has been specified:

"- effective, to meet identified restraint needs;
- flexible, to meet differing and changing needs;
- selective, by type, area and time of journey;
- fair, in its effects on personal mobility, and acceptance to the community at large;

- adaptable to the needs of business and industry in the area, so that these activities are not encouraged to relocate;
- simple and inexpensive to administer and enforce, and not open to abuse;
- easy to understand and to comply with for both casual and regular travellers." (May, 1975)

The Itchen Bridge stands up to examination by these criteria extremely well.

2.7 CONCLUSIONS

2.7.1 Even in a well-developed transport network there are opportunities to raise money by pricing the use of individual sections of road. The Itchen Bridge is currently an example of the mixed funding approach which is gaining attention in the United States; costs are being met by a combination of tolls and rate fund contributions. This has enabled construction of a useful local link which would not have been built under conventional road financing arrangements, although it was public, not private, capital that was involved.

2.7.2 The toll structure clearly exerts an influence on the vehicular composition of traffic flow using both the Itchen Bridge and its radial corridor. The virtual exclusion of through trips by HCV's provides a measure of environmental protection to the Woolston district.

2.7.3 In Section 2.3.5 it was concluded that the tolls do influence the volume of traffic using the bridge, but sensitivity was much less than predicted in the original studies which advised the City Council on the appropriate level of tolls to be charged. Elasticities are unlikely to remain constant, however, and prediction of future response to toll price changes would need to take account of factors other than simply the percentage toll increase. Tolls do provide a useful general control on traffic volume but such restraint cannot be precise in the sense of limiting flows to below some pre-determined maximum limit.

2.7.4 Although the regressive nature of the tolls cannot be entirely disproved, it appears that the financial resources available to motorists are not a significant factor affecting bridge choice, and hence route choice.

2.7.5 Although the capabilities of the tolls as a means of controlling traffic flow have not yet been fully utilised, pricing has provided a very effective mechanism by which to control the use of the bridge. It meets virtually all the requirements set out for the appraisal of so-called "traffic restraint" systems.

CHAPTER 3

THE VALUE OF TRAVEL TIME SAVINGS: AN EMPIRICAL STUDY USING ROUTE CHOICE

3.1 INTRODUCTION

3.1.1 In order to determine priorities for transport investment it is necessary to evaluate the economic benefits resulting from them. These benefits can then be considered with scheme costs and environmental factors to decide whether an individual scheme is worthwhile, or which of several alternative schemes provides the best value for money. For trunk roads in this country, it has been estimated that 80% of economic benefits are due to travel time savings (Department of Transport, 1978), with the remaining portion being vehicle operating cost reductions and accident prevention. Thus the value of travel time is a highly significant factor in the evaluation of transport proposals.

3.1.2 In the market economy the value of any product is that which the consumer is willing to pay. This will automatically determine, in competitive supply conditions, just how much of a commodity is provided. For travel time, however, there is no market and it is usual to impute a value derived from society's general "willingness-to-pay", as revealed by consumer behaviour. For example, by studying a traveller's choice between a quicker, more expensive mode and a slower, cheaper one, a value of travel time can be obtained. This study derives a value of travel time through consideration of drivers' route choice between tolled and untolled river crossings in Southampton.

3.1.3 For an alternative view on the necessity of specifying a monetary value for travel time savings for evaluation purposes, see Chapter 5.

3.1.4 Because of its crucial importance in transport evaluation and decision-making the valuation of travel time savings has received a considerable amount of attention. The best reviews of the literature

up to the late 1970's are those by Hensher (1978) and Bruzelius (1979). However, despite the large volume of studies, reliable empirical evidence obtained in appropriate circumstances and analysed by the currently accepted methods is surprisingly scarce.

3.1.5 As other parts of the Department of Transport's economic appraisal method (COBA) were successively refined (e.g. improved quantification of delays at junctions, the inclusion of delays during construction, etc.) the imbalance in precision between these estimates and the values assigned to them was recognised. A major study was commissioned from a collaborative research team drawn from the MVA Consultancy, the Institute of Transport Studies at Leeds University and the Transport Studies Unit at Oxford University. This study is still in progress and only a little of the work has been formally published. In many ways the study reported here complements some initial empirical work carried out as a part of the D.Tp. study. Papers on both were presented consecutively at the PTRC Summer Annual Meeting at Sussex University in July 1983 (Atkins, 1983; Broom et al, 1983).

3.1.6 Another recent development has been increasing interest in "stated preference" data as a source for travel time valuation (Bates and Roberts, 1983; Bates 1984). Rather than observing actual behaviour, a statement of how the consumer would react if circumstances changed is sought. Although it is well known that people frequently react differently in practice from how they say they they would in response to survey questions,there are considerable advantages in using this technique.

3.1.7 Responses to stated intention questions give not only the direction of the preference but also some degree of quantification. While some approaches to stated preference have constructed scales from qualitative descriptions of preference strengths (e.g. Bates, 1984; approaches reviewed by Louviere, 1978 or Tischer 1981), a more powerful method involves the measurement of preference difference in terms of a variable quantifying a travel attribute. This would usually be cost

but could theoretically be any other variable (e.g. travel time). This technique has become known as the "transfer-price" method (Hensher, 1976).

3.1.8 If such methods can be shown to be free of bias, or can have bias removed from their estimates, then they offer the attraction of similar degrees of accuracy with much smaller sample sizes, due to their greater information content. An added advantage is their ease of application to a wide variety of transport contexts. It would no longer be necessary to seek out the particular and practically infrequent circumstances in which time and money are actively traded in an actual transport choice. The trading could be achieved in the questionnaire design. The Southampton study location offered an opportunity to use and investigate this technique in addition to the more conventional "revealed preference" approach.

3.2 LOCATION OF SURVEY

3.2.1 The location, background and development of the toll structure of the Itchen Bridge have already been described in Chapter 2. Northam Bridge is the next road traffic bridge to the north and is not subject to tolls (see Figure 2.1 for location map). Many residents of south-eastern Southampton, therefore, live in locations where for many of their trips they can choose between a route which is perceived as slower but cheaper (Northam) and one which is faster but more expensive (Itchen). By studying their perceptions and choices, values of travel time savings can be derived. Further details on survey location within this general area are given later.

3.3 ADVANTAGES OF THE SOUTHAMPTON LOCATION

3.3.1 The advantages of the Southampton location as a site for measuring travel time values are best seen by reference to Harrison's list of conditions for valuation of travel attributes (Harrison, 1974), as summarised below:

1. The choices concerned must be real ones.

2. Where choices exist, they must be fully perceived and there must be grounds for believing that individuals are aware of the alternatives available.

3. The effects of all variables thought likely to affect choices must be explicitly considered.

4. There must be perceptible differences between alternatives.

5. The variables considered relevant must not be too closely correlated.

6. The variables affecting choice must show a fair amount of variation in the sample.

7. The sample under consideration must be assumed similar with respect to factors not included explicitly in the analysis.

8. The sample analysed must show a reasonable proportion choosing each of the relevant options.

9. The number of choices explained by the analysis must be high.

The difficulty of complying with these conditions in general is explored in some depth in Chapter 5. Here the following paragraphs set out the considerable advantages of the Itchen Bridge survey location as an investigatory site for travel time valuation studies. It is interesting to note that Phase 3 of the D.Tp study is using the Tyne Tunnel in Newcastle-upon-Tyne as a study location, one of the very few U.K. sites with parallel circumstances to the Itchen Bridge.

3.3.2 As Harrison points out, these conditions are not easy to meet. Most studies to measure travel time values have analysed choice of mode. Yet where choice of travel mode is concerned, conditions 3 and

7 are often violated because many aspects of the circumstances of the journey influence its value. These include comfort, convenience and safety as well as the effort and stress involved in driving, the availability of in-vehicle entertainment, privacy, freedom to or from smoke, the opportunity to study or work and so on. Ideally separate travel time values for each circumstance should be derived. However, many of these aspects of travel are difficult to quantify or even to partition, and traveller attitudes towards them, and hence their valuation of them, are equally problematical. The resultant complexity of analysis has implications both for the accuracy of results and sample sizes required for appropriate statistical confidence.

3.3.3 For route choice, of course, travel conditions are inherently similar. Even so, criticisms of previous route choice studies have pointed out that driving conditions are very different on, say toll autostrada compared with the general untolled road network, or on estuarial toll crossings compared with a possible lengthy detour involving lower classes of road. In the Southampton case driving conditions are very similar on both routes, even to the extent that the delay to gain access to the Bitterne Road controlled access scheme (Northam Bridge route) could be likened to a toll booth queue, both being followed by relatively free flowing traffic conditions.

3.3.4 For mode choice there are again problems in the presumption that a choice is being made (condition 1). It has been shown, for example, that as few as 10% of commuters are genuine "choosers", all others being prevented by a variety of constraints from exercising a realistic choice (Brog et al, 1977). Inferring that a choice is being made when it is not could introduce significant errors into the analysis (Heggie, 1983). For route choice, of course, a decision is essential and unavoidable as the journey proceeds.

3.3.5 Another problem with derivations of travel time values using mode choice has been the frequent lack of awareness of travellers of the existence of alternative modes. Related to this is the varying quality of knowledge of the characteristics of alternatives. For example, car owners often have only very poor knowledge about the time

and cost characteristics of public transport. Uncertainty about modal qualities can influence choice in a classic decision analysis manner. Some persons will select a mode that will get them to their destination by a particular time, rejecting a mode which might get them there quicker, but which does carry some risk of later arrival (Guttman, 1975).

3.3.6 In this location all these problems were minimised. Firstly no-one questioned failed to know of the existence of an alternative bridge. In order to ensure adequate quality of knowledge about the alternative routes, information was sought only about regular journeys, defined as being at least two previous trips to the same destination at approximately the same time of day. It is certainly likely that some respondents had not actually travelled to their stated destinations using both of the alternative routes. However, they almost certainly had used both bridges at one time or another and their estimates were therefore based upon some minimum level of knowledge.

3.3.7 It can be seen, therefore, that route choice has fundamental advantages of clarity and simplicity over mode choice. However, in normal (no toll) circumstances travel distance, time and cost are highly correlated and little evidence of trade-offs could be discerned from route-choice studies (i.e. generally a chosen route will be both quicker and cheaper than an alternative.) This contravenes Harrisons's condition Number 5. However, the presence of a toll crucially alters these circumstances.

3.3.8 Even so, not all toll facilities are appropriate locations for measuring travel time values. Consider the full statement of Harrison's sixth condition:

> "The variables affecting choice must show a fair amount of variation in the sample. For example, it might seem obvious that a value of time could be estimated from a tolled crossing situation because it presents a simple time/money trade-off. In practice it is rarely possible because in nearly all cases the crossing offers a single price to most categories of user. Hence it is only possible to say that x percent were prepared to pay so much to save time, not what the distribution of values is over the group as a whole. For this a range of prices is required."

3.3.9 This condition does present a problem for many toll facilities, particularly those in sparsely populated areas and with a substantially different alternative route. Under those conditions virtually all users would be facing the same choice. Southampton's advantage lies in the close proximity of the alternative route and the density of potential origins. This means that a reasonably wide variety of time and cost differences are faced by residents in the survey area. Of most importance is that the correlation between time and cost differences is relatively low, thus ensuring compliance with Harrison's fifth condition. In the Southampton case the value of the toll, taken in relation to the general shortness of the journeys, renders correlation much reduced. It is interesting to note that the Humber Bridge was not considered an appropriate site for travel time valuation studies, principally for this reason (Gunn, Mackie and Ortuzar, 1980).

3.3.10 Another advantage of the location is the direct analogy of the toll payment to the concept of willingness-to-pay. In mode choice costs are often concealed or at least obscured by such things as pre-purchasing of petrol or season tickets, or by the psychological disregard of "committed" expenditures (Dix and Goodwin, 1982). While these problems are not entirely excluded from this study, the

requirement for an immediate cash "out-of-pocket" payment highlights the contrast between the routes. Are consumers willing to pay to gain a perceived travel time advantage?

3.3.11 Finally, the presence of a toll facilitated the use of a stated intention or transfer price question in the survey. Possible changes in toll charges were readily understood and represented a realistic change in circumstances.

3.3.12 In short, therefore, this location presents almost unrivalled conditions for the measurement of travel time values.

3.4 OUTLINE DESIGN OF THE STUDY

3.4.1 The study needed to determine the choices made by drivers in terms of the attributes of both the chosen and non-chosen alternatives. It was therefore necessary to ask persons about those decisions and the only practicable means was by a home interview survey. It should be noted that such decisions are made on the basis of what the travellers believe the travel times on alternative routes to be (usually termed the perceived time), not the time actually spent (the "true" time) or that derived from some network model (the "engineering" value). Similar arguments on misperception apply even more strongly to journey costs which are generally less confidently known (Hensher, 1978) and vary considerably from person to person.

3.4.2 Furthermore, the attribute value reported by the respondent may not be the same as the true perceived value. The principle reasons for erroneous reporting are that people round off their replies to certain intervals (e.g. five minutes) and that they may attempt to justify their choice by exaggeration or try to give the "right" answer (i.e. that which they think the interviewer expects). For a further discussion on the aspects of perception and reporting, see Chapter 5.

3.4.3 Because of the inevitable variability of the data, and also to permit investigation of how other factors, notably journey purpose and income level, affected travel time valuation, it was necessary to obtain a relatively large sample. A target of 1,000 useable responses had been set in the study proposal. Thus the size, scale, location and survey method were determined.

3.5 THE SURVEY

3.5.1 A PILOT SURVEY

In February and March 1982 the author supervised the students on Southampton University's M.Sc. course in Transportation Planning and Engineering for their group project. For that year the task had been set to establish a value for travel time savings by reference to drivers' route choices between the Itchen and Northam Bridges. As an essential part of this exercise the students designed and undertook a household interview survey. This small survey (the sample size was approximately 160 households) effectively served as the pilot for the major survey now described. The author, through influencing the questionnaire design and by participating in the student survey, gained experience which proved useful in the design, conduct and management of the major exercise. Some further details and a comparison of results obtained between the pilot and main surveys are presented in Chapter 4.

3.5.2 QUESTIONNAIRE DESIGN AND INTERVIEW CONDUCT

3.5.2.1 Only a proportion of households would contain persons who had the necessary travel experience to respond to the survey. It was, therefore, necessary to develop some "screening" questions to avoid wasting time on inappropriate households (see Figure 3.1). After some brief opening remarks the screening questions commenced by referring to vehicle availability. In Southampton, as a whole, 42% of households do not have regular access to a vehicle (1981 census) and clearly a large number of households would be eliminated by this simple enquiry. The subsequent screening questions related to whether bridge-crossing trips were made, and whether the driver (who may not have been the persons answering the front door) would be willing to answer a few, brief questions. The concept of regular journeys was important to ensure a reasonable quality of knowledge and some element of positive route selection. For a single journey route choice could relate to highly specific journey details or be a matter of chance rather than a

considered decision. For the same reasons it was also thought preferable to use actual journeys, rather than ask for the hypothetical route that drivers would select to a specified City Centre location.

FIGURE 3.1: INTRODUCTORY WORDS FOR THE SURVEY

Good evening. I am from the University and we are conducting a survey on the use of Itchen and Northam bridges.

Is there anyone here who regularly drives a car?

(If appropriate) Can I talk to that person please?

(If they are out) Would they be in on another evening?
(Record arrangement on log sheet)

(To car driver) Do you make any regular car trips across either Itchen or Northam bridge?

Would you mind answering a few brief questions about these trips?

3.5.2.2 The screening questions automatically focussed attention on a particular journey and, having achieved a positive contact, some simple questions on purpose, destination, time of day and route chosen were asked (the questionnaire is shown in Figure 3.2). Their simplicity helped to foster confidence in the interviewee.

Form No.	C	N/I	T	C1	C2	P	I	C	INT. NO.
529									

UNIVERSITY OF SOUTHAMPTON DEPARTMENT OF CIVIL ENGINEERING

HOME INTERVIEW SURVEY FORM

1. What is the purpose of your trip? Work .....
   Shopping .....
   Education .....
   Leisure .....
   Other (Specify) .....
   .....

2. What is the destination of your trip? (Name of street or building)

3. At what time of the day do you make the journey? .....a.m./p.m.

4. Which bridge do you usually use? Itchen .....
   Northam .....

5. How long does the journey take using this route?

6. How much does the journey cost you? (including toll if applicable)

Toll Price

7. How long do you think the same journey would take using the other bridge?

8. How much do you think the journey would cost using that route? (including toll if applicable)

9. Is the car a firm's car .....?
   your own .....?
   other .....? (Specify) .....

10. Do you pay the journey cost? Yes .....
    No .....

FIGURE 3.2 THE SURVEY QUESTIONNAIRE (PAGE 1 OF 2)

11. ITCHEN BRIDGE USERS ONLY:

Assuming the travel times remain as you have stated, would you change route if the Itchen Bridge toll were:

25p 30p 35p 40p 45p 50p 60p 75p £1.00 would never change

12. NORTHAM BRIDGE USERS ONLY:

For your journey the current Itchen Bridge toll would be $\begin{pmatrix}20\\30\end{pmatrix}$ pence.
Assuming the travel times remain as you have stated would you change route if the Itchen Bridge toll were:

25p 20p 15p 10p 5p zero would never change

13. Please indicate which range contains your household income.

.....

Thank you for your co-operation.

FIGURE 3.2 THE SURVEY QUESTIONNAIRE (PAGE 2 OF 2)

3.5.2.3 The principal questions on perceived times and costs of the journey by alternative routes were then asked. In all cases these related to the one-way trip from home to destination. The estimation of journey duration was generally easily accomplished but estimates of journey cost were often the first difficulty encountered by the respondent. As the perceived cost was being sought, no clarification was given unless requested. Even then, interviewers were instructed to avoid suggesting what items should be included but, if pressed, should mention "running costs". In practice some persons responded in terms of gallons of petrol used, and others, while unable to specify a journey cost, did suggest a cost differential between the two routes. In these cases (and for other respondents, also) this was frequently but not exclusively simply the toll level. When asking for costs on the chosen route the toll price paid, if using the Itchen Bridge, was specifically noted. This was useful as an internal check on consistency but was necessary to determine whether the City resident's concessionary rate (a 5p reduction) was being paid. In fact only 5% of all bridge users pay the reduced rate.

