DEMAND FOR EMERGENCY MANPOWER

FOR AN URBAN TRANSIT AUTHORITY

BY

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This dissertation is my own work and contains no material which has already been published or otherwise used by me and to the best of my knowledge contains no copy or paraphrase of material previously written by another person except where due acknowledgement is made.

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CHAPTER 1

INTRODUCTION

The Metropolitan Transport Trust (M.T.T.) provides the majority of urban commuter public transport services for the city of Hobart and suburbs. Except for one small private bus operator who services the southern suburbs of Kingston, Blackmans Bay and Maranoa Heights, the M.T.T. has sole responsibility for the provision of regular route bus transport within a 22 kilometre circular boundary of the Hobart central city post office.

The M.T.T. is a State owned and operated public transport system and is funded from fares revenue and general State tax receipts. In 1983/84 fares collected on M.T.T. services represented 33% of the contribution required to cover operating expenditure.

Unlike other Australian capital cities, Hobart has no urban rail passenger network or significant commuter ferry service.
Rail passenger services were disbanded on the 31 December 1974, due to falling demand and rising costs.

No doubt, other State Governments would like to disband their inefficient and expensive urban rail passenger systems, but they are locked into supporting the continuation of their networks because of high infrastructure costs of transferring rail passengers to road. Hobart was able to effect the change in 1974 due to the small size of the rail network and the fact that Hobart had no vehicle congestion and no inner city parking problems at that time.

The geography of the city is ideally suited to flexible route transport especially the motor car. Hobart is second only to Brisbane in car ownership per head of population. The private motor vehicle is the major source of transport for travel to and from work. As few as one in six commuters use public transport daily.

Hobart has no viable commuter ferry services even though the city is built on either side of the River Derwent. An extensive ferry network was not established in the past because of the sparse development on the eastern shore of the river, and the fact that the rail network followed the river bank on the western shore. A small commuter ferry plies the river four times daily between the city and Kangaroo Bay, to provide a service for people living on Bellerive Bluff.

The M.T.T. has grown steadily since its establishment in 1955. This growth is due to outward growth of the city and to the failure of many of the private operators who have abandoned the market as and when their capital stock became obsolete. Most of these private operators turned to the more lucrative tourist charter work, leaving the M.T.T. to take up abandoned licences. Only recently has the Government embarked on a policy of direct subsidy of private operators to continue to provide urban route passenger bus services.

Although all M.T.T. fares on route services are heavily subsidised a recent M.T.T. survey showed that the majority of passengers using the services are captive to public transport.

Successive Governments have used the M.T.T. as a means of providing cheap transport for disadvantaged people in the community. The availability of cheap transport coupled with cheap land in outer areas fostered the development of isolated public housing estates which have, in recent years, become expensive transport burdens.

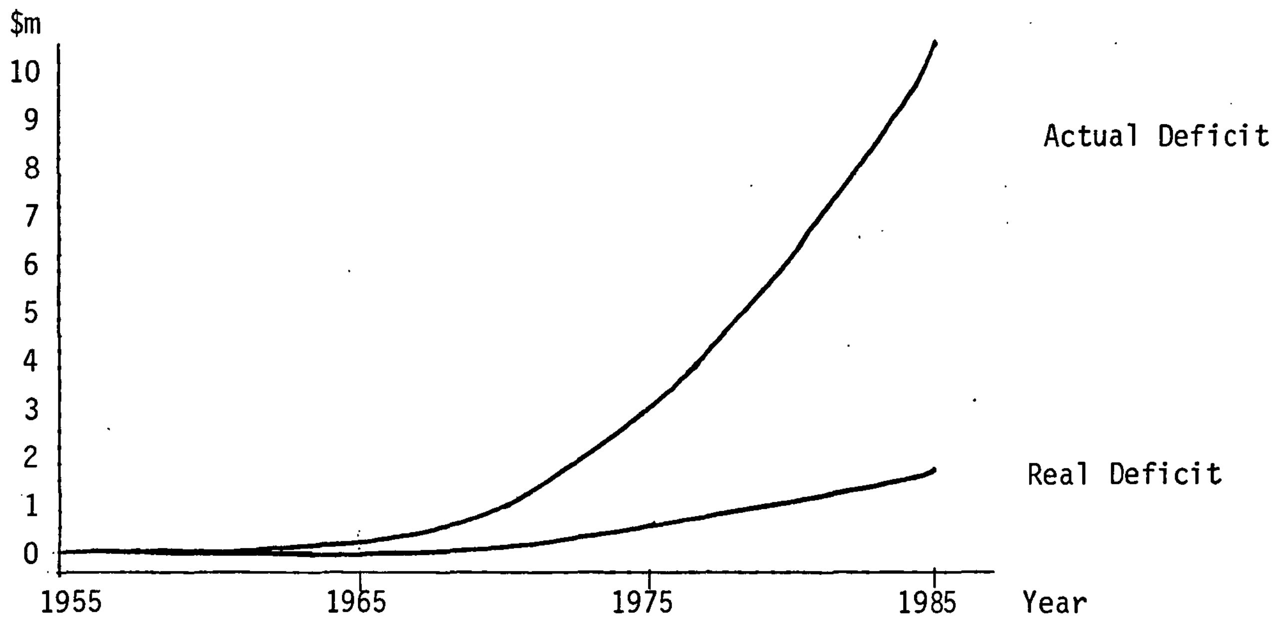
The M.T.T. is also required to provide special school buses at heavily subsidised rates. School buses are provided during peak periods and although the buses used are obsolete commuter buses the services are costly because the drivers required for these services are mostly idle during the off-peak periods. Repeated attempts to have school starting times staggered to minimize transport cost has met with opposition from the State Education Department.

Pensioner fares are also heavily subsidised even though most of the pensioners travel during the off-peak when the marginal cost of carrying them is small. Pensioners travelling off-peak make a greater contribution to fixed overheads than any other fare paying group.

The M.T.T. has operated at a deficit since commencing operations in 1955, (see Figure 1 and Appendix 1).

Figure 1

Actual and Real Deficit for M.T.T.



The increase in the M.T.T. deficit is due to a number of key factors. These are:

- inefficient use of bus and manpower resources.
- high service frequency
- increased route coverage
- rapid increase in transport costs
- suppressed fares

Of these factors major emphasis is placed in this study on the M.T.T.'s current use of manpower resources.

Prior to 1981, the M.T.T. pursued a policy of one hundred percent turnout of buses. This policy meant that the M.T.T. guaranteed that the service advertised would run on every occasion, and as a consequence maintained sufficient manpower and capital equipment to cover every contingency. In fact the M.T.T. deliberately employed excessive slack manpower resources during this period to implement the policy.

To meet State Government demands for improved efficiency, successive M.T.T. managements simply decreased slack manpower resources. By 1981, all spare manpower capacity was exhausted, and the M.T.T. changed the turnout policy by allowing the cancellation of services in cases where drivers were not available to operate services.

In 1982, the Government demanded a reduction in manpower of two percent and as a result the M.T.T. embarked on a practice of substituting overtime for additional manpower. The M.T.T. pursued this practice without any clear guidelines as to the optimum economic manpower/overtime mix. The Government unwittingly condoned the practice by measuring success in terms of reduced manpower numbers rather than total manpower cost.

The purpose of the analysis is to identify the cheapest means of providing emergency manpower for the M.T.T. In essence the task of providing services is fixed and to cover any shortfall in drivers the M.T.T. can either employ full time drivers on standby or pay overtime as and when required. This is a typical problem facing most service industries where output is non-storable.

The M.T.T. is able to call drivers back from one of their two days off each week, i.e. Days Off Cancelled (DOC), to fill a driver shortfall but as this is costly (i.e. drivers on DOC's are paid at double time) the aim is to establish the optimum level of DOC's.

The analysis is divided into two parts, firstly the identification of the causal factors that determine demand and secondly, if appropriate, the application of this information to establish the optimal manpower/DOC mix.

