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THE EFFECT OF THE FREQUENCY AND TIMING OF SECONDARY RAIL SERVICES ON DEMAND

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ABSTRACT

This piece of research looks at the effects on demand resulting from changes in the frequency and timing of secondary rail services. Firstly general information on desired travel times is analysed. Then the results of a market research survey are compared to the predictions of the model currently used by British Rail on InterCity services to see if the latter accurately predicts the changes in the different environment of the secondary railway.

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APPENDICES (AVAILABLE SEPARATELY)

I Pilot Questionnaires
II Questionnaires used in Main Survey
III Final Questionnare Developed
IV Maps of Survey Villages
V Desired Arrivals and Departures (Non-Rail)
VI Current and Improved Timetables
VII T.Calc and Doubler Programmes
VIII Rooftops Computer Programme & Output
IX Detailed Results from rooftops Model

FIGURES

CHAPTER ONE - INTRODUCTION

1.1 THE PROBLEM

The main issues addressed by this thesis are the timing and frequency of secondary rail services. The main area investigated is the impact of the timing and frequency on the number of passengers carried by the service.

The timing and frequency of a service will affect the perceived quality of the service, the number of passengers carried and thus the amount of revenue attracted to a service. The nature of the timetable therefore partly determines the size of any profit (or more usually loss) made by a railway. Relatively little research has been done in this area especially with respect to railways; when one looks at the infrequent secondary services information becomes almost non-existent. It is possible that some models for other public transport could be used on the railway, but models for low frequency services are also scarce for other modes.

The lack of evidence on low frequency services causes British Rail to suggest that for services with more than a train every three hours their standard service quality model (which has been designed for more frequent inter-city services) should be used to estimate responses to service changes. If the service is less frequent than a train every three hours no model is available. It is thus clear that the forecasting tools available to the managers of low frequency secondary lines may be suspect, if a model is available at all.

When the number of trains per day is low and there is a limited potential market available to the railway, it is critical that the trains that are run should run at the times people desire to achieve maximum loadings. In some instances the current timetable on secondary routes appears to be more a product of historical patterns (the train always left at 10.15) than any rigorous analysis. Trains appear to be withdrawn if they do not load well, when by re-timing the service, patronage may be significantly increased. A means of establishing desired travel times by rail and predicting responses when the timetable comes close to these, is therefore important to help maximise revenue on secondary services thus postponing, or even cancelling closure. This should leave rural areas with a more effective public transport system at a lower cost.

1.2 THE STUDY ENVIRONMENT

This study was carried out in the villages of Lidlington (Bedfordshire), Yetminster and Maiden Newton (Dorset). The main questionnaire used in the survey was developed in Lidlington, with the full-scale survey being done in the Dorset villages. The full-scale survey was carried out on a fairly typical rural line with trains running every two hours. For each of the villages chosen the main town associated with each village was selected and rail trips were studied to and from that town.

1.3 OBJECTIVES OF THE STUDY

The objectives of the study were to investigate people's reactions to the timing and frequency of secondary rail services, in particular to:

(1) Develop a market research based model which could estimate the extent of additional traffic resulting from an improvement in the timetable.

(2) Investigate people's desired travel times and thus their preferred duration at the destination for each activity.

(3) Investigate current rail passengers' reactions to adverse changes in the timing of train services.

(4) Measure the time-sensitivity of people when planning trips that may be made by rail for work and non-work trips

(5) Test the relationship between personal characteristics and the reaction to an improvement in local rail services. It may be possible to reject the null hypothesis of no relationship between personal characteristics and the reaction to an improvement to local rail services.

(6) Gauge people's feelings towards the frequency and timing of current services as a deterrent to rail travel. This measurement will be done for each of two villages, one having a slightly better service than the other. The hypothesis that there is no difference between the feelings of the two communities, will be tested.

(7) Compare the results of the market research based model with those of the British Rail 'Rooftops' model currently used in the prediction of flows on more frequent services. The comparison will be carried out for a series of timetables each having different characteristics to test various aspects of the model. The testing should allow some statement to be made about the use of the BR model on secondary services. It is suspected that a null hypothesis, that there is no difference between the results of the two models, will be disproved.

1.4 THE APPROACH

The study was based on the results of questionnaires. The main questionnaire was designed (after extensive piloting) to establish the times people would be prepared to make extra journeys by train to the relevant destination. This questionnaire also estimated that person's sensitivity to the train times so that it could be established whether a trip would be made or not.

A more general questionnaire was designed to establish the desired travel times of a group of people for a week.

FIGURE 1.1 General approach:

DESIGN OF METHODOLOGY AND QUESTIONNAIRES

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EXECUTION OF SURVEYS

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PRODUCTION OF GENERAL RESULTS ON DESIRED TRAVEL TIMES

↓

DESIGN A SERIES OF IMPROVED TIMETABLES

↓

INPUT DATA INTO ROOFTOPS AND ALTERNATIVE MODEL

↓

PERFORM STATISTICAL ANALYSIS AND SENSITIVITY TESTS

↓

COMMENT ON THE DIFFERENCES BETWEEN PREDICTIONS

Some on-train interviews were undertaken to look at current passengers' time-sensitivity.

A number of computer programmes were written. The first programme used information supplied by BR to replicate the output of their predictive model. A second group of programmes were written to deal with the responses from the questionnaires. The latter programmes simulate the decisions of each respondent, who stated an extra trip, so that it can be decided how many additional trips would result from any timetable improvement.

1.5 STRUCTURE OF THE THESIS

The thesis is divided into six chapters, their contents are as follows:

This chapter (Chapter 1) provides the introduction to the research, stating the problem and objectives.

Chapter 2 looks at the background to the study in more detail and why the frequency and timing of services are so important on secondary rail lines.

Chapter 3 contains the methodology of the study and looks at the concepts involved in the behavioural model used to produce estimates of the responses to timetable enhancements.

Chapter 4 looks at data collection and the design of the questionnaire. This describes the complex evolution of a questionnaire that was capable of eliciting the times that people would be likely to make additional trips by train if the timetable was improved.

Chapter 5 contains the analysis of the results where significance tests are used to test for relationships.

Chapter 6 brings together the findings of the research producing conclusions, their implications and recommendations for further work.

CHAPTER TWO - BACKGROUND TO THE STUDY

2.1 INTRODUCTION

This chapter describes the context of the problem. It illustrates the problem in the wider view and the reasons for studying it. An account is also given of the research that has been done previously in this area.

2.2 THE RURAL PUBLIC TRANSPORT PROBLEM

Providing rural public transport has always been a problem. In earlier days when even the remotest areas were served by railways it was doubtful whether much of the system made any profit. Perhaps the fundamental problem is that the demand for rural transport is low and the population is widely dispersed, with people wishing to visit the larger concentrated centers. This reduces the viability of public transport operation as conventional forms, especially rail, are just not flexible enough.

Overall, the level of transport available in rural areas has never been as good as it is now because the private car has had a liberating effect on most of the community. But for those without cars mobility is restricted, and in some cases no public transport is available at all. The people in the community who are affected by this tend to be concentrated in three groups: the old, children, and housewives, who are left without the family car when the husband goes to work. These groups are in many ways those who can least afford to be isolated and this must detract from their enjoyment of rural life.

These problems have been exacerbated in recent years by a number of trends:

(1) Continued growth in car ownership has reduced the already limited custom for public transport.

(2) A rise in the real cost of rural service provision has meant that fewer rural settlements now have facilities such as post offices and shops; these services being concentrated in larger villages and towns.

(3) The trend of rural de-population has continued in many of the least accessible areas further reducing demand for public transport.

(4) An ageing population and greater traffic hazards mean that walking and cycling can no longer play as large a part as in the past.

Such problems mean that it has long been recognized that public transport has to be subsidised to some degree. However, experience has shown that without careful management these costs can escalate to a point where the service is cut back or withdrawn completely.

2.3 THE RURAL RAIL PROBLEM

British Rail inherited a mass of often competing rural rail routes upon nationalisation and so its secondary railways are a good example of rural transport problems.

Railways formed the first large scale public transport system in rural areas and began to lose traffic in the 1930s with the development of bus services. From the late 1950s onwards the private car began to have an impact and the network became very un-profitable. Although some attempts were made to rationalise the network, it was not until Beeching's report in 1963 that any real progress was made. The report stated that in 1961 one half of the network carried only 4-5% of total traffic and that the railway had become almost insignificant in rural areas.

When the report's recommendations were implemented, the rail network shrank from 20,237 miles in 1963, to 15,242 miles by 1968. Before the report had its full effect the 1968 Transport Act began to question its implementation. The social consequences of rail closures were now also to be looked at. As a result, some lines and services scheduled for closure under the Report have survived, notably those in the Scottish Highlands.

The size of the continuing financial support for these routes means that there are many people who believe that secondary railways should be closed. Since railway management was divided into sectors, in 1982, secondary railways have been operated by British Rail's Provincial sector. The Provincial sector is itself divided and the lines considered by this report are generally classified as 'Other Provincial Services'. Rural railways are currently supported by the PSO (Public Service Obligation) grant in return for which BR are asked to run a service comparable to that of 1975.

Local authorities can, and have, topped up the PSO grant to enable BR to run additional services on a marginal cost basis. The service pattern influences the size of the running costs as well as the number of passengers and hence revenue. The objective is to increase services as long as the addition to revenue (or benefits) is greater than the increase in the cost of doing so.

In recent years great efforts have been made to reduce the losses on the whole group of secondary railways as the Government has been steadily reducing the PSO grant. Although strenuously denied by the Government, if this section of the railway is not kept within a reasonable range of losses, closures will probably take place.

Provincial is currently investing heavily in new trains and the modernisation of its lines thus offering the possibility of changing service patterns. These new trains are said to improve the passenger environment and are cheaper to operate. But there have been problems with the spacing and number of windows and the ridged wheelbase of the smaller units has resulted in the wheel flanges squealing on corners and thus causing wear on the track and wheels. The sector has benefited from the de-regulation of buses with patronage improving in many areas because of confusion surrounding the new bus services.

To illustrate the scale of the problem the following figures are taken from the British Rail Board's 1985/6 Annual Report. Provincial's losses in 1985/6 were 04.4 million, the previous year this was 61 million. Gross income in 1985/6 was 08.6 million down from 30 million the previous year. Provincial accounts for 58% of BR's stations, 34% of BR train miles and 53% of route miles illustrating the relatively low intensity of the use of its track. It must be noted that these figures include Passenger Transport Executive services which are also part of Provincial - if urban services are removed the figures are lower. In 1982 Provincial was loosing 17.9 pence per passenger mile (Kilvington) and only one percent of 'Other Provincial Services' was covering its direct operating costs.

The basic problem with rural railways is the large infrastructure overhead, typically accounting for 40-50% of costs. With rural services there are fewer passengers to contribute towards these fixed costs than there are on busier routes and so the service makes a loss. The low potential level of demand is reduced further by the poor service and thus high generalised cost associated with it discouraging travel.

Bus replacement of rail services is often suggested, but it has rarely been successful. Some argue that problems with alternative bus services were more the result of poor organisation than the idea itself and that this should be tried again (eg: Serpell 1983). Others argue that people just do not like buses. Even so, examples of alternative bus services at 1/8 the cost of current rail services are still quoted, though many of them assume the same number of passengers will use the alternative bus/coach service, from experience it is likely to fall substantially even though journey times may be matched or slightly reduced.

If secondary rail services are to continue it is important that they be made more cost effective. It is possible to dramatically improve the position of rural railways but money needs to be put into cost saving investment. In some cases the replacement of existing locomotive hauled stock by new smaller trains has meant that a more frequent service can be offered as more vehicles are available and the rolling stock is therefore more flexible.

2.4 MAIN SURVEY AREA - THE DORCHESTER-YEOVIL LINE

Under the recommendations of the Beeching report the Dorchester-Yeovil line was not scheduled for closure although all the stations along it, except for Yeovil Pen Mill, were. When the time came for closure to be carried out it was realised that the proposals were just not practical. A number of stations were reprieved. Dorchester West was saved as it generated a large proportion of the traffic on this part of the line and is the county town. Maiden Newton was saved as it was at the junction with a line to Bridport, which was kept open as it was not possible to provide an adequate replacement bus service. Yetminster too could not be served adequately by a replacement bus service.

The line is currently divided between the Western and Southern regions at Dorchester. The only traffic that remains is a local passenger service and a few summer excursion trains. It is expected that unless there are cuts in British Rail's grant or other unforeseen problems the line will be safe into the 1990s.

The Dorchester-Yeovil line has a two-hourly service calling at most stations, though a recent trend has been to reduce the number of stops at intermediate stations - Yetminster has been a victim of this policy. The trains used on this service are usually Diesel Multiple Units (DMUs) of the modernisation plan (1955-65) era. It is expected that the line will be modernised shortly which offers the opportunity to re-assess the timetable.

Competition for the line comes mainly from a subsidised bus service run by Pearce, Darch and Wilcox. This service runs from Dorchester-Yeovil and includes stops at Maiden Newton and Yetminster which are also served by the railway.

2.5 THE FREQUENCY AND TIMING ISSUES

Generally frequency has an effect on the perceived cost of travelling by public transport for an individual. The frequency and timing of a service will affect whether the individual can travel at the time he wants. The greater the deviation from this ideal travel time the less likely the individual is to use public transport. One of the main advantages of the car is that frequency is in fact infinite - the owner can go where he likes when he likes.

The influence of a change in frequency will be dependent on the current level of service. If the service is very frequent - eg, every five minutes - passengers will just arrive at the stop on the off-chance and wait for a vehicle. As the frequency of a service declines passengers are expected to plan their trips so that they arrive, say, five minutes early for the vehicle they wish to catch. With a frequent service the inconvenience felt by the passenger is pure waiting time as the passenger has to wait at the terminal, often in unpleasant surroundings. With an infrequent service passengers may only spend five minutes waiting at the stop, the rest of the 'adjustment time' from their desired time of travel can be spent pursuing some other activity. Although adjustment time involves a second best activity it is likely to be more attractive than waiting at a terminal for a vehicle.

This study deals with infrequent services and so the conventional model of passengers waiting for a vehicle is not realistic - passengers plan their journeys before they depart. Once a service become so infrequent that passengers no longer just arrive at the terminal at random, the timing element of the service comes into play. A potential passenger may decide that he wants to go shopping and will look at the timetable to see if a vehicle leaves at an appropriate time. If the service is very infrequent the passenger will look to see if there is a return vehicle at an acceptable time. If the times are unsuitable the trip will be made using another mode, to another destination, postponed, or not made at all. This situation represents the marginal passengers who may use public transport if the service is 'good enough'. There are, of course, many other passengers who just would not consider using the public transport whatever the frequency, perhaps because they have a car or the fares are considered too high.

Although it may appear sensible to time services exactly when desired by the majority of the population this can cause problems. Firstly, resources may not be available, for example, on a single track railway with few passing loops there is a limit to the number of trains that can be run in any period. There will also be a limited number of vehicles available to run a service. It is sometimes considered worthwhile running a service at a constant interval, eg, every hour on the hour as passengers find such times easy to remember; it is claimed that operators have gained considerable increases in patronage from doing this. Although it may be important to run trains at the desired times, the resulting complexity of the timetable and strain on resources may prove too much for the timing changes to be implemented.

It should be noted that the importance of a period of waiting and adjustment time depends on many other variables, for example, the quality of the waiting environment and what activities are available while waiting or adjusting. Passengers are also more likely to be prepared to wait for a long journey than for a five minute ride to the shops. The nature of the activity will affect people's tolerance of the waiting involved in a service - if you are going to work every day you may not be able to tolerate as much adjustment as the occasional leisure traveller. It is also important that potential passengers know about the improvements in timing and frequency as they are more likely to use the service if they know the times have become more convenient

2.6 RESEARCH ON FREQUENCY AND TIMING

2.6.1 THE NON-RAIL EXPERIENCE:

The frequency and timing of services are often considered with other factors producing an overall measure of service quality. Webster and Bly state that in general, operators do not see frequency as a significant variable in the bid to maximise demand for a service. Frequency is a side effect of supply side policies. Frequency of service has thus often been treated as a response to demand rather than a way of controlling it. For example, an operator may expect 35 passengers per hour, so they run one double decker bus every two hours. However it may be possible that by running the bus every hour the flow of passengers increases substantially.

One of the most common ways in which the value of frequency elasticity is estimated in the bus industry (Goodwin), is by comparing the number of bus miles operated to the level of patronage on the network. The bus industry typically found values of +0.5 using this approach. This revealed preference study suffers as bus miles are not the only thing to change over time and so it is difficult to isolate the effects that are solely the result of frequency changes. Some operators compare bus miles over the whole network to patronage and this obviously conceals lots of differences as frequency will have increased on some routes and have been reduced on others. It is also possible that new routes have been added to the network, further distorting any results.

Generally, with revealed preference studies, cause and effect may be confused and the time series nature of the analysis causes problems. Cross-sectional studies have been done but there are problems in finding comparable areas - a place with a higher frequency will have a higher demand anyway so these results exaggerate elasticities.

Before and after studies are likely to be more realistic - these results show smaller elasticities averaging about +0.5 (+0.7 for the above methods) though it is believed diversion from other routes may cause problems in these cases.

Some studies have been based on dis-aggregate individual cross-sectional data, this should overcome the problems caused by the two way interaction of supply and demand if care is taken in the production of the models. But it is still believed that these results are over-estimates as people who are in need of good public transport are likely to live nearer areas where there is a good service. This approach produces lower elasticities of about +0.4.

So it is only relatively recently that public transport operators have realised the importance of the frequency variable this is illustrated by the introduction of mini-bus services in urban areas since de-regulation. Although there are extra costs involved through a loss of economies of scale the operators are clearly benefiting from an increase in patronage that is more than able to offset these costs.

2.6.2 THE RAIL EXPERIENCE:

Few rail studies have tackled frequency and many of those that have produced information on frequency have been more of a spin-off from other research. As mentioned in the introduction railway research has tended to favour the 'big money' urban and inter-city routes leaving the possibilities of secondary railways neglected. Generally research on secondary railways has been concentrated on cost-benefit analysis comparing the railway to alternative bus services in an attempt to justify retention or closure.

In an investigation of inter-city rail travel Ian S Jones et al were unable to find any frequency effect after looking at time series data for 17 BR routes. It was suspected that this could be the result of the service already being at a high level. So frequency was not found to be significant in this study. A large number of problems were found in isolating the effect of frequency as it was often coupled with the introduction of new faster electric trains. These authors also estimated the approximate cost of increasing frequency on inter-city routes, ie, for a 10% increase in frequency, 10% increase in costs in the peak and a 4.5% increase off-peak.

A good example of the problems of measuring a frequency change on a particular route is offered by the modernisation (including electrification) of the railway line from Waterloo to Weymouth, due to be completed in 1988. The town of Poole in Dorset currently has one train per hour to London. Bournemouth which is only 5 miles away from Poole has three trains per hour to London. Many people who would be expected to use Poole station for long distance trips currently use Bournemouth station. New trains are to be introduced which will reduce the journey time by approximately 10-15% from Poole to London. These new trains will have the additional feature of air conditioning, being faster, cleaner and brighter. Poole will now also have three trains per hour towards London. This represents a substantial increase in frequency but as it is accompanied by so many other improvements and a likely abstraction of passengers from Bournemouth it is impossible to get an accurate idea of the result of this frequency change. This sort of package is typically introduced on other routes at times of modernisation. Frequency changes rarely occur separately from other improvements and so it is not surprising that little work has been done in this area on railways.

Often the number of services tested is restricted and in some market research surveys the respondent was just offered a choice of a high and low frequency. Frequency has often been tackled by only looking at the current users of services, or indirectly by looking at the values of waiting time relative to journey time.

The current BR approach is to use a model known as the 'Rooftops' Model for more frequent services. They recommend a 'detailed analysis of the potential market' for infrequent services. This model is discussed more fully in later chapters.

