M O D A L S P L I T A N A L Y S I S

F O R T H E

J O U R N E Y T O W O R K

by

W.N. Aplin, B.E.(Civil) (Melb).

A thesis submitted in partial fulfilment of the requirements for the Degree of Master of Science in the Faculty of Engineering, University of Cape Town.

Department of Civil Engineering,
UNIVERSITY OF CAPE TOWN

May. 1974.

APPENDIX 1.1

A DEFINITION OF A FREE MARKET ECONOMY

Lipsey and Steiner[27] define a free market economy as "an economy in which the decisions of individual households and firms (as distinct from the central authorities) exert the primary and major influence over the allocation of resources".

In other words, the only method by which the allocation of resources (i.e. the allocation of land, labour, capital) for production of goods and services can alter is by changes in supply and demand functions generally governed by the price system.

For example, if the government were to place a freeze on land prices, this would be an external influence on the market and land could no longer be considered a free market commodity.

A DEFINITION OF PERFECT COMPETITION

For perfect competition to exist, the market must exhibit the following characteristics:

1. Many buyers and sellers;
2. No one buyer or seller can have any appreciable influence on the market price by varying the amount he buys and sells;
3. Freedom of entry or exit into the market, i.e. anyone, with the necessary capital, can decide to produce and/or sell whenever he wishes.

APPENDIX 2.1

UTILITY AND DISUTILITY

Dupuit's[6] basic statement of utility as "the maximum sacrifice which each consumer would be willing to make in order to acquire the object" is demonstrated graphically in figure A.2.1.1[30].

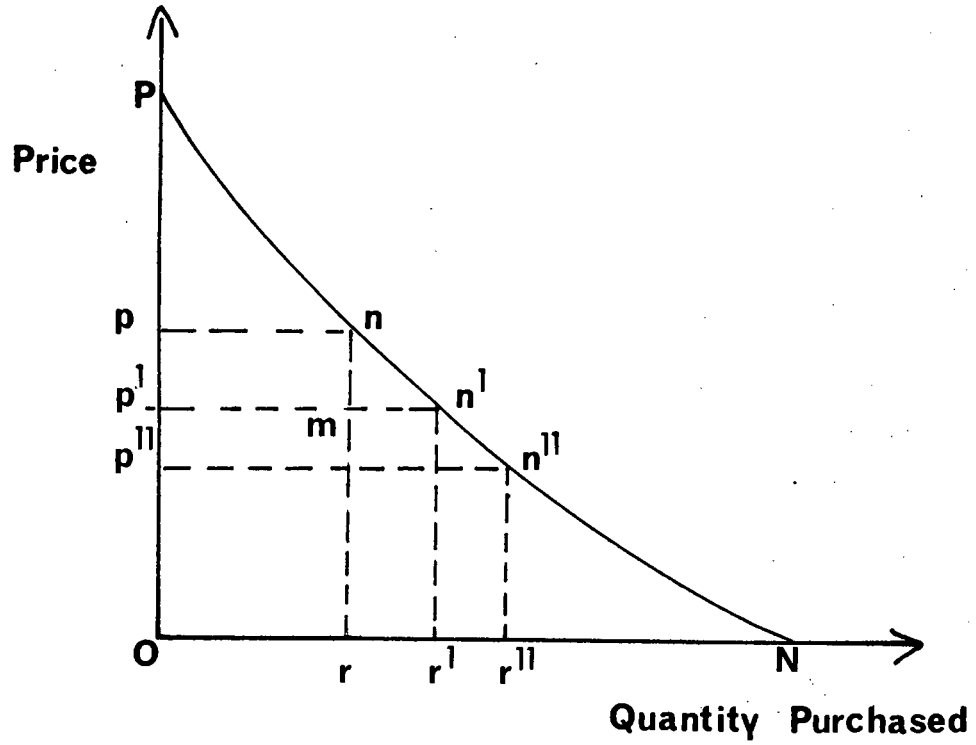


Fig. A.2.1.1 **The Calculation of Utility**

In this figure, PN represents the demand curve (i.e. for a market or a group of consumers, the change in quantity demanded with change in market price), whilst r represents the amount of goods purchased at price p.

The absolute utility of the r articles is given by the mixtilinear trapezium OPnr. In other words there is a surplus to the consumers of npP. This is known as consumer's surplus or relative utility. It can be thought of as the

utility remaining to the consumer after he has paid for the r goods.* If the price falls to p', due to a shift in the supply curve, which would now cut the demand curve at n', the relative utility would now be n'p'P. The increase in this relative utility is therefore p'n'np. More importantly this increase is made up of two parts. It consists of pnmp', which represents the increased utility enjoyed by the original consumers and the area nmn' which makes the good available to more people and can be regarded as the relative utility of the good to these new consumers. It is this area nmn' which will be of importance in Chapter 6 in relation to congestion or restraint taxes. For (p-p') represents the tax which would need to be imposed on these <u>additional</u> consumers in order for them to forego consumption of goods (r'-r).

If we increase the consumption to r'' (noting that r'' - r' = r' - r, that is an equal increment of consumption). The respective changes in total utilities for the equal changes r to r' and r' to r'' are rr'n'n and r'r''n''n'. We note that the told utility per good is decreasing so that the marginal utility is a decreasing function of the goods consumed. This is demonstrated in the figures A.2.1.2 and 3.

If consumption is increased to the point where the marginal utility becomes negative (i.e. any further consumption of a good involves some dissatisfaction) then such negative marginal utility is termed disutility.

---

* The market price p is the point at which the supply curve cuts the demand curve, i.e. at the point n in the case above.