3.5.2.4 After these questions on cost, the matter of who actually pays the cost was investigated. Many persons receive subsidy from their employers or payment from passengers towards travel costs. Obviously travellers who did not personally bear the journey costs were not making the requisite choice and would be eliminated from the analysis.

3.5.2.5 The "transfer price" question was then asked, always related to possible changes in the price of the Itchen Bridge toll. For current Itchen Bridge users successive toll increases were offered until the respondent stated either that they would change their travel behaviour, or that they would never change. For Northam Bridge users it was thought necessary to initially confirm the appropriate Itchen Bridge toll price for their journey, before offering successive price reductions. Clearly the toll reduction offered could only be as far as a zero toll, limiting the range of transfer prices available. This disadvantage, however, was considered to be less significant than the potential problems that would be caused by suggesting increases of

price on their currently untolled route. Such an option would be unlikely and unrealistic and hence would not be treated seriously by some respondents.

3.5.2.6 Respondents were then shown a form with income ranges (see Figure 3.3) and asked to indicate which category contained their household income. This question was last on the questionnaire to minimise data loss as refusal to answer sometimes, but not always, implies termination of the interview. If relevant journeys for another purpose or by another household member were made further questionnaires were completed. Finally, the interviewee was thanked for their co-operation.

FIGURE 3.3: HOUSEHOLD INCOME RANGES		
A	less than £5,000 per year	(£100 per week)
B	£5,000 - £7,500 per year	(£100 - £150 per week)
C	£7,500 - £10,000 per year	(£150 - £200 per week)
D	£10,000 - £12,500 per year	(£200 - £250 per week)
E	£12,500 and above per year	(above £250 per week)

3.5.3 ORGANISATION AND CONDUCT OF SURVEY

3.5.3.1 Timing

The nature of the survey meant that it involved calling at homes at a time when drivers would be likely to be present. It was essential, therefore, that the survey take place in the early evenings between the time when the majority of workers return home and the time at which door-knocking could cause annoyance or disturbance. It was decided that no calls would be made after 9.00 p.m. and that the survey should commence as soon as practicable after 6.00 p.m. In practice the first calls of the evening generally took place a little before 6.30 p.m.

3.5.3.2 The timing of the survey quickly resolved a choice between early June or September/October 1982. It had already been decided that the survey duration should not exceed two weeks, this period being a balance between the desirable use of a small number of interviewers and the need to make the duration as short as possible. A short duration would minimise the likelihood of variations in perceptions of journey times and costs caused by factors such as variations in traffic congestion or changes in petrol prices. To use the survey staff most efficiently it was obvious that the major holiday period between mid-July and the end of August should be avoided. In addition the 1982 World Cup Football competition was to be held in Spain between mid-June and mid-July with many matches, including those of England, Scotland and N. Ireland being televised live during the early evenings. Although this event may have ensured the presence at home of a certain type of individual, this was more than offset by the possible increase in non-response or non co-operation with the survey by some of those persons. The two weeks just prior to this event included the Bank Holiday of Monday, 31st May and it was therefore decided to conduct the survey on the weekday evenings between Tuesday, 1st June and Friday, 11th June, 1982.

3.5.3.3 Area of Survey

It was required to interview persons making regular trips over either Itchen or Northam Bridges. In general, those persons living closest to the bridges are more likely to make bridge-crossing trips than those who live further away. In particular those living outside the City boundary could work, shop and conduct their social activities in Hamble, Bursledon and areas further to the east such as Fareham, without the necessity for regular trips to the west of the Itchen. The most useful information would be obtained from those persons who perceived a time/money trade-off in their choice of bridge route. These "traders" would be likely to reside in the area contained between he main approach roads to each bridge: Northam/Bitterne/Bursledon Roads to the north and Portsmouth Road to the south. Persons living in Woolston south of Portsmouth Road, for example, would be likely to

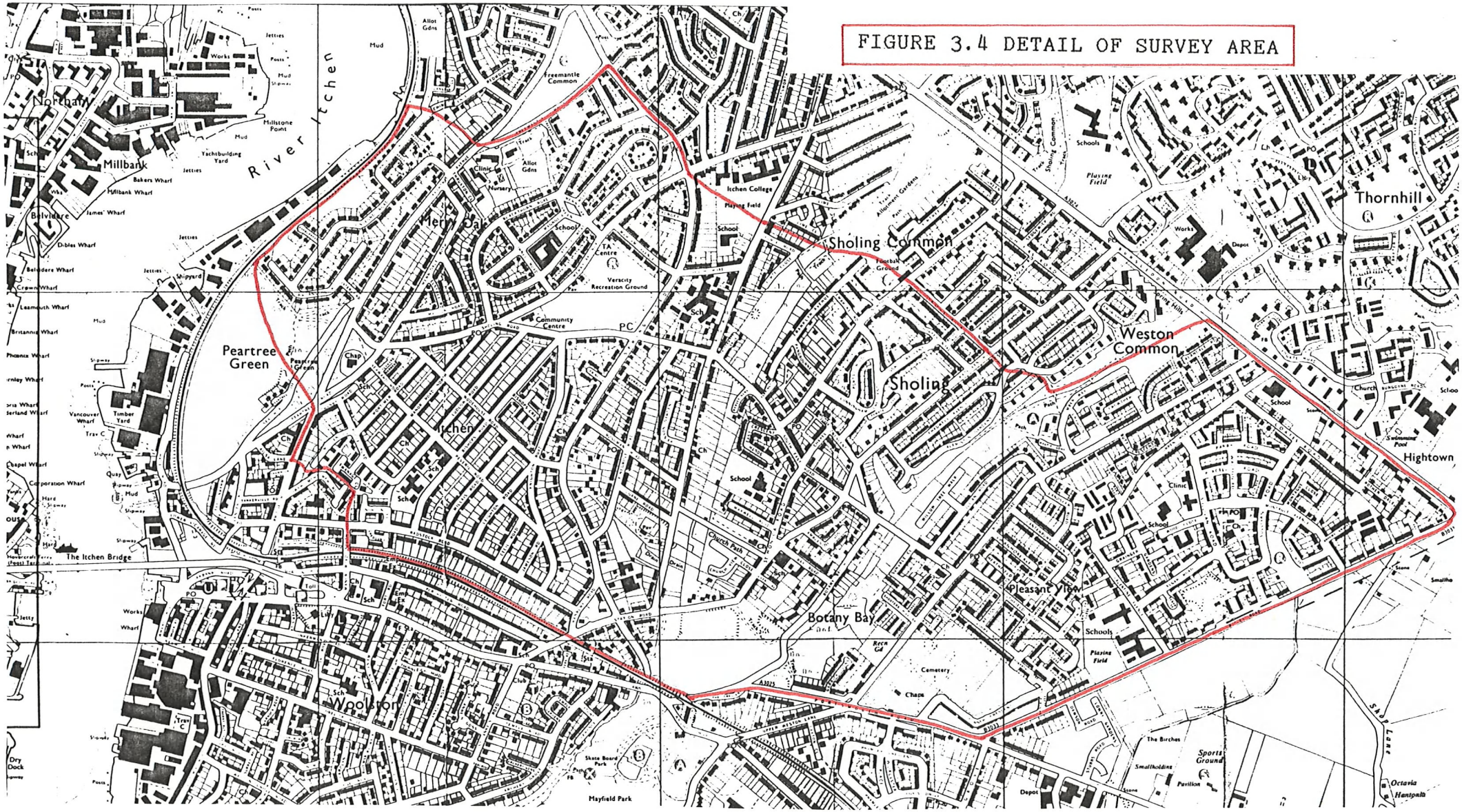
perceive Itchen Bridge as being both quicker and cheaper for their city-centre trips and would therefore be "non-traders". Within this broadly defined area the effect of the Itchen tolls means that traders would be more likely to be found in the southern part of this area, and hence the approximate survey area boundaries shown on Figure 3.4, were drawn up.

3.5.3.4 Preparation for Survey

Electoral registers for the survey area were acquired to ascertain the approximate number of households in each street with the defined area. Registers also provide useful indications of the sub-division of properties into flats. As the survey area was not well-known to the author two separate reconnaissance trips were made to the area. These helped clarify the nature of the area and identify suitable places where the Transportion Research Group vehicle (a Ford Transit minibus) could be parked as a base for a particular evening's survey activities. During these visits house numbers at street corners were noted so that long streets could be sub-divided into smaller sections for the assignment of individual interviewer's tasks. A map was then produced showing the approximate number of households in each street or street section.

3.5.3.5 It was estimated, with some help from the experience with the student project work, that each interviewer could visit about 60 households per evening. With some knowledge of the likely number of interviewers available each evening a tentative plan for the first few evenings was drawn up including parking positions and suitably sized groups of households for each interviewer to visit. This was not a simple task. Amalgamations of streets or street sections into household totals approximately equal to sixty without involving excessive walking distances and all within reasonable access of a pre-established base point proved quite problematical. Flexibility was aided by the willingness of some individuals to use their own transport (if suitably recompensed) to travel a little further afield, but particularly during the first couple of survey evenings, close availability of advice and supervision was desirable. As interviewers did not always work on

FIGURE 3.4 DETAIL OF SURVEY AREA



consecutive evenings it was necessary to pre-determine the assembly point (base point for the vehicle) a few days in advance and it also proved difficult to predict the exact number of interview staff who would present themselves on a particular evening. Furthermore, the inclusion of callbacks (on households where no answer was obtained or where the driver was unavailable at the time of the first visit) further complicated the survey planning. Thus the design of the survey programme became a continuous daily necessity throughout the survey period.

3.5.3.6 Survey Equipment

Having planned the evening's work programme it was necessary to prepare the interviewer's equipment for rapid deployment at the survey base site. Each interviewer was equipped with:

(i) A clipboard onto which a street plan of the survey area had been attached.

(ii) Twenty five questionnaires.

(iii) Approximately three log-sheets, on which the individual's assignment for the evening had been written (see Figure 3.5).

(iv) An information sheet showing:
introductory words,
screening questions,
tolls and related times for Itchen Bridge,
income groups to be displayed to the respondent,
(see Figure 3.6)

(v) A pen or pencil.

SOUTHAMPTON UNIVERSITY DEPARTMENT OF CIVIL ENGINEERING

HOME INTERVIEW SURVEY LOG SHEET

FIGURE 3.5
INTERVIEWER'S SURVEY LOG SHEET

Road or Street .....

Interviewer Number ..... Date .....

House or Flat No.	No Answer	Empty	Refused	No car	Car but no Bridge Trips	Call Back Arranged (Day + Time)	Interview Form No.

SOUTHAMPTON UNIVERSITY DEPARTMENT OF CIVIL ENGINEERING

HOME INTERVIEW SURVEY - INFORMATION SHEET

(A) INTRODUCTORY WORDS

Good evening. I am from the University and we are conducting a survey on the use of Itchen and Northam bridges.

Is there anyone here who regularly drives a car?

(If appropriate) Can I talk to that person please?

(If they are out) Would they be in on another evening?
(Record arrangement on log sheet)

(To car driver) Do you make any regular car trips across either Itchen or Northam bridge?

Would you mind answering a few brief questions about these trips?

(B) ITCHEN BRIDGE TOLLS

0600 - 0930	6.00 a.m. - 9.30 a.m.	PEAK 30p cars
1600 - 1830	4.00 p.m. - 6.30 p.m.	
All other times		OFF-PEAK 20p cars

(Southampton residents may use concessionary tokens saving 5p, but very few actually do this)

(C) HOUSEHOLD INCOME GROUPS

A	less than £5,000 per year	(£100 per week)
B	£5,000 - £7,500 per year	(£100 - £150 per week)
C	£7,500 - £10,000 per year	(£150 - £200 per week)
D	£10,000 - £12,500 per year	(£200 - £250 per week)
E	£12,500 and above per year	(above £250 per week)

FIGURE 3.6 INTERVIEWER'S INFORMATION SHEET

3.5.3.7 Experience throughout the survey showed that the estimates of sixty households per evening and 25 questionnaires were broadly correct. On a few occasions interviewers returning early were re-assigned to other streets and on one occasion an interviewer did manage to use all 25 questionnaire forms.

3.5.3.8 Recruitment of Survey Staff

Survey staff were recruited from three main sources. Certain postgraduate students from the M.Sc. course in Transportation Planning and Engineering were invited to participate and four eventually did so. Southampton Job Centre proved extremely efficient, advertising the work and arranging a series of interviews for me in my own office of potential staff. This arrangement proved highly effective as the confidence to attend an interview and the ability to find a specific location were highly appropriate job requirements. I was able to accept for the interviewer team all who attended. Three of these "Job Centre" applicants were final year students from La Sainte Union College, LSU, who had completed their assessment procedures earlier this year. (Most University students were preparing for,or taking, examinations at this time.) These persons then informed others of the same circumstances and eventually some seven persons from LSU were involved with the survey. Apart from these three groups, my secretary at the University, Ms. Anna Dabrowska, became sufficiently interested to become a team member for a few evenings and my own indisposition with a back injury necessitated the recruitment at very short notice of a friend to act as driver for the minibus. For a couple of evenings the author directed proceedings from a prone position, stretched out across the triple seat in the minibus!

3.5.3.9 Pre-survey Briefing of Interviewers

An instructional evening for interviewers was held on Friday, 28th May, 1982 at the University. The purpose of the survey was outlined and a detailed explanation of the survey forms was given. Opportunities for questions and clarifications were provided and interviewers then practised on each other for a short while. Each interviewer took away

with them a set of survey forms (log sheet, questionnaire and information sheet) for perusal before starting work the following week. Two interviewers who were unavailable on the Friday evening were briefed separately by the author on the afternoon of 1st June and other interviewers recruited subsequently were briefed on their first evenings attendance.

3.5.2.10 A total of 21 interviewers, including the author, were used and 114 interviewer-evening sessions were finally achieved.

3.5.3.11 Support and Guidance During the Survey

For the first interview evening of 1st June, two of the experienced postgraduate students were issued with walkie-talkie radio sets that provided communication to the author in the survey base vehicle. They patrolled the survey area for about the first hour. In this way the early progress of every interviewer was checked and an opportunity to clarify procedures provided at the very commencement of the work. After this initial period the author then completed a full circuit to check personally with every interviewer, ensuring that they were fully conversant with the survey procedures and that no problems had arisen. After the first evening's work the completed questionnaires were reviewed by the author for any omissions or inconsistencies, and any matters arising from this were then dealt with before the interviewer again started work. As not every interviewer started work on the first evening, this general procedure of early support and guidance, and careful checking of their first batch of completed forms was repeated with each new interviewer. Further checks on returned forms continued as far as possible throughout the survey period and enabled some clarification of responses in a number of cases. This activity was integrated with the analysis of the completed log-sheets which was necessary to prepare work schedules for the subsequent evenings, of particular importance when callbacks were being programmed.

3.6 ANALYSIS

3.6.1 PRELIMINARY WORK

3.6.1.1 After completion of the survey two preliminary stages in the analysis were undertaken. Firstly the data from the interviewers log sheets were collated and tabulated. The principal results of this analysis are presented in Figure 3.7. One hundred interviewer-evenings and one thousand usable survey forms were the targets. In practice one hundred and fourteen interviewer-evenings produced 1,241 usable journey records.

FIGURE 3.7 REVIEW OF LOG-SHEET DATA (HOUSEHOLDS)

	NA	E	R	NC	NB	C	I	TOTAL
First Calls	1128	75	217	1405	255	198	1269	4547
Second Calls	228	11	39	124	136	28	213	779
TOTAL	1356	86	256	1529	391	226	1482	5326

Codes:
- NA No Answer
- E Empty
- R Refused
- NC No Car
- NB No Regular Bridge-Crossing Trips
- C Callback (Car Driver Unavailable)
- I Interview completed

3.6.1.2 It can be noted that the "strike-rate" in finding appropriate households was 28% and varied little between first and second calls. From first calls that were answered the no-car households can be deduced as 35%. This seems reasonable compared to the rate of 42% in Southampton as a whole, bearing in mind the character of the area. The potential number of "callbacks" was 1326 (NA plus C) of which 779 (59%) were achieved. For callbacks the percentage of "no-answers" increased from 25 to 37 per cent as might be anticipated in a holiday season. The level of refusals at 5% was encouragingly small and was also consistent between first calls and callbacks.

3.6.1.3 Secondly the data from the questionnaires was coded and transferred to computer filestore on the University ICL 2970. The 1482 households produced 1574 completed questionnaires of which 1559 were coded and punched and 15 rejected for reasons of illogicalities or insufficient data. Of the 1559 forms 1339 came from first calls and 220 from callbacks and of the callbacks 175 came from previous non answers and 45 from households where drivers were known to reside.

3.6.1.4 The 1559 were further reduced by excluding those persons who were unable to provide time and cost differences between the routes, and by eliminating those for whom the route choice decision may have been affected by financial assistance from either employer or passengers. (The survey responses indicated 9.5% of the vehicles were owned by a firm and 8.6% of drivers received some or all of their vehicle running costs for the journey reported. These statistics agree very well with the corresponding figures at 9% and 8.5% reported by TEST (1984) derived from the 1978/79 National Travel Survey.) These reductions restricted the data set to 1241 journey records and this is the principal sample size for subsequent analysis. Some response frequencies are shown in Figure 3.8.

Figure 3.8: RESPONSE FREQUENCIES (Sample size = 1,241)

Purpose		Income		Bridge	
Work	49%	< £5,000	22%	Itchen	59%
Shop	36%	£5,000 - £7,500	27%	Northam	41%
Social	13%	£7,500 - £10,000	23%		
Other	2%	£10,000 - £12,500	11%		
		> £12,500	6%		
		unknown, refused	10%		

3.6.1.5 The response summaries were generally encouraging. Harrison's eighth condition requires a reasonable proportion choosing each option and a 59/41 split of bridge choice is certainly acceptable. The income and purpose responses also seem reasonable although these have not been checked against independent data.

3.6.1.6 The ranges and correlation of time and cost differences are shown in Figure 3.9. Although some of the reported cost and time differences seem very high, these are perceived values. Thus while not, perhaps, well-judged responses they may reflect the interviewee's convictions. They probably also reflect rationalisation bias (Bonsall, 1983), exaggerating the advantages of the chosen alternative to justify their decision. The ninety percentile ranges are more encouraging. The lack of correlation between the time and cost differences satisfies Harrison's condition number 5 as discussed earlier (paragraph 3.3.9).