2.7 SUMMARY

It is clear that reactions to timing and frequency are extremely complex. Until recently it seems that operators have treated frequency and timing of services as a side issue. It is difficult to produce a realistic model because of the large number of variables involved. Few serious attempts have been made at estimating the effects of frequency, especially on railways. For secondary railways there is hardly any information and research on timing effects are even more scarce. This thesis attempts to go some way to rectifying these short-comings.

CHAPTER THREE - THE METHODOLOGY

3.1 GENERAL:

3.1.1 CONTENT:

This chapter contains the methods, and their logic, that were used in the research. The reasons behind the method chosen for the research and the structure of the techniques in use, for example statistics and computers.

3.1.2 INTRODUCTION:

The effects of changes in the frequency of rail services have been well researched for inter-city and commuter based lines but at present there is very little known about the effect of changing frequency on rural railways. It is believed that as rural trains are so infrequent the exact timing is important. The British Rail 'Rooftops' model is currently used on higher density routes.

3.2 THE BRITISH RAIL APPROACH:

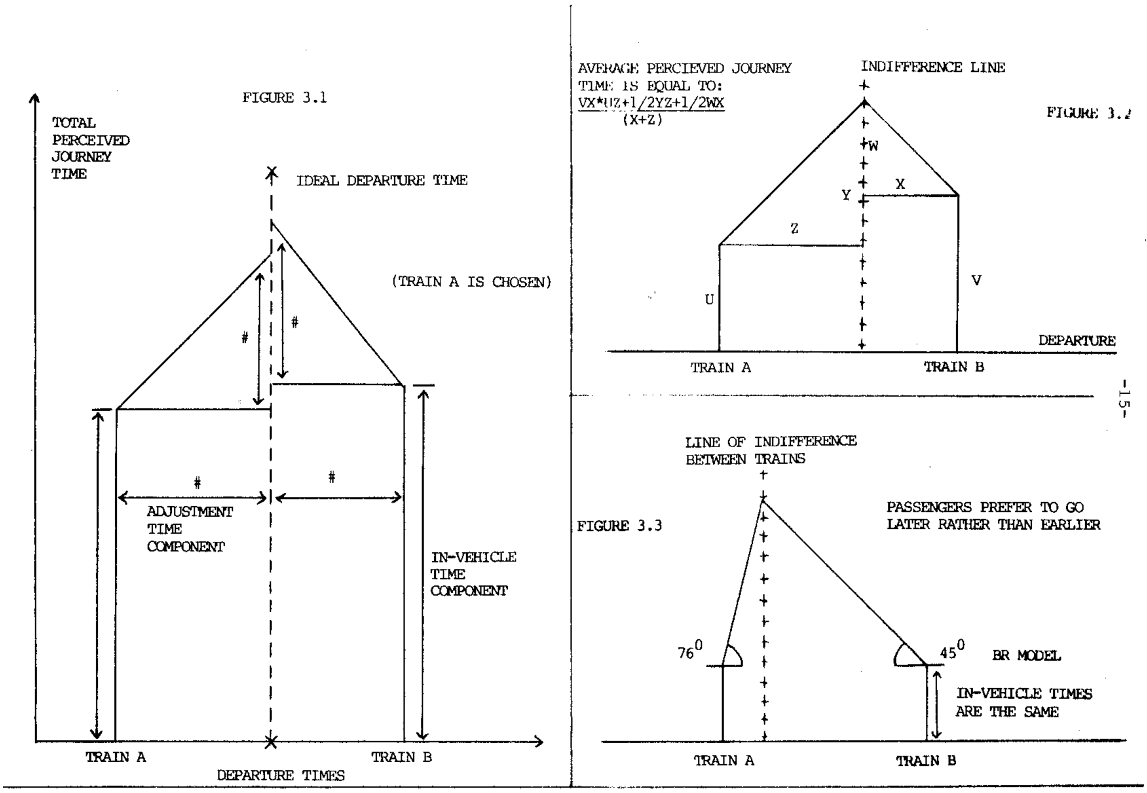
3.2.1 BASIC PRINCIPLES:

A change in the frequency of a rail service will have an effect on people's perception of service quality and hence patronage. The conventional BR method of assessing the demand implications of a timetable change is to convert the service interval into an equivalent journey time, for which there are known elasticities. The equivalent journey time reflects the cost incurred to the customer as a result of waiting and disruption to their personal timetables. The equivalent journey time is estimated by multiplying the service interval by 'P'. The size of 'P' can be chosen to reflect any relevant factors, such as the relative value of waiting time compared to in-vehicle time.

The greater the value of 'P' the greater the emphasis placed by passengers on waiting time. A figure for the perceived journey time is calculated by adding in-vehicle time to the equivalent journey time. Passengers are assumed to adjust their personal timetables to minimise this perceived journey time. With this approach a reduction in frequency has the effect of reducing perceived journey time; demand then increases according to the journey time elasticity.

As an example, imagine an hourly service with in-vehicle and waiting time valued at the same rate. A passenger has a fixed time at which he wishes to arrive at his destination and he will leave on the nearest train to this ideal time. In the worst situation he will arrive 1/2 the headway away from his desired time. If our passenger wishes to be at his destination at 1pm and trains arrive at 12.30pm and 1.30pm, it is clear that this is the worst case with an hourly headway and he arrives 1/2 the headway from his ideal arrival time. On average (if activities are spread evenly throughout the period) the passengers will be 1/2 of the maximum time away from his desired time, thus giving an average equivalent journey time ('P') of (1/2 * 1/2) 1/4 the headway. The perceived journey time would be in-vehicle time plus 1/4 of the headway.

This model estimates the total perceived journey time for the timetable as a whole, and thus the effect of frequency changes. But this basic approach can only be used on very simple fixed interval timetables, with all trains running at the same speed. Most services are not this simple. Trains do not all run at the same frequency and speed so a more complex model is required.



3.2.2 THE ROOFTOPS MODEL:

The current model is known as the 'Rooftops' model and is fairly flexible to allow various assumptions to be adopted. The model compares passengers' ideal departure times with those that are possible according to the timetable. The closer these are the more passengers will use the service. The various combinations of people on a service will affect the average value of 'P' and thus the size of the effect that a change in the timetable will have.

The Rooftop model (figures 3.1 to 3.3) is used to estimate the total and thus average perceived journey times between any two stations for all passenger trips during the timetable period. In the diagrams the horizontal axis represents the departure times of trains, while the vertical axis displays the total perceived journey time for passengers. Trains are represented by vertical lines, positioned horizontally according to departure time - their heights represent in-vehicle time. A potential passenger is assumed to have a desired departure time 'X' and some level of aversion to travelling earlier or later, the extent of this aversion is reflected by the angle of the diagonal lines in the model.

A passenger's ideal departure time is represented by a vertical line up from the horizontal axis - either side of his line will be lines representing earlier and later trains (unless there are no trains earlier or later, or if he by chance is able to board a train at exactly his ideal time). The horizontal distance between his ideal departure time and the trains either side represents the adjustment time that will be involved if one of the sub-optimal trains is caught (figure 3.1). The passenger will add this adjustment time (weighting it by some value) to in-vehicle time to get a perceived journey time. This addition of adjustment time is achieved graphically by drawing diagonal lines from the top of the train time line to the passenger's ideal departure time line. The diagonal line that intercepts the passenger's ideal time line lowest down will be the optimum train for that passenger's journey.

If adjustment time is valued the same as in-vehicle time a 45 ° angle is drawn between the lines so that adjustment time is added directly to in-vehicle time to get the perceived travel time. If adjustment time is valued lower than in-vehicle time then the angle will be less than 45 ° and vice versa. A further possibility is that a passenger may prefer to leave before rather than after his ideal departure time, in such a case adjustment time after the ideal time will be valued more highly than adjustment time before departure. This situation would be reflected by steeper angles for trains after the ideal departure time and shallower ones before the ideal time (figure 3.3). Where the angled lines from trains either side of the ideal departure time meet, perceived journey time is the same by both trains, and the passenger is indifferent between either train. Such intersections therefore define the sphere of influence that a train has in the timetable (figure 3.3).

A passenger will therefore choose between travelling earlier or later than his ideal time. The train chosen will be the result of him comparing the speeds of individual trains and the degree of adjustment necessary to his departure time to catch a given train. This model therefore identifies the train that an individual will travel on and the perceived journey time of doing so.

The BR model uses information on the current timetable pattern and the proportion of travellers who are commuters and non-commuters as inputs. As the distribution of demand throughout the day is assumed to be uniform, the overall value for the total perceived journey time on a particular route is represented by the area under the Rooftops. This total value is then divided by the period covered by the timetable to give a mean perceived journey time. If a new timetable with an increased frequency is introduced, a similar calculation will estimate the mean perceived journey time under the new circumstances. The two figures can now be compared and the journey time elasticity applied to give the increase in demand for the service.

The equation below allows pairs of angles for the Rooftop to be established. BR believe 'P' to be about 0.4, meaning that adjustment time is valued at (0.4/0.25) = 1.6 * in-vehicle time. This figure is based on a number of studies including Government value of time research. The equation is only satisfied by angle pairs which weight adjustment time by 1.6 of in-vehicle time. BR's model MOIRA assumes the angles of the Rooftops are fixed in all situations with L=45 ° and therefore K=76 ° (K= 79 ° in the manual which is an error).

$$P\ (0.4) = \frac{(\tan K * \tan L)}{2 * (\tan K + \tan L)}$$

The overall journey time elasticities are: for commuters (0.3) and non-commuters (0.8). The parameters used in the model do not vary according to the line under consideration and, as stated above, the model assumes a constant level of demand throughout the day.

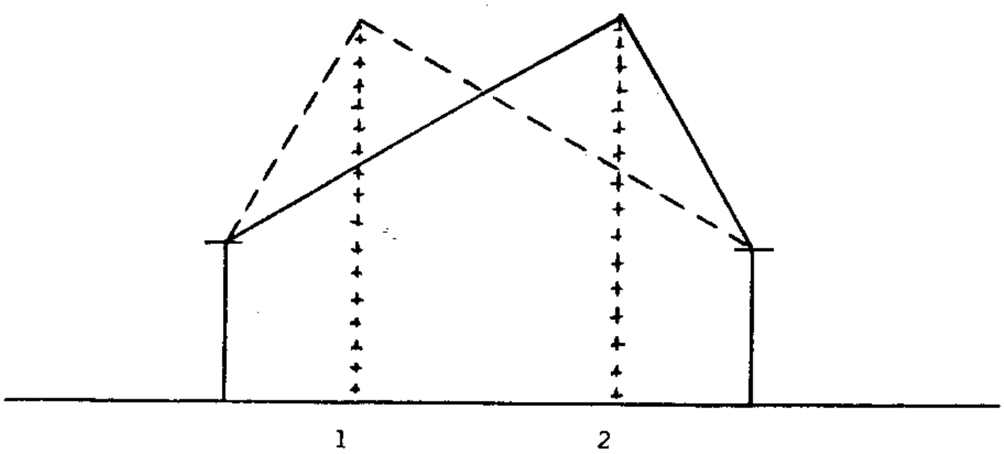
3.2.3 ADAPTATIONS ALLOWED BY THE MODEL:

The Rooftops model has a number of variables that can be changed to make it more applicable (should it prove un-reliable) in the rural situation.

Firstly the angles 'K' and 'L' could be changed. If the value of 'P' is held constant it is clear that an increase in one angle must be compensated for by a reduction in the other angle (figure 3.4). With 'P' fixed and a constant level of demand, changes in 'K' and 'L' will affect the total perceived journey times for individuals, whilst making little difference to the overall figure. The average perceived journey times will not change significantly because changes in individuals' total perceived journey times will cancel out overall - this is illustrated in the diagram below. If 'P' is not held constant, changes in the angles may change the value of 'P'.

ANGLES CHANGED WITH 'P' CONSTANT

FIGURE 3.4



The value of 'P' could be changed, this represents the relative value of waiting and in-vehicle time. It is suggested by BR that with frequent services passengers arrive at the station at random and therefore wait for trains. With less frequent services passengers do not wait in the conventional sense of the word. These latter passengers are referred to as 'adjusting' passengers. Their time will be valued proportionately less than that of 'waiting' passengers as they can engage in some positive activity while waiting for the train and are in a more 'acceptable' environment.

Adjusting travellers will plan their travel times around the train times and turn up at the station just before the train arrives. A day spent on Yetminster station confirmed this belief, with most of the passengers arriving within 10 minutes of a scheduled service. If it is believed that if there are a lot of 'adjusting' passengers on a line it may be wise to reduce the value of 'P' used in the equation as adjustment time will be valued lower than wait time.

Finally, the journey time elasticities used in the calculations can be changed. In the BR manual it assumes an elasticity of -0.3 for commuter trips and -0.8 for all other trips. Although these elasticities may not be appropriate in a rural environment it is beyond the scope of this thesis to examine them.

3.2.4 THE DEFICIENCIES OF THE ROOFTOPS MODEL:

On an infrequent service the constant demand assumption is likely to produce un-reliable results as the model takes no account of the timing of the services. If the current service has very inconvenient timings there is likely to be a greater response to a frequency change than for a current service with very good timings. A poor service will miss the peaks in demand - an increase in frequency is very likely to result in these peaks being 'hit'. A well timed service will already hit the peaks and so will experience a smaller number of additional rail trips. In terms of elasticities, if the current service is badly timed few people will be using it; a large increase on this small base would produce very large elasticities. For a well timed service there will be much smaller figures.

FIGURE 3.5 Procedure for using Rooftops model:

COLLECT DATA ON FLOWS AND PROPORTION OF WORK TRIPS

↓

SELECT ORIGIN-DESTINATION

↓

RUN COMPUTER MODEL

↓

INPUT TIMETABLE

↓

EXTRACT AVERAGE PERCEIVED JOURNEY TIME

↓

RELATE CHANGE IN PERCEIVED TIME TO JOURNEY TIME ELASTICITIES

↓

PREDICTED INCREASE IN PASSENGER FLOWS

If we had two timetables each with the same average frequency, the the Rooftops model would predict the same patronage for each regardless of how well or badly timed they were. This is the case even if the parameters of the current model were changed, for example, a reduction in the value of 'P' would reduce the effect of a frequency change but the errors caused by the ignorance of the timing effects would remain. With the more frequent services for which the Rooftops model has conventionally been used there is less likelihood of such a timing effect. This is because a frequent service cannot avoid hitting the peaks in demand and so the overall effects predicted by the Rooftops model would be acceptable. The model would still produce inaccurate results but the errors would be small enough to ignore.

The other problems with the Rooftops model are that like all models it is a generalisation - it takes no account of the individual circumstances surrounding a trip. It treats all places as alike whether they have, for example, more bus competition or an older population.

It is believed that the different environment of the rural railway will show the current model to be un-reliable in such circumstances and so an alternative model is proposed.

3.3 THE ALTERNATIVE MODEL:

3.3.1 GENERAL APPROACH:

The suspect value of the Rooftops model on secondary routes with a low frequency service provided the opportunity to develop a new method for estimating the effects of changes in the frequency and timing of services. As with the Rooftops model the alternative model predicts additional flows for a specific origin-destination pair. The alternative model is based upon the results of a market research survey and so looks more closely at the individual circumstances surrounding each trip. The model will predict, for any individual, the number of additional trips they will make given any set of improved timetables. The total response from these individuals gives elasticities for the chosen O-D.

It was decided to use a market research survey to elicit the information about the response to frequency changes. Market research was used because very little data is available about actual frequency changes. Any real life examples have usually been accompanied by changes in other variables making the estimation of a frequency elasticity hazardous. The only previous market research study of this type was done by a consultancy for BR, but this only looked at the importance of frequency on people who were already using the train. Their technique involved a trade-off game which typically took 40 minutes to complete, this may be satisfactory on an inter-city service with a long interval between stops, but would not be applicable to local journeys of under 1/2 an hour.

A self completion household survey was decided upon as it meant that all potential users were covered. It would also mean that a reasonable sample of people could be gained. As it was not expected that many people would produce sets of extra journeys it was critical that the sample sizes be maximised.

3.3.2 ESTIMATING UNDERLYING DEMAND:

The technique chosen was to get respondents to imagine that they could run trains whenever they wished so that they could travel at any time. For each extra trip that would be made respondents were asked to write down the times that they would have preferred to arrive and depart from the town in question. So that people would make realistic estimates of extra trips, a kind of trade-off was used in the questions where the current train fare was quoted so that people did think seriously before indicating any extra trips.

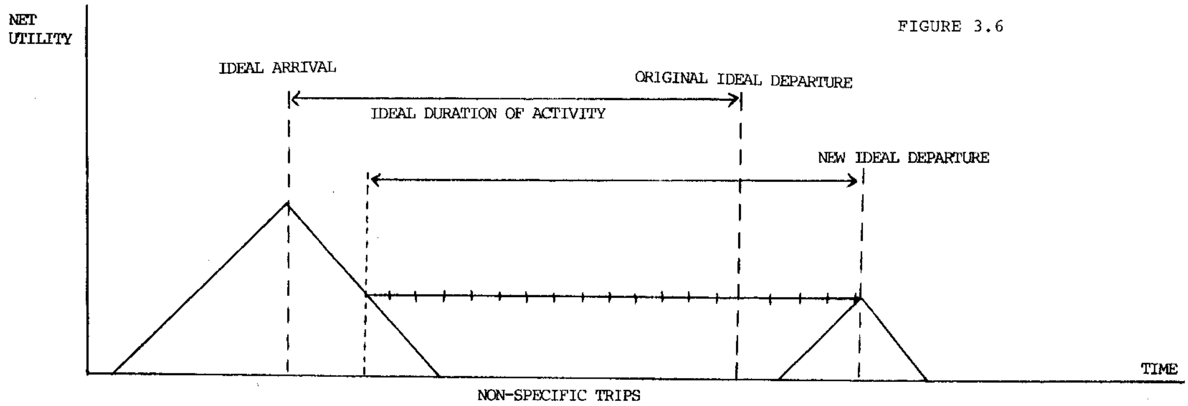
The extra trips had to be measured over some period and this was chosen as the last seven days. The idea was that respondents would relate back to their actual and desired activities over a period that they could remember reasonably well. Respondents were expected to think about trips they might have made by train if the timetable was more convenient to them. A potential drawback with this approach is that some people may not have made any extra trips in the last seven days but may have done so over a longer period. However, the converse is equally true and so it is assumed that the two effects cancel out.

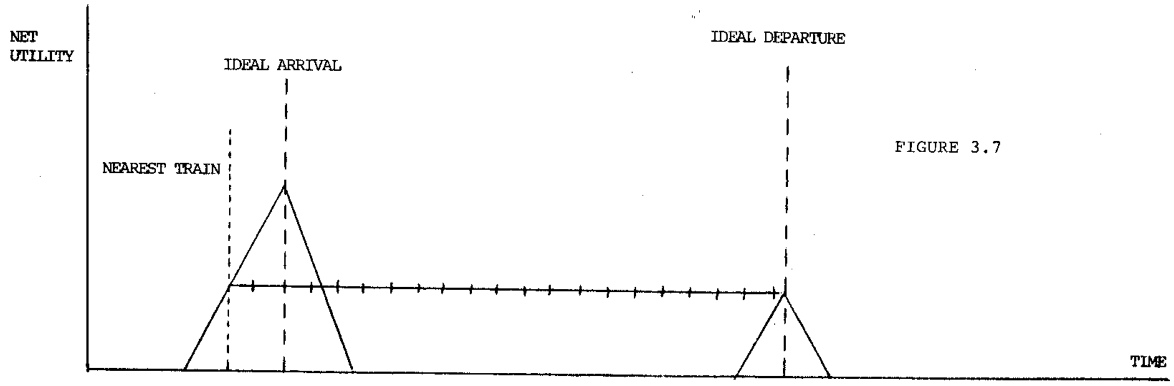
This part of the model has therefore produced a distribution of the additional times people would have travelled by train during the last seven days if the train ran, for example, every minute. This latent demand coupled with the demand that is already apparent from current users shows the total potential demand for a rail service between the specified places.