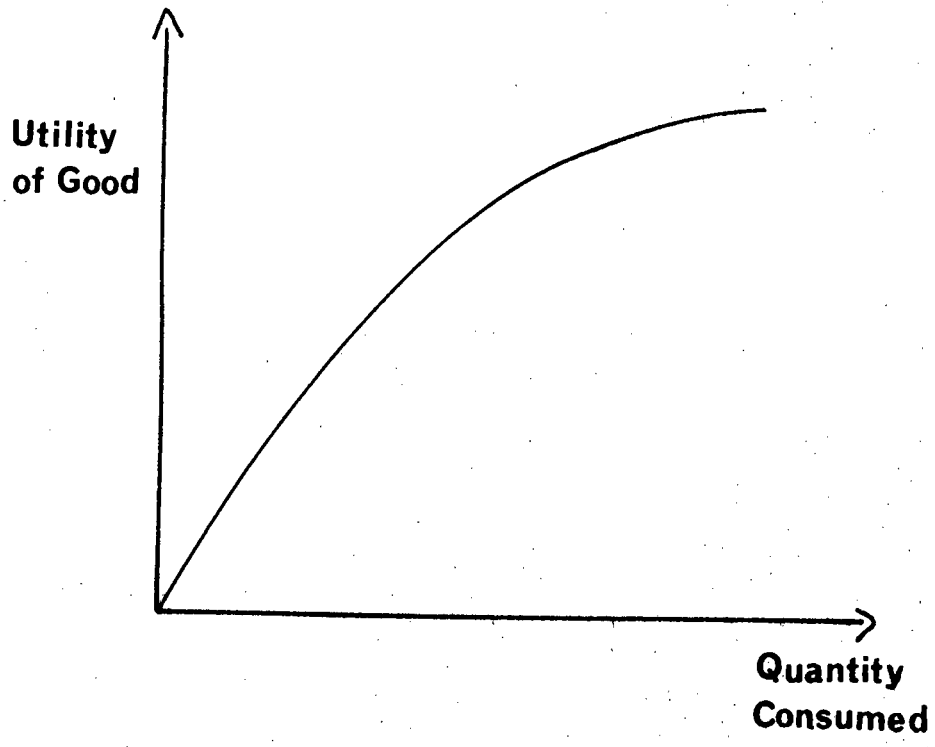


Fig A.2.1.2 **Total Utility Curve**

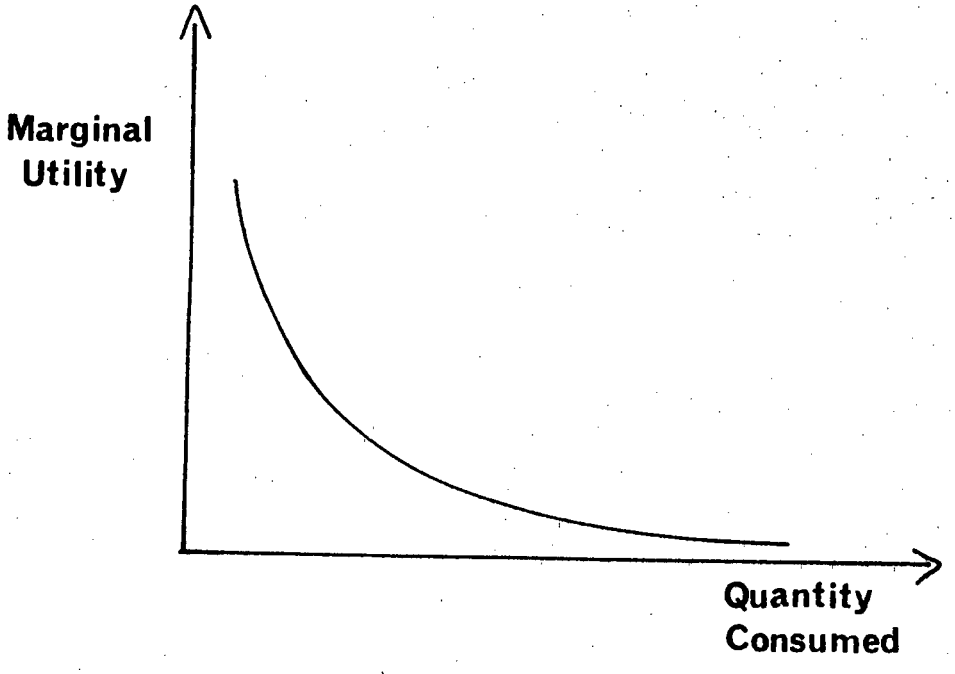


Fig A.2.1.3 **Marginal Utility Curve**

APPENDIX 2.2

BUDGET CONSTRAINTS, UTILITY MAXIMIZATION AND SUBSTITUTION

Scarcity is a term in economics to denote the inability of available resources to satisfy everyone's desires. A household is faced with a limited budget and is forced to choose which goods to consume within that budget.

For a hypothetical "two commodity universe" (say food and clothing) a budget constraint line can be drawn to represent the sets of possible choices open to a consumer who is assumed to spend his whole income. Such a line is shown in figure A.2.2.1.

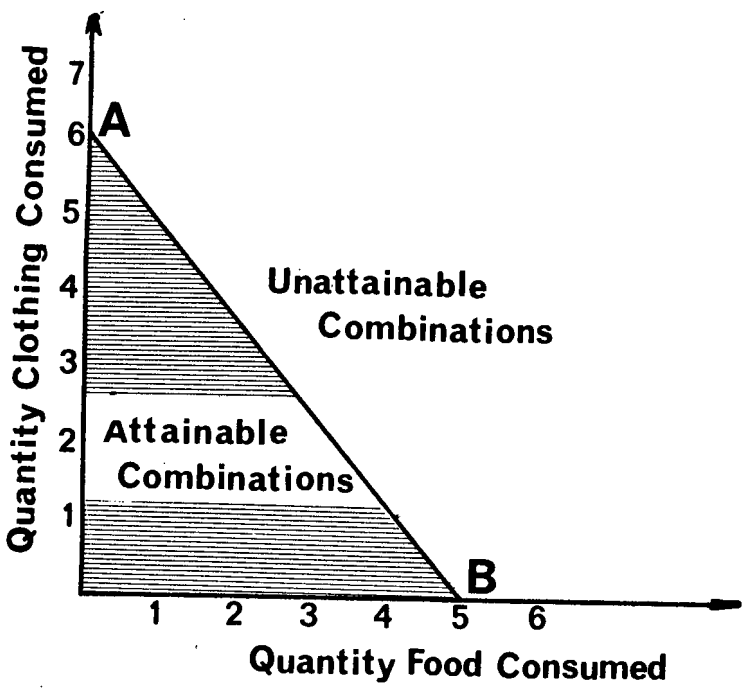


Fig.A.2.2.1. Budget Line

The shaded region represents all those combinations of food and clothing attainable by the consumer. The budget line represents those combinations just attainable by the consumer, and areas to the right of the line are unattainable.

The slope of the budget line represents the opportunity cost of a good. Opportunity cost is the amount of one good which is sacrificed in order to consume one unit of the other good.

If a curve of equally satisfactory combinations of food and clothing were drawn, i.e. an indifference curve, the budget constraint determines what level of satisfaction is attainable. An increasing utility occurs with curves furthest from the origin (see figure A.2.2.2).

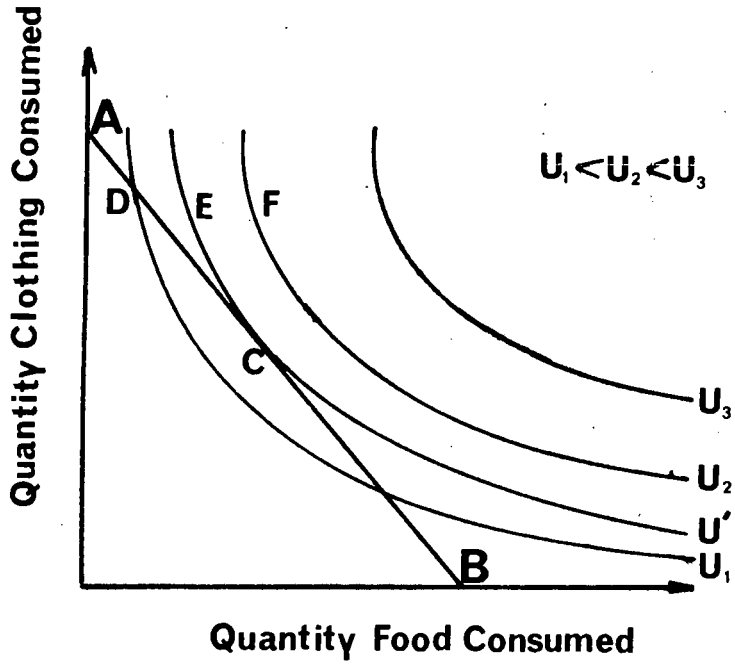


Fig. A.2.2.2 Indifference Curves

For a budget constraint of A-B the point at which the consumer maximizes his utility is at the point C where the budget line is tangential to the indifference curve U'. This can be demonstrated by examining sample points D, E and F. E has equal utility to C but is unattainable. F has higher utility than C and would be preferred but is also unattainable whereas D is attainable but has less utility than C.

The convex shape of the indifference curves indicates a basic hypothesis of indifference theory - the diminishing marginal rate of substitution. This means that the less of one commodity a consumer has and the more of another, the less willing he will be to substitute the former good for the latter on the grounds that he would lose satisfaction in the exchange.

APPENDIX 3.1

QUESTIONNAIRE SURVEY FORM

This form was used in the final questionnaire survey described in Chapter 3. The Afrikaans version is printed from the back to the front and the opposite way up to the English version.

JOURNEY TO WORK

CAPE TOWN PILOT SURVEY

1973

This survey is being conducted by the:

Department of Civil Engineering,
University of Cape Town

and the

Transport Research Centre,
University of Stellenbosch.

Your journey to work is of importance both to yourself and to those responsible for planning future transportation facilities. It is indeed a major factor in the planning of urban transportation and this survey will assist in providing information necessary for a pilot study of Cape Town's requirements.

Your help is therefore requested in filling out this questionnaire which will take about 5-10 minutes of your time.

Your answers will be strictly confidential and no individual replies will be divulged to anyone.

Your co-operation will be very much appreciated.

SIEN KEERSY VIR AFRIKAANS

Slegs vir kantoorgebruik

9. Indien u vandag van bus- of treinvervoer gebruik sou maak, hoeveel keer sou u moes oorstap?

Geen ☐ 0 Een ☐ 1 Twee ☐ 2 Drie of meer ☐ 3 ☐ 26

10. Waarom verkies u om eerder per motor as met openbare vervoer werk toe te kom? (Dui slegs die vernaamste redes aan.)

☐ ☐ ☐ 27 28 29

(i) Geen openbare vervoer beskikbaar ☐ 1

(ii) Rit per motor is goedkoper ☐ 2

(iii) Rit per motor is vinniger ☐ 3

(iv) Moet oorstap by bus/treinvervoer ☐ 4

(v) Te ver om te stap na bushalte/stasie ☐ 5

(vi) Moet te lank wag vir bus/trein ☐ 6

(vii) Mag motor/afleweringswa gedurende werksure nodig hê ☐ 7

(viii) Openbare vervoer is te ongerieflik ☐ 8

(ix) Neem kinders skool toe op pad na werk ☐ 9

(x) Ander redes - meld asseblief..... ☐ 10

.....