FIGURE 3.9: RANGES AND CORRELATION OF DATA (SAMPLE SIZE 1241)

	Time Difference (Mins)	Cost Difference (Pence)
Absolute range	-30 to +75	-200 to +100
Range containing 90% of the observations	-10 to +15	- 30 to + 30
Time and Cost Differences:	Correlation	R -0.43 (R^2 = 0.18)

3.6.2 DATA ANALYSIS PACKAGES AND COMPUTING FACILITIES

3.6.2.1 Following advice from the Department of Social Statistics the principal analysis of fitting a logit model to the perceived time and cost differences between routes (for details of the theory see later paragraphs) was to be achieved using the computer package GLIM. This interactive package was only available on the Honeywell 6080 machine. Because of the very limited filestore space available on the Honeywell (it is used principally as a teaching machine) the initial file editing and data summaries were carried out using the SPSS package on the ICL 2970 machine. Subsequently, it proved that not only was the filestore space restricted on the Honeywell, but also the capacity of the GLIM programme was only sufficient to deal with two variables for a data set as large as that produced by this study. This meant that the data had to be partitioned to investigate the way in which journey purpose or income group affected travel time values. Due to the limited filestore

space on the Honeywell and the fact that data transfer between the two machines could only take place overnight, data analysis proceeded rather slowly. Only subsequently was it discovered that the GENSTAT package, available on the ICL machine was not only capable of fitting logit models but also had ample capacity to accommodate the dimensions of this data set. Therefore, although most of the early analysis used GLIM, some of the published results (Atkins, 1983b) were due to GENSTAT. Subsequently all analysis has been repeated using GENSTAT to avoid any possible inconsistencies.

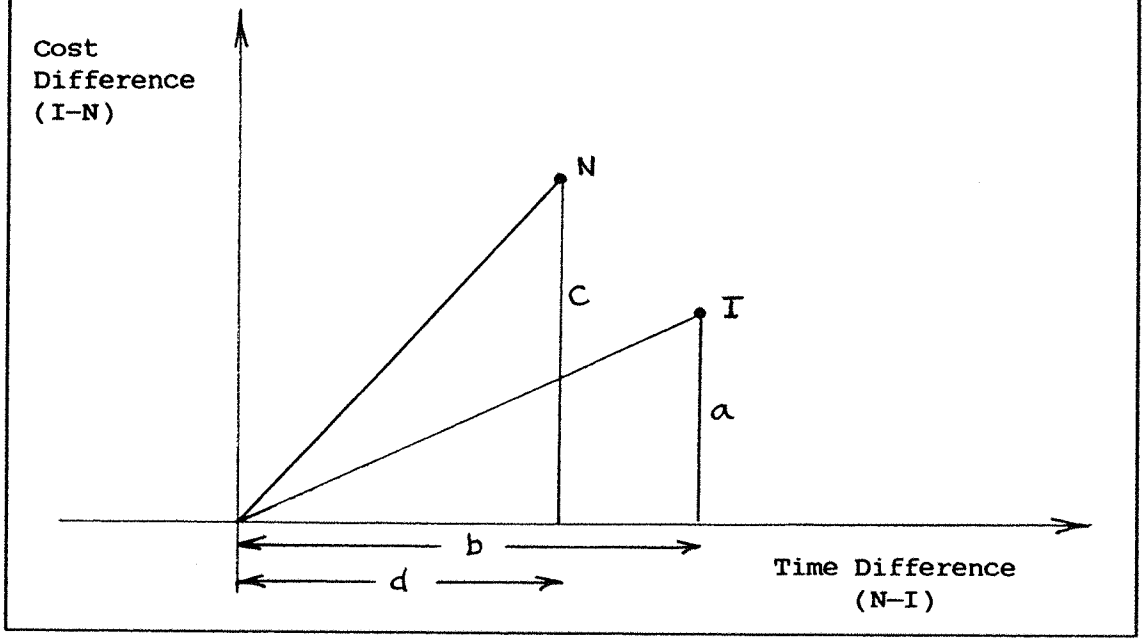
3.6.3 THEORY – DERIVATION OF TRAVEL TIME VALUES

3.6.3.1 The principal analysis to obtain travel time values is based on the so-called "revealed preference" of a traveller for a particular route, given the cost and time differences between the chosen and non-chosen alternatives. Although supposedly based on actual travel behaviour the journey was not in fact directly observed but merely reported during an interview and is therefore termed "reported behaviour" in this report. Further questions probed the traveller's response to changes in travel conditions and this technique is generally called "stated intention" or "stated preference". In this application the change in price necessary to cause a change in behaviour was sought, this difference being termed the "transfer price".

3.6.3.2 Reported Behaviour

From the route choice of any single driver it is only possible to determine a limit to their value of travel time savings. This is depicted in Figure 3.10 for the Southampton case study with I = Itchen Bridge and N = Northam Bridge route choices.

FIGURE 3.10: CHOICES PLOTTED ON ATTRIBUTE DIFFERENCE SCALES



Thus the Itchen Bridge chooser, I, is willing to pay a pence to save b minutes and must therefore have a value of travel time of at least a/b. The Northam Bridge chooser, N, is unwilling to pay c pence to save d minutes and must therefore have a travel time value of less than c/d.

3.6.3.3 Early attempts at travel time valuation in the U.K. followed the method of Beesley (Beesley, 1965) who, using data plotted in this way, simply found the single line which minimised the misclassification of choices. This technique clearly places great emphasis on the "traders" in quadrants 1 and 3 and virtually excluded the non-traders (where one option is preferred in both time and cost attributes) in quadrants 2 and 4. Subsequently Quarmby (1967) and others used discriminant analysis to provide a superior statistical method to the Beesley approach.

3.6.3.4 Later analysis methods have been based upon models which assume that consumer choice is related to utility maximisation behaviour. In transport such utility is derived from the perceived benefits of a trip, constant across transport options, less the time, cost, effort and other factors expended in making the journey. Thus rather than maximising overall utility the problem becomes one of

minimising the disutility implicit in the journey. It is further assumed that this disutility is a linear function of the journey attributes, modified by some random disturbance or "error" factor which includes unmeasured journey attributes or individual characteristics. Thus:-

$$U_{jk} = A_{0k} + A_{1k} X_{j1k} + A_{2k} X_{j2k} \ldots\ldots + \epsilon_{jk}$$

where U_{jk} = disutility of individual j for option k

X_{jik} = some measure of journey attribute i (eg. time, cost,etc)

A_{ik} = coefficient to be calibrated

ϵ_{jk} = "error" or disturbance term.

3.6.3.5 Different model types result from different assumptions about the statistical properties of the disturbance term ϵ_{jk} (Horowitz, 1983; Kanafani, 1983). The most justifiable assumption is probably one of normality. If this term accounts for various unmeasured factors then their summation would be normally distributed by the central limit theorem (Bruzelius, 1978). However this probit model is computationally complex whereas the assumption that the disturbance term follows a Weibull distributon produces the logit model. Not only is this simpler to manipulate but the two distributions are very similar in their most sensitive mid-range sections. The logit model has become the standard method for discrete choice problems in transport, including travel time valuation. For the logit model the probability of choosing option k for a set of n alternatives, $P(U_{jk} < U_{jl}$ for all l of set n), is then given by:-

$$P_{jk} = \frac{e^{-U_{jk}}}{\sum_{l=1}^{n} e^{-U_{jl}}}$$

3.6.3.6 With only two options, a binary choice between options k and l, this would reduce to:

$$P_{jk} = \frac{e^{(U_{jk}-U_{jl})}}{1 + e^{(U_{jk} - U_{jl})}}$$

In terms of the Southampton case study this can be written as:-

$$P(x) = \frac{\exp L(x)}{1 + \exp L(x)} \text{ with } L(x) = a_o + a_1 M + a_2 T \quad \ldots\ldots\ldots (1)$$

Where: $P(x)$ = probability of choosing Itchen Bridge.

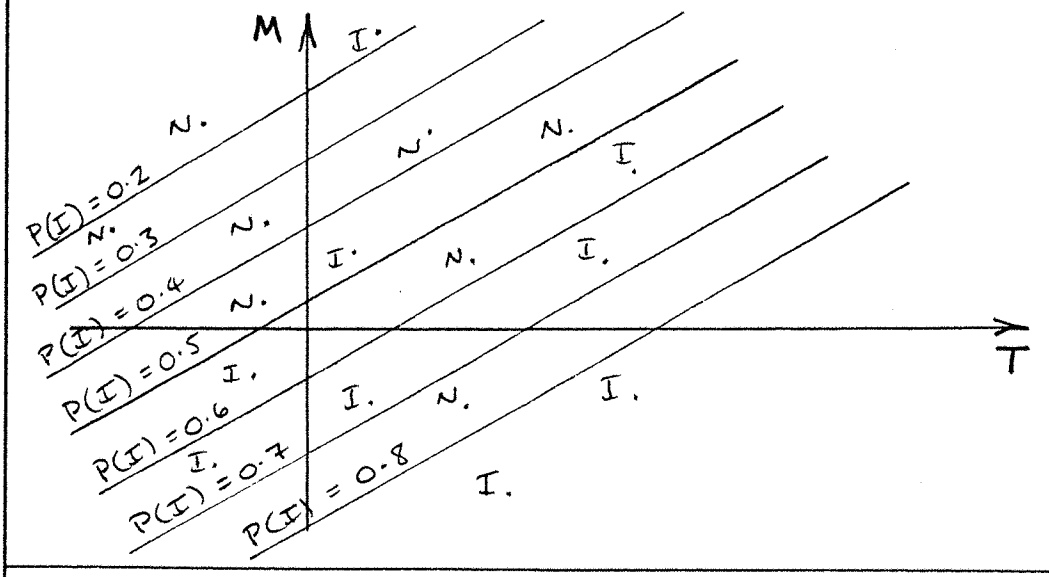
M = perceived excess cost of using Itchen Bridge.

T = perceived time saving in using Itchen Bridge.

w = value of travel time = $-a_2/a_1$.

3.6.3.7 This can be visualised as fitting a probability surface to the data (see Figure 3.11), determining both the orientation of the lines (the value of time) and the rate-of-change of the probabilities (which relates to the distribution of the disturbance term) by reference to the full data set. This contrasts with the "Beesley" method mentioned earlier which utilises only the data points at the margin.

FIGURE 3.11: PROBABILITY SURFACE FITTED TO CHOICE DATA



M = Excess Cost of Using Itchen Bridge
T = Time Saved Using Itchen Bridge
I = Itchen Bridge Chooser
N = Northam Bridge Chooser

3.6.3.8 As noted above this analysis was performed on the total data set and on sets disaggregated by journey purpose categories and income groups. The results are presented in the next section of this report.

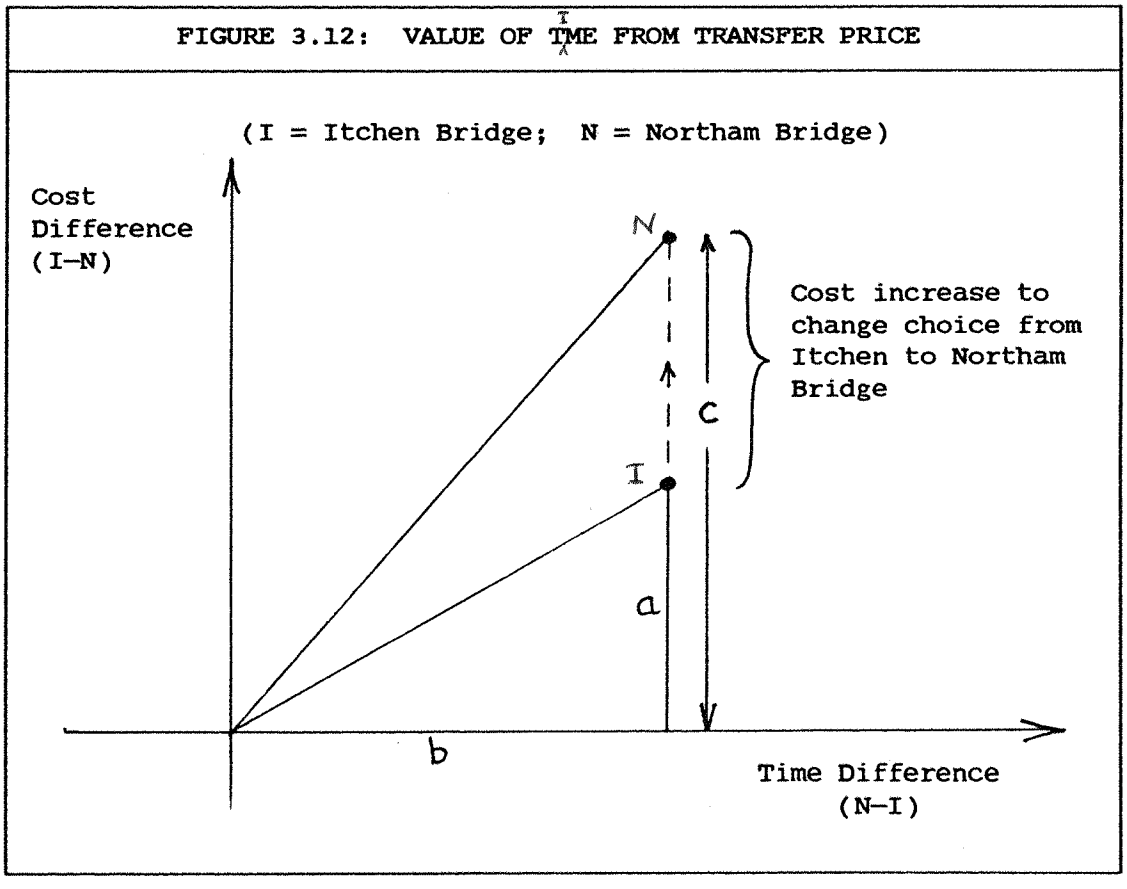
3.6.3.9 During preliminary checks on the data and with Harrison's ninth condition in mind, the sample was examined for choices inconsistent with the hypothesis that only cost and time differences determined route choice. Ninety-five trips exhibited such "illogical" choice, just under 8% of the total thus adequately fulfilling Harrison's requirement. It is a matter for debate whether these 95 trips should remain in the data for subsequent analysis. It could be argued that as these persons clearly have criteria other than cost and time as important factors in determining their route choice, they should be excluded as suggested by Harrison under condition 3. However, unless one can identify the particular ways in which these persons differ from the remainder of the sample, then the same factors may be present in the whole sample but simply to a lesser degree. Indeed when considering the application of travel time values, when similar "illogical" persons are likely to be present, it seems appropriate that the full sample be used. However, as a matter of interest analysis was performed on both the "logical" 1146 data set as well as the "full" 1241 sample. The parallel results for the "logical" choosers are also included in the next section.

3.6.3.10 Transfer Price Data

While an individual choice of travel option can reveal only a limiting value of travel time, by further questioning it may be possible to determine the point at which the person is indifferent between two options. This reveals a precise estimate of the valuation of the travel time savings. This is usually done by offering successive cost changes in the options until the respondent states that he or she would change their choice, and this has led to the technique being called "transfer price".

3.6.3.11 For example, on Figure 3.12 (which corresponds to Figure 3.10 for Reported Behaviour) the Itchen chooser is confronted by the possibility of increased costs on their preferred option until they state that they would change their route choice. This last reply is taken to identify their point of indifference. This is not strictly true as it would probably be necessary to overcome a perception or habit threshold (Goodwin, 1977) above the indifference point to cause a behavioural change. Thus the traveller would be prepared to pay c pence to save b minutes, although the price currently paid is only a pence. The value of time is inferred as c/b.

FIGURE 3.12: VALUE OF TIME FROM TRANSFER PRICE



3.6.3.12 There are several ways of treating this data. One approach considers that each individual response provides a different value of time. The average is obtained simply by averaging the individual values calculated as above and as illustrated in Figure 3.12. However, this is only possible for those who are actively "trading" time and money;

there are problems when the travel time saved is zero (leading to infinite values) and when the value is negative (i.e. choices in the 2nd or 4th quadrants of Figure 3.12). It is necessary to exclude these persons, thus reducing the sample size. The results are given later.

3.6.3.13 If it is assumed (as for the Reported Behaviour Data) that all persons have the same travel time valuation then a simple regression technique can be used. Using the axes of Figure 3.12:

$$M' = a_0 + a_1 T \qquad \ldots\ldots\ldots (2)$$

where M' = excess cost of using Itchen Bridge at which route choice changes

ie. M' = M + TP where TP = Transfer Price

M = excess cost of using Itchen Bridge for original choice

T = time saved using Itchen Bridge

a_0, a_1 are coefficients to be determined,

a_1 = value of travel time

This could be re-written more generally as:

$$TP + MD = a_0 + a_1 TD$$

where MD = money difference

and TD = time difference for the original chnoice.

3.6.3.14 However, this assumes that the original cost difference between the routes is perceived at the same rate as the transfer price. This is not necessarily the case (particularly in mode choice situations) and hence MD is usually incorporated into the right hand side, allowing the data to determine the coefficient (see for example Gunn, 1984):

$$TP = a_0 + a_1 TD + a_2 MD \qquad \ldots\ldots\ldots (3)$$

Even this specification is not strictly in agreement with utility maximisation theory. If the transfer price represents a measure of the utility difference between options then the regression should be:

$$TP = \alpha_0 + \alpha_1 \Delta u$$

where Δu = utility difference = $b_0 + b_1 MD + b_2 TD$

hence $TP = \alpha_0 + \alpha_1 (b_0 + b_1 MD + b_2 TD)$

(Dummy Variable)

or $TP = a_0 + a_{1_A} + a_2 MD + a_3 TD$ ..... (4)

Thus the expression for the transfer price requires calibration of two constants a_0 and a_1 ($= \alpha_1 b_0$) as well as the time and cost coefficients a_2 and a_3. The second constant a_1 is usually referred to as the "alternative specific constant" or ASC as it represents the relative utility arising from use of the alternative, regardless of its attributes (see Broom et al, 1983 or Bates, 1983).

3.6.3.15 The coefficient a_0 represents the transfer price that would be necessary, regardless of the changes in attributes of the options. This has been inferred as the habit threshold factor (see para 3.6.3.11) by various authors (Hensher, 1976; Broom et al, 1983; Bates, 1983) although this is claimed to be an erroneous specification by Gunn (1984). Some discussion on this point is also contained in Goodwin, Dix and Layzell (1985).