From an analysis of the literature and discussions with representatives of some of the major transit authorities in the U.S.A., England and Australia, it would appear that no detailed disaggregate econometric analysis has been undertaken on the demand for emergency manpower in a large public bus transit system.

Chapter Two provides a detailed explanation of the nature of the M.T.T.'s manpower structure and how any driver shortage is covered by emergency arrangements.

Chapter Three is devoted to the development of an econometric model to explain the factors that cause demand for emergency manpower and the use of the model for forecasting and policy evaluation.

The final chapter gives a summary of results and deals with the more important conclusions and policy implications of the econometric analysis for the M.T.T.

CHAPTER 2

M.T.T. MANPOWER

2.1 Manpower Framework

All M.T.T. employees are covered by industrial awards and are members of one of three unions namely, Municipal Officers Association (M.O.A.), Amalgamated Metal Workers Union (AMWU) and the Australian Tramways and Motor Omnibus Employees Association (AT & MOEA).

The AT & MOEA is the largest of the unions and provides coverage for drivers and cleaners under the Metropolitan Transport Trust (Tasmania) Traffic Employees Award 1981. Electrical and mechanical tradesmen, apprentices and workshop labourers are covered by the AMWU under the Metal Trades Award. Office staff and inspectors are covered by the Municipal Officers Award.

As this study is concerned with driver emergency manpower the AT & MOEA award conditions are the only award conditions considered in detail.

Under the Traffic Award the M.T.T. is able to operate three types of shift:

- Day Shift (AM) - any shift excluding a broken shift that finishes before 6.30 pm.
- Night Shift (PM) - any shift excluding a broken shift that finishes after 6.30 pm.
- Broken Shift - any shift where there is a break (other than a rostered meal break) that finishes no later than 8 pm.

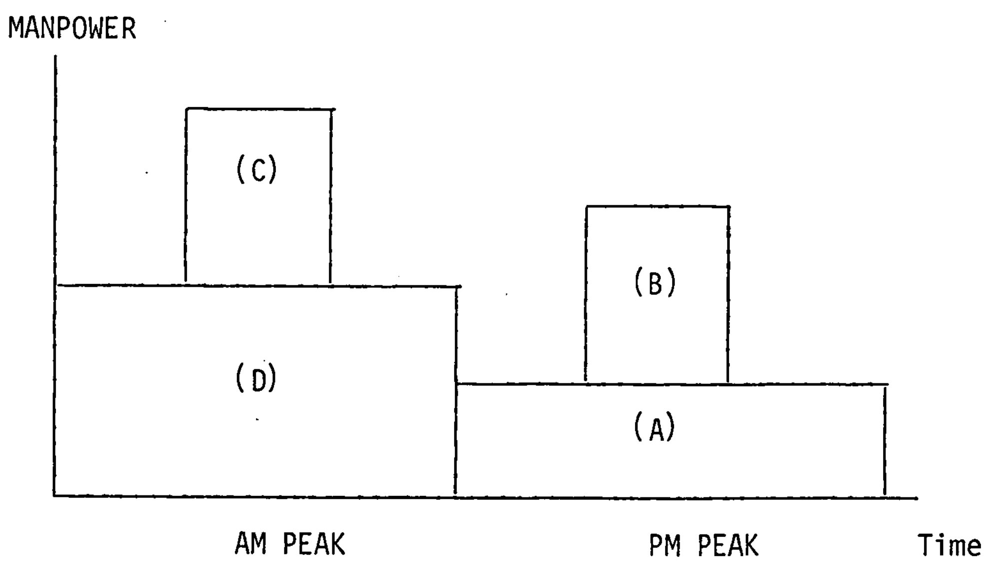
Day and Night shifts are straight shifts of nine hours duration with a meal break of not more than one hour. The award allows the M.T.T. to add up to one hour overtime to these shifts. Day shifts are used to provide one AM peak service and some day time off-peak services. Night shifts are used to provide two PM peak services and night time off-peak services.

Broken shifts are limited to eight hours work but are broken into two separate portions spread over a period of between ten and a half and twelve hours. Broken shifts must finish before 8 pm. The award specifies that Broken shift portions must be no less than three hours or more than five hours in length. Broken shifts are designed to cover the two peak periods and a small number of off-peak services. There is no provision for overtime on Broken shifts and the M.T.T. has an agreement with the union not to operate more than 100 Broken shifts.

The M.T.T. operates 86 Broken shifts. The number of Broken shifts is limited by the design of off-peak timetables. The number of night time services after 8 pm is the most important factor in determining the number of Broken shifts required. The number of services after 8 pm determines the number of PM straight shifts (see Figure 2(A)). The number of PM Broken shift portions are determined by deducting the number of PM straight shifts from the maximum PM demand (see Figure 2(B)). As there is no provision in the award for part-time drivers, PM Broken shift portions must equal AM Broken shift portions (see Figure 2(C)). By deducting the number of AM Broken shift portions from maximum AM demand the number of AM straight shifts can be established, (see Figure 2(D)).

Figure 2

M.T.T. Shift Structure



The M.T.T. could conceivably realize savings of up to fourteen drivers by converting 28 straight shifts to 14 broken shifts. Conversion of these shifts would, however, result in a substantial reduction in night, day time and early morning off-peak services.

Table 1 shows the number and type of shifts operated by the M.T.T. on week days and weekends.

Table 1

M.T.T. Shift Types

Day	Shift Type			Total
	AM	PM	BROKEN	
Week day	69	51	86	206
Saturday	25	29		54
Sunday	11	10		21
	105	90	86	281

There are no broken shifts at weekends because of different passenger demand which results in there being only one peak period on both Saturday and Sunday.

M.T.T. drivers work a 38 hour week and are guaranteed 8 hours work each day in a 19 day month. This differs from other Australian capital city transit authorities where drivers work a 38 hour week as other authorities vary driver daily hours of work from 7 to 9 hours without payment for overtime.

M.T.T. drivers are paid weekly, on the basis of a flat award rate, plus an amount for length of service, and any other shift penalties or overtime entitlements.

Overtime is paid at a rate of time and a half for the first three hours and double time thereafter. Shift penalties are paid on the basis of a 15% loading for any work between 5 pm and 7 am. Drivers on straight shifts finishing after 8 pm are paid a penalty rate of 15% for the whole of the shift.

Broken shift penalties are paid on the basis of the spread of hours over which the shift is worked. Although the award allows for a broken shift spread of between nine and a half and twelve hours by agreement, no broken shift is spread over a period of less than ten and a half hours. Drivers on broken shifts are paid on a shift that is spread over ten and a half to twelve and a half hours, at the rate of double time for the period worked after ten and a half hours.

Straight shifts at weekends are paid at a rate of time and a half on Saturdays and double time on Sundays.

The M.T.T. employs 250 drivers; 206 for week day work; 10.8 for Saturdays (54 shifts); 4.2 for Sundays (21 shifts), and 29 drivers to cover annual leave, long service leave, sick leave, failure to report and other leave.

Drivers are allocated five shifts each week and organized into shift rosters. There are four types of shift rosters, these are:

- Fixed duty roster
- No. 1 Straight shift roster
- Broken shift roster
- Articulated bus roster (city depot only).

Fixed duty roster drivers are allocated the same work each day. Fixed shifts are designed for drivers unable to undertake normal duties for reasons such as ill health or special family circumstances. These shifts do not operate at weekends or after 7 pm on week nights. Fixed duty shifts are almost entirely made up of school runs. Fixed duty drivers are therefore under utilised during school holidays. All fixed duty drivers are required to take annual leave during the Christmas school holiday break. The M.T.T. has 22 fixed duties on the Hobart and Mornington rosters.

The No. 1 straight shift rosters for Hobart and Mornington are the largest of the M.T.T. roster categories. In all 119 drivers are required to fill these rosters. Drivers are rotated through the roster so that they work an equal work load and receive equal payment. Drivers on No. 1 straight rosters work five AM shifts one week and five PM shifts the next. As there are more AM than PM shifts drivers reaching the end of the roster work a number of AM shifts consecutively. The major disadvantage of a rotating roster system is that drivers must be taught every route and fare section location. This means it is difficult to convey any changes in route design to drivers, and there is an increased probability of a driver taking the wrong route or charging the wrong fare.