.....

Dit handel Deel 'C' af.

Baie dankie.

How to Complete this Form

1. General Section: This is to be completed by everyone; together with ONE ONLY of the following:

   PART 'A': To be completed by those who do not own a car.

   PART 'B': To be completed by car-owners who did not come to work TODAY in their own car.

   PART 'C': To be completed by car-owners who came to work TODAY in their own car.

2. Questions with a box: please tick the box indicating your answer.

3. Questions not containing a box: please write your answer.

General Section

To be completed by everyone

Office Use Only

1. What is your position in your household?

Husband	☐ 1	Wife	☐ 5
Son	☐ 2	Daughter	☐ 6
Male Lodger	☐ 3	Female Lodger	☐ 7
Male Living Alone/Sharing	☐ 4	Female Living Alone/Sharing	☐ 8

☐ 2

2. Do you personally own a car?

Yes ☐ 1 No ☐ 0 ☐ 3

3. How many car driving licences are held by members of your household?

None ☐ 0 One ☐ 1 Two ☐ 2 Three or more ☐ 3 ☐ 4

Slegs vir kantoorgebruik

6. Hoeveel minute het dit vir u geneem om vandag by die werk te kom? (Deur-tot-deur tyd, insluitende tyd van parkering asseblief.)

0 - 10 min ☐ 1 11 - 20 min ☐ 2

21 - 30 min ☐ 3 31 - 40 min ☐ 4

Meer as 40 min ☐ 5

☐ 22

7. (a) Indien u nie per motor gereis het nie, hoe sou u anders by die werk gekom het?

Passasier in motor ☐ 1 Bus ☐ 2 Trein ☐ 3 Huur-motor ☐ 4

Stap ☐ 5 Motorfiets ☐ 6 Fiets ☐ 7

☐ 23

(b) Hoeveel minute sou hierdie metode van reis in beslag geneem het?

0 - 10 min ☐ 1 11 - 20 min ☐ 2

21 - 30 min ☐ 3 31 - 40 min ☐ 4

41 - 50 min ☐ 5 Meer as 50 min ☐ 6

☐ 24

8. Indien u nie vandag u motor gebruik het nie, hoe lank sou dit geneem het om na die naaste bushalte of stasie te stap?

0 - 5 min ☐ 1 6 - 10 min ☐ 2

11 - 15 min ☐ 3 Meer as 15 min ☐ 4

☐ 25

Office Use Only

4. How many children do you have under 16 yrs. of age?

None ☐ 0 One ☐ 1 Two ☐ 2 Three or more ☐ 3 ☐ 5

5. How did you come to work today? (Please tick main method only.)

Car Driver ☐ 1 Car Passenger ☐ 2 Motor Cycle/Scooter ☐ 3 ☐ 6

Bus ☐ 4 Train ☐ 5 Taxi ☐ 6 Bicycle ☐ 7 Walked ☐ 8

Drive to train or bus ☐ 9

6. Do you come to work in a car pool? (A car pool means taking turns driving your car and riding as a passenger in another.)

Yes ☐ 1 No ☐ 0 ☐ 7

7. What is your occupation? (Please give brief details.)

.....

..... ☐ 8 ☐ 9

8. What is your home address? (Street, Number and Suburb.)

.....

..... ☐ 10 ☐ 11 ☐ 12

DEEL 'C'

Slegs vir kantoorgebruik

Slegs persone wat vandag in hul EIE of firma se motor of afleweringswa werk toe gekom het, moet hierdie afdeling beantwoord.

1. Parkeer u die motor/afleweringswa bedags op 'n parkeerruimte wat deur u firma voorsien word?

   Ja ☐ 1 Nee ☐ 0 ☐ 14

2. Hoeveel betaal u daagliks vir parkering? ..... ☐ ☐ ☐ 15 16 17

3. Kom u normaalweg in u eie motor/afleweringswa werk toe?

   Ja ☐ 1 Nee ☐ 0 ☐ 18

4. Is u 'n lid van 'n "motorpoel" en indien wel hoeveel passasiers het u vervoer? (D.w.s. is u lid van 'n groep persone wat gereeld beurte maak met die gebruik van hulle motors terwyl die ander lede as passasiers ry.)

   Ja ☐ 1 Nee ☐ 0 ☐ 19

   Aantal passasiers:

   Geen ☐ 0 Een ☐ 1 Twee ☐ 2 Drie ☐ 3 Vier of meer ☐ 4 ☐ 20

5. As die weer die dag baie sleg is (byvoorbeeld mis of reën) laat u dan u motor tuis en maak van openbare vervoer gebruik?

   Soms ☐ 1 Nooit ☐ 0 ☐ 21

Office Use Only

9. Between which range does your salary fall? (Before deductions.) (This question is optional.) (This information is strictly confidential.)

Monthly: 0 - R200 ☐ 1 R201 - R400 ☐ 2

R401 - R600 ☐ 3 R601 - R800 ☐ 4

More than R800 ☐ 5

OR

Annually: 0 - R2400 ☐ 1 R2401 - R4800 ☐ 2

R4801 - R7200 ☐ 3 R7201 - R9600 ☐ 4

More than R9600 ☐ 5

☐ 13

Slegs vir kantoorgebruik

(d) Hoeveel minute moet u vir die bus of trein wag?

0 - 5 min ☐ 1 6 - 10 min ☐ 2

11 - 15 min ☐ 3 Meer as 15 min ☐ 4

☐ 24

(e) Is daar enige beskutting by u bushalte of stasie?

Ja ☐ 1 Nee ☐ 0

☐ 25

(f) Indien u per motor sou reis, hoe lank sou die rit u geneem het?

0 - 10 min ☐ 1 11 - 20 min ☐ 2

21 - 30 min ☐ 3 31 - 40 min ☐ 4

41 - 50 min ☐ 5 Meer as 50 min ☐ 6

☐ 26

6. Indien u vandag per bus gereis het, hoeveel was u reisgeld? .....

☐ 27 ☐ 28 ☐ 29

7. (a) Indien u vandag per trein gereis het, watter soort reiskaartjie het u gebruik?

Enkel ☐ 1 Retoer ☐ 2 Weekliks ☐ 3

Maandeliks ☐ 4

☐ 30

(b) Hoeveel het dié kaartjie gekos? .....

☐ 31 ☐ 32 ☐ 33

Dit handel Deel '8' af.

Baie dankie.

Office Use Only

PART 'A'

If you do not own a car please answer this section

1. Is the method you used to come to work today your usual method?

Yes ☐ 1 No ☐ 0 ☐ 14

If your answer is no, please tick your usual method.

Car Passenger ☐ 1 Train ☐ 2 Bus ☐ 3 Taxi ☐ 4 ☐ 15

Motor Cycle ☐ 5 Walk ☐ 6 Bicycle ☐ 7

2. How many minutes did it take you to come to work today? (Door to door time.)

1 - 10 mins ☐ 1 11 - 20 mins ☐ 2 21 - 30 mins ☐ 3 ☐ 16

31 - 40 mins ☐ 4 41 - 50 mins ☐ 5 more than 50 mins ☐ 6

3. Did you use both bus and train in your journey to work today?

Yes ☐ 1 No ☐ 0 ☐ 17

4. If you came to work today by bus what was your fare? (Single fare)

..... ☐☐☐ 18 19 20

5. Did you have to change buses?

Yes ☐ 1 No ☐ 0 ☐ 21

Slegs vir kantoorgebruik

(v) Verkeer op paaie te druk ☐ 5

(vi) Gebrek aan gerieflike parkeerfasiliteite by werk ☐ 6

(vii) Rit per motor neem te lank ☐ 7

(viii) Motor word gediens ☐ 8

(ix) Is lid van 'n "motorpoel" (d.w.s. is lid van 'n groep persone wat gereeld beurte maak met die gebruik van hulle motor terwyl die ander lede as passasiers ry). ☐ 9

Indien u vandag van OPENBARE VERVOER gebruik gemaak het om te kom werk, beantwoord asseblief vrae 5, 6 en 7.

5. (a) Was dit vandag vir u nodig om van bus of trein te verwissel gedurende u rit werk toe?