3.3.3 THE DECAY OF UNDERLYING DEMAND:

As the train service deteriorates from the ideal situation discussed above the number of trips made between the two places must diminish. For this situation to be replicated in a model there must be some mechanism to determine which of the additional stated trips will be made. It is therefore important to be able to establish whether a stated trip would be made if a train ran close to, but not at the ideal time stated by the respondent. At one point it was thought that some in-depth attitudinal questions could be used to determine the time flexibility of potential passengers, but the questionnaire became too complex for self-completion. Such difficulties meant that it was decided to ask people directly about their range of tolerance around the times they had stated.

The model assumes that people can produce a time that would be a threshold where they would no longer make a trip. So someone going to work (knowing that he could return at any time) could say 'I am not prepared to arrive in X before 7.50'. For this individual, if an extra train was laid on at 7.49 he is assumed not to use it. This assumption does not have to strictly hold as long as errors either side of the stated limits are equally distributed. That is to say that equal numbers of passengers overstate their thresholds, compared to reality, as understate them.





This issue is made more complex as passengers make travel decisions based on both the outward and return timings of a service. Some way has to be found of aggregating the adjustment caused by both the outward and return times into a figure that will reveal whether the trips are made. To achieve this a behavioural model has been produced.

It is assumed that a traveller will make a trip by rail if this results in him experiencing a higher level of utility than by choosing the next best alternative. This next best alternative may be the use of a bus service, trying to get a lift from a car owner or simply not making the trip at all. The extent of the excess utility associated with making the trip by rail is referred to as the 'net utility' of the rail trip. If the net level of utility is positive the trip will be made by rail. If the net level of utility is zero the individual is indifferent as to whether he makes the trip or not and if net utility is negative the trip will not be made.

The individual will experience some level of net utility from making a trip by rail at the ideal time. This level of utility will gradually decline as the train times become less convenient, until net utility falls to zero and the rail trip is no longer made. It is important to distinguish between this net level of utility and the probability of making the stated trip. Respondents have stated that as long as the train ran between their threshold limits they would have made the additional trips. This is equivalent to assuming that the probability of making the stated trip is one until net utility falls to zero where the probability of making the trip becomes zero. So although an individual's net utility may be reduced by 50% as a result of the trains running at less than ideal times, the probability of him making the trip remains one until the threshold is reached. This assumption will be changed later in the analysis to show the effect of allowing for a decreasing level of probability of the trip being made as the deviation from ideal times increases.

Individuals who stated that they would be likely to make additional trips as a result of an improvement in the timing and/or frequency of the rail service were asked to give four time ranges. Firstly, they were asked (assuming that no other adjustment is necessary) to give the earliest and latest that they would be prepared to arrive at the destination. Secondly, they were asked (assuming that they had arrived in the destination at their stated ideal time) to give the earliest and latest they would be prepared to return home. These threshold times represent points where net utility has been reduced to zero. This means that each of the four stated thresholds mentioned must be equal in terms of utility foregone.

For many people rail will not be considered even if the times are ideal for their trip. For the permanent non-user rail will have a negative level of utility at all levels of service and, except in un-foreseen circumstances, these people will never use the train. It is the marginal cases, where their rail journeys may produce some net utility, that we are interested in when measuring the effect on patronage of service improvements.

For the purposes of this study it has been assumed that this net level of utility falls linearly as train times move away from the passengers' ideal times. This may not be a realistic assumption but the questionnaires would have become too complex for any substantial results to be obtained if this was investigated more thoroughly.

Two main types of trip were identified in the pilot stage of the study. Firstly there are the 'specific' trips. Specific trips are characterised as having an activity in the destination that is fixed in time, for example most work trips. The traveller has a set time at which his activity begins and ends.

The second type of trip considered by the model is the 'non-specific' trip. These trips are characterised by having no fixed times at the destination, it is more important for the individual to spend a certain amount of time in the destination rather than to arrive or depart at any particular time. There are, of course, certain limits to the times non-specific trips will be made. Generally it can be said that specific trips are affected by the timing of the service, while non-specific trips are more related to frequency.

The model weights the deviations from the stated ideal travel times, caused by the timetable, according to the relative size of the ranges quoted by each individual. Time is therefore valued differently according to where and when it occurs. A set of stated times might look those below:

```
                Ideal arrival: 8.45
Earliest arrival: 8.20          Latest arrival: 8.55

               Ideal departure: 17.20
Earliest departure: 17.10       Latest departure: 17.40
```

3.3.4 SPECIFIC TRIPS: If the times above represented a specific trip then we can see that this passenger would be prepared to accept a deviation from his ideal arrival time of -25 minutes or +10 minutes, on the return journey the deviation is -10 minutes and +30 minutes. The extent to which these allowances are used by an ill-timed train represents the amount of net utility lost to the passenger. If the nearest train to the ideal arrival time arrived at 8.30, the proportion of net utility lost is:

(Actual early deviation/Early allowance)*100

(15 minutes/25 minutes)*100

60% of the net utility has been lost meaning that the passenger has only 40% left to allow for adjustments on the return trip. If the nearest return train ran at 17.40 the trip would not be made as the total adjustment required represents 140% of the net utility budget. If the nearest return train departed at 17.25 the trip would be made, as this represents a total of (12.5% + 60% = 72.5%) of net utility.

3.3.5 NON-SPECIFIC TRIPS:

So for specific trips people are assumed to combine their outward and return adjustment to decide whether they make a trip or not. But for non-specific trips this is not the case. For such trips passengers also combine two timing elements, though in this case it is the time of arrival at the destination and the length of the time spent there. For non-specific trips a passenger who is forced to arrive later than his ideal time will still want to spend the same amount of time at the destination. With a specific trip this is not the case as the passenger will still have to return home at the same time. The concept of net utility is retained for non-specific trips. It was my ignorance of this latter trip that caused the failure of the first pilot surveys. To use another example:

```
                    Ideal arrival: 10.30
Earliest arrival: 9.00           Latest arrival: 12.00

     Ideal departure (if arrived at ideal time*): 14.20
Earliest departure*: 13.50        Latest departure*: 15.00

 Ideal time at destination = Ideal departure - Ideal arrival
```

In this case it can be established that the ideal amount of time for this individual to spend at the destination is 3 hours and 50 minutes. The individual will accept a deviation of -30 minutes and +40 minutes around this. The proportion of net utility lost on the outward stage of the trip is calculated in the same way as with specific trips. The proportion of net utility lost by the duration deviation is similarly calculated with the total loss in net utility being the sum of the two. Again if the total loss of net utility represents more than 100% of the budget the trip will not be made.

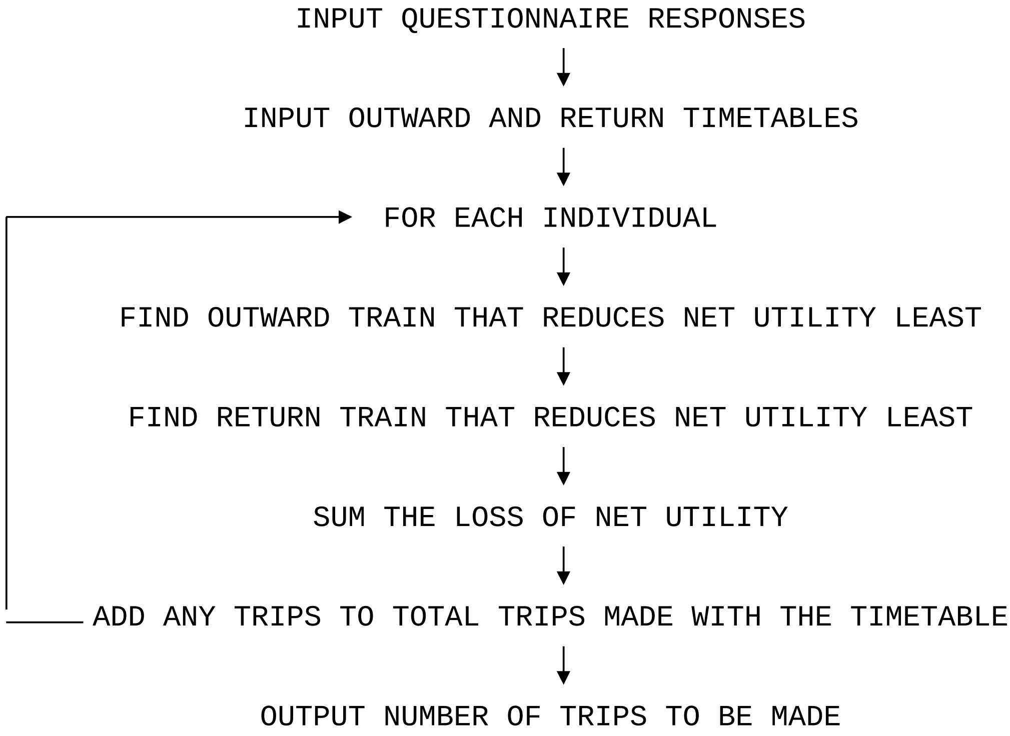
The final element of the model is to attach some level of certainty to the additional trips stated by the respondent. This is achieved by getting respondents to say the trips are either definite or possible. This gives a range of estimated additional trips - the minimum being only the definite trips and the maximum being the sum of the definite and possible trips. In the analysis possible trips are treated as being half as likely as definite trips.

At this point it is obvious that this model represents people's stated intentions to travel and cannot therefore be taken as a concrete figure - it only provides an estimate of the number of extra trips resulting from improvements in the level of service on secondary railways. It is also important to stress that the model is not suggesting that people, when planning one of these rail journeys, sit down with a calculator and calculate whether their net utility from making the trip will be positive. It does suggest, however, that they will act in a way that is consistent with this arithmetic.

3.3.6 IMPLEMENTATION OF MODEL:

A computer programme was written which analyses each set of stated times, comparing them to the trains in the entered timetable. By doing this the programme finds the train that comes nearest to each set of stated times. The programme then outputs the number of trips that would be made for any pair (outward and return) of timetables fed into it. The programme 'T.Calc' finally produces a range of estimates based on people's stated probabilities. It is fairly easy to modify the programme to take account of changed assumptions. This will be done to see the effects of a gradual reduction in the probability of an individual trip as the deviation from ideal times increases.

FIGURE 3.8: Procedure used by T.Calc



The approach used to estimate elasticities assumes that the current time-tabled trains will always run so that no current passengers are lost by these times being changed. This technique is used as I am not able to predict the loss of current passengers by re-timing present services, the model can only predict the result of additional trains in the timetable. For the analysis to work trains are inserted in between current times. This concept of inserting extra trains is illustrated below with a current and possible timetable. Trains run from village 'X' to town 'Y'. The result of this exercise is a measure of the elasticity over the relevant arc.

ORIGINAL TIMETABLE:

X	6.20	9.20	12.20	15.20	18.20
Y	7.00	10.00	13.00	16.00	19.00
Y	7.00	10.00	13.00	16.00	19.00
X	7.40	10.40	13.40	16.40	19.40

ENHANCED TIMETABLE:

X	6.20	7.50	9.20	10.50	12.20	13.50	15.20	16.50	18.20
Y	7.00	8.30	10.00	11.30	13.00	14.30	16.00	17.30	19.00

Y	7.00	8.30	10.00	11.30	13.00	14.30	16.00	17.30	19.00
X	7.40	9.10	10.40	12.10	13.40	15.10	16.40	18.10	19.40

3.4 COMPARISON OF THE TWO MODELS

A number of timetables have been designed to test various aspects of the models performance. Both models have been produced in the form of computer programmes (Appendix VII and IIX) so that results for these timetables can be obtained in a reasonable amount of time. The use of computers means that many more timetables can be analysed than if the results were calculated by hand. As the results of the market research survey are only a sample of the population the standard error is calculated so that differences between results caused by un-representativeness can be taken in to account. The assumption that an additional trip will always be made, as long as a train runs between the stated threshold times, will be changed during the analysis to see the effect this has on the results.

As mentioned in the earlier chapters a more general analysis of desired travel times is also being done as part of the research. Some statistical analysis will be done on this data to test for relationships.

3.5 SUMMARY

The model currently used by BR is expected to have some deficiencies on services with a low frequency. This problem means that an alternative way has been found for estimating the response to an improvement in the timing and frequency of services on secondary routes. The alternative model is based on the results of a market research survey and is specifically designed to be able to deal with timing as well as frequency effects. Both models have been incorporated into computer programmes so that the results of the two can be compared for a variety of different timetables.

CHAPTER FOUR - DATA COLLECTION:

4.1 GENERAL

This chapter covers data collection, the design of the surveys and a description of the problems encountered.

4.2 DEVELOPMENT

Three forms of questionnaire/interview were developed during the thesis. The least complex questionnaire just asked about desired travel times for various sorts of trips - this is referred to as the non-rail survey, as the questions were not related to a rail service. A second semi-structured on-vehicle interview was carried out to look at the time sensitivity of current rail trips. This showed there were difficulties with the length of the adjustment period needed for the passenger to decide whether they would discontinue the current trip. The third and main questionnaire was used in the development of the frequency model. The complexity of the main questionnaire meant that it had a considerable development period. The following is an account of that period. Both the semi-structured on-vehicle interview and the questionnaire used just to establish desired travel times benefited considerably from the experience gained in developing the frequency model questionnaire.

4.2.1 FREQUENCY MODEL QUESTIONNAIRE.

From the methodology it was clear that the questionnaires used to establish additional trips from individuals had to be for self completion. In simple terms this means that the questions must be totally un-ambiguous and the questionnaire must not bore the respondent. It must also present the illusion of requiring little work. These factors meant that it was decided that all questionnaires must be restricted to one sheet of paper. Respondents would be asked only about trips to the major rail destination from the village concerned; this would result in a reasonable number of additional trips being stated and would make the analysis simpler. For Lidlington, Maiden Newton and Yetminster, the main destinations were Bedford, Dorchester and Yeovil respectively.

Initially it was thought that a household survey would be done, with respondents being given two timetables, each showing an improved local rail service. People would be asked to write down the number of additional journeys they would make to the specified town, if these timetables were implemented. But by giving people timetables the questionnaire looked as though a lot of work would be involved in its completion and it is suspected that the response rate would have fallen to very low levels. This method also does not address the timing issue.

As well as the data necessary to estimate the response of demand to a more frequent service, it was felt that the analysis could be further expanded if people were asked about their personal characteristics. A further question was also employed to gauge people's feelings towards requency as a deterrent to them using the train.

Although there were a number of different questionnaires used during the extensive development phase, all had the same basic structure. Initially the respondent was asked about their current use of the train on the route selected. People were then asked about their personal characteristics. This was followed by a question asking about the effect the frequency of the service had on their use of the train to the selected destination. Next there was a filter question which asked if the respondent would have made any extra trips over the last seven days if the train times had been more convenient to them. If their response to this question was no then they had finished the questionnaire - if not they had to state at what times extra trips would have been made during the last seven days. For each of these trips passengers were asked to give a range of acceptable times to be used in the behavioural model.

All the questionnaires were extensively tested on colleagues, friends and relatives. A series of pilots (Appendix I) was also undertaken in the village of Lidlington which is on the Bedford-Bletchley line and is conveniently close to college. Approximately 30 questionnaires were distributed in each pilot.

In the first two pilots it was learnt that not all trips had specific arrival and departure times at the destination. For some trips, for example shopping, it is more important to spend a certain amount of time at the destination rather than to arrive or leave at a set time. The wording of some of the questions was also clumsy and occasionally ambiguous.

One factor that may have affected the results of the first two pilots was the introduction, where it was stated that the research was being done with the co-operation of British Rail. It was thought this statement would make the survey appear more official improving the results. But it appeared that the belief that the results may be seen by BR was causing people to exaggerate their views of their need for the service. It was noted on a few occasions in all the rail surveys that respondents were worried about the line being closed and there is a chance that this caused people to state trips that would not be made. It is interesting to note that in the actual surveys some people stated that they would not do the survey if it was to be used for commercial purposes. The fact that it was being carried out by a student and appeared 'unofficial' seemed to be an advantage.

The second pilot gave the opportunity to add some more detailed questions about personal characteristics. The filter question (which directs the respondent whether to write down the times of additional trips or not) was also modified, as the Yes-No division of pilot 1 was felt to be too harsh. Although pilot 2 still only considered trips with fixed arrival and departure times, an advance was made in the technique for eliciting the ranges around these times.

Pilot 3 resolved the problem of the two types of trip (Specific and Non-specific). This was achieved by explaining the difference between the two trips at the beginning of the questionnaire. Respondents were then asked to consider, for each trip they stated, which type of trip this was so that they would fill in the relevant part of the questionnaire. This questionnaire was shown to be just too complex. It appeared that people did not misunderstand the questions, but that they could not be bothered to read them all.

The final pilot involved a major effort in presentation. Previously people had been able to state that they would make trips on Sundays even where there was no current service - this was abandoned for simplicity. The major change in the last pilot was to incorporate both trip types into one question by asking passengers to relate their stated times to each other in a particular way. This relating of answers, coupled with a question about the nature of each trip, meant that for non-specific trips an ideal time at the destination could be calculated from the stated ideal arrival and departure times. By printing this part of the questionnaire sideways and eliminating the complex instructions associated with the previous questionnaire, it took on a more 'friendly' look.

The actual questionnaire (Appendix II) was changed slightly from the last pilot. The question referring to the effect of frequency on respondents' use of the service was changed. Previously people were asked to rank service attributes according to the extent to which this put them off using the train, but this question was not effective as approximately 20% of answers were not filled in or done incorrectly. This question had consistently caused trouble despite attempts to reword it, so it was changed. The new question simply asked respondents to state to what extent the current timings put them off using the service. With some questions it was found that the use of examples helped the respondent, but one had to be careful with the stated trips quoted, as an early example was obviously a work trip and this made some people believe that they should only include work trips.

Although the actual questionnaires performed remarkably well, with the benefit of the 300 questionnaires administered during the thesis, a later questionnaire has been developed (Appendix III). For this questionnaire the question about the extent to which the current service put them off using the train was removed and the first side spread out to make it look simpler. On the second side the question about 'specific' trips was completely re-phrased. The number of children under 14 to be taken on each trip would have been asked for instead of being estimated from the household characteristics. Respondents would now be asked for the specific day of the trip as it was felt to be less confusing - it was found during the non-rail survey that people could remember the specific day of a trip during the last week. If the surveys could be done again this is the questionnaire I would use.

4.3 EXECUTION

4.3.1 CHOICE OF SURVEY LOCATION:

The two villages were chosen for the following reasons.

1. Their average service frequency was low, approximately one train every two hours.
2. The villages had populations of approximately 1,000 people, which was thought to be a reasonable size for the household surveys. Both villages had their main centers of attraction connected by the railway generating an acceptable number of trips from the questionnaires. One of the villages (Yetminster) had a worse service than the other and a lower passenger flow. It was felt that this difference may provide some interesting insights into the effects of timing and frequency.
3. Data was available on passenger flows, as the new PORTIS ticketing system had just been introduced.
4. The line was easily accessible.

The possibility of collecting some data on-board the train meant that the following three points were also given consideration.

5. There was no large tourist influx, though there was a large amount of through traffic. This condition makes it easier to select local passengers for interviews.
6. The line used small open plan trains (Diesel multiple units), giving easy access to passengers. The reasonable journey time would give passengers time to answer questions, with 10-15 minutes between each station.
7. A shuttle type service was operating with the train just turning round at Weymouth and passing another at Yeovil so that as little time as possible was wasted waiting around for trains.

4.3.2 MAIDEN NEWTON AND YETMINSTER SURVEYS:

The questionnaires used in both villages were identical except that the Maiden Newton one dealt with the villages Sunday service, Yetminster did not have a Sunday service. For the Maiden Newton and Yetminster surveys the sampling technique involved one out of every six houses being selected (16.7%). The respondent was asked to give each member of the household aged 14 and over a questionnaire to fill in during the next 24 hours. A record of the addresses surveyed was kept so that a second survey could be done if the response rate was very low, it also meant I would know which houses to collect the forms from the next day. If the questionnaires were not completed respondents were offered the option of a post paid envelope to return them when completed. The survey was done in the evenings (generally between 6 and 8.30 pm) to avoid any un-representativeness caused by people not being in.