When required the M.T.T. temporarily transfers a number of less difficult straight shifts from the No. 1 straight roster to a mini training roster for new drivers. Drivers are given a three week training course of which two weeks are spent on theory and practice of driving a bus, and one week on road practice.

Drivers also work rotating shifts on a broken shift roster. There are no broken shifts at weekends. Broken shifts are popular with drivers because of the high penalty rates, and the fact that broken shift drivers are not required to work weekends. There is usually a long waiting list of drivers wishing to transfer from the No. 1 straight shift roster to the broken shift roster.

Although drivers prefer broken shifts, the AT & MOEA is opposed to any increase in the number of broken shifts, because of the resulting decrease in total manpower, and because fewer straight shifts results in an increased burden on No. 1 straight shift roster drivers who are required to work the unpleasant early morning and night time shifts.

The M.T.T. operates a special articulated bus roster consisting of fourteen drivers trained to drive the extra length vehicles. This roster was introduced when the M.T.T. acquired the privately owned Ace Bus Services northern suburbs routes. Instead of employing six additional drivers, the M.T.T. negotiated an agreement with the AT & MOEA to operate three one man high capacity articulated buses. At the time of take-over the M.T.T. was able to absorb all of the off-peak services into the existing M.T.T. northern suburbs route network.

The articulated roster was introduced as a temporary measure to allow the M.T.T. time to train drivers to drive the new buses, and learn new routes. The articulated roster will be aggregated with the city No. 1 straight shift roster as soon as all M.T.T. drivers are fully trained.

Drivers are entitled to thirty five consecutive days leave for each twelve months of service. To meet this commitment, the M.T.T. rosters annual leave for seventeen drivers in each thirty five day period.

M.T.T. drivers are entitled to State Public Service Long Service Leave conditions of nine days for each year of service. Drivers are not able to take the entitlement until they have completed ten years of service. Although the timing of Long Service Leave is at the discretion of management, the M.T.T. usually meets requests for this type of leave. Drivers generally apply two years in advance for Long Service Leave. The M.T.T. employs four additional drivers to cover this type of leave.

Drivers are entitled under the award to ten days per year accumulated sick leave, verified by medical certificate, but by agreement drivers are able to take three single days without a medical certificate (grace days). Drivers are being increasingly pressured by their peers to take all available sick leave to increase days off cancelled (DOC) and thus maximise overtime payments. A driver working a rostered day off is paid at a rate of double time for the entire shift. Sick leave is increasing at about 2% annually. Grace day leave is increasing at 5% annually.

The M.T.T. has four drivers on permanent long term sick leave. These drivers are not expected to return to work. The M.T.T. employs six drivers to cover sick leave relief.

The M.T.T. employs two drivers to cover vehicle break down, driver failure to report for work, defence leave and other contingencies.

One area of leave entitlement which has been very much neglected by the M.T.T. in recent years is that of drivers' accumulated leave credits. The M.T.T. has allowed a large leave debt to build up without making any provision by way of additional manpower to offset the problem. Drivers accumulate days off in lieu as a result of working on public holidays. Normally drivers would take days off in lieu in the course of the year, but because of manpower restrictions, drivers have been refused days off. This has resulted in a reluctance to apply for days off in lieu and drivers desperate for leave resort to sick leave. No doubt this policy has contributed toward the increase in sick leave. Approximately three man years of leave in lieu has accumulated.

2.2 Emergency Manpower Framework

The supply of scheduled bus services is a non storable product and as a result the M.T.T. must balance manpower demand and supply daily. A shortage of manpower is usually caused by sick leave, driver resignation, bus break down or drivers failing to report for duty. In the short term the M.T.T. may be able to overcome manpower shortages by using clear emergency shifts which are built into the rosters, restructuring shifts, or cancelling a driver's day off (DOC).

If these methods are unsuccessful the M.T.T. may resort to running services late or cancelling services. M.T.T. Inspectors under the guidance of the Traffic Superintendent and the Traffic Manager are responsible for resolving any short term manpower shortages.

The M.T.T. has six AM and five PM straight shifts called emergency shifts built into the No. 1 straight shift rosters. These shifts are further divided into "known" and "unknown" clear emergency shifts. There are four AM and one PM clear "known" work emergency shifts which are designated in the roster as 999 and 998 shifts respectively. These shifts are used to fill gaps in the roster where it is known twenty four hours in advance that there is a shortage in manpower. For instance a 999 or a 998 shift is used to replace a driver on long term sick leave. Drivers on these "known" shifts usually work the full five days on the same shift.

To cover "unknown" emergencies there are also two AM and three PM clear emergency shifts included in the No. 1 straight shift rosters. These are used to handle day to day problems such as break down or driver failure to report. Duty numbers 105, 104, 114, 361 and 336 are used for "unknown" clear emergency. In addition, the M.T.T. employs a Driver Trainer on a PM shift who doubles as a clear emergency driver when not required to train new drivers.

The M.T.T. is able to schedule "known" work emergency drivers on "unknown" work when all "known" work is fully allocated. It is also possible to transfer shifts between depots without cost. It is, however, not possible to exchange AM and PM shifts at short notice. This means that the M.T.T. may have ample spare clear emergency manpower in one period but have to pay DOC's in the other.

The AT & MOEA will not allow the M.T.T. to have clear emergency broken shifts. This means that if a broken shift is unfilled, it is often necessary to use the peak portions of an AM and a PM clear emergency shift to cover the broken shift. However, in some cases a broken shift can be covered by using the AM peak portion of an AM clear emergency shift and the re-structuring of PM shifts utilizing shift emergency. Shift emergency is the availability of drivers due to a period of inactivity between scheduled services. Where the period of inactivity occurs in the city, or close to Mornington depot and is in excess of fifteen minutes, drivers are expected to report to their depot. Many of the new buses are fitted with two way radios and inspectors can re-direct available drivers enroute, and are thus able to use shorter periods than fifteen minutes of inactivity to re-structure shifts. There is no shift emergency during peak periods, but in the off-peak, shift emergency on

some shifts can be as long as three hours.
The M.T.T. utilizes as much of this time as possible operating school and adult charter services.

With efficient use of small portions of shift emergency, inspectors are often able to overcome manpower shortages by re-arranging driver duties. Inspectors are able to delay departure times for services by up to five minutes if this results in the provision of an emergency service without the cost of a DOC. Inspectors are not permitted to direct a driver to depart earlier than the scheduled time.

Under certain circumstances inspectors are allowed to approve the cancellation of a driver's day off.
In each case the inspectors must justify their actions in writing at the end of the shift. Each year M.T.T. inspectors cancel approximately 1,700 drivers' days off.

Drivers working DOC's are paid at a rate of time and a half for the first three hours and double time thereafter on ordinary week days, double time on Saturdays and Sundays and double time and a half on public holidays. The cost of DOC's to the M.T.T. represents approximately $170,000 per annum.

Drivers cannot refuse to work DOC's if requested by the M.T.T., but as a matter of policy, the M.T.T. only cancels the days off of drivers who have indicated they are willing to work. In the past less competent inspectors have called drivers back to work on any pretense to minimise the need to re-structure shifts. The more competent inspectors are able to save the M.T.T. substantial amounts of money annually in reduced DOC's by efficient use of shift emergency.

In 1981, the M.T.T. management made a major change to emergency manpower policy by issuing an instruction that inspectors should cancel a service without any notice to passengers if it resulted in avoiding the need to cancel a driver's day off. Under the new policy, cancellation of any service must be approved by the Traffic Manager. Only services on high frequency routes are cancelled without notice.

CHAPTER 3

METHODOLOGY ANALYSIS AND RESULTS

3.1 Purpose and Scope

The cost of emergency manpower represents about $360,000 or 3% of the M.T.T. annual operating costs. The cost of DOC's alone represents $170,000 of expenditure on emergency manpower. The decision to set the level of emergency manpower at six AM and five PM shifts was made on an ad hoc basis. The M.T.T. has not undertaken any quantitative analysis of the causes of DOC's, or of whether the level of emergency manpower is at an optimum.