3.6.3.16 One problem in analysing the TP data is presented by those persons who stated that even the largest price change offered would not affect their route choice. It could be argued that the best estimate of their TP would be the highest offer made, however, this would clearly be an underestimate. As the TP question was not symmetrical, questions being specified in terms of changes in Itchen Bridge toll prices for both Itchen and Northam users, this would undoubtedly lead to errors. Alternatively these persons could be omitted, but as they

would tend to be those persons with very high or very low values this could again introduce bias. Both procedures have been tested although it is thought that omission should be preferred.

3.6.3.17 A further alternative procedure suggested for analysis was to include the TP data with the Reported Behaviour data and to perform a logit analysis on the combined results. Here those persons who would not change their choice even at the highest TP offered could be included at that extreme TP value but retaining their original bridge choice. However, there is no reason to suppose that the error terms for the TP data would be suitably distributed for logit analysis as the sampling frame would be non-random. Therefore this idea was not pursued.

3.6.3.18 Vehicle Occupancy

Thus far it has been assumed that the value of travel time relates to the individual respondent. However, one further issue must now be considered, that of vehicle occupancy. How does it affect route selection and how is is to be incorporated into the values of time inferred from such choices?

3.6.3.19 Occupancy was not asked in the survey. Probably it should have been. It was feared that asking for details of occupancy for regular trips (rather than one specific trip) may have caused complications when occupany was not constant. However, the main problem is that even if occupany were known, it would still not be clear (without possible lengthy probing) whether this affected the choice of route. If a driver attempts to minimise travel time or travel distance in his or her route choice (see review of route choice studies in Transportation Research Group, 1985) then the criteria are the same regardless of occupancy. However, when money enters the criteria set, as it clearly does here, then in principle the cost could be shared among the occupants. Implicitly this is done, but in practice the issues of who actually pays and how this payment is perceived are very complex.

3.6.3.20 Multiple car occupancy will frequently involve members of the same household. The cost-sharing arrangements within households are often complex and highly personal in nature (eg. joint bank accounts, who earns how much, arrangements for "housekeeping" money, contribution to household expenses by young adults, etc.). If one person pays the car journey costs or tolls this may be balanced by costs borne elsewhere by another household member. In general the amount of the toll may be insignificant in a total household budget. (One example of the difficulties of cost perception is the respondent who perceived the toll cost as zero as he had been given some Toll Bridge tokens as a birthday present.) This area is clearly a minefield for an interviewer and would substantially change the nature of the survey affecting matters such as sample size, survey procedures, representativeness of sample, bias and so on.

3.6.3.21 The analysis excluded respondents who received some explicit contribution to their travel costs, but the way in which responses to this question covered cost-sharing between several vehicle users within a household may not have been consistent. In practice very few respondents ever queried such matters, responding with perhaps a "gut-reaction" type of response which probably closely mirrors their perception of such matters and also the way in which they might approach route selection. It is clear also that "satisficing" behaviour is frequently adopted, that respondents are not losing very much by making a "wrong" choice and therefore are not single-mindedly seeking the optimal choice when this involves some difficulty in determining what are the true personal costs.

3.6.3.22 Two interpretations of the results are possible. Firstly it could be hypothesised that the interviewee was responding on their own behalf only; that as the vehicle driver he or she bears the costs and makes the route choice judgement accordingly. Some support for this can perhaps be adduced from Outram and Thompson (1976) who reported a "lack of sensitivity of car occupancy to route choice criteria" (and presumably meant a lack of sensitivity of route choice criteria to car occupancy!). Without further evidence they suggest that "drivers tend

to behave to their own values rather than the values of the occupants in general". This might imply that the values of time found in this study are individual, personal ones.

3.6.3.23 However, an alternative interpretation relies on the assumptions of revealed preference theory. The choices reported are those for journeys with certain occupancy rates, and hence implicitly reflect the combined values of all vehicle occupants. It is this latter interpretation that is preferred, being the fundamental tenet of the research carried out.

3.6.3.24 This interpretation is in agreement with Dawson and Everall (1972). They found the values of time per car and then divided, by occupancy (counting children as one half!) to derive values per person. However, the fact that occupancy has little effect on route choice (Outram and Thompson, 1976; as quoted above) suggests that to derive an individual value of time one should not simply divide by occupancy. Indeed if route choice was totally insensitive to occupancy then an individual's value of time becomes equal to and synonymous with that of a car full of occupants. Determination of vehicle occupancy would be unnecessary.

3.6.3.25 This contention is not as illogical as it might at first appear. Consider a member of a household setting out to undertake a particular journey. He or she has perhaps decides on the route to be taken. At the last moment another household member decides to make the journey as well. I suggest that the route choice would be most unlikely to alter. The costs of the journey are incurred for the budgetary unit, the household, regardless of the number of persons making the trip. The household expense to travel time ratio remains the same. (It can be noted that the Itchen Bridge tolls are levied per vehicle, not per person).

3.6.3.26 Indeed, only in the case of some explicit cost-sharing arrangement between members of different budgetary groups (eg.regular commuter lift-giving or car-sharing arrangements) might occupancy become relevant. These cases were excluded from analysis in the Itchen Bridge case study.

3.6.3.27 The implications of this are considerable. The values of time currently used by the Department of Transport are derived from individual rates which are then multiplied by occupancy to give values of time for a vehicle. This might be warranted for working time, where valuation is based upon an employer's willingness-to-pay and payment would be necessary for each employee. However, following the arguments set out here this would not apply to non-working time. Currently the non-working car is held to have an occupancy of 1.87 and to form 83% of car usage. If the value of time of the non-working car is taken to be equal to that of an individual then the value of time of the average car would fall by 26%, a very significant change.

3.6.3.28 It seems unlikely that there should be no relationship between occupancy and willingness-to-pay, however, it also seems clear that assuming each occupant to have the same value as a driver alone is likely to be an exaggeration. Indeed there is a prima facie case that the values of driver and passengers would be different as the fundamental conditions of travel for each are different. For example driver stress features in the Manual of Environmental Appraisal (Department of Transport, 1983b) and motoring advertisements extoll the pleasure, excitement and status of driving. It is recommended that further investigation of this topic should be undertaken, particularly with reference to the derivation of travel time values from route choices.

3.6.3.29 For this study it has been assumed that the results give a value of time per vehicle, but that values of time per person could not be derived simply through vehicle occupancy, even if it were available.

3.7 RESULTS

3.7.1 REPORTED BEHAVIOUR

The principal results for the full data set and the "logical choosers only" are shown on Figures 3.13 and 3.14 respectively. The columns headed Constant, Time Saved and Excess Cost correspond to the coefficients a_0, a_2 and a_1 respectively in the equation given in paragraph 3.6.3.6. The figures in brackets represent the t-values of the coefficients. Deviance provides a measure of unexplained variation, DF stands for degrees of freedom, VOTT for value of time and SE for standard error. This last term was calculated from the formula:-

$$SE = \frac{1}{a_1^2}\sqrt{\left[a_2^2 var(a_1) + a_1^2 var(a_2) - 2a_1,a_2 cov(a_1,a_2)\right]}$$

Where var = variance, cov = covariance.

The income groups groups are as shown on Figure 3.3 with A = 1(lowest), B = 2, C = 3, D = 4, E = 5(highest) and no answer or refusal represented by zero.

3.7.2 TRANSFER PRICE

For the transfer price questions there were 1223 valid responses from the 1559 questionnaires in the original raw data set, after exclusion of those who received financial assistance and those who could not respond at all to this question. This compares with a simple size of 1241 for reported behaviour data. There were also a further 116 cases where respondents said they would not change their route choice, even for the largest price change offered (see paragraph 3.6.3.15). Thus the 1223 sample size included those persons with their TP estimated as the largest offer made, and a sample size of 1107 was used where these cases were excluded.

FIGURE 3.13: RESULTS: REPORTED BEHAVIOUR – FULL DATA SET 1241 CASES								
File	No. of Cases	Constant	Time Saved	Excess Cost	Deviance	DF	VOT	S.E.
ALL	1241	-0.484 (3.39)	0.208 (13.00)	-0.0501 (9.62)	1109	1238	4.14	0.569
WORK	612	-0.473 (2.19)	0.197 (9.10)	-0.0523 (7.13)	544.4	609	3.76	0.692
SHOP	440	-0.516 (2.12)	0.226 (7.29)	-0.0487 (5.21)	384.8	437	4.64	1.188
SOCIAL	166	-0.670 (2.02)	0.228 (5.17)	-0.0300 (2.09)	160.7	163	7.60	4.203
SOCIAL AND OTHER	189	-0.733 (2.15)	0.238 (5.58)	-0.0315 (2.27)	176.0	186	7.47	3.768
INCOME GROUP								
1	275	-0.822 (2.77)	0.209 (6.06)	-0.0417 (4.11)	257.5	272	5.01	1.591
2	340	-0.546 (2.14)	0.186 (6.46)	-0.0296 (3.69)	336.1	337	6.29	2.162
3	289	-0.335 (1.11)	0.205 (6.34)	-0.0565 (4.87)	259.2	286	3.63	0.992
4	141	-0.093 (0.16)	0.322 (4.46)	-0.1390 (4.76)	78.13	138	2.32	0.571
5	74	-0.754 (1.29)	0.383 (3.60)	-0.0948 (3.22)	52.11	71	4.04	1.043
0	122	0.395 (0.76)	0.197 (3.72)	-0.0870 (3.97)	90.37	119	2.27	0.851

FIGURE 3.14: RESULTS: REPORTED BEHAVIOUR-"LOGICAL" DATA SET 1146 CASES

File	No. of Cases	Constant	Time Saved	Excess Cost	Deviance	DF	VOT	S.E.
ALL	1146	-0.387 (2.01)	0.327 (13.40)	-0.1054 (12.16)	702.3	1143	3.11	0.299
WORK	572	-0.300 (1.06)	0.298 (9.55)	-0.1008 (8.96)	363.5	569	2.96	0.400
SHOP	402	-0.633 (1.88)	0.373 (7.74)	-0.1069 (6.61)	230.4	399	3.49	0.633
SOCIAL	150	-0.143 (0.29)	0.338 (5.16)	-0.1172 (4.22)	95.13	147	2.88	0.799
SOCIAL AND OTHER	172	-0.312 (0.64)	0.359 (5.51)	-0.1133 (4.35)	105.9	169	3.17	0.844
INCOME GROUP								
1	247	-0.401 (0.88)	0.334 (5.86)	-0.1270 (5.99)	140.1	244	2.63	0.534
2	306	-0.712 (1.94)	0.320 (7.06)	-0.0824 (5.48)	201.7	303	3.88	0.863
3	268	-0.393 (1.05)	0.315 (6.80)	-0.0925 (5.75)	177.8	265	3.41	0.697
4	138	0.074 (0.11)	0.413 (4.25)	-0.1827 (4.54)	62.02	135	2.26	0.469
5	71	-0.496 (0.68)	0.518 (3.37)	-0.1428 (3.37)	39.16	68	3.63	1.814
0	116	0.246 (0.36)	0.301 (4.03)	-0.1127 (3.88)	65.56	113	2.67	0.889

3.7.3 For the analysis where the value of time of each individual response in the sample is considered, it is necessary to exclude those cases leading to a negative value of time (i.e.those responses in the 2nd and 4th quadrants – see paragraph 3.6.3.12). A further exclusion was also made of those cases with a zero value of time; responses where the cost difference at which a route change would be made was zero. Figure 3.15 presents these results.

3.7.4 Taking time and cost as the only relevant criteria (called the "logical" view point earlier), there should be no transfer price data points in the 2nd and 4th quadrants of diagrams such as Figure 3.12. Where respondents perceived the Itchen Bridge route to be quickest, then current Itchen Bridge users should not change route until facing a cost disadvantage, while current Northam Bridge users should switch at a zero cost differential at the latest. Similar arguments apply to those persons perceiving Northam Bridge to be the quickest route.

3.7.5 However, in practice, a considerable proportion of cases did have their transfer price data points in the second and fourth quadrants. This arose in six basic ways as illustrated in Figure 3.16.

(a) Itchen users switching too soon,

(b) Northam users switching too soon,

(c) Northam users not switching at zero cost, but seeking to gain both time and cost advantage before choosing Itchen,

(d) Itchen users not switching at zero cost, but to gain both time and cost advantage before choosing Northam.

There were also some data points where the original route choice was "illogical". These cannot possibly achieve a transfer price data point in the first or third quadrants, although their subsequent choice does now become a "logical" one. These are illustrated as:

(e) Former "illogical" Itchen choosers, now "logically" choosing Northam,

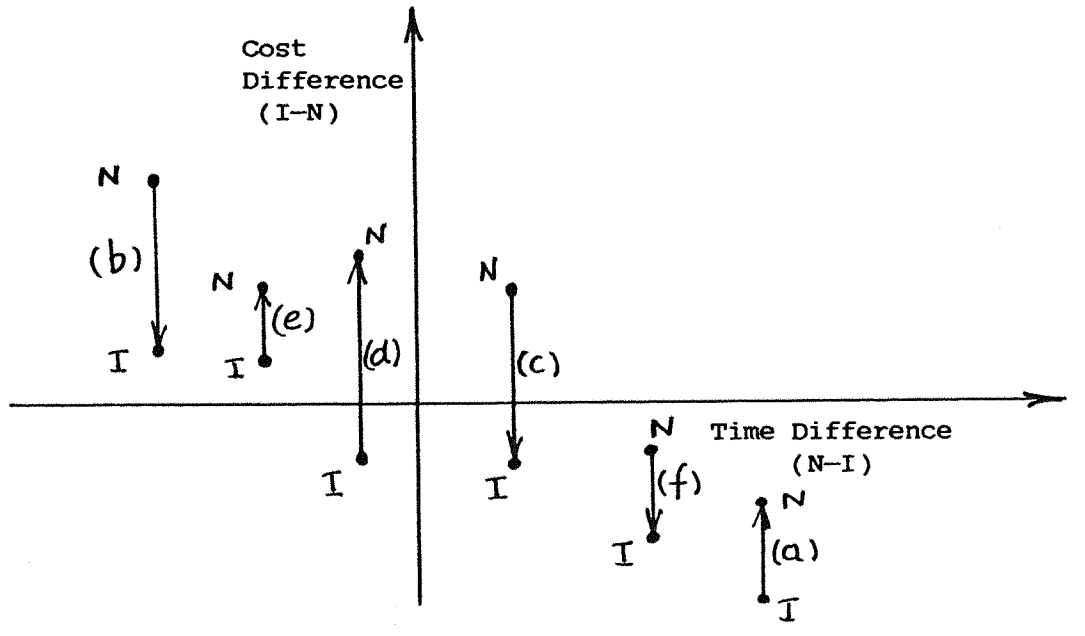
FIGURE 3.15: TRANSFER PRICE:VALUES OF TIME FROM INDIVIDUAL RESPONSES

	(A) Using "precise" TP values only N = 1107			(B) Using "best estimate" TP values N = 1223		
	N	Mean VOTT (pence/min)	Standard Deviation	N	Mean VOTT (pence/min)	Standard Deviation
(i) Excluding points with negative values	717	2.32	2.49	751	2.44	3.34
(ii) Also excluding points with zero values	648	2.57	2.50	669	2.74	3.42

(f) Former "illogical" Northam choosers, now "logically" choosing Itchen.

A discussion on the reasons for some of these choices is given later.

FIGURE 3.16: TRANSFER PRICE – "ERRONEOUS" DATA POINTS



3.7.6 The numbers of these types of "erroneous" choices for each data set is shown in Figure 3.17.

FIGURE 3.17: TRANSFER PRICE – NUMBERS OF "ERRONEOUS" DATA POINTS

	"Precise" TP Values	"Best Estimate" TP Values
Full Data Set	1107 (A)	1223 (B)
Response to TP question: "logical"/"illogical" [(a) to (d) type errors]	919/188 (C) (17.0%)	999/224 (D) (18.3%)
Response to TP question: "satisfactory"/"erroneous" [(a) to (f) type errors]	827/280 (E) (25.3%)	897/326 (F) (26.7%)

3.7.8 The effect of these "erroneous" responses was to make the regression analysis results based on equation(2) in paragraph 3.6.3.13 quite worthless. As can be seen by reference to Figure 3.18 (where the data set identifiers correspond to those on Figure 3.17) the R-squared values are all very small. For the full data sets the regression lines had negative slopes. Having regard to both the numbers of the "erroneous" decisions and the regression results, it was reported that the stated intention or transfer price results did not produce "an acceptable statistical explanation of the data" (Atkins, 1983b).

FIGURE 3.18: TRANSFER PRICE – REGRESSIONS OF TP+MD (EQUATION 2)

Data Set	Sample Size	Constant	Slope (=VOTT)	R^2
A	1607	11.5	- .31	.010
B	1223	10.1	- .15	.003
C	919	14.2	- .35	.015
D	999	13.0	- .20	.005
E	827	11.8	.52	.059
F	897	10.0	.77	.110

3.7.9 However, further analysis was undertaken using equations (3) and (4) and the results are shown in Figure 3.19 and Figure 3.20. Only data sets A, B and E were tested.

FIGURE 3.19: TRANSFER PRICE – REGRESSION OF TP (EQUATION 4)

Data Set	A	B	E
No. of Cases	1107	1223	827
Constant	1.18 (2.74)	1.81 (3.54)	- 0.99 (1.67)
ASC	12.09(38.9)	13.25(34.0)	11.30(27.4)
Time Difference	- 0.206(5.12)	- 0.300(6.27)	- 0.213(4.19)
Cost Difference	- 0.093(8.00)	- 0.103(7.16)	- 0.184(8.16)
R^2	0.71	0.66	0.71
VOTT (p/min)	2.22	2.91	1.15

ASC : Alternative Specific Constant
VOTT : Value of Travel Time
t values of coefficients given in brackets

FIGURE 3.20: TRANSFER PRICE – REGRESSION OF TP (EQUATION 3)

DATA SET	A	B	E
No. of Cases	1107	1223	827
ASC	1.84 (2.78)	3.38 (4.77)	-2.72 (3.35)
Time Difference	-0.750 (12.9)	-0.916 (14.8)	-0.837 (13.3)
Cost Difference	-0.212 (12.3)	-0.229 (11.8)	-0.489 (17.9)
R^2	0.32	0.34	0.45
VOTT (p/min)	3.55	4.01	1.71

3.8 DISCUSSION

3.8.1 REPORTED BEHAVIOUR DATA

Figure 3.21 shows the results from previous UK value of time studies as reviewed by Hensher (1978). Many of these were obtained by methods that are now no longer recommended, and the adjustment by changes in the Retail Price Index may not be entirely appropriate. The range of results is so wide that little can be said about the comparison with the principal finding from this study.