An introduction was read to the respondents to avoid any bias resulting from their introduction to the survey. It read:

'I am sorry to trouble you. I am dropping off questionnaires on local travel patterns. Could I please leave one for each person in the household aged 14 and over to complete so that I can pick them up tomorrow?'.

There are a number of reasons behind the phrasing of this introduction. It was found that by stressing that the questionnaires were being dropped off and that people did not therefore have to do them 'now' and on the doorstep, the response rate was raised considerably. A significant number of people stated that they liked the idea of being able to fill in the questionnaires when they wanted. This technique also results in more thought being given to the answers as the respondent is not trying to get the whole episode 'over with' to such a degree. This was especially important as many people wanted to do other things in the evening such as eating or watching TV. It is also not possible to get each member of the family aged 14 and over to the door one after another to answer questionnaires.

It was found that by introducing the questionnaire as a survey of local travel patterns more people were prepared to answer it. In the pilots it was found that as soon as the word 'railway' was mentioned many car owners said 'I never use the train, so it is not relevant to me'. It was found that once the car owners were given the questionnaire they were quite prepared to fill it in. It is interesting to note that with the non-rail survey some car owners stated that it was a pleasant change not to be directly asked about public transport.

Maiden Newton:

Population:	763
Population aged 14 and over (estimated):	662
Questionnaires handed out:	125
Valid questionnaires returned:	97
Response rate:	77.6%
Sample proportion (of population 14 and over)	14.65%

Yetminster:

Population:	896
Population aged 14 and over (estimated):	766
Questionnaires handed out:	125
Valid questionnaires returned:	108
Response rate:	86.4%
Sample proportion (of population 14 and over)	14.10%

It was felt that children under 14 would not fully understand the questionnaire and would also not be likely to travel on a train on their own. It was noted that on approximately 30 train journeys spread over a week that the number of children on the trains was very small. The approach used to take account of extra journeys by children was to look at the additional times given by their parents - if these were during school hours there would be no children travelling on this trip. If the trip was out of school hours and all adults in the household were travelling it was assumed that the children would be travelling on the train with the adults. There is of course the possibility that some adults may be out even if not using the train and so even if one adult is on the train the children may have to go as well.

When the data was received the complications caused by children's trips proved academic as there was only one instance in the whole data set where people with children would be travelling out of school hours and in this case only two children were involved. It was assumed in this case that no children would be travelling as only one out of three adults would be on using the train at any one time. It would of course been much simpler to ask the question, 'How many children under 14 would be travelling with you on this trip?' as was in the final questionnaire designed with hindsight.

General information is shown below for the two village surveys, all population figures are taken from the 1981 census:

4.3.3 ON-VEHICLE INTERVIEWS:

About 10 semi-structured interviews were carried out on trains spread over the morning period. The intention of this was to get a feeling for peoples response to a frequency reduction. Passengers were asked about the purpose of the trip they were on and how sensitive the timing of the trip was in both the immediate and and longer terms. The results meant that the way in which people planned their trips and the long and short term implications of removing trains could be investigated.

4.3.4 BRADFORD PEVERELL SURVEY:

For the Bradford Peverell (non-rail) survey one out of every two houses was selected (50% sample). The technique was similar to the frequency survey with the questionnaires being delivered in the evening. The respondent was again asked to distribute questionnaires to each member of the household aged 14 and over. Questionnaires were picked up the following day. By going round again after the first collection, usually about an hour later, it was found that most of the 'missing' questionnaires were returned. This approach meant that the response rate was kept very high. One problem that emerged with the Bradford survey was that for car drivers the times people gave were in effect the times when they would be out of the house. Some people were worried that if this information was to get into the wronghands they may be burgled; it was therefore very important to stress the confidentiality of the survey's findings.

General information on the survey follows:

Bradford Peverell:

Population (1981):	349
Questionnaires handed out:	80
Questionnaires returned:	71
Response rate:	88.75%
Sample proportion (of total population)	20.34%

4.4 ORGANISATION OF DATA FOR ANALYSIS

All the data received from the questionnaires was input to the Statistical Package for Social Scientists (SPSS) which was run on an IBM PC compatible machine. Some time was spent on cleaning and testing the data for errors. Most of the questionnaires were error free but inevitably some had to be dealt with.

Where trip purpose was asked for some respondents put down more than one trip, in these cases what looked to be the main reason for the trip was taken to be the trip purpose. Some errors will be caused by this procedure but few multi-purpose trips were recorded.

One precaution that had been taken was to staple all the questionnaires together that were received from any house. This was necessary as some people did not bother to fill in personal details of the household if they knew another member of the household had done so. By keeping the questionnaires together they could be checked against each other being amended as necessary. Where a value was missing and could not be estimated the value was recorded as missing on SPSS so that it did not affect the analysis.

The stated times used in the frequency model were input using a data entry programme on a Commodore 128D where it was saved onto files that could be read by T.Calc.

4.5 PROBLEMS WITH THE APPROACH

There are a number of difficulties with a market research approach. People are known to exaggerate their opinions if they think an improved service may result. There is also a possibility of collusion between the members of the household so that all the questionnaires returned have the same responses.

Despite the apparent un-reliability of the technique the majority of the households questionnaires were filled in, and with different handwriting on most of them suggesting that they were handed around to the appropriate people. There was, however, a small number of occurrences where people who answered the door were obviously not prepared to take questionnaires for other members of the household.

It proved important to do some homework on the village to be surveyed as in two instances the days of the questionnaires coincided with the annual village fairs. This meant that it took longer than usual to collect the completed questionnaires.

Errors could be caused by an un-representative sample, though great care was taken to avoid this problem. As already stated errors from the activities of children under 14 are expected to be insignificant. One slight problem persisted in the use of this filter question, this was that people either said they would have made extra trips in the last seven days and were then unable to state any times, or people realised that they could get out of answering the questions on the second side of the questionnaire by stating no extra trips. This latter group of people became apparent as some people had ticked that they would make extra trips and then crossed this out ticking 'no'. However this group was small and some of these people may have genuinely changed their minds.

4.6 SUMMARY

A number of surveys were carried out during this thesis. Three household surveys were carried out during the research, two of these were used in the development of the frequency model and the third elicited desired travel times.

The frequency questionnaire had an intensive development phase, it was important to get it right so that the extensive analysis of its results would be as valid as possible. This development phase meant that a lot was learnt about the way people planned their trips by rail with an infrequent service. It would appear from this exercise that, although complex, it is possible to estimate the number of additional trips that result from a service improvement on secondary railways.

A general survey was carried out on people's desired travel times in Bradford Peverell. This questionnaire was relatively straightforward but benefited considerably from the extensive testing of the frequency model questionnaire. A small scale on-vehicle survey was also carried out in a semi-structured way to investigate current rail travellers sensitivity to the timing of the rail service.

The data from the questionnaires was input into computers where it was checked allowing the analysis to begin.

Although there are a number of potential errors from the market research technique, it is not believed that they are of such a magnitude as to make the approach invalid. Nevertheless some care should be taken in the interpretation of the frequency results.

CHAPTER FIVE - RESULTS

5.1 GENERAL

This section contains the analysis of the data and findings from the research.

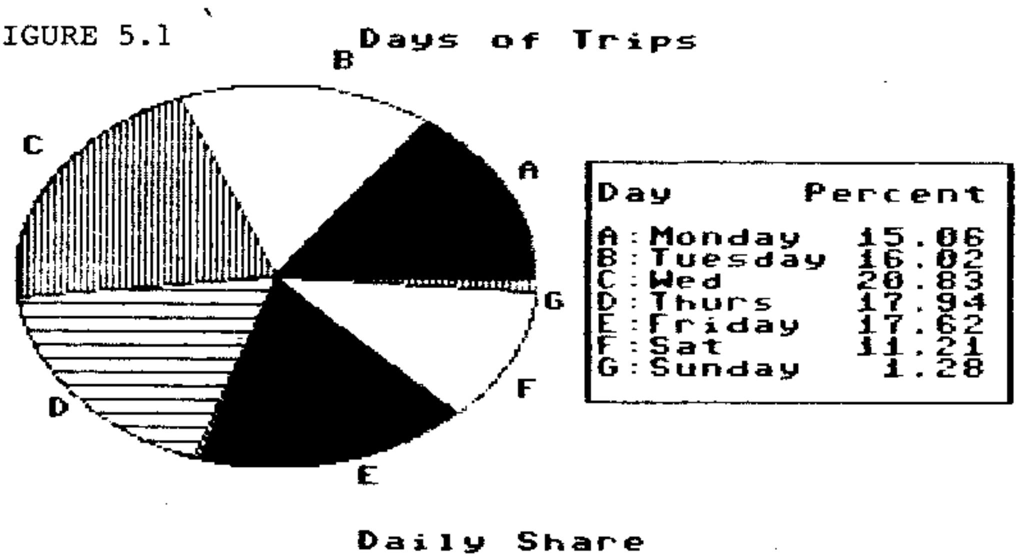
5.2 BRADFORD PEVERELL - NON-RAIL RESULTS

All the Bradford Peverell results stated below represent the sample population. It should be noted that all the histograms presented below have a uniform vertical scale so that the magnitude of the desired trips can be compared across the various charts. With all these diagrams one must realise that the grouping of the data necessary for the histograms has resulted in the loss of some detail. It can be seen in the raw data (Appendix V) that the peaks in the charts are often made up of a series of smaller more time- sensitive peaks. The histograms all show the combined results of five Weekdays, one Saturday and one Sunday.

5.2.1 DESIRED TRAVEL TIMES BY DAY (GENERAL):

The pie chart below shows the days of desired trips. It is clear that Wednesday is the most popular day for trips overall. This is as expected as Wednesday is market day in Dorchester. Thursdays and Fridays follow as the next busiest days with Tuesdays and Mondays following shortly behind respectively. The most surprising thing about these results is the smaller share of trips on Saturdays. Sundays have only just over 1% of the trips for the whole week.

FIGURE 5.1

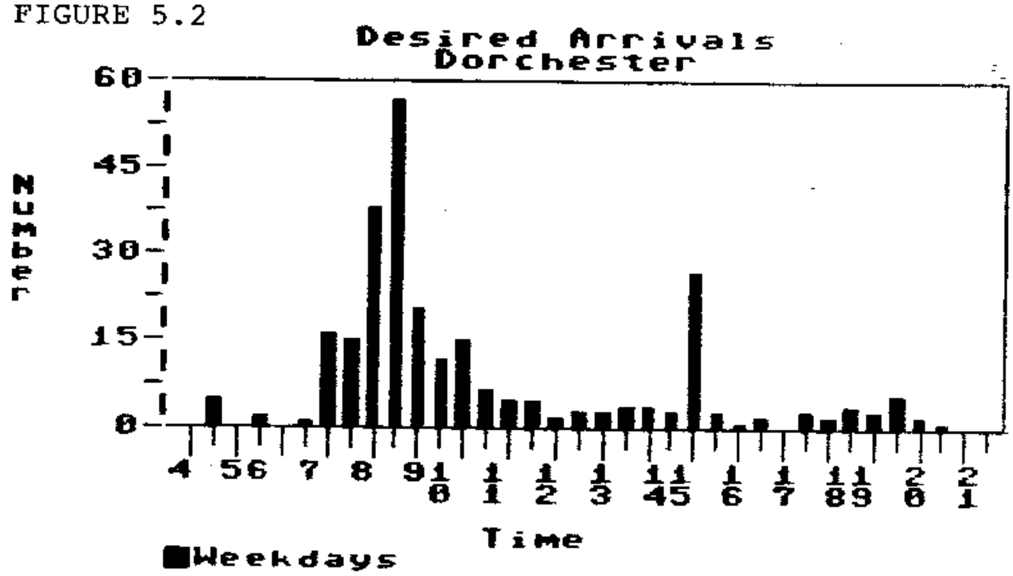


5.2.2 DESIRED TRAVEL TIMES BY DAY (OUTWARD):

Firstly we shall deal with the desired travel times for each day. Desired travel times are sub-divided into Weekdays, Saturdays and Sundays. Unfortunately the Sunday figures are of little use as only 4 of 151 desired trips were on Sundays, this does show that there is little demand for Sunday travel to Dorchester.

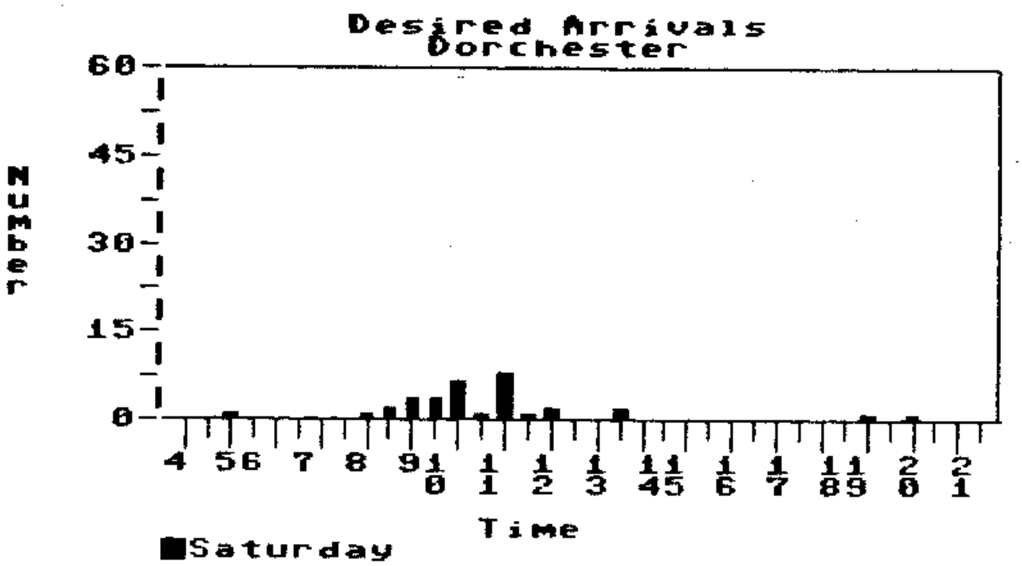
Figure 5.2 shows the desired times of arrival in Dorchester on weekdays. This diagram shows the expected peak between 7.00 and 10.30, it also illustrates evidence of peaks within the peak. There is also another significant peak at about 15.00. This latter peak is a result of parents going in to town to collect their children from school, this figure may be distorted by the way the questionnaire was structured which did not allow for children to be dropped off - expecting them to travel out and back with their parents.

FIGURE 5.2



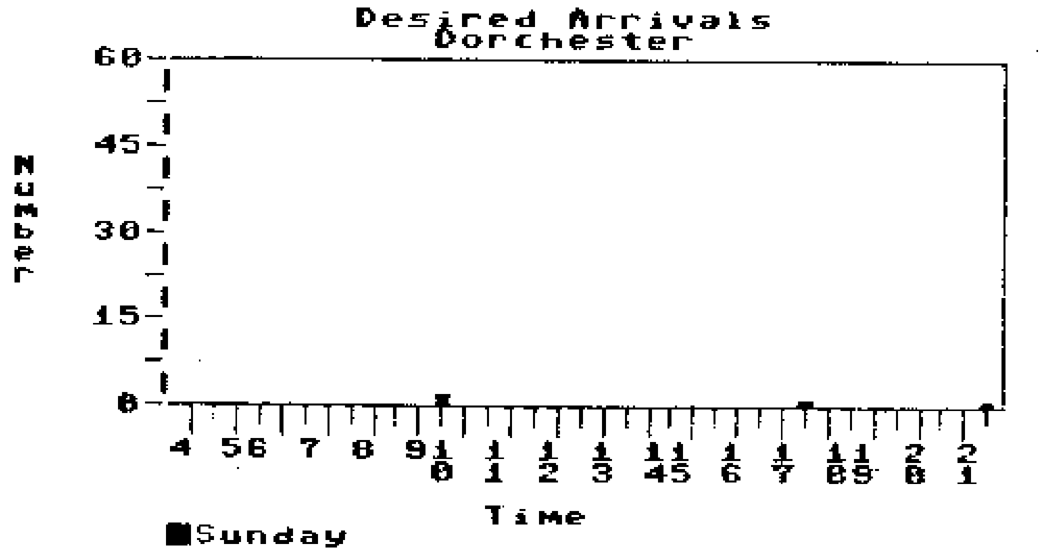
Arrivals on Saturdays show peaks at 10.00 and 11.00.

FIGURE 5.3



As already mentioned the Sunday arrival figures are of little use.

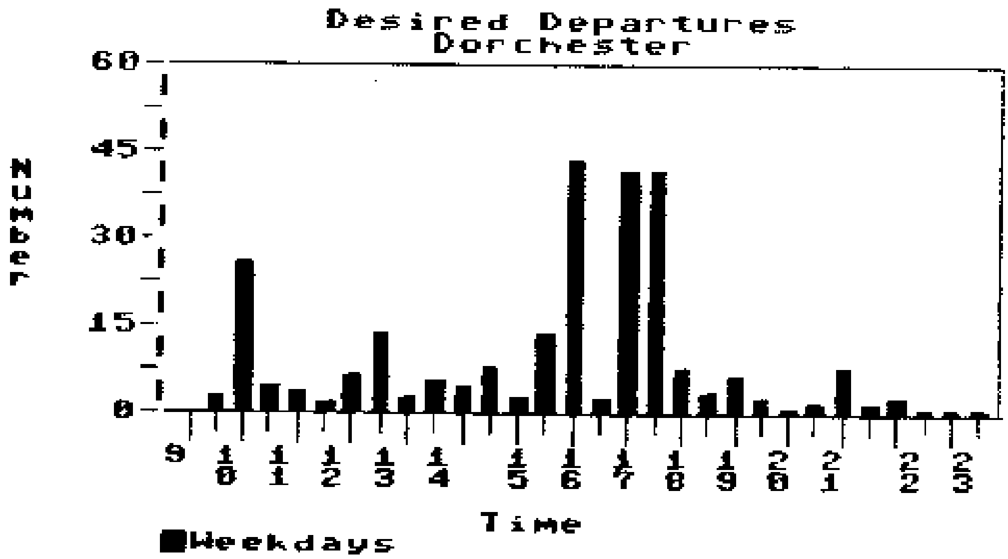
FIGURE 5.4



5.2.3 DESIRED TRAVEL TIMES BY DAY (RETURN):

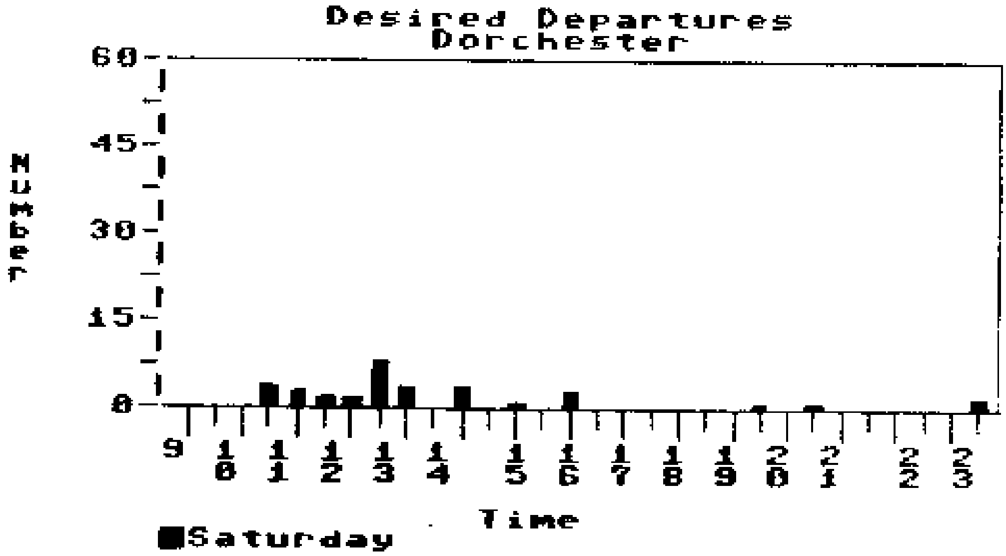
The desired departure times on Weekdays show a peak at 10.00 which is again due to the problems with the school trips. Then there are peaks at 12.30, 16.00 and 17.00 to 17.30. The major peaks are in the latter periods.