This study is aimed at rectifying this shortcoming by identifying the causual factors of demand for DOC's and developing an optimum manpower/DOC mix.

The study should form the basis for the development of a quantitative manpower planning policy for the M.T.T.

3.2 Methodology

This study is divided into three stages namely structural analysis, forecasting and policy evaluation.[1.]

Structural analysis is the use of an econometric model to identify and quantify the factors that cause the demand for DOC's. This process includes the identification of variables, collection of information on each of the variables, specification of the model, estimation of the parameters and statistical testing of the model and parameters.

In the forecasting stage the structural model is used to predict the number of AM and PM DOC's for a sample period outside the period used in the estimation of the model. The forecasting ability of the structural model is compared to a Naive forecasting process and the most suitable model chosen for use in the policy evaluation stage.

Finally the model selected is used to choose between alternative levels of emergency manpower.

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1. M.D. Intriligator, "Econometric Models Techniques, and Applications", (North-Holland 1978), p. 5.

Manpower is added at the margin and the cost of additional manpower compared to the cost savings from reduced DOC's.

The optimal manpower/DOC mix is reached when cost savings from adding additional manpower to the system is less than the full cost of employing an additional bus driver on a clear emergency shift.

3.3 Structural Analysis

This section deals with the use of econometric techniques to identify the variables and to quantify the underlying relationship between them.

The purpose of the analysis is to develop a reliable demand model which can be used to measure and test these relationships.

Variables must be identified, the model specified, data on each of the variables collected, a statistical estimation procedure selected and parameters quantified.

Statistical tests are applied to the estimated model to check to ensure the model and parameters are acceptable.

3.3.1 Model Variables

The Delphi technique, which is a survey of expert opinions whereby the experts are allowed to review one anothers ideas was chosen as the means of identifying the variables.

Eleven M.T.T. personnel were selected from the ranks of inspectors, drivers and management and asked to prepare a list of the factors they considered contribute to the shortage of manpower and subsequently DOC's. The responses were summarised and re-circulated for further discussion. The expert team identified a number of leave related elements including annual leave, long service leave, sick leave and a general category of other leave which covers defence leave and compassionate leave, etc., for inclusion in the model. Other suggested variables were drivers failing to report, demand for manpower on M.T.T. rosters, the supply of M.T.T. drivers available to cover rosters, the number of emergency drivers and the amount of emergency time on normal shifts. Grace days where a driver is entitled to three single days off each year without a medical certificate were also considered to be a major contributing factor.

Finally management suggested the inclusion of a change of policy variable which is designed to account for the policy of no longer guaranteeing that every service on the time-table would operate if DOC's could be saved.

For the purpose of analysis the above generalized list of variables had to be refined by expanding some of the variables and discarding others. Sick leave was expanded into two discrete variables of sick leave of more than one day, and sick leave of one day or less. This division was required in order to account for the different effects on DOC's of the amount of notice of manpower shortage. Grace days were included into the second category of sick leave because they are taken one day at a time and have the same affect as single sick days.

A separate variable was not needed to account for the number of emergency shifts because the number remained the same throughout the analysis.

Although the demand for manpower on the rosters changed due to the permanent cancellation of a number of shifts it was not considered that the small loss of shift emergency was large enough to warrant the inclusion of a separate variable.

The supply of drivers is covered by the inclusion of a variable called driver spares. The variable accounts for situations where the supply of drivers exceed the rosters (e.g. mid year school holidays).

A variable to estimate the ability of inspectors was considered to be a most contentious issue. Not only were management reluctant to have the matter quantitatively analysed but also inclusion could have prejudiced the whole data collection programme. Inspectors had agreed to voluntarily collect some of the necessary data and had they become aware of the inclusions of such a variable they would more than likely have refused to assist. In addition, data on the variable would have been of dubious reliability because of the many influences on the shift patching process (e.g. different combinations of inspectors and the influence of the traffic office superintendent, traffic manager and drivers). At the time it was considered the loss of accuracy was overshadowed by the more far reaching effects of inclusion of the variable.

The final list of variables chosen for inclusion in the model were:

- annual leave (AL)
- long service leave (LSL)
- other leave (OL)
- sick leave of more than one day (SL2)
- sick leave of one day or less (SL1)
- failure to report (FTR)
- demand for drivers (DD)
- change of policy (CP)
- spare drivers (SP)

Annual Leave (AL)

Drivers on annual leave reduce the availability of manpower, and are expected to increase the number of DOC's. The variable coefficient should be positive. Annual leave is rotated for all drivers, except those on fixed duties. To provide drivers with annual leave, the M.T.T. maintains a roster of seventeen drivers on annual leave in each five week period. The number of drivers on annual leave increases to thirty five during the Christmas break between December and February.

Long Service Leave (LSL)

Drivers are entitled to long service leave of ninety days after ten years of continuous service. The M.T.T. usually budgets for up to four drivers on long service leave at any one time. It is difficult to maintain a regular roster because long service leave depends on drivers making application for leave. Like annual leave, the long service leave variable is expected to have a positive effect on the demand for emergency manpower. Although the M.T.T. has some flexibility with regard to approval of long service leave, the long lead time for notification and approval means that the M.T.T. is unable to use this as a means to overcome short term shortage of manpower.

Other Leave (OL)

This category covers defence leave, compassionate leave, days off in lieu, union leave and any other miscellaneous leave. The M.T.T. has a policy that it will not usually approve this type of leave if it results in a DOC. Therefore if the M.T.T. policy is effective the variable will not be significant.

Sick Leave of More Than One Day (SL2)

This variable is designed to cover long term sick leave where drivers are absent for more than one day with a medical certificate. In these cases inspectors are aware twenty four hours in advance of manpower shortage. It is believed that with prior warning inspectors are more likely to cancel days off. The M.T.T. has four drivers on permanent long term sick leave, these drivers are not expected to return to work at the end of their sick leave entitlement. The variable is expected to have a positive coefficient.

Sick Leave of One Day or Less (SL1)

This variable accounts for sick leave where inspectors are given little or no notice of driver absence. Inspectors are less likely in cases of SL1 to cancel days off, because drivers are more difficult to locate. In these cases inspectors may be forced to patch and fill shifts or cancel services.

The first day of long term sick leave (SL2) is included in the short term (SL1) classification because it has the same effect as a single day sick leave. It is anticipated that the coefficient of SL1 will be positive but smaller than SL2.

Failure to Report (FTR)

This variable was included to cover situations where drivers fail to report for duty at the rostered time. In most cases there is little or no notice of absence and the manpower shortfall is not realized until the shift is about to commence. It is not expected that DOC's will result from these circumstances as in most cases "unknown" shift emergencies are used to overcome the shortfall. The variable has been included to test this hypothesis and if the logic is correct the coefficient will not be significant.

Demand for Drivers (DD)

Within the M.T.T. the demand for drivers is called roster demand and refers to the number of drivers required to fill the rosters. Driver demand is different in school holidays to school days and different again at weekends and on special holidays. In many cases the M.T.T. runs Saturday or Sunday time-tables on public holidays.

The variable was included as a scale variable to take account of the size of M.T.T. operations. The larger the number of drivers on the roster the more likely a shortfall will arise therefore the variable is expected to have a positive coefficient.

Change in M.T.T. Policy (CP)

Early in 1983 the M.T.T. changed its policy on the level of bus schedule reliability. A number of services were identified as being dispensable, and inspectors were told to cancel these services if by cancellation a DOC could be avoided. To minimize passenger inconvenience the services cancelled were those on high frequency routes. Until this time, the M.T.T. had aimed at providing all time-tabled services at any cost. As the policy was aimed at reducing DOC's the coefficient of the variable is expected to be negative. A 1/0 dummy will be used to identify the change in policy.