FIGURE 3.21: VALUES OF TRAVEL TIME – PREVIOUS U.K. STUDIES

Researcher	Survey Date	Purpose	Value Reported per person	Equiv.in June 1982 (pence per hour)
Quarmby	1966	to/from work	2/9 – 3/6	74 – 93
Stopher	1966	"	3/3 – 3/6	92 – 93
Beesley	1967	"	5/–	130
Lee & Dalvi	1967	"	61p	316
LGORU	1967	"	42p	218
Colenutt	1968	recreational	26p – 156p	129 – 773
Mansfield	1968	"	77p – 514p	382 – 2547
Smith	1969	"	50p	235
Watson	1969	"	63p	296
Ebden & Hall	1970	leisure	44p	194
Veal	1970	short trips	5p – 40p	22 – 177
Ebden & Hall	1970	to/from work	81p – 215p	358 – 950
SCPR	1970	"	61p	269
(Source: Hensher, 1978)				
c.f. Atkins	1982	All	(per vehicle)	248

3.8.2 Figure 3.22 shows a comparison with more recent results from the preliminary surveys conducted for the Department of Transport's Value of Time project. It should be noted that the results of Broom et al and Bates are per person, whereas those for this study represent per vehicle rates. It is interesting to note the remarkably close

FIGURE 3.22: RECENT U.K. VALUES OF TRAVEL TIME (BY REVEALED PREFERENCE/REPORTED BEHAVIOUR METHODS)

Source	Location	Survey Date	Purpose	Mode	Value (pence per hour)	95% Confidence Intervals
Broom et al (1983)	West Yorkshire	1982	to/from work	Car	180.4	46.1 – 314.6
				Public transport	116.6	11.4 – 221.8
Bates (1984)	North Kent	1983	to/from work	Rail/Coach	189.0	128.8 – 252.8
Atkins	Southampton	1982	all purposes	Car	248.4 (186.6)	181.5 – 315.3 (151.2 – 222.0)
			work	Car	225.6 (177.6)	144.2 – 307.0 (130.6 – 224.6)

(Figures in brackets from "logical" data set)

agreement of the studies, particularly with the "logical only" set. This perhaps gives some support to the notion that per vehicle and per person rates are very similar (see paragraph 3.6.3.24).

3.8.3 However, the 95% confidence intervals show the wide variations implicit within all the data sets. Given the sensitivity of highway appraisals to this factor, a narrower band for confidence intervals would be highly desirable. In fact, the Itchen results are superior in this respect with 95% confidence intervals of ± 27% (±19% for the "logical" data set) compared with ±56% reported in the text of the paper by Broom et al (1983). Some earlier results include ± 62% for Quarmby's work (Quarmby, 1967) and ±60% for a sample size of 1,000 estimated by reference to Daly and Zachary (MVA et al, 1981b). The results of this case study rely on a larger sample size but also on the less complex issue of route choice.

3.8.4 The Department of Transport identifies two categories of time values, one for time spent travelling during working hours and one for all other times including travel to and from work as well as leisure, shopping, social purposes, etc. It is considered that the appropriate comparator is the behavioural value of time for non-working cars. Although travel in the course of paid employment was not separately identified in the survey, this component should be very small as (i) the journeys considered were all home-based ones and a high proportion of trips during working time would be expected to be non-home based, and (ii) it was anticipated that trips during working time would be in receipt of some monetary contribution to costs and these trips had already been excluded from the analysis. The comparison is shown in Figure 3.23.

FIGURE 3.23: COMPARISON OF RESULTS WITH D.TP. VALUES (PENCE/HOUR)

Source: Department of Transport (1980)

	1979	Equivalent June 1982
Working Car	480.2	693.8
Average Car	181.9	262.8
Non-Working Car	122.1	176.4

This Study	Mean	95% Confidence Limits
Full Data Set (1241)	248.4	181.5 - 315.3
"Logical" Data Set (1146)	186.6	151.2 - 222.0

3.8.5 The current D.Tp. value of working time is based upon the price an employer would have to pay, this being represented by wage rates plus overheads. Non-working time is then valued at 25% of the average working time value, this arbitrary proportion being based on an approximated average figure from several surveys conducted around 1970 (Department of Transport, 1981a). The methodology and analysis of several of these studies has since been called into question by later work. From the reported income groups for this study a mean annual household income of £7,500 was estimated. Assuming a 50 week/40 hour pattern, an average wage rate of £3.75 was calculated. Hence the results represent 66% (or 50% for the "logical" set) of the earnings rate. Note that this would be a car time/household income ratio, however.

3.8.6 The Department of Transport figure of 122.1 pence per hour in 1979 has been converted to 1982 by reference to the retail price index alone. It is anticipated that the Value of Travel Time Savings will grow in accordance with the growth in Gross Domestic Product (GDP) (see Department of Transport, 1981a) and so the figure of 176.4 may be slightly too low. However, this figure is derived from national average data for journey purpose and occupancy, and these may well have been different in the Southampton case. Thus the 176.4 should be taken as an approximate guide only. The study result of 248 pence/hour may seem slightly high but again the "logical" data set shows good agreement. Both the D.Tp. figures and the results from this study

represent values of time per vehicle, although the D.Tp ones are derived through estimation of individual values and assuming equal willingness-to-pay for all occupants.

3.8.7 The general accord of these results,and particularly the "logical" data set, with the D.Tp. figures is heartening. The methodology, assumptions and analysis of the studies on which the D.Tp. values are based has been called into question by more recent developments. Empirical verification from a recent survey in an approximate location must be re-assuring.

3.8.8 However, not all the results were so neat. It was anticipated that disaggregation by journey purpose would produce values of time which were higher for "work" purpose and less for social trips. This expectation was based on the experience of previous studies which suggested that the less essential the journey, the less highly the time was valued. For this study, however, not only was the division into different purposes not warranted (there was not a significant reduction in deviance), but also the values obtained were often contrary to expectation (see Figure 3.13). Although the "logical" data set produced more consistent results, again the breakdown was not statistically warranted. It has been suggested that trip frequency may provide an explanation, that persons are willing to pay more highly for occasional trips but are more cost conscious when the trip is made nearly every day. Unfortunately the data base does not permit exploration of this issue.

3.8.9 Disaggregation by income group was statistically justified, but the results obtained do not lead to any useful conclusions. There is no apparent relationship between reported income and the value of travel time savings. This aspect of the results has been discussed in Chapter 2 (section 2.4.2.).

3.8.10 One further disquieting factor is the quite large changes in results that arise from the exclusion of 8% of the data. Omitting the 95 "illogical" choosers, that is those who chose routes perceived as both slower and more costly, reduced travel time values, narrowed

confidence limits and lessened variation between subdivisions of the data set (Figure 3.14 cf. 3.13). As discussed earlier such exclusion cannot really be justified. One can exclude data on the basis of certain pre-determined characteristics that are unacceptable (e.g. receipt of payment from external source), but not simply on the matter of the reported choice. It is also disappointing in the sense that the "logical" data set shows close resemblance to the D.Tp. figures and those from other recent studies (Figures 3.23 and 3.22).

3.8.11 Such matters of data exclusion are not frequently reported, and it is disturbing, given the evidence shown here, that it should be done at all. However, two quotations from value of time literature show that this does occur, and the practice is doubtless more widespread than this:

> "A small number of outliers have also been discarded on the grounds of having provided unusually extreme transfer prices"
>
> (Gunn, 1984; although he does note that the subject of the paper is theoretical rather than an attempt to find a "true" value of travel time).
>
> "After removing non-responders (40%), those with no alternative (15%) and those who apparently 'did not trade' (i.e. had a cheaper, faster mode available) or those who made 'inconsistent' choices (i.e. took a slower dearer mode), together accounting for 33% of the data set....."
>
> (MVA, 1981a; reporting the studies of Lee and Dalvi in 1969)

3.8.12 It has been suggested that such persons may have little influence on results. For example, Daly, arguing for inclusion of non-traders, states:

"If a particular individual's choice tells us little about his valuations of journey attributes, then in a properly constructed model his effective weight will be small." (Daly, 1978).

However, this work suggests that a very small number of observations could cause substantial changes in results, perhaps because their information content is large.

3.8.13 TRANSFER PRICE

As indicated in Figures 3.17 and 3.16 there were many cases where the transfer price question led respondents to give answers in which their revised route choice was either inconsistent with a decision based solely on time and cost criteria or inconsistent with their previous choice. Depending upon which definition was used either 18% or 25% of the responses could be classified in this way. This contrasts with just 8% for the reporting of current behaviour (see paragraph 3.6.3.9).

3.8.14 To see why so many persons made such apparently erratic choices, it is necessary to consider the different kinds of bias involved in TP questions. Bonsall (1983) presents a good review, identifying four major types of non-commitment bias:

(i) Affirmation bias: the tendency of the interviewee to give the answer that they think the interviewer wants. For example in this study the pattern of offering successive increases of the TP conveys to the respondent that they are "expected" to switch route at some cost change; the sooner they reply positively the sooner the interview will be terminated.

(ii) Unconstrained response bias: a failure to consider negative consequences of the change in behaviour, for example that their original route choice is still their best alternative.

(iii) Rationalisation bias: a failure to appreciate the advantages of the currently rejected option, for example, a prejudice against paying tolls (see also later comments) or a kind of "brand loyalty".

(iv) Policy Response bias: an attempt to influence policy decisions. For example an Itchen Bridge user would report a change in behaviour for a very small toll increase, in the hope of deterring, delaying or reducing any real price increase.

Bias of these types would be present throughout the whole sample, not just in the subset of "erroneous" choices.

3.8.15 Other types of bias may be identified which could affect both the reported behaviour as well as the transfer price data. For example rationalisation or "post-purchase" or "post-selection" bias was clearly present in some reporting of the attributes of the current choice or the rejected option. Such exaggeration to overstate or justify current behaviour then placed the respondent in a dilemma when faced with subsequent questions on how he or she might respond to changed circumstances. Should they answer "correctly" with their likely true response, or "consistently" with their previous,exaggerated reply?

3.8.16 A further peculiar kind of bias associated with toll payment is also felt to exist in the Itchen Bridge case. Many residents of eastern Southampton clearly considered that toll payment is unfair; they should not have to pay an additional price to gain access to the City Centre and beyond (see paragraph 2.6.2 for discussion of this equity issue). In extreme cases these persons would not use the Itchen Bridge on principle, even when they perceived it to be the most advantageous for their journey. For others it may affect their perceptions, or their reporting of their perceptions. To a certain extent this aversion to tolls may be countered by a "novelty" effect where some persons may actually

enjoy the relatively unusual nature of toll payment. However, these persons are unlikely to be local, regular travellers and such an effect would be expected to have declined since the opening of the bridge. These kinds of "policy response bias" again affect reported behaviour as well as transfer price data.

3.8.17 For this study it is certain that some of these bias effects were quite strong. It is considered that the policy response bias is inevitably very important where toll payment is concerned. Some respondents raised this issue during their interview. Although suitably reassured that the data would not be used to determine toll prices, they were not necessarily convinced. The dilemma resulting from overstatement of the advantage of the current choice was also thought to be important, notably when respondents replied boldly and perhaps without due consideration. Attempts to avoid such problems would raise many issues for survey method, sample size and the representativeness of the sample. Although it is impossible to assess the extent of such bias effects, some indication of their influence may be inferred from the fact that 25% of persons responded with "illogical" choices and that the elasticities derived from these responses were much greater than those observed (see paragraph 2.3.3.26).

3.8.18 The implication of the transfer price question from the point of view of forecasting travel behaviour has been discussed in Chapter 2 (paragraphs 2.3.3.22 to 2.3.3.26). However, despite the fact that stated intent in response to questionnaires can often vary considerably from subsequent actual choice (see Bonsall, 1983 for some examples) it has been suggested that this may not be so important in the context of determining travel time values:

> "It is important to distinguish between the use of TP data for the valuation of travel time savings and the use of the same method to produce predictive models. Arguments which weaken the conclusions of TP models on the basis that

'expected option characteristics' may not equal 'out turn option characteristics', or even that the characteristics that may be deemed relevant may change on experiencing a real choice, would not necessarily criticise value of time derived on the basis of the TP data." (MVA et al, 1981a).

3.8.19 Thus it is implied that an interviewee's response can correctly reflect his or her perceived relative weights of time and cost,even if they would not actually behave in the way stated. That is, if respondents truly believe that is how they would behave given those options, then their implied value of time is "correct", even when it is anticipated that their actual choice would be different.

3.8.20 First, if that belief in their future behaviour is not genuine, but is modified by bias effects such as those listed above, then the approach must be invalid. Secondly if that belief in their future behaviour is sincere, but fails to account for reality, does the decision truly reflect their value of travel time savings or is it little more than a guess made through participation in a game? It does seem questionable whether values of travel time savings inferred simply on uncommitted (and possibly erroneous) belief rather than observed or even reported behaviour are in fact an appropriate basis for investment decisions (see Chapter 5 for further discussions on such issues).

3.8.21 In this case I would be unhappy to place much reliance on values of travel time savings inferred from a sample in which 25% selected their routes on a basis inconsistent with the primary assumptions of the analysis, i.e it would appear that for this data the reported transfer price is not an effective measure of the utility difference between the options. Thus while the changes in toll prices were clearly well understood, and seemed realistic to the respondent, this advantage was outweighed by the disadvantages of bias effects caused by the nature of toll payment.

3.8.22 Despite my lack of conviction that in this case the Transfer Price analysis can support practical evidence of travel time valuation, the results are still worthy of some consideration. Figure 3.24 shows

the principal results using Equation (4) for Data Set A compared with other recent results from Broom et al (1983) and Gunn (1984). The results have been re-scaled to monetary units throughout by making the coefficient of the cost difference equal to one, after Gunn (1984).

FIGURE 3.24 TRANSFER PRICE – COMPARISON OF RECENT RESULTS (EQUATION 4)

Source	Gunn (1984)	Broom et al (1983)	Atkins
Location	North Kent	West Yorks	Southampton
Sample Size	452	482	1107
Constant	1537.2 (76.1)	135.5 (11.1)	12.7 (2.7)
ASC's	c.f.coach	c.f. bus	c.f.Northam
Train	97.0 (–)	25.5 (1.7)	
Car driver		70.6 (3.6)	
Itchen			130.1 (38.9)
Walk Time	3.1 (2.1)	0.7 (1.9)	
Wait Time		0.6 (1.1)	
Main in –veh time	2.2 (2.0)	1.1 (3.8)	2.2 (5.1)
Other in –veh time	3.5 (1.6)		
Total cost	[1.0] (2.5)	[1.0] (7.1)	[1.0] (8.0)
R-squared	0.95	0.27	0.71
re-scale factor	7.3	2.1	10.8

Notes: ( ) denotes t -ratio for the unscaled model
[ ] denotes fixed by assumption

3.8.23 Firstly it can be seen that the constant term, interpreted as the habit factor, is substantially lower here. This seems sensible in that route-switching is inherently easier than mode changes which involve the acquisition of certain knowledge about schedules and other factors. Secondly the alternative-specific constant in this case is high, perhaps due to the policy-response bias effect. Thirdly the re-scale factor (effectively a ratio of transfer price units to perceived cost value) is also very high. This suggests that toll changes are perceived very highly in comparison to other costs. While

this proposition seems reasonable the other costs already involve a toll component in some cases, and the factor of ten does seem very high.

3.8.24 Figure 3.25 shows the alternative analysis method noted by Gunn, omitting the habit factor (i.e. Equation 3). Despite habit being a relatively small influence in the Itchen Bridge case-study, the results are noticeably different from those shown earlier. This demonstrates the acknowledged need to reconcile the analysis techniques (Bates, 1984), as attempted by Gunn (Gunn, 1984).

FIGURE 3.25: TRANSFER PRICE - OMITTING 'HABIT' FACTOR (EQUATION 3)

Source	Gunn (1984)	Atkins
Location	North Kent	Southampton
Sample Size	452	1107
ASC's	c.f. coach	c.f. Northam
Train	23.2 (-)	
Itchen		48.7 (2.8)
Walk time	2.4 (4.9)	
Wait time	5.9 (6.5)	
Main in-veh time	2.5 (7.6)	3.5 (12.9)
Other in-veh time	2.0 (2.7)	
Total cost	[1.0] (7.6)	[1.0] (12.3)
R-squared	0.39	0.32
re-scale factor	1.87	4.73

Notes: ( ) denotes t - ratio for the unscaled model
[ ] denotes fixed by assumption

3.9 CONCLUSIONS

3.9.1. The particular circumstances of location and tolls investigated have fulfilled their promise of suitability for derivation of travel time values. The advantages of route choice, particularly in terms of clarity and statistical reliability, seem to be confirmed. One reservation must concern the relatively small absolute values of the travel attributes involved. Travel time values were inferred for quite small perceived time savings, often on the basis of small differences in perceived costs. While this may be realistic for many applications to the appraisal of highway improvements, the results may not be applicable in all circumstances. In this connection, it is also clear that many people were not actively seeking the optimal decision as implied in the theory, but were quite happy with one that was near-optimal, provided their perceived "losses" were not too great. This "satisficing" behaviour is quite logical, particularly when some effort may be involved in precise estimation of journey attributes. It is reassuring that good statistical fit of the models was obtained despite this fact.

3.9.2 The most authoritative results from this work are those obtained from the revealed preference (or reported behaviour) approach. The derivation of travel time values from the logit model is a recognised, standard technique, in contrast to the stated intention or transfer price methods which are still subject to academic debate. The results from the RP method show broad agreement with those for cars currently recommended by the Department of Transport for appraisal purposes. Similarly there is good correspondence with values derived from the preliminary surveys of the joint Value of Time Research Project team. In both cases it is the "logical" data set that provides the best match.

3.9.3 The confidence limits from this case-study are quite wide, but are still better than all other published U.K. results. This is partly attributable to the relatively large sample size, but also to the advantages of the route choice issue. The implications of the accuracy of the estimates for precision in evaluation are important. Stratification by trip purpose was not statistically justified. Stratification by reported household income group was statistically justified, but no relationship between the value of time and income was discernable. The mean values of time represented 66% or 50% of the estimated mean of reported household income.