Ja ☐ 1 Nee ☐ 0 ☐ 21

(b) Hoeveel minute het dit u geneem om vandag u werk te bereik? (Deur-tot-deur tyd asseblief.)

0 - 10 min ☐ 1 11 - 20 min ☐ 2 ☐ 22

21 - 30 min ☐ 3 31 - 40 min ☐ 4

41 - 50 min ☐ 5 Meer as 50 min ☐ 6

(c) Hoeveel minute het dit vir u geneem om na die bushalte of stasie te stap of te ry?

0 - 5 min ☐ 1 5 - 10 min ☐ 2 ☐ 23

11 - 15 min ☐ 3 Meer as 15 min ☐ 4

Office Use Only

6. If you came to work today by train:

(a) At which station did you commence your trip?

..... 22 23

(b) What type of ticket did you use?

Single ☐ 1 Return ☐ 2 Weekly ☐ 3 Monthly ☐ 4 — 24

(c) What was the cost of this ticket? 25 26 27

7. If you owned a car would you use it to come to work?

Yes ☐ 1 No ☐ 0 — 28

8. Do you hold a current car drivers licence?

Yes ☐ 1 No ☐ 0 — 29

9. Which of the following is most inconvenient about coming to work on Public Transport? (Tick main reasons only.) 30 31 32

(i) Distance to walk to or from bus stop or station ☐ 1

(ii) Waiting for train or bus ☐ 2

(iii) Uncertain of a seat on train or bus ☐ 3

(iv) Lack of shelter at stop or station ☐ 4

(v) Bus or train arrives late or too early for work ☐ 5

(vi) Having to change bus or trains ☐ 6

(vii) Public transport vehicle is unclean ☐ 7

(viii) Others. (Please state.) ..... ☐ 8

.....

Slegs vir kantoorgebrui

DEEL 'B'

Moet deur motoreienaars voltooi word wat NIE vandag hul motors gebruik het om werk toe te kom nie

1. Word daar gratis parkering by u werk voorsien?

Ja ☐ 1 Nee ☐ 0 ☐ 14

2. As dit swaar reën of baie koud is, kom u dan in u eie motor werk toe?

Soms ☐ 1 Nooit ☐ 0 ☐ 15

3. (a) Is die metode waarvolgens u vandag werk toe gekom het u gereelde metode?

Ja ☐ 1 Nee ☐ 0 ☐ 16

(b) Indien u antwoord NEE is, dui dan asseblief u gereelde metode aan.

Eie motor ☐ 1 Bus ☐ 2 Trein ☐ 3 Huurmotor ☐ 4 ☐ 17

Stap ☐ 5 Fiets ☐ 6 Motorfiets ☐ 7

4. Waarom het u nie vandag met u eie motor werk toe gekom nie? (Dui asseblief slegs die vernaamste rede(s) aan.)

(i) Onkoste van motorrit te hoog ☐ 1

(ii) 'n Ander familielid gebruik die motor werk toe ☐ 2

(iii) Vrou gebruik motor vir inkopies ☐ 3

(iv) Vrou gebruik motor vir ander doel ☐ 4

☐ ☐ ☐ 18 19 20

Office Use Only

OR

(ix) Public transport is not inconvenient ☐ 0

10. If you have an alternative mode of public transport (e.g. bus instead of train) how long would it take you to come to work by this method?

0 - 10 mins ☐ 1 | 11 - 20 mins ☐ 2 | 21 - 30 mins ☐ 3 | ☐ 33

31 - 40 mins ☐ 4 | 41 - 50 mins ☐ 5 | more than 50 mins ☐ 6

11. Would the alternative fare be:

less expensive ☐ 1 | more expensive ☐ 2 | the same ☐ 3 | ☐ 34

as your present fare to work?

This completes Part 'A'

Thank you.

Slegs vir kantoorgebruik

9. Watter van die volgende beskou u as die ongerieflikste sover dit u werkrit met openbare vervoer aangaan? (Dui slegs die vernaamste redes aan.)

(i) Te ver om te stap na die naaste bushalte of stasie ☐ 1

(ii) Moet te lank vir 'n bus of trein wag ☐ 2

(iii) Onsekerheid oor 'n sitplek op die bus of trein ☐ 3

(iv) Geen beskutting by bushalte of stasie nie ☐ 4

(v) Bus of trein arriveer te vroeg of te laat vir werk ☐ 5

(vi) Moet by bus- of treinvervoer oorstap ☐ 6

(vii) Openbare vervoermiddel is vuil ☐ 7

(viii) Ander redes (meld asseblief.)..... ☐ 8

.....

OF

(ix) Openbare vervoer is nie ongerieflik nie ☐ 0

☐ ☐ ☐ 30 31 32

10. Indien u 'n alternatiewe vorm van openbare vervoer na u werk kan gebruik (byvoorbeeld bus i.p.v. trein) hoe lank sal dit dan vir u neem om u werk te bereik indien u daarvan gebruik maak?

0 - 10 min ☐ 1 11 - 20 min ☐ 2 21 - 30 min ☐ 3

31 - 40 min ☐ 4 41 - 50 min ☐ 5 meer as 50 min ☐ 6

☐ 33

11. Sou die alternatiewe tarief:

Goedkoper ☐ 1 Duurder ☐ 2 Dieselfde ☐ 3

as die huidige tarief na u werk wees?

☐ 34

Dit handel Deel 'A' af.

Baie dankie.

PART 'B'

Office Use Only

To be completed by car owners who DID NOT use their own car to come to work today

1. Is there parking space at your work free of charge?

Yes ☐ 1 No ☐ 0 ☐ 14

2. On days of heavy rain or extreme cold do you bring your own car to work?

Sometimes ☐ 1 Never ☐ 0 ☐ 15

3. (a) Is the method you used to come to work today your usual method?

Yes ☐ 1 No ☐ 0 ☐ 16

(b) If your answer was NO, please tick your usual method.

Own Car ☐ 1 Bus ☐ 2 Train ☐ 3 Taxi ☐ 4 ☐ 17

Walk ☐ 5 Bicycle ☐ 6 Motor Cycle ☐ 7

4. Why did you not come to work today in your car? (Please tick main reasons only.) ☐ ☐ ☐ 18 19 20

(i) Car trip too expensive ☐ 1

(ii) Another member of family uses car to travel to work ☐ 2

(iii) Wife uses car for shopping ☐ 3

Slegs vir kantoorgebruik

5. Moes u tussen busse oorstap?

Ja ☐ 1 Nee ☐ 0 ☐ 21

6. Indien u vandag per trein werk toe gekom het:

(a) By watter stasie het u opgeklim?

..... ☐ 22 ☐ 23

(b) Watter soort kaartjie het u gebruik?

Enkel ☐ 1 Retoer ☐ 2 Weekliks ☐ 3 ☐ 24

Maandeliks ☐ 4

(c) Hoeveel het dié kaartjie u gekos? ..... ☐ 25 ☐ 26 ☐ 27

7. Indien u wel 'n motor besit het, sou u dit gebruik om mee werk toe te kom?

Ja ☐ 1 Nee ☐ 0 ☐ 28

8. Is u in besit van 'n geldige rybewys?

Ja ☐ 1 Nee ☐ 0 ☐ 29

Office Use Only

(iv) Wife uses car for other purposes ☐ 4

(v) Roads too crowded ☐ 5

(vi) No suitable parking arrangements at work ☐ 6

(vii) Journey takes too long by car ☐ 7

(viii) Car being serviced ☐ 8

(ix) Travel by car pool (a car pool means where you take turns in driving your car and riding as a passenger in another). ☐ 9

If you came to work by PUBLIC TRANSPORT, please answer Q.5, 6 and 7.

5. (a) Did you need to change buses or trains on your trip to work today?

Yes ☐ 1 No ☐ 0 ☐ 21

(b) How many minutes did it take you to come to work today? (Door to door time please.)

0 - 10 mins ☐ 1 11 - 20 mins ☐ 2 ☐ 22

21 - 30 mins ☐ 3 31 - 40 mins ☐ 4

41 - 50 mins ☐ 5 more than 50 mins ☐ 6

(c) How many minutes did it take you to walk or drive to bus stop or station?

0 - 5 mins ☐ 1 6 - 10 mins ☐ 2 ☐ 23

11 - 15 mins ☐ 3 more than 15 mins ☐ 4

DEEL 'A'

Slegs vir kantoorgebruik

Indien u nie 'n motor besit nie, beantwoord asseblief hierdie deel.