Spare Drivers (SP)

There are periods during the year when the M.T.T. has spare drivers available to act as extra emergency. For example, during mid-year school holidays when fixed duty drivers are not required to operate school services, there are up to fifteen spare drivers. The presence of spare drivers is expected to reduce the demand for DOC's and result in a negative coefficient.

3.3.2 Model Specification

The functional relationship for the model is

DOC = F(AL, LSL, OL, SL2, SL1, FTR, DD, CP, SP)

Where: AL = annual leave

LSL = long service leave

OL = other leave

SL2 = sick leave more than one day

SL1 = sick leave one day or less

FTR = failure to report

DD = demand for drivers

CP = change in policy (dummy)

SP = spare drivers

There is no reason to suspect that the functional relationship between the variable is not additive.

On this basis two separate models were specified one for AM DOC's and the other for PM DOC's.

As the data was collected on a daily basis dummy variables were included in the final specification to account for the day of the week. The use of the day dummy variables is a more efficient method than estimating all 126 parameters for the AM/PM models for each day of the week.

The final full model specification is as follows:

$$\begin{aligned} \text{AM DOC} = \; & a_1 + a_2\text{AL} + a_3\text{LSL} + a_4\text{ AMOL} + \\ & a_5\text{ AMSL2} + a_6\text{AMSL1} + a_7\text{AMFTR} + \\ & a_8\text{ AMDD} - a_9\text{CP} - a_{10}\text{AMSP} + a_{11}\text{DAY 1} + \\ & a_{12}\text{DAY 2} + a_{13}\text{DAY 3} + a_{14}\text{DAY 4} + \\ & a_{15}\text{DAY 5} + a_{16}\text{DAY 6} \end{aligned}$$

Equation 1

$$\begin{aligned} PM\ DOC = {} & b_1 + b_1AL + b_2LSL + b_3PMOL + \\ & b_5PMSL2 + b_6PMSL1 + b_7PMFTR + \\ & b_8PMDD - b_9CP - b_{10}PMSP + b_{11}DAY\ 1 + \\ & b_{12}DAY\ 2 + b_{13}DAY\ 3 + b_{14}DAY\ 4 + \\ & b_{15}DAY\ 5 + b_{16}DAY\ 6 \end{aligned}$$

Equation 2

Where: a_1, b_1 constants

$a_2, a_3 \ldots a_{16}$ = AM parameters

$b_2, b_3 \ldots b_{16}$ = PM parameters

DAY 1, DAY 2 .... DAY 6 = Dummy variables for day of week.

DAY 1 = Sunday ....

DAY 6 = Friday

3.3.3 Data

An analysis of the existing M.T.T. data collection procedures revealed that the information on some of the variables could not be collected from historical records and therefore historical data could not be used for the analysis.

It was necessary, therefore, to initiate a special time series data collection programme to obtain the observations on all the variables.

The M.T.T. staff who were to collect the data were asked to assist in developing the programme. The purpose of including these people from the outset was to circumvent any classification or collection problems.

The M.T.T. rosters clerk collected data on the number of drivers on AL and LSL.

Data on SL2, SL1, FTR and OL was collected by the M.T.T. timekeeper with the assistance of the inspectors.

Unless the period of absence extended over a full peak period no observation was recorded on the SL2, SL1 and OL variables.

The criteria for classification of data on the FTR variable was based on drivers signing on more than twenty minutes late for work.

The demand for drivers was established by counting the number of shifts on daily rosters.

Information on the SP variable was obtained from analysing inspectors daily report forms. These report forms show the manpower available for use by inspectors to cover any short fall on the rosters. The number of available drivers were compared to the short fall on the rosters and surplus drivers recorded as driver spares.

A total of 861 observations were collected on each of the variables for both AM and PM DOC's. Three quarters of the data or 646 observations were used to calculate the structural parameters. The remaining 215 were retained for ex-post forecasting analysis.

Seven days observations were excluded from the structural analysis because of a strike which occurred from 23 September 1981 to 29 September 1981. Only one significant problem occurred during the data collection programme. The time keeper took his annual leave of three weeks in December 1981 and his temporary replacement had not been adequately briefed. Fortunately it was possible to fully reconstruct the data on return of the timekeeper. In 1982, the timekeeper's replacement was fully briefed and the problem did not re-occur.

3.3.4 Estimation of Parameters

The objective of this section is to detail the method used to quantify the parameters of the variables from the time series data for the AM and PM models specified in section 3.3.2.

It is desirable to select an estimation technique which exhibits statistical properties of unbiasedness, efficiency and consistency. Under certain conditions the Regression technique of Ordinary Least Squares (OLS) will meet these requirements and provide estimates of the sample parameters which are both unbiased and have minimum variance. The conditions rely on the introduction of an error term and the existence of a number of specific assumptions. The independent variables must have finite means and variances and must be uncorrelated with the errors of the model. There can be no collinearity between two or more variables in each of the models and the errors must be independently distributed with an expected value of 0 and constant variance.

The introduction of the error term accounts for the probabilistic nature of the regression model and is included to cover any errors of measurement of data and the effect of missed variables.

The least squares regression procedure is based on identifying the parameters which minimizes the sum of squares of the residual error.

The TSP program on the Prime Computer at the University of Tasmania was used to calculate the values of the parameters using an OLS estimation technique.

3.3.5 Testing the Model and Parameters

As the coefficients on the variables are used to determine the change in AM or PM DOC's as a result of any unit change in the variables it is important to test for the reliability of the calculations.

The individual coefficients can be tested for the null hypothesis using a t distribution. In this case the sample is large and the standard normal distribution can be used.

The t test is not reliable where the error for one time period is related to the next. This is called serial correlation and can be tested for by using the Durbin Watson statistic.[2]

By definition DW is the sum of the squared first differences of the residuals divided by the sum of the squared residuals.

There is a range of results for the interpretation of the DW statistic but in general for large sample sizes there is no first order correlation if the DW statistic is close to 2.

Because there is a gap in the data due to the strike the numerator in the Durbin Watson statistic must be adjusted.

Where serial correlation exists the estimator is no longer efficient and the standard errors are biased downward which subsequently biases the t statistics upward. Given these conditions there is a tendency to reject the null hypothesis when it should have been accepted.

The $\overline{R}^2$ or coefficient of determination adjusted for degrees of freedom is a test to measure the goodness of fit of the estimated models to the data. The statistic measures the proportion of the variation

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2. D.W. Challen and A.J. Hagger "Modelling the Australian Economy", Longman Cheshire, 1979, p. 29.

in the models which is explained by the multiple regression. The $\bar{R}^2$ is the regression sum of squares divided by the total sum of squares and adjusted for degrees of freedom. The range of the statistic is between 0 and 1 and the closer to 1 the better the fit.

The F statistic is used to test the significance of the coefficient of determination. The statistic tests the hypothesis that none of the explanatory variables helps to explain the variation of the AM and PM DOC's about their means. If the F statistic is close to zero the null hypothesis is accepted. Where the calculated value exceeds the critical value of the exact numerical distribution of the F statistic based on degrees of freedom and significance level the null hypothesis is rejected.

Multicollinearity arises when two or more variables, or combinations of variables are highly correlated to each other. The symptoms of the problem are usually low t values accompanied by a high $\bar{R}^2$ and an acceptable F statistic.[3]

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3. R. Pindyck & D. Rubinfeld, "Econometric Models & Economic Forecasts", McGraw Hill 1981, p. 81 .

3.3.6 Results

The OLS estimators are used to calculate the value of the parameters for the variables specified. The initial results for AM and PM full model specification are shown in Table 2.