3.9.4 The omission of 8% of the data set, those whose choice of route was not based solely on time and cost criteria, produced more consistent results across both purpose and income, and narrower confidence limits. However there is not a prior justification for this exclusion. A more detailed interview process would have clarified the reasons for these "illogical" choices, but would not necessarily have led to their exclusion. While such an in-depth survey technique is desirable on data quality grounds there are some problems in ensuring that a representative sample is obtained. Within the budget resources for this study it was a conscious decision to opt for a large sample but less detailed survey. It is recognised that the survey technique conditions the responses obtained under either method.

3.9.5 Vehicle occupancy was not asked in the survey, an unfortunate omission. However, from rational considerations, and with some reference to previous work, it is not at all clear that values of time should be measured on a per person basis. The per vehicle values produced from this research are sufficient in many applications. Further study is undoubtedly necessary on this topic.

3.9.6 The transfer price technique was applied in circumstances that were easily understood and quite realistic. However, the frequency of responses that were illogical or inconsistent with respect to time and cost factors suggests that response bias was widespread. It

is suggested that the nature of toll payment is particularly susceptible to the policy response bias effect, in which respondents attempt to influence the setting of future toll levels through their answers. The results obtained show some logic but unless or until a suitable theoretical reconciliation between the revealed preference and transfer price methods can be shown, it is considered that the revealed preference results must be given more credence. In particular the revealed preference method corresponds better with the economic principles of valuation, having actually demonstrated a "willingness-to-pay".

CHAPTER 4

EXPERIENCE FROM A REPEATED TRAVEL SURVEY

PART I: THE PAPER

4.1 INTRODUCTION

4.1.1 In February 1982 the students from Southampton University's M.Sc. course in Transportation Planning and Engineering, supervised by the author, undertook a small travel survey in the city as a part of their coursework. Their objective was to determine the value of motorists' travel time by reference to travellers' route choice between the Itchen Bridge where tolls are charged and the toll-free Northam Bridge. The task was viewed as a consultancy brief with the students left to devise, organise and programme their own activities to meet the required study aim. The client, the author, exerted suitable influence on the study design at periodic management meetings.

4.1.2 The procedure adopted was a limited house-to-house survey, initially establishing whether a car was available and then whether it was used for regular trips across either of the bridges. If so, then a survey form was completed for each bridge-crossing trip. Information was requested on the perceived time and cost of the trip currently made, and the perceived time and cost of making the same trip via the other bridge. A "transfer-price" question concerning response to a change in toll levels was also put, together with an income group question. Finally, and at the client's request, respondents were asked whether they would be willing to answer further questions at a later date. This was asked in anticipation that one of the students might make use of these co-operative respondents as a part of their individual project work later in the year. More than 70% of the households where a survey form was completed expressed willingness to respond again and a total of 111 households were identified in this way.

4.1.3 Subsequently, in March 1982, the University was persuaded to devote a small amount of money from the last vestiges of its research fund to a similar but more extensive study under the author's direction. This survey took place in early June (prior to the World Cup) and involved some 20 interviewers making 5,500 house-calls resulting in approximately 1500 completed questionnaires. Further details of this survey were given in Chapter 3. It was decided to include the previously identified "co-operative households" as a special component sample of this second survey.

4.1.4 A similar survey procedure of house-to-house calls was used in the June survey. The information sought remained the same but the opportunity was taken to slightly redraft and clarify some questions in the light of the experience gained from the first survey. In general terms, however, these changes were minimal. The interviewers employed for the second survey included some of the more confident, capable and impoverished students from the M.Sc. course, and these persons were selected to perform the special re-visit interviews. In no case, however, was the same household visited by the same interviewer in each survey. No additional or special questions were asked in the re-visit interviews and the interviewers did not have the corresponding previous survey form available. The only extra information available to them was the previous respondent's name (except in a few cases where only the address had previously been noted) and thus a slightly different preamble to interview was used from the main part of the second survey.

4.1.5 Thus the same information was sought using substantially the same survey procedure at previously co-operative addresses some sixteen weeks later. The remainder of this paper presents the results of comparison between individual responses from the two surveys and discusses some of the issues raised.

4.2 RESULTS

4.2.1 When conducting a house-to-house survey of this kind a "no-answer" response is a common occurrence. Similarly in trying to pinpoint specific trips it is quite likely that the particular

trip-maker may be absent although other house occupants may be present. As was standard practice in the June survey some repeat calls were made to these "non-contact" houses in an attempt to reduce bias in the sample. (It could be hypothesised, for example, that those households where no answer was obtained were more likely to be active and mobile households whose members may have distinctly different time values). Of the first calls on the 111 identified households, 24 "no-answers" and 14 "absent trip-makers" were received, giving a potential total of 38 households for a second call. For practical and operational reasons it was only possible to make 25 of these repeat calls. Collating responses from both first and repeat calls produced the household responses shown in Figure 4.1.

FIGURE 4.1 HOUSEHOLD RESPONSES

No answer or no contact with particular trip-maker	25
Houses now empty	2
Previous respondents moved away	3
"Did not answer previous survey"	3
"Nothing more to say"	2
Refusal	8
Now no car	1
Car off road	1
Now no bridge-crossing trips made	5
Interviews recorded	61
TOTAL	111

4.2.2 From the 61 households where interviews proceeded, a total of 76 trip records were obtained. Of these 76 reported trips, 57 concerned a journey from the same address and for the same purpose as in the first survey, but 19 had no corresponding previous trip. The nature of these 19 cases varied widely. In one case the respondent had

retired from work, so no work trip was reported but leisure and shopping trips were now made. One previously unemployed person now had a job and therefore a new work trip was described. Another person now made two work-related journeys instead of one as before. From one house a work trip in the first survey was replaced by a hospital trip in the second. Many other changes with perhaps less obvious behavioural bases were also identified.

4.2.3 From the 57 trips identical in origin and purpose still more changes took place (see Figure 4.2). In 10 cases the trip destination had altered, sometimes also involving a change of bridge use. In one case a different mode was used, motorcycle replacing car use. Four trips now took place at a significantly different time of day and five persons had altered their route to use the other bridge. Therefore, there remained 37 trips where one might reasonably expect similarities in reported travel times and costs between the two surveys.

FIGURE 4.2 TRIPS FROM SAME ADDRESS

Change in trip purpose	19
Change in destination	10
Change in mode	1
Change in time of day	4
Change of bridge use	5
Similar in all respects	37
TOTAL	76

4.2.4 For the 37 identical trips the reporting of travel times and costs for the selected and alternative route often exhibited inconsistencies between surveys. Only 9 respondents could be considered to be highly consistent, with variation of less than five minutes and 20 pence between reported values from the two surveys, although a further 16 could be termed reasonably consistent with

reported variations of less than 10 minutes and 30 pence. However, 7 respondents made gross changes in their reporting of at least 15 minutes or 50 pence.

FIGURE 4.3 REPORTED DIFFERENCES IN TRAVEL TIMES AND COSTS	
	(Cumulative total)
Differences > 15 mins or 50 pence	7
Differences > 10 mins or 30 pence	12
Differences > 5 mins or 20 pence	28
TOTAL	37

4.2.5 Finally, the income group question can be reviewed with respect to those 61 households participating in both survey sets. Five income groups were presented to respondents ranging from less than £5000 to greater than £12,500. The same reply (same income group or refusal) was reported in 29 cases and at 18 households the response differed by only one category. However, in 8 households the difference was more than one category and 6 households refused to answer this question in one survey but not in the other. Figure 4.4 summarises these responses.

FIGURE 4.4 RESPONSE TO INCOME QUESTION	
Same response (same group or refusal)	29
Different by one category	18
Different by more than one category	8
Refused in one or other survey (not both)	6
TOTAL	61

4.3 QUALIFICATIONS AND RESERVATIONS

4.3.1 Before discussing the implications of the above results it would be prudent to review the possible sources of discrepancy between the surveys, and examine any predisposition to change arising from sample selection or other causes.

4.3.2 DISCREPANCIES ARISING FROM SURVEY PROCEDURES AND PRACTICE

Differences reported between the surveys might be attributable to poor survey conduct. This section reviews factors which might be relevant in this context.

4.3.3 Interviewer experience was not equal between surveys. All M.Sc. students participated in the first survey, including overseas students with perhaps less than perfect English or pronunciation peculiarities, those with strong regional accents and some less confident, introverted characters. For almost all of them it was their first interviewing experience. For the purposes of the second survey all interviewers had been through a briefing and practice session in addition to their previous experience and the re-visit interviews were also conducted towards the end of the survey period. This probably ensured a more competent performance than might have been anticipated in the first survey.

4.3.4 Clearly "errors" in survey recording (e.g. ticking wrong box, misinterpretation of response) can occur however experienced the personnel involved. Similarly poor survey methodology by omission or error in survey conduct or procedure could lead to discrepancies. For example the response "did not answer previous survey" could result from simple recording errors; from poor interview technique; from failure to contact the appropriate household member (in turn perhaps partly attributable to poor briefing or supervision); or from poor procedural techniques in erroneously distinguishing this from "previous respondent moved". One procedural error that could explain some differences in

the results above arises from the fact that in a few cases only the contact address was known and not the particular respondent. Unless sufficient care was taken to ensure that the respondent in the repeat survey was the same person that answered previously, another car driver from the same household could have been questioned, leading to different trips being reported.

4.3.5 It should be noted that survey procedures were not devised with the kind of analysis that this Chapter sets out in mind, the principal objective was altogether different.

4.3.6 CHANGES IN CIRCUMSTANCE, PERCEPTION OR REPORTING

With "perfect" survey methodology the differences between survey responses can be attributed to different answers being provided, but this could arise from three possible sources. Firstly, there may be genuine changes in circumstances, and one must beware attributing unreliability or error status to authentic change. For example a change of reported income of more than one category may truly reflect circumstances such as retirement, redundancy or gaining or changing employment. Similarly changes in actual travel times or costs over a 16-week period is certainly possible. In fact petrol prices were virtually identical between February and early June, although some variation had occurred in the intervening period. Although seasonal changes in traffic volumes may affect travel times, greater changes take place between different hours of the same day than between the same hour on different days. No significant roadworks or "artificial" delays were present in the relevant area during the survey periods.

4.3.7 Secondly circumstances may be identical but individual perception of, say, travel times or costs may have altered. Perception changes could have been stimulated by a wide variety of causes.

4.3.8 Finally both circumstances and perception may be identical but reporting of that perception would be subject to measurement errors. Generally travel times were reported rounded to five minute intervals. A "true" perception of say, nine minutes could well be reported as ten

minutes in one survey or as "five to ten minutes" (coded as 7.5 minutes) in the second. It is virtually impossible to distinguish between the causes of these reported differences; we can merely note that the reported result is different from before.

4.3.9 PREDISPOSITION TO REPORTED CHANGE

It should firstly be noted that the household sample was not random. The selection was partly geographical, in that areas slightly closer to the Itchen Bridge were selected in an attempt to maximise the time/money traders contained in the sample. The student task was also specified in terms of a minimum sample size. To gain maximum profitable use of their time the group selected interview areas where it was anticipated that car ownership would be relatively high, thus perhaps more prosperous, middle-class areas were chosen, although only on the basis of a cursory reconnaissance trip. Furthermore the sub-group identified were those expressing willingness to respond again, which would also introduce bias into the sample.

4.3.10 Secondly not all trips from households were sampled, only a particular group of car driver bridge-crossing trips. One might perhaps expect greater stability to be exhibited from a wider range of trips and less from a narrowly determined sub-sample. However, the relevant trips were regular ones, defined as a trip to the same destination for the same purpose at approxiamtely the same time, made on at least two previous occasions. (This condition was included to ensure that knowledge of the trip times and costs on the preferred and the alternative routes could be expected to be authoritative). Therefore, greater stability of these trips was anticipated than from a survey of all household travel.

4.3.11 It is possible that behaviour, perception or reporting may have been changed as a result of participation in the first survey. This artificial stimulation of change effect is probably small but certainly bridge choice could have been influenced simply by the fact of having to state perceived values of time and costs on alternative routes. Similarly both perception and reporting could have been

influenced if re-evaluation of these factors took place in the light of the first survey. Some respondents may be more cautious in the second survey, having previously gained some knowledge of the kind of question that will feature later in the questionnaire. It is noticeable that some respondents appear to exaggerate or overstate the advantage of their chosen route, perhaps, for instance, stating that it is both quicker and cheaper. When faced with a question concerning toll increases they then may be put in a dilemma about answering "correctly" with their likely true reaction or "consistently" with their previous, exaggerated, replies. Some experience of likely questions may reduce this "overstatement" effect. However, a period of four months between surveys probably reduces these influences to a low level.

4.3.12 On balance, therefore, a bias towards stability might be expected on the basis of area selection, co-operative respondents and regular trips. Clearly it should also be noted that the overall sample size is relatively small.

4.4 DISCUSSION

4.4.1 The results reported above record significant changes in travel behaviour within a relatively short time period for data where a bias towards stable travel habits might be anticipated. Even the possibility that there may have been gross errors or procedural faults in the surveys which may have contributed to these discrepancies cannot entirely overcome the sense of unease which these findings create.

4.4.2 CONSISTENCY

One issue raised by the results is reliability, perhaps more accurately expressed as consistency of response. When reporting times and costs of identical regular trips some 19% of respondents made large alterations in reported values. The magnitude of these changes, of at least 15 minutes of 50 pence, should be seen in relation to the average reported times and costs, which were 17 minutes and 55 pence. It seems unlikely that they could be attributable to real changes such as those arising from seasonal effects. Although responses to income questions

are notoriously unreliable, reasonable consistency might be expected. However, under half the sample reported the same income category in each survey, 13% gave very different answers and 10% were inconsistent in their attitude to the question, answering in one survey but not in the other. Clearly some of these reported income differences do truly reflect changed circumstances.

4.4.3 In sampling particular households from a certain population, one seeks a representative response. It is normally assumed that responses reflect true values reported without error, If variability arises not only from differences between households but also involves measurement errors in reported values, there are implications either for appropriate sample sizes or for the confidence intervals of the measured factor. These results serve to re-emphasise that data obtained by interview is not directly observed behaviour showing revealed preferences but merely reported behaviour subject to the influence of the survey method.

4.4.4 TEMPORAL STABILITY

A further issue concerns the temporal stability of travel patterns. The results indicate a surprising propensity to change, including, for example, a 6% change in residency, a 3% change in car availability and a 7% change in household travel such that relevant trips were no longer made. At the level of individual trips, a cumulative series of 25% purpose change, 13% destination change, 1% mode change, 5% timing change and 7% route change combine to leave less than half the reported regular trips having a corresponding record in the previous survey.

4.4.5 The traditional urban transportation planning process is founded on a pre-supposition that travel patterns in a city are of a regular and repetitive nature. For small scale applications a certain travel pattern (OD matrix) is sampled to provide an estimated OD matrix assumed to be representative of typical daily travel desires. For large scale applications this pattern is synthesised from sampled trip ends and sampled trip purpose characteristics. In both cases OD matrices would be calibrated by reference to observed traffic flows at

screenlines. Frequently large "adjustments" are necessary, often attributed to under reporting of trips. (See, for example, Clarke, Dix and Jones [1981]). These procedures focus on OD matrices and tend to lead to an implied assumption of an invariable daily travel pattern. While common-sense dictates an appreciation that many people travel to different places at different times on different days, the appealing conceptual simplification of precisely the same travel pattern occurring each day is a trap for the unwary. This is not to deny that many trips do take place on a highly regular and repetitive basis, for example, some work trips, most school trips and certain shopping and leisure activities. However, even some of these kinds of trip do vary in some aspect like destination or time of day and discretionary travel will generally show less repeatable character. The evidence of this Chapter suggests that much greater variability exists in travel patterns than might have been expected, even for supposedly regular trips. Although observed at an individual level, aggregation to zonal level would mask but not eliminate this tendency.

4.4.6 Trends in social behaviour also imply greater variability in future travel patterns. These include firstly reductions in the number of trips where regular patterns are likely, for example through persistent high levels of unemployment and by the decline of manufacturing industry where fixed working hours are more common. Secondly there has been growth in less regular tips through flexible working hours in many offices and by the increase in service employment where many activities are inherently less programmed and part-time employment is more common. Thirdly a number of changes in retail organisation and location, for example out-of-town shopping centres, longer shopping hours, discount warehouses, sunday markets, farm shops, cash dispensers and home freezers all lead to greater freedom of choice for travel and imply a likely increase in variability of travel patterns.

4.4.7 However, traffic flows in individual network links do still tend to exhibit regular and repetitive characteristics. This probably is a function of the statistical nature of events, various constraints or compensatory actions and certain underlying adaptive behaviour such

as "intelligent" route selection by drivers. It is suggested that in reality there exist numerous travel patterns each of which contrive to produce remarkably similar loading to the network. In other words, quite substantial changes in travel pattern may occur without discernable differences in traffic flows. This has important implications for network design. A design which accommodates a particular travel pattern highly efficiently may be less desirable than one which copes with several reasonably likely demand patterns in a satisfactory way.

4.5 CONCLUSIONS

4.5.1 It has become standard academic practice, almost fashionable, to advocate the acquisition of better quality data through improved survey methodology. While this is indisputably advantageous, if the rapid variation in travel patterns and inconsistency of response shown in this limited exercise were generally present, then data quantity as well as quality again become relevant. Guidelines for sample sizes developed in previous years (for example the criteria developed by the U.S. Bureau of Public Roads) may be inappropriate if the variability of travel patterns does increase, as seems likely from social trends.

4.5.2 A distinction has been drawn between the variability of travel patterns but the relative stability of traffic flows. Concentration upon a single OD matrix could be misleading despite the fact that different OD matrices can produce similar traffic loadings. If travel patterns do become less regular, less repeatable and hence less predictable then fundamental re-appraisal of the need for and purpose of travel forecasting will be necessary.

PART II: A COMMENTARY

4.6.1 Since the paper was first written in the Autumn of 1982, a number of papers have been published which have directed attention to various aspects of travel variability. There appears to be an increasing awareness of the importance of this topic. In order to place the first section of this chapter in context, some of these developments in transport planning research are now reviewed. I believe it is possible to identify three inter-related areas where the particular interest in the variability of travel patterns has been aroused.