1. Is die wyse waarop u vandag werk toe gekom het, u gereelde manier?

Ja ☐ 1 Nee ☐ 0 ☐ 14

Indien u antwoord NEE is, dui asseblief u gereelde manier met 'n kruisie aan.

Passasier in motor ☐ 1 Trein ☐ 2 Bus ☐ 3 Huurmotor ☐ 4 ☐ 15

Motorfiets ☐ 5 Stap ☐ 6 Fiets ☐ 7

2. Hoeveel minute het dit u geneem om vandag by die werk te kom? (Deur-tot-deur.)

1 - 10 min ☐ 1 11 - 20 min ☐ 2 21-30 min ☐ 3 ☐ 16

31 - 40 min ☐ 4 41 - 50 min ☐ 5 meer as 50 min ☐ 6

3. Het u vandag van beide bus- en treinvervoer in u werkrit gebruik gemaak?

Ja ☐ 1 Nee ☐ 0 ☐ 17

4. Indien u per bus gereis het, hoeveel het u kaartjie gekos? (Enkel)

..... ☐ ☐ ☐ 18 19 20

Office Use Only

(d) How many minutes did you have to wait for your bus or train?

0 - 5 mins ☐ 1 6 - 10 mins ☐ 2

11 - 15 mins ☐ 3 more than 15 mins ☐ 4

☐ 24

(e) Is there shelter provided at your stop or station?

Yes ☐ 1 No ☐ 0

☐ 25

(f) If you had driven your car, how long would your journey have taken you?

0 - 10 mins ☐ 1 11 - 20 mins ☐ 2

21 - 30 mins ☐ 3 31 - 40 mins ☐ 4

41 - 50 mins ☐ 5 more than 50 mins ☐ 6

☐ 26

6. If you came by bus today what was your fare?..... ☐ ☐ ☐ 27 28 29

7. (a) If you came by train today what type of ticket did you use?

Single ☐ 1 Return ☐ 2 Weekly ☐ 3 Monthly ☐ 4

☐ 30

(b) What was the cost of this ticket? ..... ☐ ☐ ☐ 31 32 33

This completed Part 'B'

Thank you.

Slegs vir kantoorgebruik

9. Tot watter salarisskaal behoort u? (Voor aftrekkings.) (Hierdie vraag is opsioneel en die inligting verskaf, sal as streng vertroulik beskou word.)

Maandeliks:

0 - R200	☐ 1	R201 - R400	☐ 2
R401 - R600	☐ 3	R601 - R800	☐ 4
Meer as R800	☐ 5		

OF

Jaarliks:

0 - R2400	☐ 1	R2401 - R4800	☐ 2
R4801 - R7200	☐ 3	R7201 - R9600	☐ 4
Meer as R9600	☐ 5		

☐ 13

Office Use Only

PART 'C'

Only those persons who came to work today in their own (or firm's) car or van should complete this part

1. Did you park your car/van in space provided by your firm?

Yes ☐ 1 No ☐ 0 ☐ 14

2. How much do you pay per day to park your car/van?

..... ☐ ☐ ☐ 15 16 17

3. Do you usually come to work in your own car/van?

Yes ☐ 1 No ☐ 0 ☐ 18

4. Do you travel in a car pool and if so how many passengers do you bring? (A car pool means where you take turns driving your own car and riding as a passenger in another.)

Yes ☐ 1 No ☐ 0 ☐ 19

No. of passengers:

Nil ☐ 0 One ☐ 1 Two ☐ 2 Three ☐ 3 Four or more ☐ 4 ☐ 20

5. On days of very bad weather (e.g. fog or rain), do you leave your car at home and travel by public transport?

Sometimes ☐ 1 Never ☐ 0 ☐ 21

Slegs vir kantoorgebruik

3. Oor hoeveel rybewyse vir motors beskik die lede van u huishouding?

Geen ☐ 0 Een ☐ 1 Twee ☐ 2 Drie of meer ☐ 3 ☐ 4

4. Hoeveel kinders jonger as 16 jaar, het u?

Geen ☐ 0 Een ☐ 1 Twee ☐ 2 Drie of meer ☐ 3 ☐ 5

5. Hoe het u vandag werk toe gereis? (Dui slegs die vernaamste metode aan.)

Bestuurder van motor ☐ 1 Passasier in motor ☐ 2 Motorfiets/ Bromponie ☐ 3 ☐ 6

Bus ☐ 4 Trein ☐ 5 Huurmotor ☐ 6 Fiets ☐ 7

Stap ☐ 8 Ry na trein of bus ☐ 9

6. Is u 'n lid van 'n "motorpoel" tussen u werk en u woning? (Dit wil sê is u 'n lid van 'n groep persone wat gereeld beurte maak met die gebruik van hulle motor terwyl die ander dan as passasiers ry.)

Ja ☐ 1 Nee ☐ 0 ☐ 7

7. Wat is u beroep of ambag? (Verskaf asseblief enkele besonderhede.)

.....

..... ☐ 8 ☐ 9

8. Wat is u huisadres? (Straat, nommer en voorstad.)

.....

..... ☐ 10 ☐ 11 ☐ 12

Office Use Only

6. How many minutes did it take you to come to work today? (Door to door time, please, including parking time.)

0 - 10 mins ☐ 1 11 - 20 mins ☐ 2 21 - 30 mins ☐ 3 ☐ 22

31 - 40 mins ☐ 4 more than 40 mins ☐ 5

7. (a) If you had not driven to work, how would you have travelled?

Passenger in car ☐ 1 Bus ☐ 2 Train ☐ 3 ☐ 23

Taxi ☐ 4 Walked ☐ 5 Motor Cycle ☐ 6

Bicycle ☐ 7

(b) How many minutes would this method of travel have taken you?

0 - 10 mins ☐ 1 11 - 20 mins ☐ 2 ☐ 24

21 - 30 mins ☐ 3 31 - 40 mins ☐ 4

41 - 50 mins ☐ 5 more than 50 mins ☐ 6

8. If you had not driven your car to work, how many minutes would it have taken you to walk to your nearest bus stop or station?

0 - 5 mins ☐ 1 6 - 10 mins ☐ 2 11 - 15 mins ☐ 3 ☐ 25

more than 15 mins ☐ 4

Hoe om hierdie vraelys te voltooi:

1. Algemene Afdeling: Hierdie afdeling moet deur almal voltooi word, asook EEN van die volgende:

   DEEL 'A': Moet voltooi word deur persone wat nie 'n motor besit nie.

   DEEL 'B': Moet voltooi word deur motoreienaars wat nie vandag in hul eie motor werk toe gekom het nie.

   DEEL 'C': Moet voltooi word deur motoreienaars wat vandag in hul eie motor werk toe gekom het.

2. Vrae met 'n blokkie: maak 'n kruisie in die betrokke blokkie wat u antwoord aandui.

3. Vrae sonder 'n blokkie: skryf asseblief u antwoord woordeliks uit.

Algemene Afdeling

Moet deur almal beantwoord word

Slegs vir kantoorgebruik

1. Wat is u status in u huishouding?

Man	1	Vrou	5	2
Seun	2	Dogter	6	
Manlike Loseerder	3	Vroulike Loseerder	7	
Man-Woon Alleen/Deel met ander	4	Vrou-Woon Alleen/ Deel met ander	8	

2. Besit u 'n motor?

Ja 1 Nee 0 3

DIE WERKRIT

LOODSSTUDIE VAN KAAPSTAD

1973

Hierdie ondersoek word gelei deur die:

Departement van Siviele Ingenieurswese,
Universiteit van Kaapstad

en die

Sentrum vir Vervoernavorsing,
Universiteit van Stellenbosch.

U werkrit is nie net vir uself van belang nie, maar ook vir diegene verantwoordelik vir die beplanning van toekomstige vervoerfasiliteite. Dit is inderdaad 'n hooffaktor in die beplanning van stedelike-vervoer en hierdie opname sal bydra tot die inligting benodig vir 'n loodsstudie van Kaapstad se vervoerbehoeftes.

U samewerking word gevolglik gevra by die voltooiing van hierdie vraelys wat slegs sowat 5-10 minute van u tyd in beslag sal neem.

Die inligting sal as streng vertroulik beskou word.

U samewerking sal hoog op prys gestel word.