Table 2

Full Model: AM and PM DOC Mode Estimation

Variable	AM		PM	
	Estimated Parameters	t-Statistic	Estimated Parameters	t-Statistic
c	10.510	4.427	29.426	9.952
Day 1	- 1.684	- 8.733	1.225	4.685
Day 2	- 2.055	- 5.619	- 1.309	- 3.396
Day 3	- 2.248	- 6.605	- 0.685	- 1.741
Day 4	- 1.797	- 5.216	- 0.879	- 2.225
Day 5	- 1.769	- 5.057	- 1.497	- 3.747
Day 6	- 2.125	- 6.109	- 0.314	- 0.793
AL	- 0.006	- 0.835	0.001	0.145
LSL	0.345	8.616	0.275	5.620
OL	0.005	0.876	- 0.002	- 1.981
SL2	0.203	9.461	0.467	9.661
FTR	0.068	0.308	0.400	1.273
SL1	0.145	4.645	0.374	6.664
DD	0.011	4.936	0.029	4.944
DSP	- 0.143	-10.595	- 0.397	- 8.714
CP	- 0.466	- 2.427	- 2.210	- 9.417
	Model Test Statistics			
$\bar{R}^2$	0.473		0.491	
DW	1.348		1.370	
$F_{15,620}$	36.752		39.271	

The results in Table 2 show that many of the t statistics are highly significant but the low DW statistics are well below 2 suggesting the likely presence of first order serial correlation. The low DW statistic may be due in part to the omitted inspector efficiency variable which if included would be likely to behave in a similar way to observed economic variables. The possible presence of serial correlation means that the t statistics cannot be relied upon. To overcome the problems the models can be respecified and the models re-estimated using OLS or the existing relationships can be manipulated in such a manner that the disturbance on the original models are purged of the serial correlation and a non linear least squares regression technique applied to the transformed relationships.[4]

There is no theoretical basis for changing the specification and in addition it would not be possible to collect data on any additional variables.

Therefore the second alternative is selected and the Cochrane-Orcutt iterative procedure is used to generate the error process to which the second random variable is added.

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4. D.W. Challen and A.J. Hagger "Modelling the Australian Economy", Longman Cheshire, 1979, p. 29.

The results of the estimation of the full model using the Cochrane-Orcutt transformation process are shown in Table 3.

There is no evidence to suggest the presence of multicollinearity.

Table 3

Full Model AM and PM Moded Estimation
With Cochrane - Orcutt Transformation

Variable	AM		PM	
	Estimated Coefficient	t-Statistic	Estimated Coefficient	t-Statistic
c	10.405	3.146	29.459	7.233
Day 1	- 1.689	-10.607	1.247	5.597
Day 2	- 2.145	- 6.327	- 1.449	- 3.988
Day 3	- 2.207	- 6.691	- 0.784	- 2.064
Day 4	- 1.779	- 5.284	- 0.982	- 2.568
Day 5	- 1.725	- 5.100	- 1.580	- 4.125
Day 6	- 2.075	- 6.378	- 0.391	- 1.074
AL	- 0.008	- 0.954	0.001	0.054
LS	0.339	6.328	0.268	4.129
OL	- 0.009	- 1.122	- 0.034	- 1.918
SL2	0.193	8.060	0.447	8.230
FTR	0.023	0.117	0.419	1.460
SL1	0.156	5.489	0.378	7.347
DD	0.011	5.340	0.032	5.605
DSP	- 0.135	- 7.993	- 0.378	- 6.808
CP	- 0.465	- 1.772	- 2.203	- 6.896
	Model Test Statistics			
$\bar{R}^2$	0.423		0.436	
DW	2.034		2.062	
$F_{15,620}$	29.514		31.192	
RHO	0.325		0.314	
t(RHO)	8.666		8.352	

The DW statistics for the transformed AM and PM models indicates that the serial correlation has been removed from the disturbance term. The t statistics are therefore a more reliable measure of the statistical significance of the parameters.

Generally the t statistics on the variables that are expected to be significant are high. The variable parameters are not significant for AM AL, AM OL, AM FTR, AM CP, PM Day 6, PM AL, PM OL and PM FTR.

In the case of AM and PM AL the possible reasons for lack of significance is that the M.T.T. does not use annual leave as a tool to combat short term manpower shortages and as a result there is little variation in observations on the variable.

The low significance level on the t statistics for AM OL suggest that inspectors at least in the AM are generally adhering to the policy of not permitting a driver to take other leave if it results in a DOC.

The t statistics on a AM FTR and PM FTR support the hypothesis proffered in Section 3.3.1 that in most cases insufficient notice is given to inspectors to enable them to cancel a driver's day off and the shortfall is covered by use of "unknown" emergency shifts, patching and filling shifts or cancellation of services.

In the transformed model the t statistic on the AM CP parameter is not significant while the PM CP coefficient is highly significant. In the final analysis, however, when the insignificant variables are removed and the models re-estimated the PM CP coefficient also proved to be insignificant (t statistic of -1.613). The conclusion is that it is unlikely that the change in the M.T.T. policy to allow for the selective cancellation of services is effective in reducing DOC's.

All the signs on the significant parameters are as expected which supports the initial logic used to establish the variables for inclusion in the demand model.

The size of the coefficient for AM and PM SL2 is larger than AM and PM SL1 which supports the hypothesis that SL2 is more likely to cause DOC's because inspectors have more time to organize them and drivers are more easy to contact.

The F statistic with 15 and 620 degrees of freedom is highly significant at 1% level of significance which indicates that the null hypothesis that all explanatory coefficients are jointly zero should be rejected.

The $\bar{R}^2$ statistics for both AM and PM regression models are disappointing given the large number of degrees of freedom and the fact that time series data is used. The regression models for the AM and PM only explain 42% and 43% of the variation in DOC's respectively.

Finally the high t statistic accompanied by a low R^2 and acceptable F statistic tends to suggest the absence of any multicollinearity.

The low t statistics on the FTR OL AL and CP sample parameters are insignificant and therefore it is not possible to rule out the possibility that the population parameters are zero. On this basis the models were re-estimated excluding these variables.

Table 4 shows the final AM PM estimation results.

Table 4

Final Re-Specified AM and PM Model
Estimation with Cochrane Orcutt Transformation

Variable	AM Estimated Coefficient	AM t-Statistic	PM Estimated Coefficient	PM t-Statistic
c	0.720	3.589	- 0.288	- 0.896
Day 1	- 1.689	-10.670	1.213	5.482
Day 2	- 2.128	- 6.297	- 1.453	- 3.949
Day 3	- 2.181	- 6.637	- 0.769	- 1.993
Day 4	- 1.739	- 5.191	- 0.952	- 2.443
Day 5	- 1.700	- 5.064	- 1.590	- 4.105
Day 6	- 2.045	- 6.365	- 0.399	- 1.097
LS	0.353	7.636	0.420	6.439
SL2	0.189	8.027	0.446	7.658
SL1	0.154	5.497	0.381	7.336
DD	0.011	5.259	0.031	5.537
DSP	- 0.138	- 8.263	- 0.393	- 6.399
	Model Test Statistics			
$\bar{R}^2$	0.413		0.378	
DW	2.043		2.143	
$F_{11,624}$	41.131		35.686	
RHO	0.348		4.189	
t(RHO)	9.370		11.637	

The fall in $\bar{R}^2$ between Tables 3 and 4 is due to the loss of explanatory information associated with removal of AL OL FTR and CP variables even though they were insignificant.

In the final model the DW statistics indicate the absence of serial correlation in the disturbance term for the transformed relationship. All t-statistics except for the PM constant term and the PM Day 6 parameter are highly significant. The F statistics with 11 and 624 degrees of freedom suggests that the hypothesis that none of the explanatory variables help to explain the variation of DOC's above their means should be rejected.

Again the adjusted coefficients of determination are lower than anticipated. In fact the standard errors of the regressions are unsatisfactorily high. The standard errors of 1.22 and 1.57 for the final equations in relation to the means on the dependent variables of 1.29 and 1.80 are 94 and 87 percent for the AM and PM regression models respectively. Although there is no quantitative acceptable level it is suggested by Pindyck and Rubinfeld [5] that the percentage standard error should be around 10 to 15 percent.

The analysis has supported the hypotheses on OL and FTR, rejected the CP policy dummy and identified the causal

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5. R. Pindyck & D. Rubinfeld, "Econometric Models & Economic Forecasts", McGraw Hill 1981, p. 85.

factors for DOC's. In the next section the structural model will be tested for its suitability as a means of forecasting DOC's for the ex-post out of sample period.