FIGURE 5.5



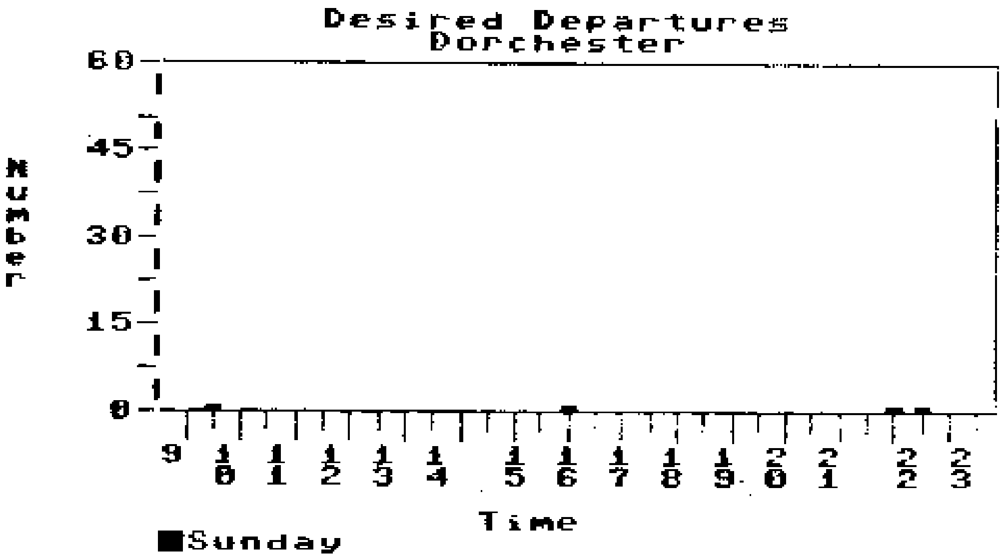
The desired departures for Saturdays show a small peak at 12.30 and surprisingly no times were mentioned around 17.00. This suggests that return timings are more dispersed on Saturdays than on Weekdays.

FIGURE 5.6



Sunday departure times are again not significant.

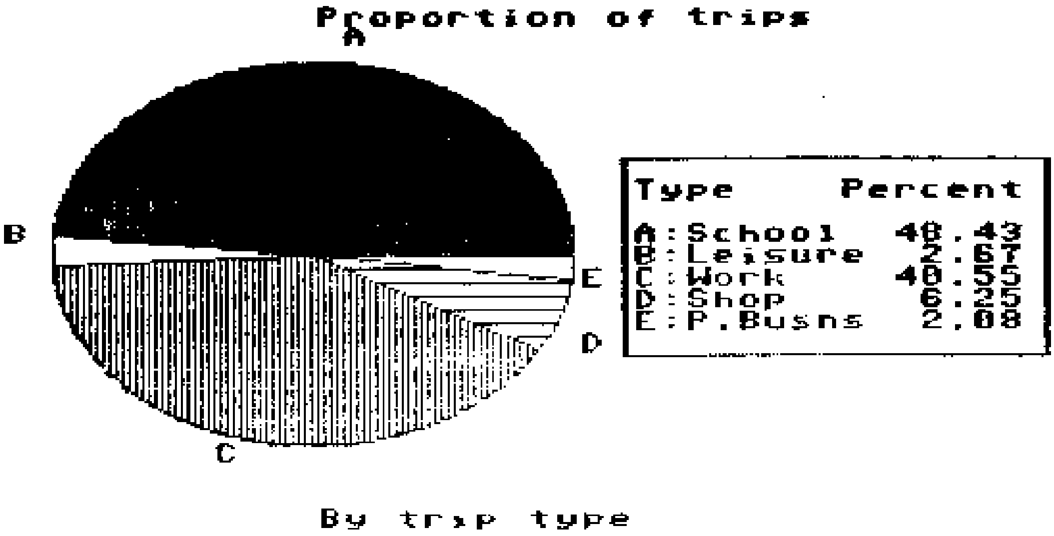
FIGURE 5.7



5.2.4 DESIRED TRAVEL TIMES BY TRIP TYPE (GENERAL):

The pie chart below shows the proportion of trips by trip type. This shows that school (exaggerated) and work trips dominate, these are followed by shopping trips. Personal business and leisure trips would be made least often if desired travel patterns were realised.

FIGURE 5.8

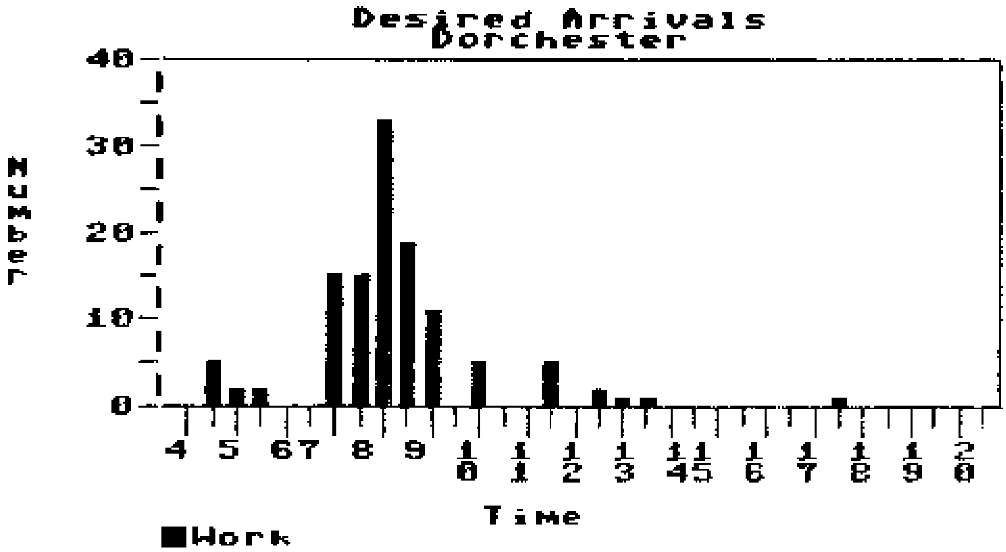


5.2.5 DESIRED TRAVEL TIMES BY TRIP TYPE (OUTWARD):

These results are more interesting. Trip types were broken down into five categories: work, shopping, leisure, school and personal business.

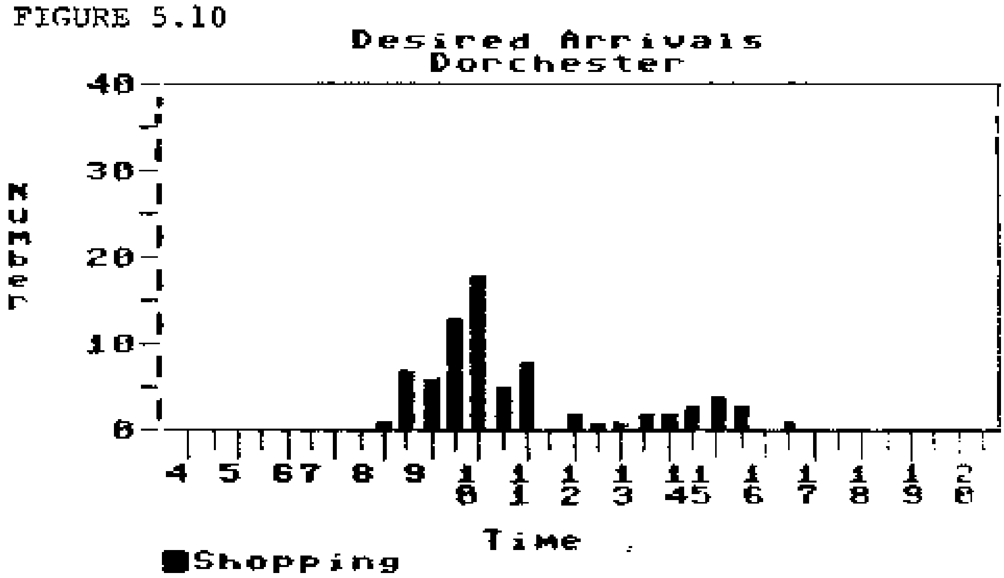
For outward work trips there is a significant peak between 7.00 and 9.00. There are then further smaller peaks at 10.00, and 11.30.

FIGURE 5.9



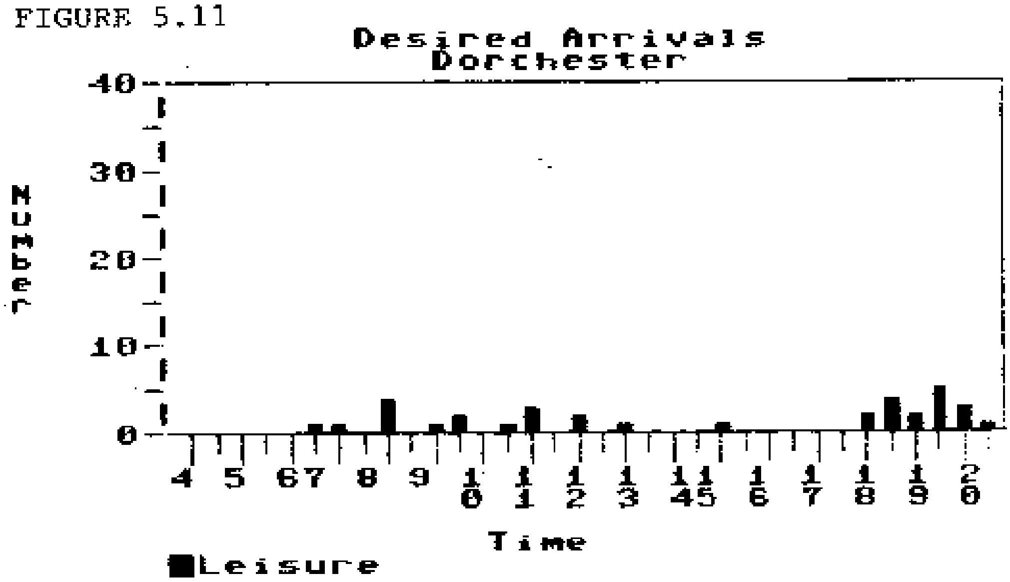
For outward shopping trips there is a peak between 8.30 and 11.00 with peaks within this. There is also a dispersed arrival in Dorchester during the afternoon.

FIGURE 5.10



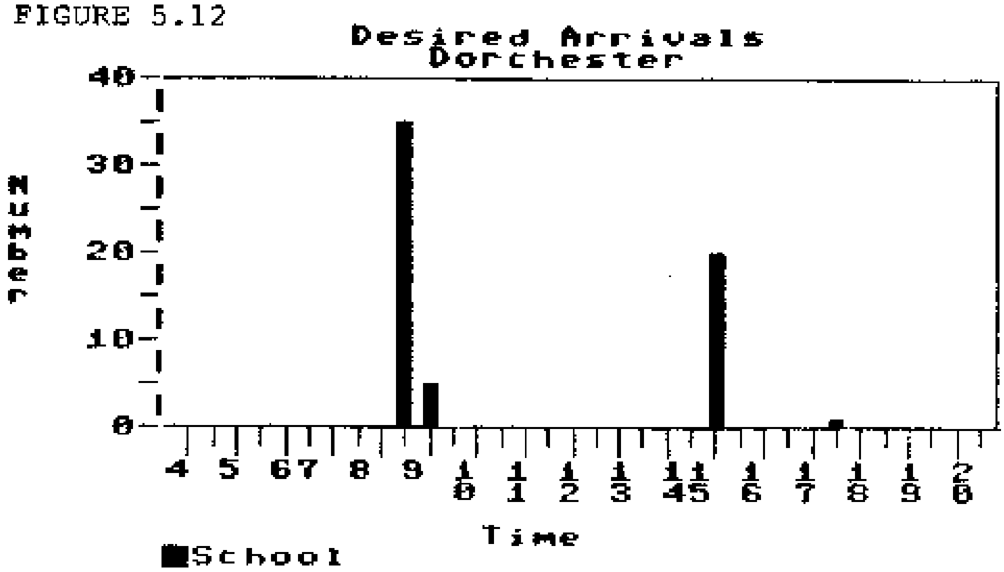
Outward leisure trips appear to have no real peaks seeming to be spread fairly evenly throughout the day. The most concentrated period is between 18.00 and 20.30.

FIGURE 5.11



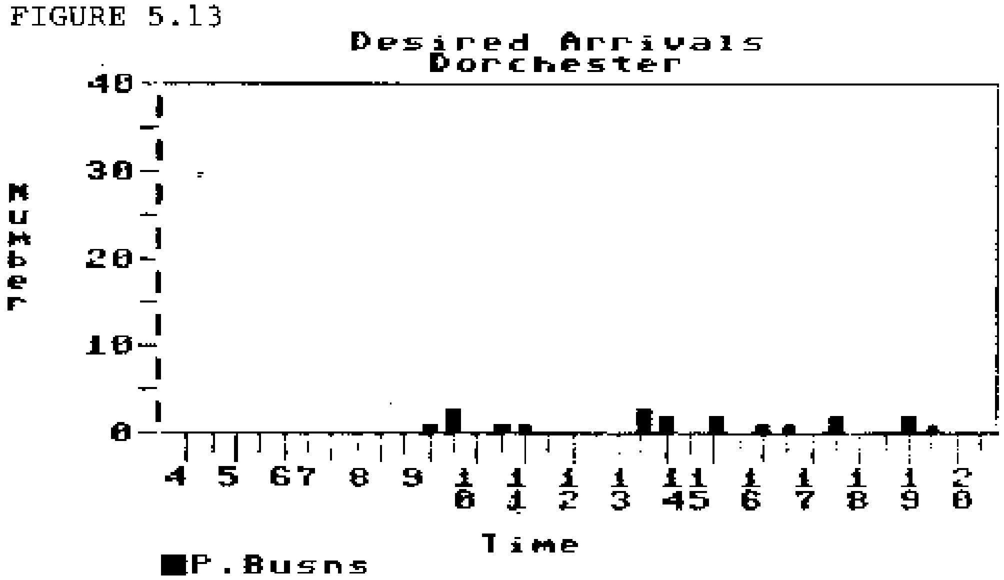
Outward school trips are the most peaked of all the activities with 8.30 being the most popular time desired for an arrival in Dorchester. The peak in the afternoon is exaggerated by an imperfection in the questionnaire.

FIGURE 5.12



Personal business trips are fairly dispersed but are concentrated between 9.00 and 19.30. There is a gap in the desired arrivals at lunchtime.

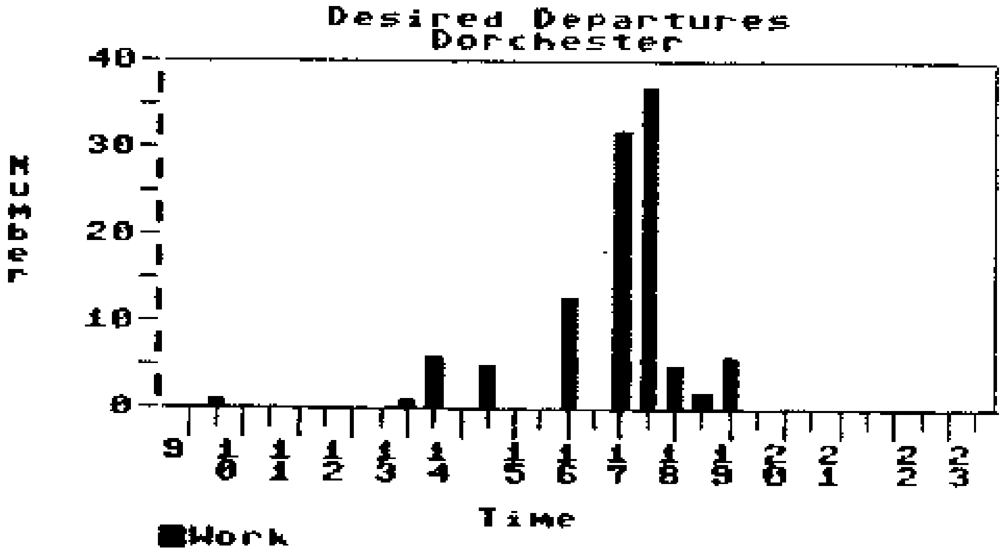
FIGURE 5.13



5.2.6 DESIRED TRAVEL TIMES BY TRIP TYPE (RETURN):

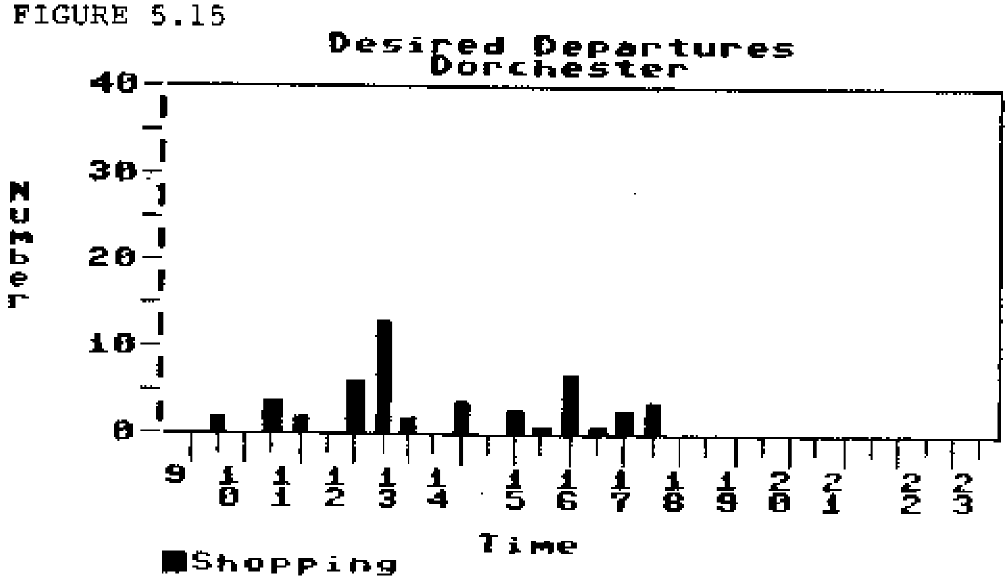
Desired departures from Dorchester for work trips show an expected peak at 17-17.30. There are smaller peaks at 13.30 and between 18.00 and 19.00.

FIGURE 5.14



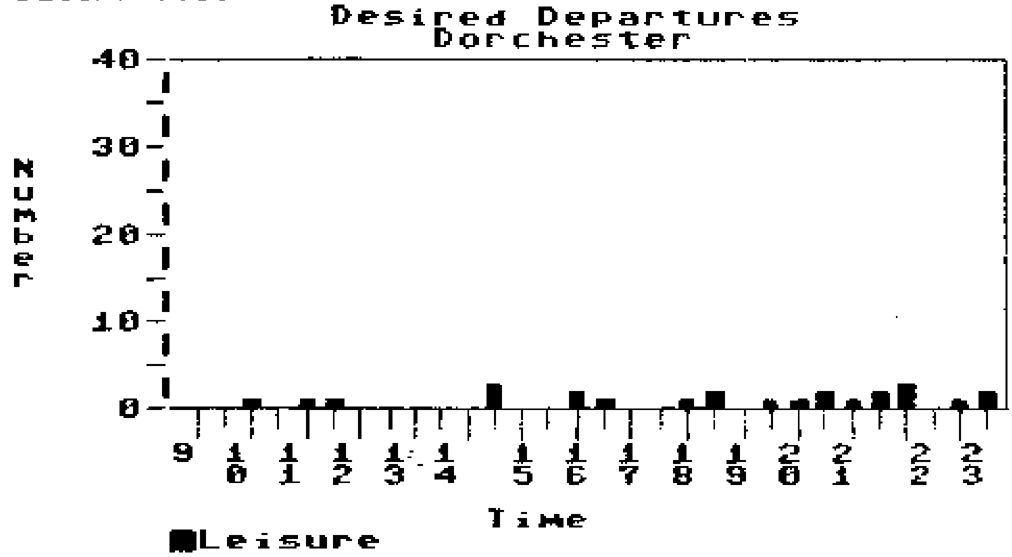
Desired departures for shopping trips show the major peak at 12.30, these return trips are generally dispersed but are concentrated between midday and 17.30.