SEE OVER FOR ENGLISH

Office Use Only

9. If you had travelled to work by bus or train today, how many changes would you have had to make?

Nil ☐ 0 One ☐ 1 Two ☐ 2 Three or more ☐ 3 ☐ 26

10. Why do you prefer to come to work by car rather than public transport? (Tick main reasons only.)

☐ 27 ☐ 28 ☐ 29

(i) No public transport available ☐ 1

(ii) Car trip is cheaper ☐ 2

(iii) Car trip takes less time ☐ 3

(iv) Would have to change train/bus ☐ 4

(v) Too far to walk to stop/station ☐ 5

(vi) Too long to wait for bus/train ☐ 6

(vii) Use my car/van during working hours ☐ 7

(viii) Public transport is too uncomfortable ☐ 8

(ix) Take my children to school on way to work ☐ 9

(x) Other - please state ..... ☐ 10

.....

This completes Part 'C'

Thank you.

APPENDIX 3.2

THE FIRMS' CIRCULARS TO THE STAFF

A sample of four circulars sent by the management to their staff informing them of the survey and requesting their cooperation are presented on the following pages.

On page A.3.2.6 is a copy of the form requesting certain information regarding the distribution of the forms.

The Department Head.

TRANSPORT INVESTIGATION/RESEARCH

The Society has been asked to assist a Research project and it has been agreed that we do so by asking some members of the White Office Staff to complete the enclosed questionnaire. It should only take 5 - 10 minutes to complete.

The only criterion is that they be White Staff. Age, sex and residence is immaterial.

Please could you arrange for the few enclosed questionnaires to be completed by separate members of your staff and have them returned to the Receptionist in Staff Department by 24th August, 1973.

Your co-operation will be appreciated.

MANAGER
OFFICE STAFF ADMINISTRATION

KE/ES
17.8.1973

NINHAM SHAND AND PARTNERS

MEMORANDUM

TO: All Staff FROM: Administrative Partner

Ref.: 0000/9 Date: 9th August, 1973.

SUBJECT: TRANSPORTATION STUDY

Citp.

The Department of Civil Engineering of the University of Cape Town and the Transport Research Centre of the University of Stellenbosch are conducting a pilot survey of the "journey to work" pattern in Cape Town.

We have agreed to co-operate on this survey which will take place on Thursday, 16th August. All staff in office on that day will be required to complete a simple 5 to 10 minutes questionnaire. Mrs. I. Burgers will hand out the forms and staff members are requested to hand their completed form to their section's secretary.

It should be understood that this questionnaire is strictly confidential to the research bodies concerned and is not intended in any way as a census of our staff for any reasons whatsoever.

B. B. STRICKLAND

3.2.4

SOUTHERN REGION

EMPLOYEE RELATIONS DEPARTMENT

22 August, 1973.

MEMORANDUM TO : All members of Rondebosch Staff

We have agreed to help the Department of Civil Engineering at U.C.T. by asking members of our staff at Rondebosch to complete the accompanying Transport Survey Questionnaire. Please help by filling in the appropriate section of the form and returning it to Mrs. Marshall - Room 50. It will only take you a few minutes.

LNR/lm

L.N. RYDEN

TO ALL STAFF

The Civil Engineering Department at the University of Cape Town and the Transport Research Centre of the University of Stellenbosch are conducting a survey into the journey to work pattern in Cape Town. I have agreed to co-operate in this project.

On Thursday, August 16th, two members of the survey team will be distributing a simple questionnaire to the staff and these will be collected the following morning.

Kindly give every assistance to the project. I have been assured that this survey is anonymous and any information given will be treated in the strictest confidence.

S.S. Morris
City Engineer

JOURNEY TO WORK

QUESTIONNAIRE SURVEY

Could the following details please be completed by those persons distributing the questionnaires.

A. FIRM: .....

B. LOCATION: .....

C. DATE OF DISTRIBUTION: .....

D. DATE OF COLLECTION: .....

E. No. of FORMS HANDED OUT: .....

F. No. of REFUSALS TO ACCEPT FORMS: .....

G. No. of FORMS COLLECTED: .....

N. Aplin

APPENDIX 3.3

MAP OF SURVEY AREA DIVIDED INTO ZONES

The map indicates the zonal divisions chosen for the survey area. The zone numbers are indicated in each zone.

APPENDIX 3.4

QUESTIONNAIRE CODING FORMS

These forms indicate the format used in the coding of the questionnaire data. Data cards were punched and verified from these coding sheets.

UNIVERSITY OF CAPE TOWN COMPUTER CENTRE

FORTRAN Coding Form

PROGRAM QUESTIONNAIRE SURVEY ANALYSIS | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE

PROGRAMMER | DATE | PUNCH | CARD ELECT*

STATEMENT NUMBER | CONT. | FORTRAN STATEMENT

1 2 3 4 5 | 6 | 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72

CODING FOR GENERAL SECTION

11005 2 0 1 0 5 0 02 025 2

Col. 26 Income
Cols. 22-24 Zone
Cols. 19-20 Occupation
Col. 17 Car Pool
Col. 15 Mode of Travel
Col. 13 No. of Children
Col. 11 No. D. Licences
Col. 9 Car Owner
Col. 7 Household Status
Cols. 3-5 Questionnaire No.
Col. 2 Part Answered
Col. 1 Workplace

(N.B. Cols. 1 and 2 became the workplace code after editing)

1 2 3 4 5 | 6 | 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72

*A standard card form. IBM electro 888157, is available for punching statements from this form

FORTRAN Coding Form

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE

PROGRAMMER | DATE | PUNCH | CARD ELECTR

STATEMENT NUMBER | CONT. | FORTRAN STATEMENT

1 2 3 4 5 | 6 | 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72

CODING FOR PART A

GENERAL SECTION → 1 0 2 1 020 0 10 4 560 1 0 256 3 2

Col. 28 Usual Method
Col. 30 Usual Mode
Col. 32 Total Time
Col. 34 Bus and Train
Cols. 36-38 Bus Fare
Col. 40 Bus Changes
Cols. 42-43 Station
Col. 45 Ticket Type
Cols. 47-49 Train Fare
Col. 51. Car Use
Col. 53 D. Licence
Cols. 55-57 Preferences
Col. 59 Alternative Time
Col. 61 Alternative Cost

1 2 3 4 5 | 6 | 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72

*A standard card form, IBM electio 888157, is available for punching statements from this form

UNIVERSITY OF CAPE TOWN COMPUTER CENTRE

FORTRAN Coding Form

PROGRAM | PUNCHING INSTRUCTIONS | GRAPHIC | PAGE

PROGRAMMER | DATE | PUNCH | CARD ELECT

STATEMENT NUMBER | CONT. | FORTRAN STATEMENT

1 2 3 4 5 | 6 | 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71

CODING FOR PART B

← GENERAL SECTION →

0 1 1 0 156 0 3 2 1 1 2 000 2 056

Col. 28 Free Parking

Col. 30 Weather

Col. 32 Usual Method

Col. 34 Usual Mode

Cols. 36-38 Reasons for choice

Col. 40 Transfers

Col. 42 Total Time

Col. 44 Walking Time

Col. 46 Waiting Time

Col. 48 Shelter

Col. 50 Car Time

Cols. 52-54 Bus Fare

Col. 56 Ticket Type

Cols. 58-60 Rail Fare

1 2 3 4 5 | 6 | 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71

*A standard card form, IBM electro 888157, is available for punching statements from this form

FORTRAN Coding Form

PROGRAM | PROGRAMMER | DATE | PUNCHING INSTRUCTIONS | GRAPHIC | PUNCH | PAGE | CARD ELEC

STATEMENT NUMBER | CONT. | FORTRAN STATEMENT

CODING FOR PART C

GENERAL SECTION

0 100 1 0 0 0 3 3 4 1 0 378

Col. 28 Firm's Parking
Cols. 30-32 Parking Cost
Col. 34 Usual Method
Col. 36 Car Pool
Col. 38 Passengers
Col. 40 Weather
Col. 42 Total Time
Col. 44 Alternative Mode
Col. 46 Alternative Time
Col. 48 Alternative Walking Time
Col. 50 Transfers
Cols. 52-54 Preferences

* A standard card form, IBM # [illegible] is available for punching statements [illegible]