4.6.2 First a new major focus of attention in transportation planning is the derivation of travel demand matrices from traffic counts. While this can be seen to be closely related to partial matrix methods (Wootton, 1977; Kirby, 1979; Day and Hawkins 1979) which are generally applied at a city-wide scale, the application to finding turning movements at junctions (see for example: Jeffreys and Norman, 1977; Norman, Hoffman and Harding, 1979; Mekky, 1979; Van Zuylen, 1979; Mountain and Westwell, 1983; Maher, 1984) and to the production of Origin/Destination matrices at a 'town-centre' scale for traffic management proposals (e.g. Willis and May, 1981; Van Zuylen and Willumsen, 1980; Willumsen, 1981; Robertson, 1984; Geva, Hauer and Landau, 1983; Maher, 1983; Han and Sullivan, 1983; Gur, 1983) have gained most attention. The attractiveness of such techniques is great as even for small networks origin-destination information is relatively expensive to acquire whereas traffic counts are routinely and cheaply obtained.

4.6.3 In practice the range of possible trip matrices that are consistent with traffic count information is often very large indeed. It is therefore necessary to use additional information in seeking to determine the "most-likely" matrix. The additional or "prior" information may arise from previous surveys, from old transportation studies or, for junctions, from average turning proportions obtained at similar junctions (Surl, 1982). Methods of information-minimising (Van Zuylen, 1979), entropy-maximising (Willumsen, 1981) and Bayesian

statistics (Maher, 1983) have been used to merge old and new data sources. However, the possibility of both measurement errors in the counts and variability in the prior producing uncertainty in the resultant matrix, have only been explicitly dealt with by Maher (1983), employing Bayesian statistical theory.

4.6.4 The crucial importance of variability lies in the application of these "O-D's from counts" models. Bonsall et al (1984) state: "Contemporary transport planning practice emphasises the role of traffic management in fine tuning the network to meet the demands put upon it and in managing demand to match the capacity available." For the "town-centre" scale of application, the matrix produced would be loaded to a variety of different network proposals (e.g. perhaps involving pedestrianisation, bus lanes, one-way streets, linked signals or other junction controls, etc.) and from the loaded link flows a number of measures of operational efficiency, or of economic and environmental consequences could be calculated. In this way the "best" or recommended traffic control strategy could be identified. However, unless the possibility of variability in the trip matrix is considered, wrong judgements could be made. Whilst a particular proposed network may deal very effectively with the predicted matrix, how would it cope with other O-D patterns? While it can be shown that the flows on a network may arise from a wide range of possible O-D matrices, there is no guarantee that a particular network could cope with variability in travel demand without detailed sensitivity testing. For example, Willumsen has recognised the need to consider "the error involved in using the trip matrix estimated for one day as representative for other days or time periods" (Willumsen, 1981).

4.6.5 What price flexibility of a system to deal with wide range of different flow conditions? While the focus of conventional studies has traditionally been peak-hour commuting, many other circumstances place demands on the highway network. These range from known, planned events like sports fixtures, concerts and street markets through likely events such as highway repairs to unknown emergencies likes fires and bomb scares. The advantage of a system capable of dealing with these circumstances has already been recognised (e.g. emergency vehicle

routing in UTC systems; Coventry UTC has a plan to expedite the rapid departure of visiting football fans), but it is one which is very difficult to evaluate.

4.6.6 The inclusion of variability data as a standard output from the Bayesian methods raises some important possibilities. Firstly it provides a routine measure of output "quality", all too frequently lacking in transportation models. Maher states that "...standard errors are extremely desirable information in any estimation process, as without them it is difficult to know how accurate are the point estimates and therefore how they should be interpreted" (Maher, 1984). It has been argued that the absence of such information inevitably credits traffic flow forecasts with a false impression of accuracy (Atkins, 1977, Robbins, 1978). This may affect the interpretation of traffic-volume related impacts compared with less quantifiable factors within the evaluation process. Secondly it also provides a way in which to measure the effects of improved accuracy of data inputs. While the acquisition of better quality data is frequently advocated, the relationship with output quality is still not well understood. Decisions on appropriate data collection quality and quantity (and even appropriate model structure) would be aided considerably. If such variability measures could also take account of the likely variation in traffic routing, currently a fixed input component of these models, then a very powerful tool would result.

4.6.7 The work reported by Bonsall et al (1984) is particularly relevant to that reported in this chapter. As part of a wider study of traffic congestion, the repetition of the occurrence of number plates in the traffic stream on the same stretch of road from day to day was studied. Less repetition was found than anticipated (i.e. greater variability than expected), and one conclusion was that "conventional questionnaires.....underestimate the occurrence of day-do-day variability in trip-making behaviour". Also by "allowing ourselves some licence", Bonsall et al produce the following Figure 4.5.

FIGURE 4.5 NUMBER PLATE REPETITION SURVEY, LEEDS

"If we could trace 100 drivers, observed on a commuter radial between 0815 and 0830 on a given weekday, we would find that, a week later –

30 will drive past the same point between 0815 and 0830

15 " " " " " " " 0715 and 0815

15 " " " " " " " 0830 and 0945

7 " " " " " " before 0715 or after 0945

14 will drive to the same destination by a different route

8 will make the journey by a different mode

5 will travel to a different destination

5 will stay home

1 will have sold his car!"

Source: Bonsall, Jones and Montgomery, 1984

4.6.8 It is possible to compare these results with those obtained in Southampton from Figure 4.2 as shown below:

FIGURE 4.6 TRAVEL BEHAVIOUR VARIABILITY (PERCENTAGES)		
Location Time Lag Sample	Leeds One Week Commuter Radial	Southampton Four Months "regular trips"
Same Behaviour	60%	49%
Different Time	7%	5%
Different Route	14%	7% (bridge)
Different Mode	8%	1%
Different Destination	5%	13%
No Journey/Different Journey	6%	25%

4.6.9 Despite the very small sample size involved for the Southampton survey the correspondence between the sets of results appears plausible (i.e. lesser percentage making the same journey after four months and greater destination changes; mode changes for regular travellers are likely to be less; route switching opportunities less in Southampton location, etc).

4.6.10 A second area of interest in variability arises from a longer-term concern of transport research: the way in which survey method and procedure may introduce bias into data sources. Werner Brog of Socialdata in West Germany is perhaps the best-known researcher on systematic errors arising from survey design as opposed to random errors in responses. His paper with Ampt (Brog and Ampt, 1983) provides a good review of this line of empirical research. One aspect of survey design is the variability of travel behaviour in time. The appropriate length of survey period has been a concern, for example whether "a one-day record of (travel) behaviour constitutes a sufficient data base for theory and model building" (Hanson and Huff, 1982). The same authors ask: "Does the interpersonal variability in travel behaviour present in a large sample adequately replicate the intrapersonal variability in an individual's behaviour over time?" As

indicated earlier in this chapter, social trends have certainly influenced the patterns of travel behaviour towards greater flexibility, and hence the likelihood of greater variability. (See for example Wachs, 1982).

4.6.11 This aspect of seeking a representative sample of travel at one period in time (a cross-sectional survey) contrasts with what I have identified as a third impetus for the study of variability: the dynamics of travel patterns. There the principal focus of attention is the identification of the stimulus which causes a significant change in travel behaviour.

4.6.12 It is perhaps possible to distinguish between a relatively stable pattern of travel for an individual or household, with which small random peturbations or variations in aspects such as departure times, route choices, destination choice for shopping trips, etc. This "regular" pattern may then be disturbed by occasional "life-shock" events such as job change, home location changes, car acquisition and so on. But the pattern is also affected by changes in travel conditions or opportunities which exceed some perceived threshold of acceptability (e.g. congestion delays, fares or petrol price increases). These changes trigger a re-examination of travel patterns and perhaps promote new travel choices. The identification of the way in which travel patterns are, or are not affected, by changes in travel conditions is vital for transport policy appraisal. Time series analysis provides the most efficient means of monitoring such changes and the instigation of panel surveys by a number of authorities (Latchford, 1984; Smart, 1984) is a response to this need.

4.6.13 In practice the distinction between what is or what is not a stable travel pattern is not easy to decide. The more likely condition is one of continual change in response to a wide variety of changes in activities, circumstances and preferences, including, but not exclusively, those affecting travel opportunities. The dynamics of travel demand therefore includes factors such as the influence of lag and habit (Goodwin, 1979), the constraints on travel choice and adaptation to change within households (Jones et al, 1983) and the time

series approach to studying transport policy changes (Layzell, 1983; Goodwin and Layzell, 1985). The dynamics of travel behaviour is one aspect of the research of the Transport Studies Unit at Oxford University and has become a part of the "TSU Approach" (Banister, 1984).

4.6.14 One recent study from that school (Dix, 1985) reports on a re-survey of dwellings with a seven-year interval. It was discovered that almost exactly one half of the dwellings had changed occupancy but that one half of the "incomers" were at a similar "lifecycle stage" to those they replaced. Similarly one half of the dwellings where occupany had not altered had changed lifecycle group (through births, family members leaving home, retirement, etc.). Although based on a small survey the "half-life" of house occupancy of seven years is similar to common belief. The details of travel pattern changes between the surveys was not included in the paper; one could only expect as very small amount of repetition to be present over a seven year time span.

4.6.15 Another example of tenure change is discernable in Chatterjee, Wegman and McAdams (1983). The authors report that in Johnson City, Tennessee, a target sample of 200 was set for a "before" survey. However, six months later: "several persons could not be reached as they had moved from their old residence", resulting in 155 persons being interviewed in the "after" survey.

4.6.16 These studies are not presented as definitive works on the topics of housing tenure or the stability of travel patterns. They are mentioned merely as examples from within the transport literature where variability has been identified as an issue, and which show some support for the Southampton data presented earlier in the chapter.

4.7 CONCLUSIONS

4.7.1 The paper given in the first part of this chapter identified considerable variability in travel patterns reported by household interviews over a period of four months. Despite reservations concerning the particular survey procedures and the small sample size, a sense of unease was expressed about the results.

4.7.2 The subsequent review has shown that the issues raised by that paper are important concerns of several aspects of current transport research. Some correspondence with other empirical data has been shown. Although almost all transport research concerns data variability to some degree, it does seem likely that not just the mean values but the temporal variation of travel patterns in both short and long-term contexts will remain an important issue for some time to come.

CHAPTER 5

WHY VALUE TRAVEL TIME? A CASE AGAINST THE MONETARY VALUATION OF TRAVEL TIME SAVINGS

5.1 INTRODUCTION

5.1.1 Changes, usually savings, in travel time are a major output of most highway schemes. For the purposes of project evaluation these changes must be compared with other impacts, including those to which a definite cost can be allocated. It has been conventional U.K. practice, therefore, to attempt to place a monetary value on travel time savings in order to improve perception of the trade-off implied by an evaluation decision. This paper seeks to present an alternative case, that the valuation of travel time is unnecessary, that it is inconsistent with current evaluation procedures and that in many cases it can even be unhelpful.

5.1.2 Firstly, it is argued that the current U.K. "Framework" approach to highway appraisal accepts that both multi-attribute considerations and the distributional aspects of those impacts are relevant, and that this necessarily implies that "political" values must be used. In this context, the retention of fixed rates of trade-off between travel time and money remains an anachronism. If the valuation of travel time could be easily and uncontroversially accomplished there would, perhaps, be little to gain from abandoning the practice. Secondly, however, it is shown that adequate measurement of appropriate travel time values is extremely difficult from a practical perspective. Thirdly, it is argued that valuation of travel time is undesirable from a philosophical, even moral, standpoint. In concluding it is suggested that by obscuring the distinction between political and technical matters, travel time valuation may bring professionalism into disrepute.

5.2 HIGHWAY APPRAISAL PROCEDURES

5.2.1 The development of the procedures for assessment of U.K. highway schemes has taken place in the context of cost-benefit analysis. Cost-benefit analysis in its purest form takes into account all consequences of a scheme and relates them by the single comparator of money. It is not surprising, therefore, that in the 1960's and early 1970's, the target of the emerging discipline of environmental assessment was the successive identification, quantification and valuation of the various impacts related to highway development (Lassiere, 1976).

5.2.2 This approach, however, has had only limited success. While procedures have been adopted for the prediction of noise levels, and some approach made to quantifying aspects of severance and visual obstruction, many of the so-called intangible effects remain unquantifiable. These clearly cannot take their place within a comprehensive cost-benefit appraisal to be directly compared with more soundly-based economic values such as engineering estimates of construction costs or the resource cost of vehicle operation. Thus it became obvious that any evaluation process could not, and indeed probably should not proceed by reference to a single criterion.

5.2.3 The adoption of the framework-based assessment procedures (Department of Transport, 1979) recognised the need to incorporate the "intangible" factors explicitly within highway appraisals, quantifying where possible and providing qualitative statements elsewhere. In emphasising the distributional aspects of costs and benefits through considering groups of affected parties, the procedures are now much more akin to a planning balance sheet than a cost-benefit analysis. Yet the inheritance of valuation remains strong and the economic component provided by COBA remains a core feature, emphasised by its appearance at both the beginning and the end of the framework layout. Given, however, the acceptance of a multi-attribute approach to appraisal, a case really needs to be made to justify why just two of the non-cost

aspects of highway effects, travel time and accidents, both of which are extremely difficult to value, alone remain expressed in monetary terms.

5.2.4 In past years it was often the case that travel time savings and construction cost were the dominating factors in the assessment process, and hence the definition of a specific rate of trade-off between these two aspects may have been useful. However, the emphasis of much of the road construction programme is now on environmental issues with small town by-passes being given increasing priority (Department of Transport, 1983a). For many of these schemes, the economic appraisal may be of secondary importance and in some cases the NPV (net present value) may well be negative. It should be more widely appreciated that there is nothing unacceptable about such results.

5.2.5 In order to arbitrate between competing projects it is now necessary to consider not just the single trade-off of travel time against money but also travel time against noise and travel time against severance and severance against visual intrusion and, indeed, comparisons between all possible combinations of factors. Simultaneously, it is also necessary to balance the relative merits of the competing claims of various interest groups affected by the proposals. The impact of, say, a noise increase on one group of people must be judged against reduced visual intrusion for another group. In general the concerns of a particular group of people will span several different impact factors leading to a very complex set of inter-relationships. Thus, it is necessary to consider who is impacted, how and to what degree they are affected, whether any loss would be compensated and, considering their current position in society whether any further burden would be appropriate. Indeed considerations of distributional issues would now seem to be required by law, at least between ratepayers and public transport passengers (House of Lords, 1982). In no way could it be claimed that this is a technical or engineering problem. It clearly involves value judgements and must lie, in our democratic system, within the province of the politicians. Why then should two and only two of these inter-factor trade-offs have

fixed parity rates of comparison, effectively denying value judgements to be made on these relationships when taking into account specific local circumstances?

5.2.6 For many projects the components of time savings are substantially different between, say, residents and visitors, through and local traffic or one location and another. Fixed parities declares that these issues are not negotiable but yet, in practice, one knows that such issues do affect political decisions. While some steps have been taken to isolate travel time savings (they are now presented separately from vehicle operating costs and by each vehicle type, in contrast to previous practice), by placing a monetary value on this factor it is firmly allocated to the economic analysis and quite possibly subsumed within it. In some cases this may have the effect of concealing relevant detail if the overall end product of the economic component of assessment (NPV) is simply contrasted with the environmental effects which may constitute the majority of the framework.

5.2.7 For example, at a recent inquiry in Southampton just two pages out of fourteen of the Appraisal Framework (Department of Transport and Mott, Hay and Anderson, 1982) concerned the economic analysis. Certainly such environmental issues often dominate the debate on the merits of a project with little attention being given specifically to travel time savings. Yet detailed examinaton of the economic appraisal is often revealing. For example in one scheme, 53% of the net benefits (122% of the NPV) arose from just two junctions (Department of Transport, 1981b). This sensitivity did not emerge at the public inquiry.

5.2.8 To a certain extent accident savings are already freed from the strait-jacket of fixed parity with money. In the framework presentation the expected number of casualty reductions is given in addition to their monetary value. To the ordinary member of the public this surely represents double counting as the casualty numbers exert a powerful influence on public perception over and above that supposedly

fully represented by their economic value. Much play is made by both media and politicians to exploit this emotive issue which can work either for or against a project development.

5.2.9 As an example of this, at a public inquiry in Portsmouth objectors suggested that a scheme showed an NPV loss of £5.3 million and the inspector's findings of fact stated that "this was not substantially challenged" by the proponents (Departments of the Environment and Transport, 1980). The inspector's recommendation against the proposal was overturned by the Secretary of State, however, principally on the grounds that "action should be taken as quickly as possible to ..... avoid further accidents and loss of life" (Departments of the Environment and Transport, 1981). Effectively the Secretary of State was placing a much greater value on accident savings than the standard D.Tp. values which had been used in the cost-benefit appraisal. He was also implicitly expressing interest group weightings, for example, in favour of those living close to the alternative route and against tax and rate payers who would be paying well above the "normal" rate for safety improvements.

5.2.10 Transport planning is inherently political, it concerns the allocation of scarce resources to locations, problems and people, it materially affects their welfare and is inevitably subject to conflicting views. Society has established procedures by which such conflicts are decided. It is not the job of transport professionals to substitute their own values for those of the elected representatives. The political nature of the values of travel time and accidents is perhaps best demonstrated by two interventions made into the valuation process. Firstly the pain, grief and suffering component of accident costs was arbitrarily and substantially increased following recommendations of the Advisory Committee on Trunk Road Assessment (ACTRA) (see Department of Transport, 1980). Secondly, non-working travel time values are rated as equal regardless of journey mode, personal income or locational factors, again for political reasons and, in this case, despite the advice of ACTRA (Department of Transport, 1978).

5.2.11 The valuation of travel time and accidents, including consideration of distributional aspects, is clearly based on political judgement. Why should these be enshrined in a supposedly technical process which claims to be neutral and independent? Given the flexibility of treatment which exists for virtually every other parameter, the adherence of travel time to a fixed value remains a peculiar exception.

5.3 MEASURING THE VALUE OF TRAVEL TIME SAVINGS

5.3.1 Despite all that has been said above, if travel time could be valued easily and uncontroversially, with similar authority to, say, vehicle operating costs, then there would be little merit in its deletion from the appraisal process. This is far from being true, however.