3.4 Forecasting

The purpose of forecasting is to provide the best prediction of out of sample estimates of AM and PM DOC's which can then be used to form the basis for establishing emergency manpower policy.

As only 646 of the 867 observations were used to estimate the regression model the remaining 215 or 25% of the total data set is available for ex-post forecasting analysis. An ex-post analysis has the advantage that a major source of forecasting error, that of errors on the forecasts of the explanatory variables, can be avoided. Having the actual results for AM and PM DOC's also allows for further refinement of the model.

The structural model developed in the previous section can be used to forecast the DOC's but there is no guarantee that it is the best method for forecasting. The classical tests of t, F and $\bar{R}^2$ are not acceptable measures of how well the model forecasts. In fact the model could forecast well even with low $\bar{R}^2$'s and insignificant parameters especially if there is very little variation on the AM and PM dependent variables. The structural model is also subject to other sources of forecast error including error due to mispecification, the random nature of the disturbance process and the fact that different samples give different estimates of the population parameters.

The means of measuring the forecast error is that of calculating Root Mean Squared Error (RMSE) which is the positive square root of the sum of the squared differences between the actual and the forecast DOC's divided by the number of observations.

Ideally the RMSE should be as close to zero as possible. Unfortunately there is no upper limit for the statistic and a subjective judgement has to be made as to whether the RMSE is acceptable.[6.]

One method of gauging whether the forecasting model is relatively acceptable is to compare the RMSE for the structural model to the RMSE for a Naive method of forecasting. In this case Naive means the expected value or mean for AM and PM DOC's.

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6. D.W. Challen and A.J. Hagger, "Modelling the Australian Economy", Longman Cheshire, 1979, p. 141.

The AM and PM structural models have the added complication of serially correlated errors. The errors in the original specification before Cochrane Orcutt transformation are no longer time independent and the information contained therein must be taken into account.

The forecasting error can be made smaller by a factor of $(1 - RHO)^2$ if the forecasting procedure includes the added information on the error term.[7]

The TSP program provides for forecasting using a Cochrane Orcutt transformation procedure. The results of RMSE's from TSP forecasting for AM and PM models are 1.3956 and 1.5024 respectively.

In the Naive approach the mean or expected value is a weighted average of the outcomes where the probability act as weights.[8]

These probabilities are calculated from an analysis of the 646 observations on the AM PM DOC's. Tables 5 and 6 show the probability distributions for zero or more DOC's for the sample period.

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7. R. Pindyck & D. Rubinfeld "Econometric Models Economic Forecasts", McGraw Hill, 1981, p. 216.

8. Ibid., p. 20.

Table 5

Probability Distribution for
AM DOC's

DAY	NO. DOC's								
	0	1	2	3	4	5	6	7	8
Sunday	0.853	0.041	0.074	0.032					
Monday	0.359	0.131	0.141	0.163	0.141	0.054	0.011		
Tuesday	0.286	0.132	0.143	0.143	0.264	0.032			
Wednesday	0.200	0.111	0.078	0.223	0.233	0.144	0.011		
Thursday	0.198	0.110	0.143	0.121	0.242	0.164	0.011		0.011
Friday	0.198	0.099	0.154	0.220	0.296	0.033			
Saturday	0.154	0.274	0.198	0.176	0.132	0.044	0.011	0.011	

Table 6

Probability Distribution for
PM DOC's

DAY	NO. DOC's											
	0	1	2	3	4	5	6	7	8	9	10	11
Sun.	0.043	0.109	0.359	0.261	0.131	0.054	0.032	0.011				
Mon.	0.304	0.131	0.087	0.098	0.098	0.131	0.119	0.032				
Tues.	0.298	0.132	0.088	0.098	0.098	0.132	0.122	0.032				
Wed.	0.122	0.100	0.100	0.133	0.133	0.156	0.189	0.067				
Thurs.	0.143	0.077	0.220	0.110	0.198	0.165	0.065	0.022				
Fri.	0.099	0.088	0.121	0.055	0.132	0.142	0.099	0.088	0.132	0.033	0	0.011
Sat.	0.132	0.285	0.220	0.154	0.143	0.033	0.022	0.011				

Table 7 shows the means or expected values for the persistent forecasts used in the Naive approach.

Table 7

Means or Expected Values

DAY	AM	PM
Sunday	0.285	2.673
Monday	1.802	2.591
Tuesday	2.063	2.620
Wednesday	2.645	3.614
Thursday	2.701	3.008
Friday	2.415	4.318
Saturday	2.089	2.133

When compared with the actual values for the AM and PM DOC's for the out of sample period the RMSE for the Naive model is 1.6069 and 1.8512 respectively.

The results of the RMSE analysis indicates the structural model is better at forecasting the DOC's than the Naive approach for the ex-post forecast period. This may not be true for any ex-ante analysis where the data on explanatory variables is not known with certainty.

The forecast results from the structural model are therefore used in the policy evaluation to follow.

3.5 Policy Evaluation

As the structural model is relatively more efficient at forecasting than the Naive approach the structural model is used to predict the number of AM and PM DOC's for the ex-post forecast period. Tables 8 and 9 provide a summary of the predicted DOC's for the AM and PM for each day of the week.

Table 8

Predicted AM DOC's for the Ex-post Sample Period

DAY	Number of DOC's 0	1	2	3	4	5	6
Sunday		3	17	7	3		
Monday	25	4	1				
Tuesday		4	9	14	4		
Wednesday	1	4	9	10	7		
Thursday		3	8	9	11		
Friday		2	5	9	12	3	
Saturday	1	3	3	12	12		

Table 9

Predicted PM DOC's for the Ex-post Sample Period

DAY	Number of DOC's 0	1	2	3	4	5	6
Sunday		2	15	8	3	2	
Monday	1	2	14	12	1		
Tuesday	9	11	9	1	1		
Wednesday		7	11	8	5		
Thursday	1	2	6	8	9	3	2
Friday	2	2	12	8	6	1	
Saturday		1	2	7	13	4	4

From the results shown in Tables 8 and 9 the optimal combinations of shifts are established which maximize the number of DOC's saved over the ex-post forecasting period for each additional full time emergency driver employed.

Tables 10 and 11 show the optimum shift structure for adding up to four AM and PM emergency shifts. These Tables also show the expected DOC savings from each additional unit of manpower.

Table 10

AM Shifts and DOC Saving From Additional Manpower

ADDITIONAL AM MANPOWER	SHIFTS SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.	EXPECTED DOC SAVINGS
1			X	X	X	X	X	153
2			X	X	X	X	X	137
3			X	X	X	X	X	103
4			X	X	X	X	X	49

Table 11

PM Shifts and DOC Saving From Additional Manpower

ADDITIONAL PM MANPOWER	SHIFTS SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.	EXPECTED DOC SAVINGS
1		X		X	X	X	X	150
2		X	X	X	X	X		128
3		X		X	X	X	X	93
4			X	X	X	X	X	63

(X = days worked on shifts).

DOC cost savings from the addition of emergency manpower can be established by multiplying the number of DOC's saved by the marginal cost of a DOC.

As at 24 April 1982, the marginal rate of pay for a driver was $6.82 per hour (see Appendix 10). The average hours of paid time for a DOC for the M.T.T. is 15.15 hours. Thus the marginal cost of a DOC was $103.32.

Tables 12 and 13 show the expected cost savings from reduced DOC's from the addition of the four AM and four PM clear emergency shifts.

Table 12

Predicted Cost Savings From Additional AM Emergency Manpower

ADDITIONAL MANPOWER	PREDICTED COST SAVINGS	COST OF ADDITIONAL MANPOWER	NET SAVING/COST TO M.T.T.
	$	$	$
1	15,808	10,979	4,829
2	14,155	10,979	3,176
3	10,642	10,979	- 337
4	5,063	10,979	-5,916

Table 13

Predicted Cost Savings From Additional PM Emergency Manpower

ADDITIONAL MANPOWER	PREDICTED COST SAVINGS	COST OF ADDITIONAL MANPOWER	NET SAVING/COST TO M.T.T.
	$	$	$
1	15,498	11,362	4,136
2	13,222	10,515	2,707
3	9,608	11,362	-1,754
4	6,509	11,362	-4,853

An inspection of Tables 12 and 13 indicate that the M.T.T. would only entertain the addition of two AM and two PM clear emergency shifts as the predicted marginal cost savings from DOC exceed marginal costs of additional manpower for the first two AM and PM shifts.