APPENDIX 3.5

COMPUTER PROGRAMME FOR CAR TIME STUDY

The computer programme used to analyze the OD time survey for cars is given in this appendix. The programme involves a main programme which establishes information for each OD pair. This data then becomes the input arguments for the subroutine TIMEOD. TIMEOD determines the times for each vehicle number plate matching and calculates the average and standard deviations of these times for each OD pair.

```
      DIMENSION LO1(200,20),LD1(200,20),LO2(200,20),
     1LO3(200,20),LD3(200,20),I(6),LD2(200,20)
  200 FORMAT(/5X,'LO1 TO LD1')
  201 FORMAT(/5X,'LO1 TO LD2')
  202 FORMAT(/5X,'LO2 TO LD1')
  203 FORMAT(/5X,'LO2 TO LD2')
  204 FORMAT(/5X,'LO3 TO LD3')
  205 FORMAT(/5X,'LO1 TO LD3')
  206 FORMAT(/5X,'LO2 TO LD3')
  207 FORMAT(/5X,'LO3 TO LD2')
  208 FORMAT(/5X,'LO3 TO LD1')
  700  FORMAT(///10X,'ORIGIN ONE')
  701  FORMAT(///10X,'ORIGIN TWO')
  702  FORMAT(///10X,'ORIGIN THREE')
  703  FORMAT(///10X,'DESTINATION ONE')
  704  FORMAT(///10X,'DESTINATION TWO')
  705  FORMAT(///10X,'DESTINATION THREE')
  112   FORMAT(F8.3)
C.....................................
C   READ IN THE NOS. OF VEHICLES PASSING
C        EACH SURVEY POINT.
C.....................................
C  READ IN THE DISTANCES BETWEEN EACH
C     PAIR OF SURVEY LOCATIONS
C.....................................
      READ(8,1) L,LI,LJ,LK,LM,LN
      READ(8,112) DIST11
      READ(8,112) DIST12
      READ(8,112) DIST13
      READ(8,112) DIST21
      READ(8,112) DIST22
      READ(8,112) DIST23
      READ(8,112) DIST31
      READ(8,112) DIST32
      READ(8,112) DIST33
    1 FORMAT(6I4)
C.....................................
C  READ IN THE TIMES AND REGISTRATION
C  NUMBERS FOR ALL THE SURVEY POINTS.
C.....................................
      READ(8,100)((LO1(M,N),N=1,20),M=1,L)
      READ(8,100)((LO2(M,N),N=1,20),M=1,LI)
      READ(8,100)((LO3(M,N),N=1,20),M=1,LJ)
      READ(8,100)((LD1(I,J),J=1,20),I=1,LK)
      READ(8,100)((LD2(I,J),J=1,20),I=1,LM)
      READ(8,100)((LD3(I,J),J=1,20),I=1,LN)
  100 FORMAT(20I4)
      READ(8,400)(I(IJ),IJ=1,6)
  400 FORMAT(6I6)
```

```
      READ(8,500)NI
  500 FORMAT(I5)
      READ(8,501)NJ
  501 FORMAT(I3)
      WRITE(5,700)
      WRITE(5,12)((LO1(M,N),N=1,20),M=1,L)
      WRITE(5,701)
      WRITE(5,12)((LO2(M,N),N=1,20),M=1,LI)
      WRITE(5,702)
      WRITE(5,12)((LO3(M,N),N=1,20),M=1,LJ)
      WRITE(5,703)
      WRITE(5,12)((LD1(I,J),J=1,20),I=1,LK)
      WRITE(5,704)
      WRITE(5,12)((LD2(I,J),J=1,20),I=1,LM)
      WRITE(5,705)
      WRITE(5,12)((LD3(I,J),J=1,20),I=1,LN)
   12 FORMAT(20I4)
      I1=100
      I2=190
      I3=70
      I4=150
      I5=60
      I6=140
C.....................................
C  THE SUBROUTINE TIMEOD IS CALLED
C  FOR EACH PAIR OF O.D. STATIONS.
C.....................................
      WRITE(5,200)
      CALL TIMEOD(LO1,LD1,DIST11,L,LK,I1,I2,NI,NJ)
      WRITE(5,201)
      CALL TIMEOD(LO1,LD2,DIST12,L,LM,I1,I4,NI,NJ)
      WRITE(5,202)
      CALL TIMEOD(LO2,LD1,DIST21,LI,LK,I3,I2,NI,NJ)
      WRITE(5,203)
      CALL TIMEOD(LO2,LD2,DIST22,LI,LM,I3,I4,NI,NJ)
      WRITE(5,204)
      CALL TIMEOD(LO3,LD3,DIST33,LJ,LN,I5,I6,NI,NJ)
      WRITE(5,205)
      CALL TIMEOD(LO1,LD3,DIST13,L,LN,I1,I6,NI,NJ)
      WRITE(5,206)
      CALL TIMEOD(LO2,LD3,DIST23,LI,LN,I3,I6,NI,NJ)
      WRITE(5,207)
      CALL TIMEOD(LO3,LD2,DIST32,LJ,LM,I5,I4,NI,NJ)
      WRITE(5,208)
      CALL TIMEOD(LO3,LD1,DIST31,LJ,LK,I5,I2,NI,NJ)
      STOP
      END
```

```
      SUBROUTINE TIMEOD(LO1,LD1,DIST11,NQ,NZ,IO,ID,NI,NJ)

      DIMENSION LO1(IO,20),LD1(ID,20),SPEED(4000),
     1DISC(4000),KTIME(4000)
      REAL KTIME
 13   FORMAT(8X,F8.3,5X,I5,8X,F8.3)
 20   FORMAT(//25X,F8.3)
 29   FORMAT(1HI.10X,4HTIME,5X,7HVEHICLE,8X,5HSPEED)
 30   FORMAT(///20X,13HAVERAGE SPEED)
 47   FORMAT(///20X,34HNUMBER OF VEHICLES FROM ONE TO ONE)

 114  FORMAT(///25X,I5)
 117  FORMAT(/////20X,12HDISTANCE KM.)
 118  FORMAT(//25X,F8.3)
 119  FORMAT(///20X,41HTHE STANDARD DEVIATION OF
     1THESE SPEEDS IS)
 120  FORMAT(///20X,F10.5)
 121  FORMAT(///20X,31HTHE COEFFICIENT OF VARIATION IS
      WRITE(5,29)
C.....
C    THE NEXT STEP IS TO COMPARE NO. PLATES
C    AT ORIGIN AND DESTINATION SITES IF
C    THEY AGREE ATIME IS CALCULATED FOR
C    THE TRIP FROM LO1 TO LD1
C.....
      NK=NJ
      L=0
      K=0
      DO 5 M=1,NQ
      DO 6 N=2,20
      IF(LO1(M,N)) ,6
      DO 8 I=1,NZ
      DO 9 J=2,20
      IF(LD1(I,J)) ,9
      KDIFF=LO1(M,N)-LD1(I,J)
      IF(KDIFF)9,4,9
    4 RL=FLOAT(LO1(M,1))
      RLO1=RL/100.0
      IRL=IFIX(RLO1)
      IRL=IRL*60+LO1(M,1)-100*IRL
      RD=FLOAT(LD1(I,1))
      RLD1=RD/100.0
      IRD=IFIX(RLD1)
      IRD=LD1(I,1)-40*IRD
      KTIME(K)=IRD-IRL
      IF(KTIME(K).LT.1.0) GO TO 9
      IF(KTIME(K).GT.NI) GO TO 9
      IF(KTIME(K).GT.60.0) GO TO 9
      SPEED(K)=DIST11*60.0/KTIME(K)
      WRITE(5,13)KTIME(K),LOI(M,N),SPEED(K)
      K=K+1
C.....
C    THE NEXT STEP IS TO COUNT THE NUMBER
C    OF VEHICLES IN THIS O-D PAIR
C.....
      L=L+1
   9  CONTINUE
   8  CONTINUE
   6  CONTINUE
   5  CONTINUE
```