5.3.2 Currently, the U.K. Department of Transport's values of travel time are considered in two categories: working and non-working time. Working time is valued at the rate at which an employer would be willing to buy a worker's time, that is the cost of wages plus overheads. Non-working time, including commuting journeys to and from the workplace, is in principle valued on the basis of "willingness-to-pay"; seeing what values are reflected in consumer choices which trade-off travel time and money. In practice this has been estimated at 25% of the working time value on the collected, but somewhat inconsistent evidence from a number of studies which investigated that issue (Department of Transport, 1981a). As already mentioned a single average value for non-working time is used regardless of where or to whom such time savings accrue; the "equity value" of time savings. It is estimated that just 15% of vehicle usage relates to working time journeys and 85% to non-working.

5.3.3 It is obvious that the willingness-to-pay for travel time savings is dependent upon both the nature of the individual traveller and the circumstances under which the time is experienced. One would expect greater willingness-to-pay from those with more resources, and household income has commonly been used to assess this factor.

Similarly the pleasantness of journey conditions incorporating comfort, convenience, safety, the effort or stress involved in driving, the availability of in-vehicle entertainment, privacy or companionship, freedom to or from smoke and the opportunity to study or work all affect the rate at which someone might be prepared to pay to reduce travel time. The length of time saved may also affect its value. Appraisals are often highly sensitive to the value applied to small, possibly unperceived, time savings. Ideally travel time values should reflect all these characteristics; practically a wide range of travel conditions must be examined both for reasons of application and to avoid substantial bias. What is required, therefore, are situations in which travellers, across a comprehensive range of circumstances, make choices which reflect their preferences between travel time and money. Unfortunately, however, appropriate situations are not easily found.

5.3.4 EMPIRICAL STUDIES OF TRAVEL TIME VALUES

The situations from which travel time values might be obtained, in principle at least, include route choice, mode choice, destination choice, choice of driving speed and home location choice. Extensive reviews of the literature on this subject are given by Hensher (1978) and Bruzelius (1979) to which the reader is referred for more detail. In practical terms mode choice and route choice seem the most promising approaches. However, before any particular situation can be used, certain basic conditions must be fulfilled. Harrison (1974) has specified nine conditions for valuation of travel attributes which can be summarized as follows:

1. The choices concerned must be real ones.

2. Where choices exist, they must be fully perceived and there must be grounds for believing that individuals are aware of the alternatives available.

3. The effects of all variables thought likely to affect choices must be explicitly considered.

4. There must be perceptible differences between alternatives.

5. The variables considered relevant must not be too closely correlated.

6. The variables affecting choice must show a fair amount of variation in the sample.

7. The sample under consideration must be assumed similar with respect to factors not included explicitly in the analysis.

8. The sample analysed must show a reasonable proportion choosing each of the relevant options.

9. The number of choices explained by the analysis must be high.

Careful examination of these requirements shows that situations providing these conditions are likely to be extremely rare. Some of the difficulties for mode and route choice studies are now considered.

5.3.5 MODE CHOICE

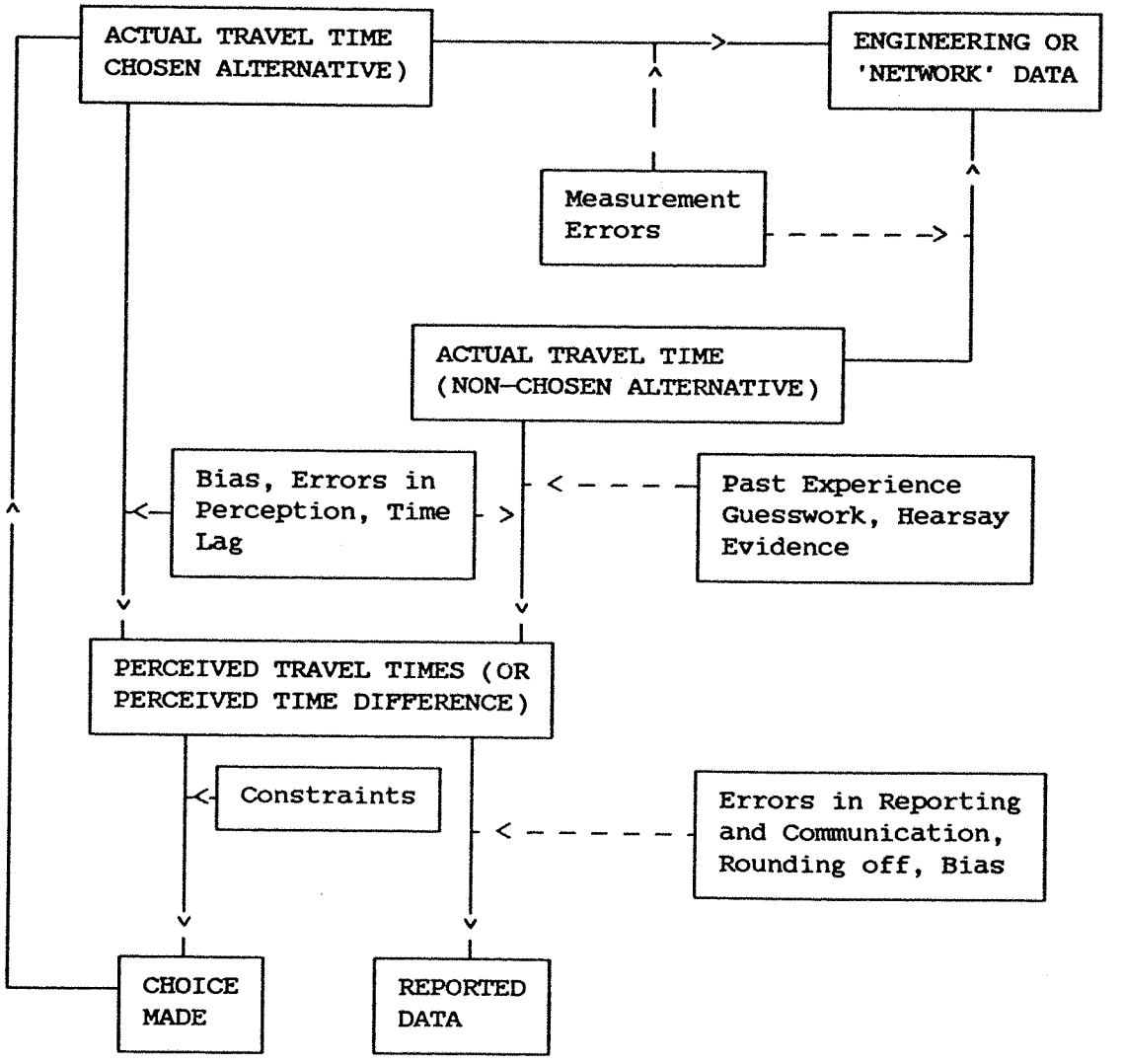
Mode choice has been used most frequently but is prone to a number of difficulties, often overlooked or ignored in past studies, which can lead to serious methodological errors. The most fundamental is that many persons presumed to be making a choice of mode often have no real choice. (Harrison, Condition 1), they are constrained by other factors (e.g. use of car by another family member, public transport does not operate at required times). Reporting studies in Germany by Brog, Heggie (1983) suggests that as few as 10% of travellers could be regarded as genuine "choosers", the majority being captive to their usual mode. Inferring values of time from non-existent choices is clearly dangerous as responses may merely be characterising the difficulty of the use of the alternative mode.

5.3.6 Associated problems lie with the degree and quality of knowledge of the traveller about alternatives (Harrison, Condition 2). At a fundamental level awareness of the existence of alternative modes cannot be assumed. Furthermore, in many cases individuals may be aware of an alternative but possess insufficient knowledge about its characteristics for it to be a realistic option. Often the feasibility of an alternative mode for a particular journey cannot be known unless and until the journey has actually been made by that mode, perhaps on a number of occasions. Use of an alternative mode may be tolerable for a limited number of occasions although the same choice may be unacceptable on a regular basis, particularly if it involved other compensatory impacts on household routine. Certainly, aspects such as reliability and frequency of overcrowding could not be known without direct experience.

5.3.7 In deriving values of travel time savings, the attributes of the modes (which form the basis of the choice under consideration) cannot be derived from objectively measured engineering values, but must be obtained from those values which truly influence the traveller's choice. These "perceived" values clearly differ from the ones actually experienced or presumed to be available due to misperception or lack of information. Additionally, however, the attribute levels of alternatives as reported by individuals may not reflect these perceived values. Misrepresentation in reporting occurs by rounding, by attempts to justify a choice or exaggerate the advantage of the chosen mode, or even by replies given to comply with the answers which the respondent believes the interviewer to be seeking.

5.3.8 These difficulties of awareness, perception and reporting are illustrated in Figure 5.1 and are discussed by a number of authors (see for example Hensher, 1978; Harrison, 1974; Gunn, Mackie and Ortuzar, 1980). Collectively, these problems are such that Heggie (1983) concludes that "the value of travel time savings estimated from revealed preferences for mode choice (using subjective data) is highly suspect".

FIGURE 5.1 PROBLEMS IN PERCEPTION, MEASUREMENT AND REPORTING



(Illustrated here for travel time but applicable to other journey attributes)

Source: Adapted from Gunn, Mackie and Ortuzar (1980)

5.3.9 Even if such problems could be overcome (and Heggie implies they cannot) the process of valuation is still complicated by the very many factors affecting mode choice as mentioned earlier. People are not choosing between modes solely on the basis of time and cost factors, but by reference to a complete package of characteristics including items such as reliability, convenience, comfort and safety. Many of these factors are unmeasurable and several even have no obvious direction of advantage (e.g. privacy/company). These problems make the calibration of an appropriate multivariate modal choice model, with all the attendant requirements for data consistency and statistical validity appear to be very difficult indeed. It is interesting to note that confidence intervals for the value of travel time from empirical studies, if reported at all, are often very large. Broom et al (1983) suggest that their values of 95% confidence intervals of $\pm$ 56% are not unusual (see also Chapter 3).

5.3.10 ROUTE CHOICE

In normal circumstances the travel times and costs by different routes would be highly correlated, thus invalidating this approach under Harrison's Condition 5. The presence of a toll facility, however, should overcome this problem but even then other problems may arise as Harrison points out. Most U.K. toll facilities are at locations such as estuarial crossings where the choice between a short, direct, high standard facility and a lengthy detour often on lower standard highways may involve more than just time and money considerations (Harrison Conditions 3 and 7). Additionally many users are faced with virtually the same choice, precluding study of a wide range of trade-offs as required under Harrison's Condition 6. Indeed, these problems led to a recommendation that the Humber Bridge would not be an appropriate location for a value of time study using route choice (Gunn, Mackie and Ortuzar, 1980). The author's own study involving Southampton's Itchen Toll bridge (see Chapter 3) does appear to meet all Harrison's criteria, but can examine only one mode, car users, in a restricted location and with a fairly low maximum time saving. Whether these values are appropriate in other circumstances remains open to doubt.

5.3.11 STATED INTENTION AND TRANSFER PRICE

As an alternative to studying existing behaviour (the revealed preference approach) it is also possible to use the stated intentions of respondents to potential changes of circumstance to derive travel time values. In particular, the transfer price method which seeks to measure the value of changes in travel attributes has recently been tested (see Chapter 3 for further details). While this method has some attractions, including a much wider range of potentially useful locations where it could be applied, it suffers from the obvious drawback that people often do not do in practice what they say they will do in answer to surveys. Even if it were possible to "calibrate" for bias it seems unlikely that this approach can command sufficient confidence for the widespread application of any values it may produce. In particular it seems doubtful that any true measure of "willingness-to-pay" can be found by reference to the uncommitted responses to hypothetical questions which may be treated merely like a game (again see Chapter 3 for further discussion).

5.3.12 In concluding this section on measurement, therefore, it seems that while it may be possible in certain specific circumstances to estimate how much people are willing to pay to save travel time, in general it is extremely difficult, if not impossible, to do so reliably for an appropriate and comprehensive range of both individuals and travel circumstances.

5.4 VALUING TRAVEL TIME IS WRONG

5.4.1 Having made a case that valuation of travel time is unnecessary and shown that the measurement of that value is extremely difficult, the third major line of argument is that valuing travel time is wrong on philosophical or even moral grounds.

5.4.2 The first part of this argument is probably familiar, this is that the valuation of one person's time at a higher rate than another is fundamentally iniquitous. By use of willingness-to-pay as a criterion all that is really expressed is ability to pay, thus giving

greater emphasis to the desires and preferences of those with greater resources. Time, however, is a fundamentally different dimension from money. It cannot be stored and indeed is one of the few attributes that everyone possesses in equal quantities (at least to the extent that everyone has 24 hours per day, even if lifespans are different). It seems unfair that those already well endowed should be able to exert extra influence on transport provision as well. Perhaps the most outstanding current injustice is the valuation of a pedestrian's time at zero.

5.4.3 The usual counter-argument is that transport is an inappropriate or inefficient tool for implementing social policy (see, for example, Buchanan and Lewis, 1981), but distributional aspects are inherently and inextricably involved with any public policy and it is unrealistic to think that they can ever be disregarded.

5.4.4 If travel time values were equalised for all individuals then clearly this would go some way towards negating the above criticism. However, this immediately brings into focus whether it is worthwhile placing value on travel time savings at all; why measure in pounds rather than traveller-minutes? In placing a monetary value on travel time savings the aim is to assist the decision-maker in assessing society's collective preference for time against money. There are two neglected assumptions implicit in this process. Firstly preferences are assumed to be demonstrated by travel choice behaviour (or by some stated intent of that choice). Secondly society's value is assumed to be the sum of individual preferences. Neither of these assumptions is necessarily correct.

5.4.5 Many persons vote for politicians or parties in the full knowledge that they may be materially less well off as a result. This is because they place emphasis on other policies, usually involving matters of principle such as law and order, defence, the welfare state or education. Despite that, these people still behave in the short term as conventional economic utility maximisers. Thus inferring preferences from behaviour (or stated intention methods) is not necessarily correct. Behaviour is conditioned by the available choices

which may not in practice include the individual's preferred option. It is logically consistent for an individual to choose in current circumstances to adopt a particular course of action, but yet to prefer and even advocate structural changes which would alter those circumstances against their current choice. The absence of real choice contravenes Harrison's first condition and renders invalid any implication of "value" from observed behaviour. Secondly, it cannot be held that the preferences of society are the same as the sum of individual preferences (see Wiggins, 1981 for a longer discussion). This is illustrated by the presence of externalities; social costs not paid for by the individual consumer. For example, many authors have shown it to be in the best interest of society as a whole to restrain the amount of traffic using congested urban streets, although for individual drivers who use those streets their choice represents their own best course of action.

5.4.6 Such arguments are familiar in the context of transport policy (Independent Commission on Transport, 1974). For example, it is often held that the widespread use of cars is evidence that "society has chosen" the car in absolute terms as preferable to public transport. Yet not only does the decision of an individual to own and use a car have little influence on the availability of public transport services or the level to traffic flow passing his or her place of residence (the individual/collective dilemma) but also the preferred option of perhaps better public transport services and less environmental disbenefits is simply not available (the behaviour/preference fallacy).

5.4.7 What other advantages might there be in specifying a monetary value for travel time savings? A complete and true cost benefit analysis where all impacts are expressed in money terms would have two principal applications. First it could be used to determine an appropriate level of expenditure. Secondly, it could be used to rank schemes from different parts of the country and even from different sectors of transport. As already pointed out in Section 5.2, however, the introduction of non-monetary factors makes these applications dependent upon political judgement and values. Even if that were not

so, it seems unlikely that Cost Benefit Analysis would in practice be used in these idealistic ways. First the availability of funds is usually externally determined, often apparently, independent of consideration of needs. Secondly the extent to which such comparative analysis determines allocation of those resources also seems very small. Given the spatial nature of political representation, the geographical fairness of distribution of funds is often more important than the particular "economic" merits of different schemes. Other reasons can usually be found to advance one project within a priority list. This should not imply that such decisions are wrong, clearly geographic equity could be a legitimate criterion to adopt. Comparability between appraisals in different sectors of transport has been advocated (eg. Goodwin, 1982) and even given formal recognition (Department of Transport, 1982), but appears now to have been allowed to disappear. Therefore, there seems little to be gained in measuring travel time savings in money rather than in time units.

5.4.8 Fundamentally, evaluation is concerned with helping to decide what we, as a society, should or should not do. In seeking to value travel time, we should therefore be aiming to express society's preferences, in this case between travel time and money. However, given that society's preferences are not necessarily the summation of individual preferences; that individual preferences cannot always be shown through behaviour and that use of willingness-to-pay exerts considerable distortions, current methods seem inappropriate.

5.5 CONCLUSIONS

5.5.1 It is concluded, therefore, that the monetary valuation of travel time is unnecessary, difficult and fundamentally undesirable.

5.5.2 The views contained in this Chapter are not inconsistent with quantification of travel time gains and losses, but simply suggest that in attempting to place a monetary value on a factor that is essentially "un-valuable" decision-makers may be misled rather than assisted. It is suggested, therefore, that travel time savings (and losses) should be separately identified in vehicle or person-minutes, and included in

the appraisal framework for the relevant impacted group. It would also be advantageous to the decision-maker to consider other distributional groups as well as vehicle type; for example the distribution of travel time savings between local and through traffic or by geographic location may well be of interest. Clearly the benefits quantified in monetary terms would often be substantially reduced, possibly leading to negative Net Present Values. However, this would merely serve to clarify and not conceal these issues and would strengthen the overall appraisal process by improving understanding.

5.5.3 Overwhelmingly, this Chapter has emphasised that the valuation of travel time is a political decision, not a technical one, a point perhaps best illustrated by the arbitrary changes in valuation referred to in Section 5.2. Appraisal methods are subservient to the political process of decision-making. There are dangers in presenting political policies in the guise of technical facts. Not least is the general discrediting of professional standards when some can be shown to be based on political assumptions, thus diminishing the independence and neutrality of professional staff.

5.5.4 The ACTRA (Leitch) Report (Department of Transport, 1978) was notable for the widespread approval its publication received. Pressure groups, practitioners, politicians and the press all generally gave it a favourable reception, a considerable achievement if one recalls the acrimony and even civil disturbance at certain motorway inquiries which preceded its genesis. It dealt with a subject of public concern and political controversy to the satisfaction of almost all. The major reason for this public relations success, I suggest, was not connected to the undoubted quality of the product, but because it successfully de-politicised the controversy by re-establishing professional boundaries. The inherent conflicts of interest which arise in transport planning were firmly placed in the political arena and not confused with the technical process of simply estimating the likely changes resulting from any scheme. Valuation was (largely) separated from measurement. One further de-politicisation would be to remove the valuation of travel time from that technical process.

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