FIGURE 5.15



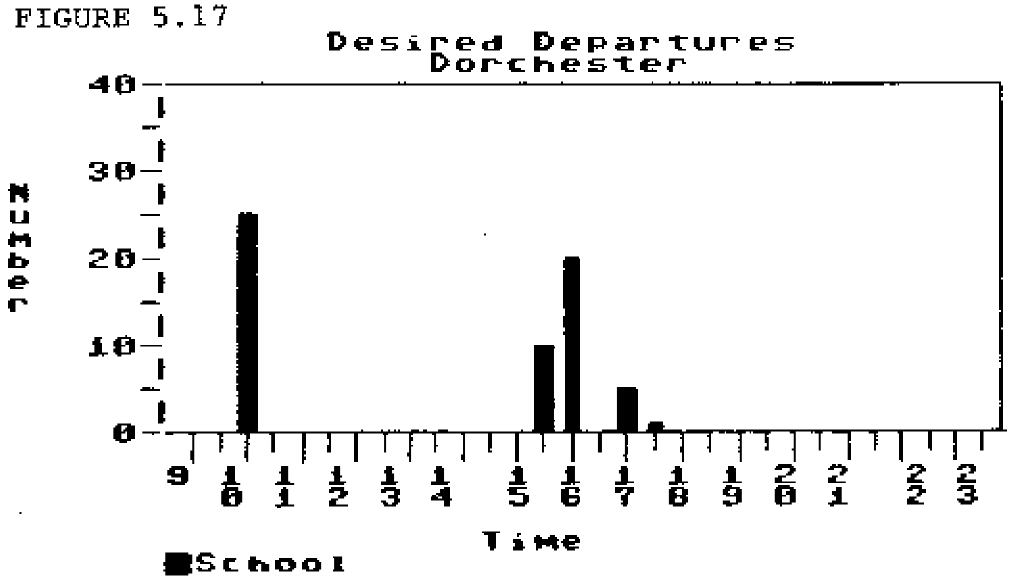
Return leisure trips are again dispersed throughout the day with the main concentration between 19.30 and 22.00. These are times when it is often difficult to use public transport and the low concentration of these figures suggests why.

FIGURE 5.16



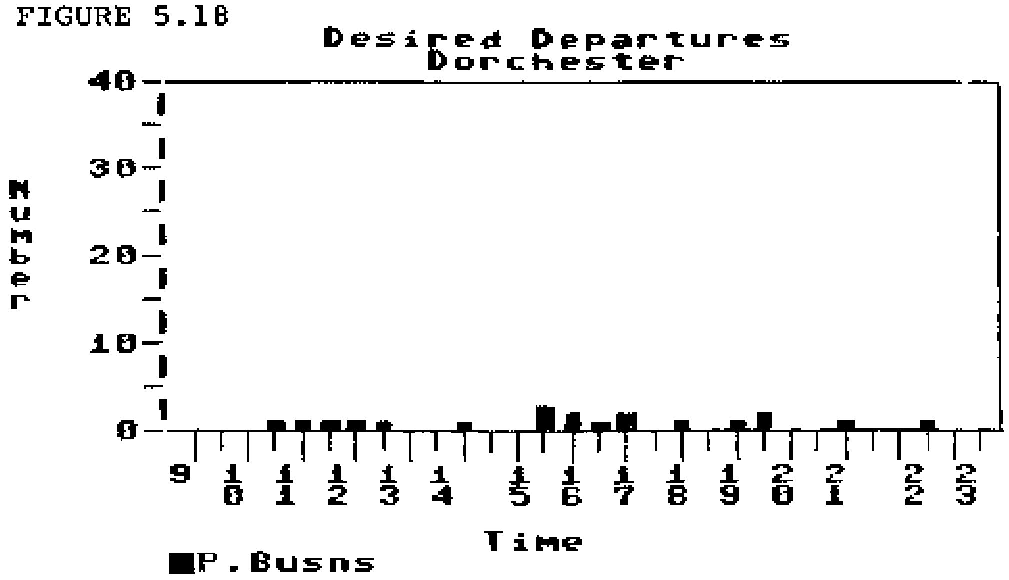
Return school trips again suffer from the distortion caused by the questionnaire, but they do show that there is more deviation in return times than in outward times. There are two possible explanations for this. The first is the obvious one that schools do not all finish at the same time. Secondly from looking more closely at the questionnaires, it appear that some of the adults who pick up children from school would use the opportunity to do some shopping afterwards. This may partly explain the lack of trips on Saturdays.

FIGURE 5.17



Return personal business trips are very dispersed and with a low volume. The only real concentration occurs between 15.30 and 17.00.

FIGURE 5.18



5.2.7 DESIRED TIME DURATION IN DORCHESTER:

The final set of results obtained from the non-rail survey should also have some application on the railway. From the times given by the respondents it is possible to establish the amount of time they would like to spend in the origin. This has been done for each trip type. The results are presented in the table below.

TRIP TYPE	IDEAL TIME	STANDARD DEVIATION
Work	8h 44 Mins	2h 30 Mins
Shopping	2h 26 Mins	1h 04 Mins
Leisure	3h 35 Mins	2h 35 Mins
School	2h 44 Mins	2h 51 Mins
Personal Business	1h 54 Mins	46 Mins

These results seem plausible though the standard deviations are quite large for all of the trips. School trips again give inaccurate results, though it is obvious what the desired duration of a school trip should be. There are a number of factors that may have increased the standard deviations associated with each trip type. For work trips the combination of full-time and part time work could be partly responsible. School trips are distorted by parents picking up and dropping off children. There are so many types of leisure activity there is bound to be a large dispersion of desired times at the activity - this is true to some extent for all the trips mentioned. The final difficulty with the times given is that some trips had multiple purposes - such trips were classified according to what appeared to be the main activity involved and this inevitably involved some distortion.

5.3 ON-VEHICLE INTERVIEW RESULTS

It was clear from about ten interviews that asking passengers about their immediate response to an adjustment in the timetable would not be successful. People needed time to rearrange their personal activities after a frequency reduction. So an immediate reduction in frequency would take some time to have an effect on patronage while passengers adjusted their travel patterns. It could be argued that such lagged effects would be equally likely after an increase in frequency and to some degree this might be the case. All the frequency model questionnaires deal with an immediate response which may be greater or smaller than the longer term effects. It may be that people will make extra trips in the immediate term because of the 'novelty value' of a better service, this effect wearing off after a few weeks. Conversely it is possible that people may adjust their living patterns to the rail service over a longer period perhaps deferring the purchase of a replacement (or second) car. So when considering the results of an increase in frequency it must be remembered that we are dealing with immediate term effects.

Nevertheless it was clear that with a frequency reduction (apart from the possibility of some form of protest) there would generally be a smaller reduction in patronage in the short term than in the longer period. The semi-structured interviews showed that some trips had to be made by train in the short term (workers with no alternative mode) but in the longer term either the location of the home or activity would be changed or an alternative means of making the journey would be found.

Another interesting finding from both on-vehicle and general interviews was the phenomena of the times of activities being arranged around the train timetable. It was found on a number of occasions that passengers had fixed the times of their appointments after checking the train times to find the most suitable time. Such activities were common among personal business trips, ie appointments.

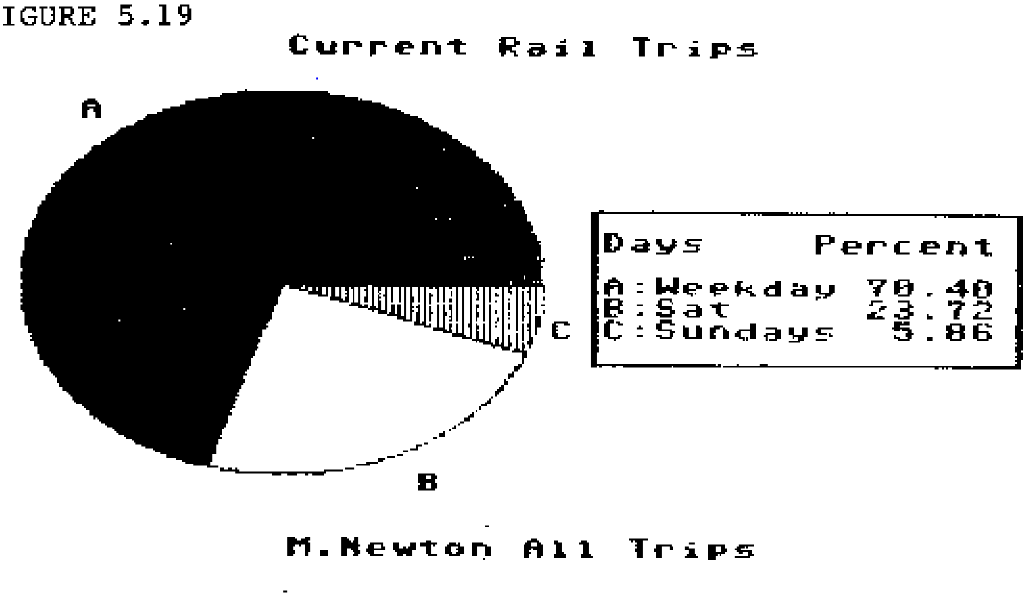
5.4 YETMINSTER AND MAIDEN NEWTON GENERAL RESULTS

These results form the main part of the thesis the earlier results were intended to produce background information about desired travel times and the effects frequency had on individuals. It should be noted that when the term weekdays is used this refers to the trips that would be made over a typical set of five weekdays, ie this is not an average weekday, but the sum of an average Monday-Friday. This grouping of weekdays had to be done for simplicity and does hide some variation between the days. This is illustrated in the Bradford Peverell results discussed above.

5.4.1 CURRENT TRIPS:

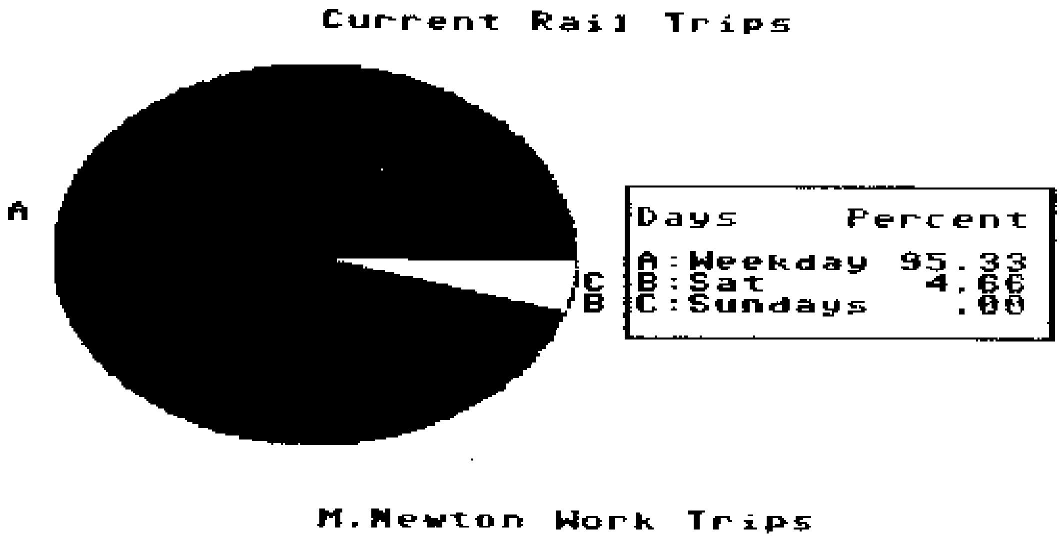
Looking at the trips that are currently made. For Maiden Newton it is clear that the five weekdays account for most of the traffic, however, Saturdays account for nearly 1/4 of all trips. For Sundays the proportion is about 1/20 of total trips.

FIGURE 5.19



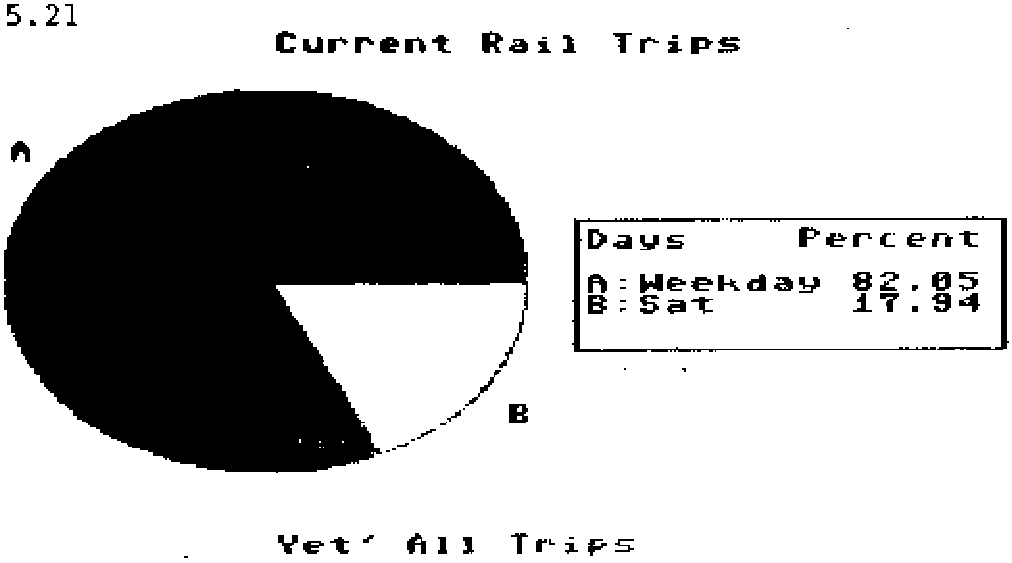
For work trips weekdays account for all but 5% of the current traffic.

FIGURE 5.20



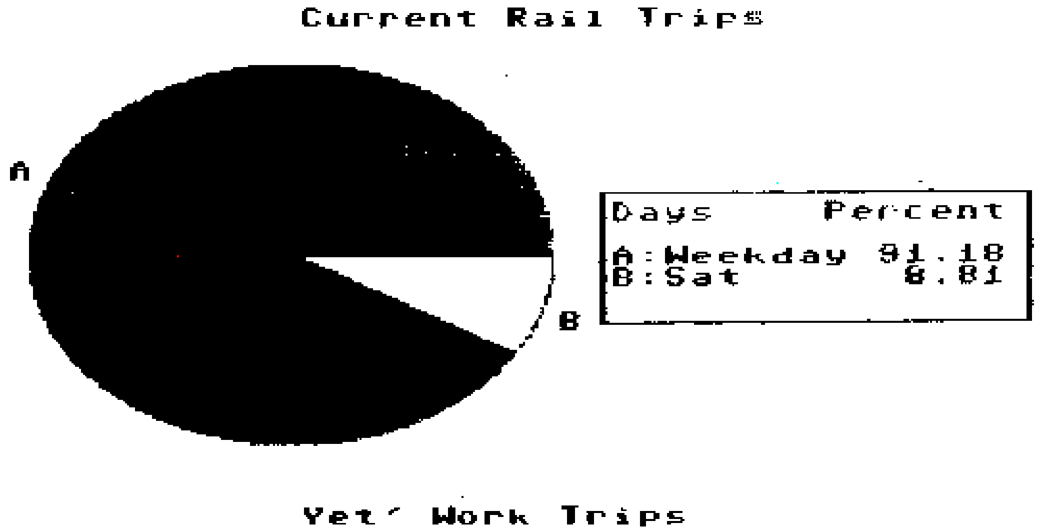
In Yetminster the five weekdays are more dominant. Saturdays are approximately equivalent to an average weekday. Sundays are not present as there is no Sunday service.

FIGURE 5.21



For work trips weekdays have the greatest share though Saturdays have a greater proportion than in Maiden Newton.

FIGURE 5.22



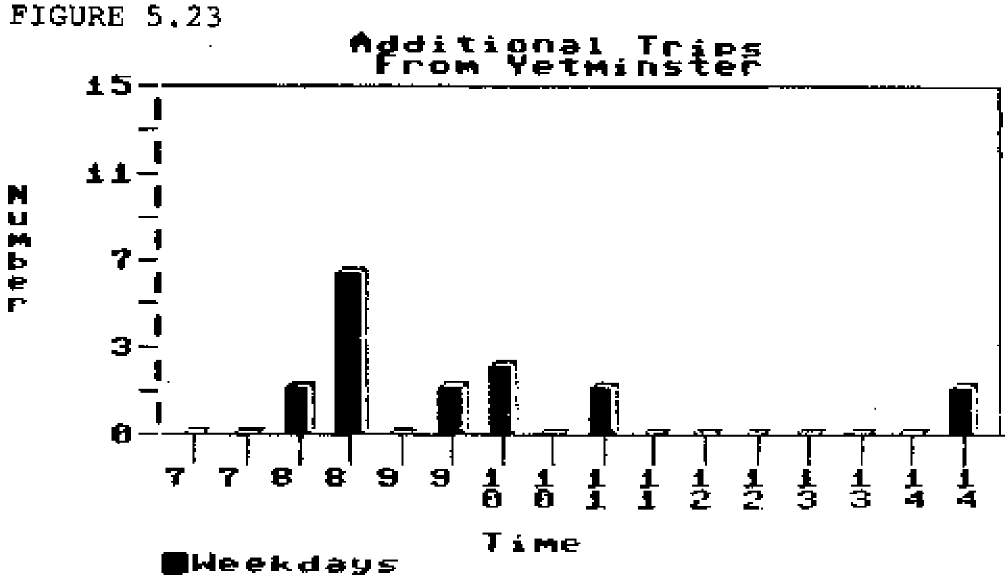
5.4.2 TIMING OF ADDITIONAL TRIPS (GENERAL):

Now we look at the additional trips people stated they would make if the train times were more convenient to them. Most of the extra trips were on weekdays in both villages.

5.4.3 TIMING OF ADDITIONAL TRIPS (YETMINSTER):

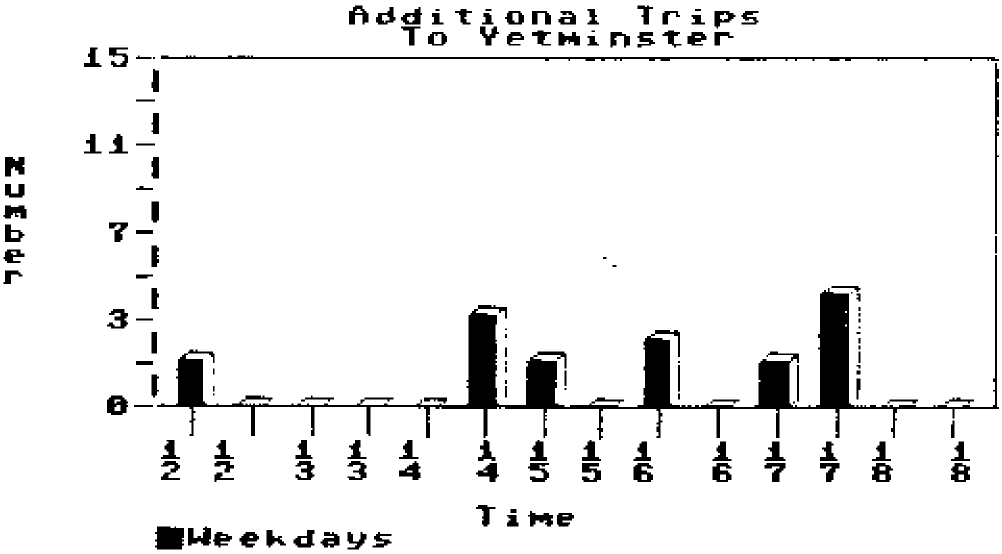
For Yetminster the most popular times for extra outward journeys were at about 8.45 and 10.00.

FIGURE 5.23



The most popular return times were around 14.30 and 17.45.