Total predicted savings from the addition of the shifts would have been $14,848 over the sample period.

As the ex-post DOC data is also available the predicted results can be compared to actual results. The actual number of DOC's that would have been saved and the resulting net cost savings from the employment of additional manpower are shown in Table 14.

Table 14

Actual DOC's Saved and Net Cost Savings For AM and PM Over the Ex-Post Period

ADDITIONAL MANPOWER	AM		PM	
	Number of Shifts	Cost/Savings	Number of Shifts	Cost/Savings
1	119	1,316	133	2,380
2	89	-1,784	121	1,987
3	70	-3,747	80	-3,097
4	44	-6,433	66	-4,543

The actual savings from the inclusion of four additional clear emergency shifts would have been $3,899.

The information contained in Table 14 suggests that there is some question that the second AM clear emergency shift should be added.

Because the viability of the second AM clear emergency shift is suspect and the Government will require convincing arguments before permitting the employment of additional manpower, the second AM emergency shift is excluded.

The optimal manpower/DOC mix will be achieved with the addition of one AM and two PM clear emergency shifts. Table 15 shows how the shifts should be structured to maximize expected return.

Table 15

Additional Emergency Shift Structure

Shift Type	Weekly Shift Structure				
	1	2	3	4	5
1 AM	Tues.	Wed.	Thurs.	Fri.	Sat.
1 PM(1)	Mon.	Wed.	Thurs.	Fri.	Sat.
1 PM(2)	Mon.	Tues.	Wed.	Thurs.	Fri.

The three additional shifts should be designated for "known" work.

CHAPTER 4

CONCLUSIONS AND POLICY IMPLICATIONS

This study set out to identify the causal factors of demand for DOC's and to establish the optimum level of emergency manpower for the M.T.T.

The results of the single equation estimation revealed that the demand for DOC's can be explained in part by the following factors:

- day of the week
- number of drivers on long service leave
- number of drivers on sick leave
- roster demand for drivers
- number of spare drivers.

Drivers on long term sick leave are more likely to contribute to DOC's than drivers taking a single day with a medical certificate or a grace day.

Equally, if not more important, arethe factors that have been excluded from the analysis. Prior to this analysis many of these factors were considered by the M.T.T. to be major contributing factors to DOC's. In fact the M.T.T. had based some of its DOC reduction policies on variables that proved insignificant in the final analysis.

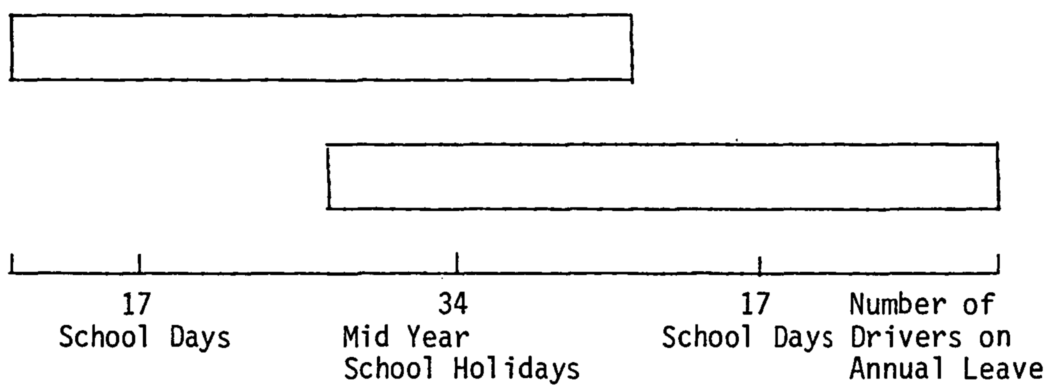
For instance the insignificance of the failure to report variable and the size of the coefficient in the short term sick leave variable compared to the long term coefficient indicates that the less advice M.T.T. inspectors get of driver short fall the less likely DOC's will result. This is contrary to present M.T.T. thinking that the more advice given, the more time inspectors have to work out alternative means of overcoming the shortfall and the less likely DOC's will be required. The M.T.T. currently insists that drivers provide the maximum notice of absence.

Similarly the failure of the change of policy variable to stand up to quantitative analysis, when specifically included by management suggest that M.T.T. management are operating under the misconception that the cancellation of services under the existing conditions is reducing DOC's. The problem appears to result from the fact that the decision to cancel services is made on the day the service is to run and not the day before when most of the decisions are made to cancel drivers days off.

The insignificance of the annual leave variable means that the M.T.T. is not using this type of leave to reduce short term driver short fall. The M.T.T. simply allows the set complement of drivers to take annual leave each five week period. The introduction of a flexible leave system to allow for cancellation of leave at short notice could result in some DOC savings. Of course the AT & MOEA would insist on some compensation payment for this facility. One alternative which would retain the present structure but provide additional manpower when most needed is an annual leave overlap arrangement, (see Figure 3). This would utilize spare drivers during school holidays and make more drivers available at other times when DOC's are more likely.

Figure 3

Annual Leave Overlap



Care should be taken not to allow too many drivers to overlap on annual leave as it was also revealed, but not reported in this study that sick leave increases during mid year school holidays.

The statistics tend to support the view that M.T.T. policy relating to conditions on the approval of other leave is effective. This means that inspectors are not approving other leave if it results in the need to cancel a drivers day off.

The low $\overline{R}^2$'s and the presence of serial correlation suggest that the structural models are not a good fit and that there are time dependent relationships between the disturbance terms. This suggests that the model could be misspecified. One possible reason could be the absence of the inspector expertise variable which was excluded for the reasons stated in section 3.3.1.

In terms of forecasting the structural model is better than the Naive approach but still inaccurate to the extent that the actual financial return was only 26% of the predicted return. However, the model did correctly predict a positive return from the decision to employ two additional AM and PM clear emergency shifts.

Further refinement to guarantee a good positive return, resulted in the exclusion of the second AM clear emergency shift.

This analysis suggests that the best emergency manpower/DOC mix is seven AM and seven PM clear emergency shifts with the additional three shifts allocated "known" work.

Finally the drivers union are certain to support the addition of three emergency shifts. However, there is likely to be some individual opposition from drivers who rely on DOC's to supplement their income.

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M.T.T. ANNUAL DEFICIT

1957 - 1984

($'000)

YEAR	ACTUAL	REAL	YEAR	ACTUAL	REAL
1957	256	250	1971	1068	745
1958	300	291	1972	987	651
1959	270	258	1973	1242	753
1960	338	512	1974	1882	989
1961	424	377	1975	3005	1375
1962	484	433	1976	3932	1608
1963	448	398	1977	4746	1677
1964	502	438	1978	5162	1690
1965	571	478	1979	5125	1537
1966	553	455	1980	5591	1526
1967	652	514	1981	6425	1601
1968	698	539	1982	7150	1616
1969	728	547	1983	8269	1704
1970	791	582	1984	9376	1888

Source: M.T.T. Annual Reports, 1957/58 - 1983/84.

Real figures adjusted for CPI. Base year 1956.

METROPOLITAN TRANSPORT TRUST

COST OF A DRIVER AS AT 24 APRIL 1982

Marginal Cost

Average weekly pay	$ 273
Cost per hour, 40 hours per week	$ 6.82

Annual Cost

Wages (273 x 47)	$ 12831
Annual leave and sick leave	$ 1575
Annual leave loading	$ 273
	$ 14679
Add on costs:	
Superannuation Payroll Tax	
Workers' Compensation insurance	
Uniforms	$ 2530
	$ 17209

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