FIGURE 5.24



All the above trips would be made on weekdays as no extra journeys were indicated on any other day. For Yetminster 18 possible additional trips were mentioned by 108 people (all figures for the last 7 days). 61.11% of the extra trips were stated as definite the remainder being possible. 61.11% of new trips were stated as specific in the times people had in mind, the remainder being non-specific. The distribution of the number of extra trips that would be made at each time, stated by an individual, is shown in the table overleaf.

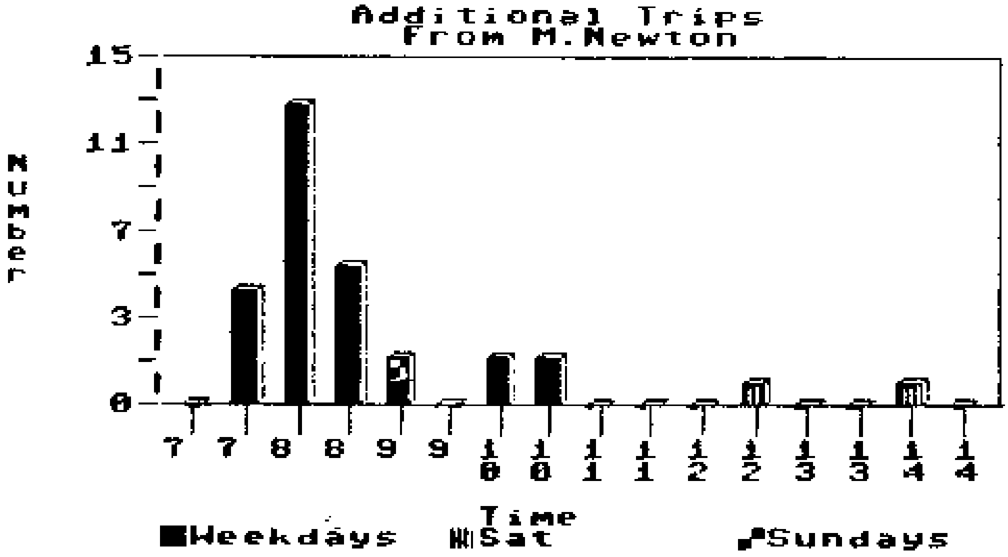
For 8 stated times.

STATED NUMBER OF TRIPS	COUNT	%
1 at each time	3	37.50%
2 at each time	5	62.50%
5 at each time	1	12.50%

5.4.4 TIMING OF ADDITIONAL TRIPS (MAIDEN NEWTON):

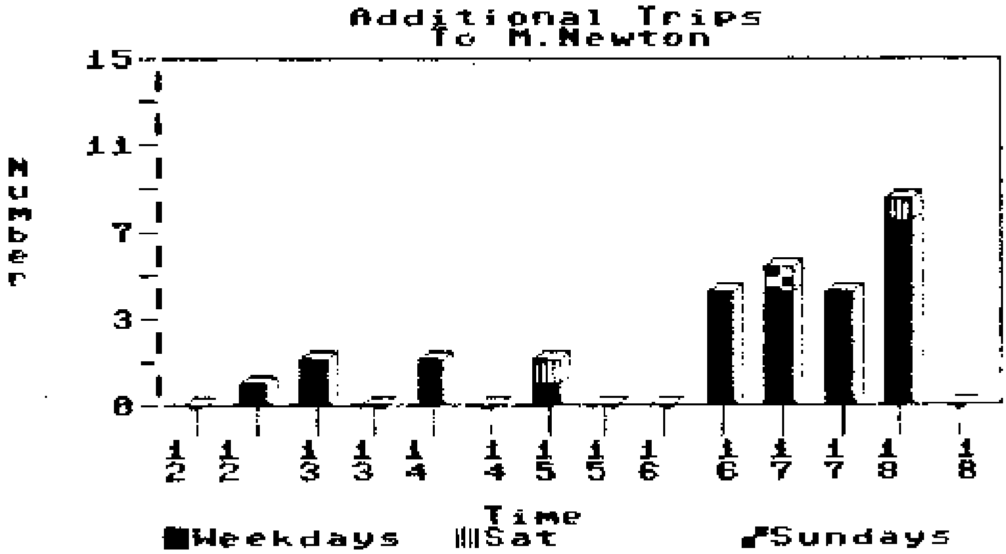
The most popular arrival times in Dorchester were at 8.15, 7.45 and 8.45. This illustrates the exact timing of work trips. The small number of additional trips on Saturdays and Sundays may make the results unreliable when looked at separately but arrivals on Saturday were at 12.30 and 14.00. On Sunday it was 9.00.

FIGURE 5.25



Departure times from Dorchester on weekdays have peaks at approximately 17.00 and 17.50. On Saturdays the additional trips were at 15.00 and 18.00. The sole Sunday trip was at 17.00.

FIGURE 5.26



For Maiden Newton 90.63% of the extra trips would have taken place on weekdays, with 3.13% on Sundays and 6.25% on Saturdays. 68.75% of the stated additional trips were of a specific nature the rest being non-specific. 68.75% were defined as definite trips the rest being possible. The table below shows the numbers of extra trips given by each person at each time. If this table is compared to the table for Yetminster it is clear that the more of the stated times in Maiden Newton involved only one trip. It is also shown that a greater proportion in Maiden Newton stated that they would make 5 trips at the stated time. The mean number of trips per stated time is 2.25 in Yetminster and 2.29 in Maiden Newton.

For 14 stated times.

NUMBER OF TRIPS	COUNT	%
1 at stated time	9	64.29%
3 at stated time	1	7.14%
5 at stated time	4	28.57%

5.4.5 ACCEPTABLE TIME RANGES FOR ADDITIONAL TRIPS:

This section looks at the range of times people would allow around the ideal times of their extra trips. These ranges represent the amount of time a train can be later or earlier than a desired time, with the respondent still using the train for that trip. The allowances assume no other adjustment is required. The time allowances were looked at in a merged data set (to give more representative estimates) from both Yetminster and Maiden Newton. Calculations were done for both specific and non-specific trips.

The initial estimates for trips stated as being 'specific' were not as expected, this was found to be as a result of appointments that were arranged around the train times. People making such trips did have a specific time in mind, when making the trip, but they could have travelled at a wide range of times thus giving specific trips a wider range than they should have. These 'arranged' trips should have been included as non-specific trips as when these trips are planned the most important concern is with the duration of the appointment - the exact times being flexible. To eliminate the error from the specific results only trips that would have been made regularly have been included. This means we are only looking at trips made more than twice a week and that were stated as specific. The results are shown in the tables below.

RANGE STATISTICS: Total trips = 60

SPECIFIC TRIPS: From 30 readings

<u>Outward Trips</u>

Early allowance:
Mean 16.33 Mins   Standard deviation 4.07 Mins

Late allowance:
Mean 4.67 Mins   Standard Deviation 1.25 Mins

<u>Return Trips</u>

Early allowance:
Mean 2.59 Mins   Standard deviation 5.67 Mins

Late allowance:
Mean 21.38 Mins   Standard Deviation 8.50 Mins

These results clearly show that for specific (mainly work) trips there is an aversion leaving later on the outward trip and leaving earlier on the return trip. This is not surprising when one considers the nature of the activity.

NON-SPECIFIC TRIPS: From 17 readings

<u>Outward Trips</u>

Early allowance:
Mean 31.76 Mins Standard deviation 26.23 Mins

Late allowance:
Mean 27.35 Mins Standard Deviation 30.15 Mins

<u>Return Trips</u>

Early allowance:
Mean 26.47 Mins Standard deviation 20.27 Mins

Late allowance:
Mean 32.65 Mins Standard Deviation 27.34 Mins

Non-specific trips only include those trips stated as such - they do not include the 'arranged' appointments excluded from the specific analysis above. For non-specific trips there is a consistency between all the ranges suggesting that potential passengers are fairly flexible in their timing allowing about 1/2 an hour of adjustment. It is also clear that non-specific trips are more flexible and there is a wider variation in their limits.

5.4.6 TOTAL STATED TRIPS:

The table overleaf shows the total number of trips stated by respondents.

VILLAGE	MEAN NUMBER OF TRIPS	STANDARD DEVIATION	TOTAL TRIPS
Maiden Newton	0.33	1.07	32
Yetminster	0.17	0.76	18

It is interesting that the mean number of trips is considerably higher in Maiden Newton than in Yetminster. This is unexpected as Yetminster has a worse service than Maiden Newton. The general comments picked up in the village gave the indication that the service had reached such a poor level in Yetminster that they regarded it as a lost cause. A number of people stated that popular trains had been withdrawn recently from the timetable. One train in particular was singled out on a number of occasions, this being a 10.00 to Dorchester.

5.4.7 CURRENT TIMETABLES AND TRAVEL DETERRENCE:

The next piece of analysis looks at the extent to which the current timetable puts people off using the train service. This is shown in the table below for each village.

EXTENT PUT-OFF	YETMINSTER	%	MAIDEN NEWTON	%
CONSIDERABLY	7	6.7	3	3.2
SLIGHTLY	14	13.3	10	10.5

NOT REALLY	15	14.3	14	14.7
NOT AT ALL	69	65.7	68	71.6

Generally the results show that over the whole population the frequency of the rail service is not seen as a major deterrent to its use. Some people did state that other factors were of greater importance, the most common reason given was the walking from the stations to the destination - this comment was especially common on the Yetminster-Yeovil route as Yeovil Pen Mill station is badly sited with respect to the town centre. The other comments were about the bad condition of the rolling stock. The table appears to suggest that people in Yetminster feel more constrained by the current timetable than people in Maiden Newton, which would be the expected result as the latter village has a better service. To test whether the Yetminster figures show a greater restriction on travel patterns the Kolmogorov-Smirnov test was used.

A null hypothesis was constructed, being that there is no significant difference between the degree of train travel deterrence felt, as a result of the current timetable, by residents in Maiden Newton and in Yetminster. The value of the statistic was 0.74 which can be compared to a Chi-Squared table (with two degrees of freedom) to test its significance. The one tailed version of this test showed that the null hypothesis could not be rejected and so there was no difference between the two data sets that could not have been the result of chance factors.

5.4.8 RELATING PERSONAL CHARACTERISTICS TO ADDITIONAL TRIPS:

An attempt was now made, using regression statistics, to see if there was any relationship between personal characteristics and the number of stated extra trips. For the regression the data sets for the two villages were merged to give a larger sample size. It was hoped that a predictive model could be built on this basis. Altogether there were five personal characteristics that could be used in the analysis (income, whether someone was employed or not, age, number of cars in the household and number of children the respondent had under 14).

For this analysis figures for income had to be estimated from the occupations given by the respondent. This exercise proved to be difficult, the approximate incomes were gleaned from the 'IDS Pay Directory', the edition available to me was a couple of years out of date and so the figures were updated by the index of wage inflation. There are two main errors in these calculations, firstly occupations were often not described precisely enough and so the income associated with a person will be just the average for that sort of job. Secondly not all jobs will have risen by the rate of wage inflation. A good example of a difficult occupation would be 'farmer'. The income results must therefore be treated with some reservation.

Initially all the variables were put into a correlation matrix to check for multi-collinearity. It was found that the 'employed' dummy variable was highly correlated with income and age and so this variable was removed from the analysis. It was also found that most of the independent variables were slightly correlated with each other which will have a small effect on the results. The statistics below show the relationships between the dependent variable (the number of additional trips stated by each respondent) and the five independent variables. The significance of the slope coefficient is given by the 'T' statistic which gives the probability of the slope being greater than (or less than) zero.

VARIABLE	CORRELATION COEFFICIENT	SLOPE	SIGNIFICANCE OF SLOPE
Income	0.0736	0.0014	65%
Employed	0.1640	0.3323	96%

Age	- 0.1722	- 0.1504	98%
Cars	- 0.1287	- 0.1094	80%
Children	0.1161	0.0555	57%

The results above show that personal characteristics do have some effect on whether a person will make extra trips or not. It is possible to say that the older someone is the less frequency elastic will be their demand for rail transport. Similarly the more cars there are in the household the less frequency elastic the occupants will be. Finally someone who is employed is likely to be more frequency elastic than someone who is not. When an attempt was made to combine the variables using multiple regression no satisfactory results were obtained. The best model that was achieved explained only 7% of the variation in the number of additional trips.

5.5 YETMINSTER AND MAIDEN NEWTON FREQUENCY RESULTS

5.5.1 GENERAL:

This is the main part of the analysis where the output of the BR 'Rooftops' model is compared to that of the behavioural model to see whether there is any significant difference between the two.

New timetables were drawn up for each day of the week. Every timetable features all the trains in the current timetable plus some additional ones. Where the number of trains was to be doubled a programme 'doubler' (Appendix VII) inserted new trains exactly halfway between the trains in the previous timetable. The use of this programme means that the number of trains in a doubled timetable is actually twice plus one of the previous timetable*. A number of sets of timetables (Appendix VI) have been developed to enable comparisons of the two models, the are as follows:

NAME	TIMETABLE DESCRIPTION
No 1	The current timetables
No 2	Double the trains of No 1*
No 3	Double the trains of No 2*
No 4	Double the trains of No 3*
No T	Trains added to No 1 at the most popular stated times
No E	One train added to No 1 in the evening, an unpopular stated time

For each of these timetable sets predictions were made from both models. Timetables are compared on the basis of the number of trips generated per week.

5.5.2 BR ROOFTOPS RESULTS:

Firstly we shall deal with the Rooftops model. For the purpose of the analysis this was set up with 'P'=0.4, K=76° and L=45°, this is the standard BR format. Each timetable was input to the Rooftops programme and the average perceived journey times were extracted. The detailed results of these calculations can be seen in Appendix IX.

Outward and return journeys are now combined, they are weighted equally. The table below shows the result of combining outward and return journeys. Figures are presented both for the overall percentage increase in the number of trains run over a week and for the overall percentage reduction in average perceived journey time (both changes are relative to timetable set 1).

Timetable No 1 is not shown as there has been no change.

TIMETABLE	PLACES	% INCREASE IN TRAINS	% REDUCTION IN PERCEIVED TIME
2.Weekdays	Maid/Dor	112.5	44.30
2.Saturday	Maid/Dor	111.76	44.14
2.Sunday	Maid/Dor	120	46.69
2.Weekdays	Yet/Yeo	115.38	60.49
2.Saturday	Yet/Yeo	116.67	59.81
3.Weekdays	Maid/Dor	337.5	64.56
3.Saturday	Maid/Dor	335.29	64.31
3.Sunday	Maid/Dor	360	68.62
3.Weekdays	Yet/Yeo	346.15	80.76
3.Saturday	Yet/Yeo	350	80.38
4.Weekdays	Maid/Dor	787.7	74.09
4.Saturday	Maid/Dor	782.35	73.79
4.Sunday	Maid/Dor	840	79.04
4.Weekdays	Yet/Yeo	807.69	88.41
4.Saturday	Yet/Yeo	816.67	88.34
T.Weekdays	Maid/Dor	18.75	6.16
T.Saturday	Maid/Dor	5.88	3.60
T.Sunday	Maid/Dor	20	7.82
T.Weekdays	Yet/Yeo	38.46	4.11
T.Saturday	Yet/Yeo	16.67	1.81
E.Weekdays	Yet/Yeo	7.69	44.87*
E.Saturday	Yet/Yeo	8.33	42.11*

*Note timetable 'E' combines the extra evening outward service with the original return service from Yeovil.

These results are now aggregated into weekly figures, this is done by taking a weighted average of the figures given (ie weekdays are five times Saturday or Sunday). This means that frequency increases are treated equally no matter which day they occur. However this is not too great an assumption as the percentage increase in the number of trains and reduction in perceived journey times varies little between days. It is also very unlikely that BR would be able to dis-aggregate its patronage data by day of the week and as this is the BR model this is the correct way to proceed.

TIMETABLE	PLACES	% INCREASE IN TRAINS	% REDUCTION IN PERCEIVED TIME
2	Yet/Yeo	115.60	60.38
3	Yet/Yeo	346.79	80.70
4	Yet/Yeo	809.19	88.40

T	Yet/Yeo	34.83	3.74
E	Yet/Yeo	7.80	44.41
2	Maid/Dor	113.47	44.62
3	Maid/Dor	340.40	65.10
4	Maid/Dor	794.41	74.75
T	Maid/Dor	17.09	6.03

The Rooftops model has converted the waiting and journey time involved in each journey into a measure of the average equivalent journey time. This means that journey time elasticities can be used on the output from the Rooftops model to predict the effect on patronage of changes in the frequency of a service.

To continue with the estimation of the additional trips generated by the timetable improvements it is necessary to get some idea of the actual passenger flows between both of the origin-destinations, during a week representative of the survey period. BR were able to provide me with the following information on patronage. The annual flow between Maiden Newton and Dorchester is: 1,672 passengers. The annual flow between Yetminster and Yeovil is: 730 passengers. 110 of the latter passengers were travelling in June (the nearest month available to the survey) this is approximately 27.5 passengers per week during this period and represents 3.767% of the annual flow. As no June figures were available for the Maiden Newton trips I have assumed that there is the same seasonal variation (which seems reasonable as both villages are similar in size and character - being on the same line). The result of this is that 63 trips per week are expected to have been made on the Maiden Newton-Dorchester run.

We now have a base number of trips for the period of the survey on which to calculate the frequency elasticities. Before the elasticities can be calculated it is necessary to know the proportion of current trips that are to/from work. This is because journey time elasticities are different for work and non-work trips. The proportion of work trips can be established from the questionnaire and is, for Yetminster 43.62%, while for Maiden Newton it is 45.57%. The recommended journey time elasticities are -0.8 for leisure trips and -0.3 for work trips. Weighting these figures by the proportion of each trip gives an overall journey time elasticity of 0.5819 for Yetminster and 0.57215 for Maiden Newton. These values are inputted to the equations below to produce the total number of trips per week for any timetable improvement.

$$\text{Elasticity with respect to journey time} = \frac{\text{\% Change in trips}}{\text{\% Change in equivalent journey time}}$$

This equation is rearranged for the analysis to give the one.
below.

$$\text{\% Change in trips} = \text{\% Change in equivalent journey time} * \text{Elasticity with respect to journey time}$$

% Change in trips

```
Elasticity with respect    =   -----------------------
       to frequency              %  Change in number of
                                    trains per week
```

Using the equations above the following table of results was constructed for the BR Rooftops model.

TIMETABLE	PLACES	TOTAL TRIPS	% INCREASE IN TRIPS	ELASTICITY
1	Yet/Yeo	27.5	0	Zero
2	Yet/Yeo	37	35	- 0.30
3	Yet/Yeo	40	46.96	- 0.14
4	Yet/Yeo	42	51.44	- 0.06
T	Yet/Yeo	28	2.18	- 0.06
E	Yet/Yeo	35	25.84	- 3.31
1	Maid/Dor	63	Zero	
2	Maid/Dor	79	25.53	- 0.22
3	Maid/Dor	86	37.25	- 0.11
4	Maid/Dor	90	42.77	- 0.05
T	Maid/Dor	65	3.45	- 0.20

5.5.3 MARKET RESEARCH RESULTS:

The alternative estimates from the market research model are now given. For each of the timetables used with the Rooftops model a set of results have been calculated using the T.Calc programme. Two sets of predictions for the market research model have been produced, these are:

1. All stated trips are made as long as train times are within the stated ranges (the constant probability assumption). It is on this basis that the questionnaire was designed.
2. The probability of making a trip declines linearly as trains become less conveniently timed. Possible trips are counted as beginning with 1/2 the probability of a definite trip. This approach will give more pessimistic results as the timetable is penalised, even for adjustments that are well within a threshold. The main estimates below are for trips based on the constant probability assumption with a trip being definitely made until the threshold is reached, after this point the trip is definitely not longer made. These estimates have a range of values, the minimum figure represents all the trips that would definitely be made with that timetable, the maximum figure also includes the possible trips.

TIMETABLE	PLACES	---- ADDITIONAL TRIPS ---- MAXIMUM NUMBER OF TRIPS	MINIMUM NUMBER OF TRIPS
1.Weekdays	Maid/Dor	1	0
1.Saturday	Maid/Dor	1	1
1.Sunday	Maid.Dor	0	0

1.Weekdays	Yet/Yeo	2	0
1.Saturday	Yet/Yeo	0	0
2.Weekdays	Maid/Dor	5	2
2.Saturday	Maid/Dor	2	2
2.Sunday	Maid.Dor	1	0
2.Weekdays	Yet/Yeo	11	6
2.Saturday	Yet/Yeo	0	0
3.Weekdays	Maid/Dor	11	7
3.Saturday	Maid/Dor	2	2
3.Sunday	Maid/Dor	1	0
3.Weekdays	Yet/Yeo	11	6
3.Saturday	Yet/Yeo	0	0
4.Weekdays	Maid/Dor	21	12
4.Saturday	Maid/Dor	2	2
4.Sunday	Maid/Dor	1	0
4.Weekdays	Yet/Yeo	18	11
4.Saturday	Yet/Yeo	0	0
T.Weekdays	Maid/Dor	6	5
T.Saturday	Maid/Dor	2	2
T.Sunday	Maid/Dor	1	0
T.Weekdays	Yet/Yeo	13	8
T.Saturday	Yet/Yeo	0	0
E.Weekdays	Yet/Yeo	2	0
E.Saturday	Yet/Yeo	0	0

From making adjustments to timetable 'T' it became clear that work trips were very sensitive to the timing of trains and that an adjustment of only a few minutes in the timing of an additional service could gain or lose 5 or 6 sample trips per week. As work trips occur in the peak this was the period where timing was particularly sensitive. In some cases the results of these additional trains suggested that it would be more productive to re-time some of the trains currently running in the timetable, however, without any specific knowledge of the time sensitivity of current passengers it is difficult to forecast the effects of such a policy.

The next stage is to combine the additional trips produced for each day, to see how many trips would be made in a week. At this point it is also necessary to factor up the number of trips stated by the proportion that the sample is of the population. From the sample size data presented in chapter 4 it can be deduced that the multiplicative factor to be used are, for Maiden Newton 6.82 and for Yetminster 7.09. As we are only dealing with a sample from the population it is important to look at the sample errors as it may be that the people I have selected are dis-proportionately pro-rail. Nevertheless great care was taken in the sampling to minimise that risk.

---- ADDITIONAL TRIPS ----

TIMETABLE	PLACES	MAXIMUM NUMBER OF TRIPS	MINIMUM NUMBER OF TRIPS
1	Yet/Yeo	14	0
2	Yet/Yeo	78	43
3	Yet/Yeo	78	43
4	Yet/Yeo	128	78
T	Yet/Yeo	92	57
E	Yet/Yeo	14	0
1	Maid/Dor	14	7
2	Maid/Dor	55	27
3	Maid/Dor	96	61
4	Maid/Dor	164	96
T	Maid/Dor	61	48

From the above figures we can derive a mean estimate (ie definite trips are treated as having a constant probability of 1 and possible trips having a constant probability of 0.5). These mid range estimates are now added to the current flows.

MEAN TIMETABLE (Yet/Yeo)	ADDITIONAL TRIPS	TOTAL NUMBER OF TRIPS	% INCREASE	ELASTICITY
1	7	34.5	25.45	Infinite
2	60.5	88	220.00	- 1.90
3	60.5	88	220.00	- 0.63
4	103	130.5	374.55	- 0.46
T	74.5	102	270.91	- 7.78
E	7	34.5	25.45	- 3.26

MEAN TIMETABLE (Maid/Dor)	ADDITIONAL TRIPS	TOTAL NUMBER OF TRIPS	% INCREASE	ELASTICITY
1	10.5	73.5	16.67	Infinite
2	41	104	65.08	- 0.57
3	78.5	141.5	124.60	- 0.37
4	130	193	206.35	- 0.26
T	54.5	117.5	86.51	- 5.06

It is clear from the information above that some extra stated trips that would be made using the current timetable. The most likely reason for these trips appearing is that these people have no idea of the current timetable and think that the current train service is worse than it is. This would suggest that just by increasing the public awareness of the timetable the number of trips could be increased in Yetminster by 7 and in Maiden Newton by 10-11.

The size of the two villages is broadly similar and the number of additional trips for any timetable shows little difference, but as Yetminster starts from a lower base the elasticities are approximately double those of Maiden Newton. Although there are more potential stated trips in Maiden Newton, a smaller proportion of these are actually made in the timetables than those stated in the Yetminster survey. This suggests that people are more sensitive to the timing of the service in the former. This sensitivity could be the result of a more competitive public transport environment in Maiden Newton than in Yetminster.

5.5.4 SENSITIVITY TESTS:

This second set of results are produced by modifying the model so that the probability of making a trip is at its maximum if there is a train at the ideal stated time, this then declines linearly as the nearest train becomes less conveniently timed. When the train is at the stated limit the probability reaches zero. The probability of making a trip at the optimum time is given as 1 for definite trips and 0.5 for possible trips.

These diminishing probability figures are shown below. Using this approach the number of additional trips predicted is reduced by approximately two thirds.

TIMETABLE (Yet/Yeo)	ADDITIONAL TRIPS	TOTAL NUMBER OF TRIPS	% INCREASE	ELASTICITY
1	0	27.5	Zero	Zero
2	13	40.5	47.27	- 0.41
3	31	58.5	112.73	- 0.33
4	59	86.5	214.55	- 0.27
T	15	42.5	54.55	- 1.57
E	0	27.5	Zero	Zero

TIMETABLE (Maid/Dor)	ADDITIONAL TRIPS	TOTAL NUMBER OF TRIPS	% INCREASE	ELASTICITY
1	3	66	4.76	Infinite
2	19	82	30.16	- 0.24
3	28	91	44.44	- 0.13
4	45	108	71.43	- 0.09
T	10	73	15.87	- 0.93

Now estimates are produced taking account of the sample error. These estimates are based on the mean values of extra trips identified from the constant probability assumption. The range of estimates is produced by looking at the standard error of the means as a result of sampling. The finite correction factor is applied as the sample size represents a significant (more than 5%) proportion of the population. The results are shown below. This is done firstly for the 95% (2*standard error) range and then for 67% (1*standard error) range.

95% CERTAINTY RANGE:

TIMETABLE (Yet/Yeo)	BR FIGURE	MINIMUM NUMBER OF TRIPS	MAXIMUM NUMBER OF TRIPS
1	27.5	27.5	48.5
2	37	27.5	150.5

3	40	27.5	150.5
4	42	34.5	226.0
T	28	27.5	180.5
E	35	27.5	48.5
(Maid/Dor)			
1	63	63	88
2	79	73	141
3	86	70	220
4	90	92	300
T	65	63	193

67% CERTAINTY RANGE:

TIMETABLE (Yet/Yeo)	BR FIGURE	MINIMUM NUMBER OF TRIPS	MAXIMUM NUMBER OF TRIPS
1	27.5	27.5	41.5
2	37	56.5	119.5
3	40	56.5	119.5
4	42	82.5	178.5
T	28	62.5	141.5
E	35	27.5	41.5

67% CERTAINTY RANGE (cont):

TIMETABLE (Maid/Dor)	BR FIGURE	MINIMUM NUMBER OF TRIPS	MAXIMUM NUMBER OF TRIPS
1	63	66	81
2	79	90	124
3	86	108	182
4	90	144	248
T	65	85	157

There are clearly quite large error ranges associated with the sample. The size of this error is a result of only a few people stating that they would make trips as a result of a better service. This means that a difference of only a few people mentioning trips could significantly affect the results.

5.6 COMPARISON OF THE 'ROOFTOPS' AND MARKET RESEARCH RESULTS

The results of the two models can now be compared. At this stage it must be remembered that the market research figures are only a survey and must not be treated as the true effect of a frequency change.

Looking at the sample error table it is clear that the error range is such that very little can be said at the 95% level of confidence.

At the 67% level of confidence it is clear that the BR model consistently under-predicts the effects of an improvement in service frequency for both villages. The only instance where the BR model is within the 67% error range is for timetable E. Timetable E is where trains are added to the large gaps in the evening services from Yetminster. The Rooftops model (because of its constant demand assumption) has predicted a relatively large increase in passengers because of this gap, even though the market research survey shows this to be a time of relatively low demand.

Yetminster results - Elasticities

TIMETABLE	BR ESTIMATE	CONSTANT PROBABILITY	FALLING PROBABILITY
1	Zero	Infinity	Zero
2	- 0.30	- 1.90	- 0.41
3	- 0.14	- 0.63	- 0.33
4	- 0.06	- 0.46	- 0.27
T	- 0.06	- 7.78	- 1.57
E	- 3.31	- 3.26	Zero

Maiden Newton results - Elasticities

TIMETABLE	BR ESTIMATE	CONSTANT PROBABILITY	FALLING PROBABILITY
1	Zero	Infinity	Infinity
2	- 0.22	- 0.57	- 0.24
3	- 0.11	- 0.37	- 0.13
4	- 0.05	- 0.26	- 0.09
T	- 0.20	- 5.06	- 0.93

Looking at the elasticity estimates for the various models. The first thing that strikes one is the wide deviation between the mean estimates from the constant probability assumption and the Rooftops estimates, the market research estimates are much higher than the BR results.

The falling probability estimates (which are based on a pessimistic assumption) are also higher than the Rooftops figures. These falling probability estimates do come quite close to the BR figures in Maiden Newton. When one takes into account the likely sample error the difference between these two estimates is probably not significant in Maiden Newton. It is in Yetminster that the BR model is substantially different and this may be a result of the BR passenger figures for Yetminster being an under-estimate thus accentuating the elasticity here. The BR model does predict a slightly higher elasticity for Yetminster but even so it is not comparable with the market research results.

Some other factors could account for the difference between the BR and market research estimates. These could be an over-estimate of the number of work trips, this would reduce the overall journey time elasticity and thus the BR estimates. Another possibility is that the market research responses assume that people know that the service has been improved, the evidence seems to be that some people think train services are worse than they are. If BR introduced one of the improved timetables without adequately informing potential users the actual result may be nearer their model.

The most important thing shown by the elasticities is the influence of timing effects. Timetable E has additional trains running at relatively unpopular times, where there is currently a big gap in the timetable. It can be seen that for timetable E the BR estimate is considerably larger than for any other timetable and it almost reaches the constant probability forecast. The prediction of the falling probability model sees no additional trips as a result of this extra evening service.

For timetable T where extra trains are inserted only at the most popular times, it is clear for both villages that there is a very large gap between the estimates of the BR model and the alternative models. As trains are added where there are smaller gaps in the timetable the Rooftops model sees there being little opportunity to gain extra passengers by inserting trains. Even the pessimistic diminishing probability model produces considerably higher estimates than the Rooftops model. Where straight frequency changes are considered the gap, whilst still significant, is smaller.

By increasing the value of adjustment time ('P') in the BR model it would be possible to bring the straight frequency estimates more into line, but the Rooftops model would still show substantial errors on the simple timing changes. It must therefore be concluded that the Rooftops model could be used to replicate the results of the straight frequency changes (ie a doubling of the number of trains) with a higher value of adjustment time, but it could not deal with the effects of adding services at specific times. Even if the values of adjustment time were increased there would still be a discrepancy between the two villages as there are greater differences between the BR model and the alternatives in Yetminster than in Maiden Newton. This difference is the result of there being a higher base level of trips in Maiden Newton than in Yetminster, the number of additional trips made in each village for each new timetable are fairly similar in size.

5.7 SUMMARY OF RESULTS

The main results from this chapter are as follows. Distributions of desired travel times have been constructed by day and trip purpose, for trips from a village to it's main urban centre. The desired duration of a number of trip types has been estimated.

Next it appears that the long-term results of a reduction in service frequency could be more elastic than in the short-term. It is also apparent that where the rail service is infrequent a significant number of activities are arranged around the train times.

The proportion of current rail trips by day of timetable and work/non-work has been estimated. The allowance people will give a train timetable around their desired time has been estimated showing that for work trips the most critical times are arriving later than the desired time and departing from the work place before the desired time. For non-work trips all periods of adjustment seem to have equal value (being greater than for work trips).

It is apparent that for the population as a whole, the frequency of the service was not seen to be a great deterrent to its use. It has been found that although the people in the village with the worst service appeared to be more constrained by the timetable this was not statistically significant. It has also been noticed that personal characteristics play some part in the individuals response to a frequency change and some general trends are visible.

Finally the market research based figures of additional trips were compared to the predictions of BR's Rooftops model. It was shown that the BR model produces consistently lower estimates than the results of the behavioural model. It was also seen that the BR model is substantially out when used to predict the effects of introducing 'timed' services to hit peaks in demand.

It must be stressed that this survey represents only a sample of the population and although great care was taken to ensure accurate responses to the questions people are notoriously unreliable when being asked hypothetical questions.

CHAPTER SIX - SUMMARY AND CONCLUSIONS

6.1 GENERAL

This chapter draws together all the elements of the research producing conclusions and recommendations for further work and policy.

6.2 SUMMARY OF RESEARCH

6.2.1 THE APPROACH:

The research involved the design and implementation of a complex behavioural model to explain and replicate the decisions of passengers, whether to use a local rail service if additional services were added to the timetable. The model was calibrated on market research responses from a sample of two Dorset villages. The resulting computer programme is able to predict, for each village, for any level of service the number of additional trips generated to a specified destination.

A more general investigation was also carried out into desired travel times and the sensitivity of current rail travellers to the timing of services.

6.2.2 THE RESULTS:

The research compared the results of the market research model to those of the conventional British Rail Rooftops model. It was found that the BR model's estimates were consistently below those of the market research model. It was noticed that the BR model was further out when dealing with the addition of individual trains to the timetable than when the number of trains was simply doubled. It is thus clear that the BR model's reliability is in doubt when timing effects are considered on a railway that has an infrequent service. The more general results follow. It was found that some of the trips that were stated as additional, to those currently made, could have been made using the current train timetable. This phenomena suggests that there may be a gain in patronage by increasing the communities' awareness of the timetable.

Distributions of desired travel times have been produced by day and trip purpose. The desired amount of time at the destination for a number of trip types has been estimated from this. It has been found that after a frequency reduction it is likely that responses will be more elastic in the long run as passengers need time to make alternative arrangements. It was noted that a number of activities are arranged around the train times.

The amount of adjustment allowed by a passenger before he no longer makes a potential trip has been estimated for four possible adjustment periods. Work trips as one would expect proved to be the most sensitive. For these trips the most critical periods were arriving in town later than the desired time and leaving town earlier than desired. For non-work trips all periods of adjustment had roughly equal value and were found to be less sensitive than work trips. For the population as a whole the current frequency of the service is not seen as a great deterrent to the use of the trains.

6.3 VALIDITY OF THE APPROACH AND RESULTS

It is felt that the market research approach has been reasonably successful in establishing basic information about people's reactions to the timing and frequency of secondary rail services. There are some areas where the results are perhaps too tentative to make strong claims. The exact values of the elasticity measures are too sensitive to variations in assumptions to be seen as rigid and reliable figures, but even with the large error ranges associated with these elasticities some significant results can be extracted.

Some small problems were experienced with the questionnaire used on the full scale survey of the response to frequency changes (Appendix II), for this reason a modified questionnaire (Appendix III) was designed after the full scale survey. It is believed that this later questionnaire coupled with an increased sample size would produce more reliable results. The main assumption of the market research model, that a linear decline in a passengers net utility associated with a trip, could be changed if evidence that this was invalid became available.

Finally, it must be stressed that these results represent a sample of the populations of only two Dorset villages. The results only consider trips from these villages to larger towns. It may be that these findings are not applicable to a different environment. It is also be possible that the people contacted, deliberately or through lack of thought, gave false information. The results of this study must therefore be treated with some reservation. However, major efforts were made to contain any potential inaccuracies.

6.4 IMPLICATIONS FOR THE REAL WORLD

It is hoped that this research does have some practical value. There are a number of areas where the findings may have some useful application. It would seem, as suggested by BR, that the Rooftops model in its current form is unreliable where services are infrequent. In their handbook BR suggest that this is only the case for services of less than one train every three hours. This research was done on a line with a service every two hours and the Rooftops model did show significant differences from the market research based approach.

It therefore seems that the Rooftops model is of suspect value on services of every two hours and less. In this research the BR model consistently under-predicted the results of service improvements. This would suggest that some services that have been planned using this model have a worse service than perhaps they could support. It may be that the best results come from re-timing current services, to make them more suitable to the local population. But it must be remembered that the needs of connecting passengers and the availability of paths for the trains have to be borne in mind when suggesting timetables are re-arranged.

One interesting feature of the stated additional times is that most of the gains are made at peak times. It is at these times that additions to services are most expensive as the current infrastructure will probably already be working at its maximum capacity. This means that the best economic solution may be to ignore the desires of potential travellers in the peak, perhaps re-timing peak services where necessary, while running additional services at the most popular off-peak times.

The removal of some stops from the service, thus reducing the service to villages on the route, may not have helped on this line. This reduction in the number of stops makes little difference to journey times which are reduced by about 2-3 minutes. The high elasticity values derived in this study may mean that this policy should be reviewed and the operation of a request stop system instituted. This would allow a better service whilst reducing journey times. It would also improve revenue protection as the train would not stop on the return journey unless the passenger spoke to the guard.

The introduction of request stops may allow the other stops to be re-opened, such as at Bradford Peverell. It seems that some of the trains in the peak in Yetminster could be re-timed to give an overall benefit to the whole service. This would benefit all other travellers going to Yeovil (which is one of the main destinations on the line) as they will all want to arrive at reasonably similar times.

Generally the information about desired travel times and duration of trips should allow the more effective planning of timetables on the basis of when local people want to travel, rather than when previous timetables have run. However, this is a complex line with through connections and the results of re-timing services would be more difficult than on a branch line with no through traffic. If re-timing was to be considered a serious possibility (rather than just adding trains) some information must be gained from passengers currently using trains that would be moved so that the loss of some of these passengers, could be balanced against the gain in passengers at other periods.

Although the exact elasticities in the study appear to make the results only of use to the line studied, this is not the case. The more general information about desired travel times and durations, should be of use to any public transport operator when planning new services. The method developed to estimate responses through a market research survey, should also be applicable in many areas of public transport.

One other possible use for the market research technique developed in this research would be in estimating the demand for completely new rail services. An expected fare could be used in the trade-off and this would produce the level of demand for a new service at various levels of quality. The technique could therefore be of some use in determining whether re-opening proposals are valid.

6.5 RECOMMENDATIONS FOR FURTHER WORK

As this study has largely investigated a new area of rail research there are many topics thrown up that should be looked at in more detail. The main area of interest is the way in which the probability of making a trip falls as the deviation from desired travel times increases - two approaches were used in the thesis one of which appears to give optimistic results whilst the other is definitely based on a pessimistic assumption. Investigation of the way this declines would therefore be most useful. It would also be interesting to see the results of this kind of survey on passengers who are currently using the rail service. It would then be possible to get a figure for people's reactions to the withdrawal of current services.

The results could also be used in social cost benefit analysis where timetable improvements are to be subsidised by a public body. The gain in passengers could be related to savings in time and accident costs on the road network in areas where congestion was a problem.

6.6 POLICY RECOMMENDATIONS

The main recommendation is that the Rooftops model, in its current form, is no longer used on services with less than a train every two hours. This is unless some account is taken of demand at different times of the day. It is also recommended that the timing of services be taken more in to account on infrequent services, so that perhaps an investigation can be made in to people's desired travel times before a new timetable is drawn up. This is especially important as it appears that in certain periods the alteration of the timing of a service by only a few minutes can significantly affect the loadings. It is therefore critical that the peaks of demand are identified so that passenger loadings can be optimised.

6.7 SUMMARY OF CHAPTER

The results of a market research study when compared to the BR Rooftops model showed a significant difference between the two. This difference was especially marked where the timing of services was considered. It is suggested that the current form of the Rooftops model is not applied to services with a frequency of less than a train every two hours. The Rooftops model could be modified to take account of the different levels of demand during the day and this would make the results more acceptable on infrequent services.

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