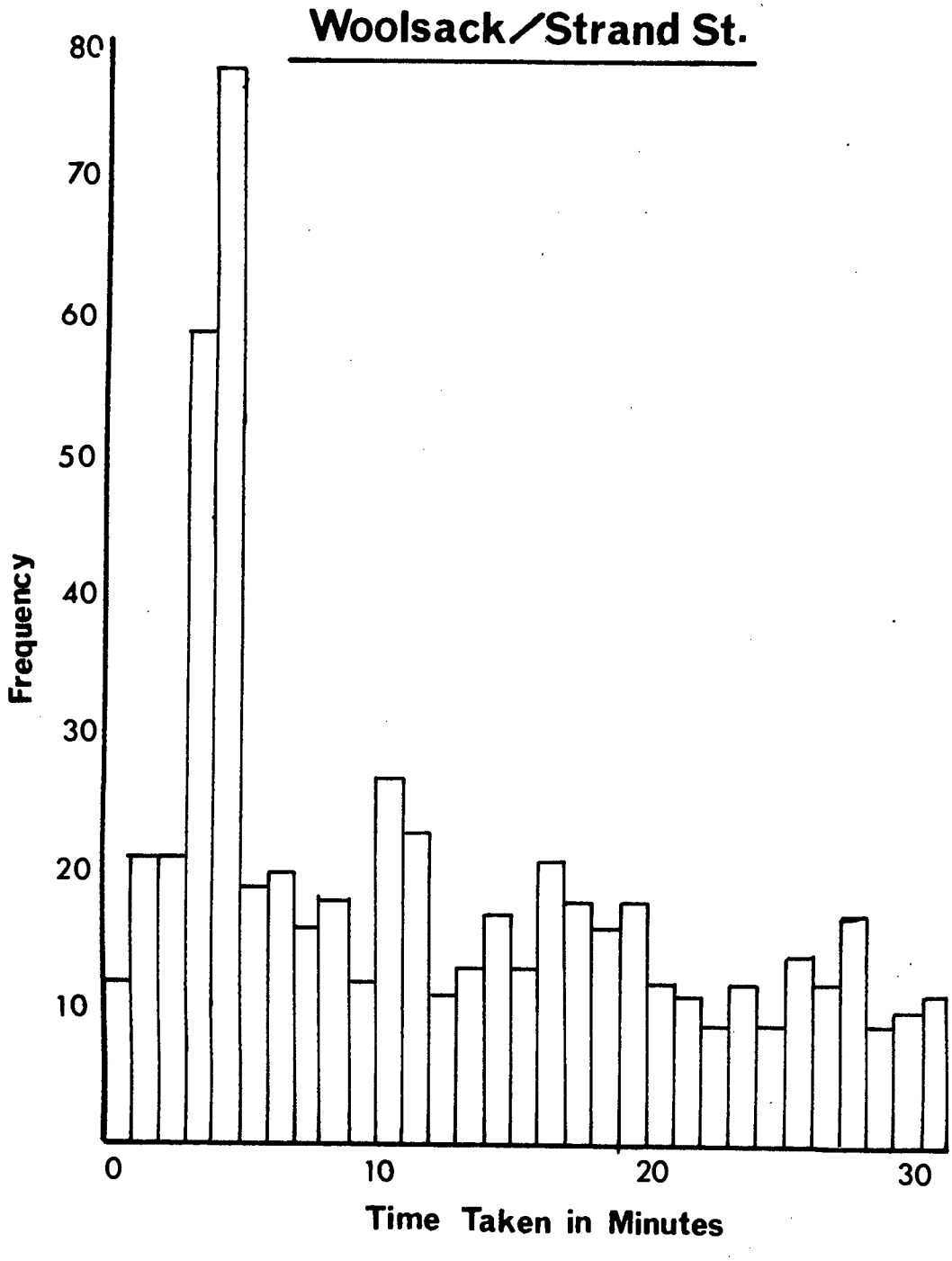
```
      N=L
      WRITE(5,117)
      WRITE(5,118) DIST11
      WRITE(5,47)
      WRITE(5,114) N
C.....................................
C   THE DISTANCE IS IN KILOMETRES
C   THE SPEED IS IN K.M.P.HR.
C.....................................
C
C   A CALCULATION OF THE MEAN SPEED
C.....................................
      SUM = 0.0
      DO 41 I=1,N
      SUM = SUM+SPEED(I)
  41  CONTINUE
C.....................................
C   CALCULATE AVERAGE VEHICLE SPEED
C.....................................
      AVSPED = SUM/FLOAT(N)
      WRITE(5,30)
      WRITE(5,20) AVSPED
C.....................................
C   CALCULATE STANDARD DEVIATION
C.....................................
      SUMSD = 0.0
      DO 40 I=1,N
      IF(SPEED(I))40,40,50
50    DISC(I)=(AVSPED-SPEED(I))**2.0
      SUMSD = SUMSD + DISC(I)
40    CONTINUE
      SD=SQRT(SUMSD/FLOAT(N))
      WRITE(5,119)
      WRITE(5,120) SD
C.....................................
C   CALCULATE THE COEFFICIENT OF VARIATION
C.....................................
      CV = 100.0*SD/AVSPED
      WRITE(5,121)
      WRITE(5,120) CV
      RETURN
      END
```

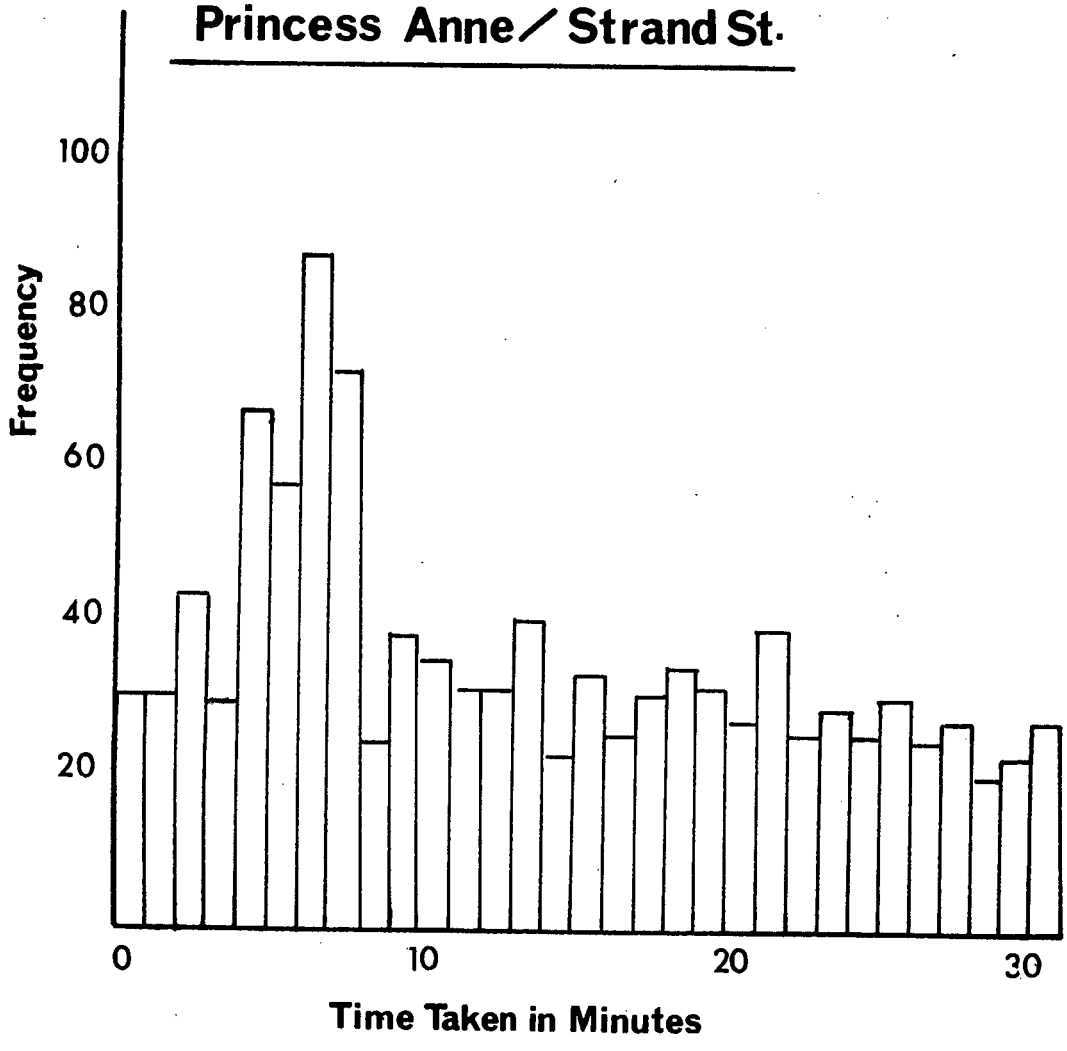
APPENDIX 3.6

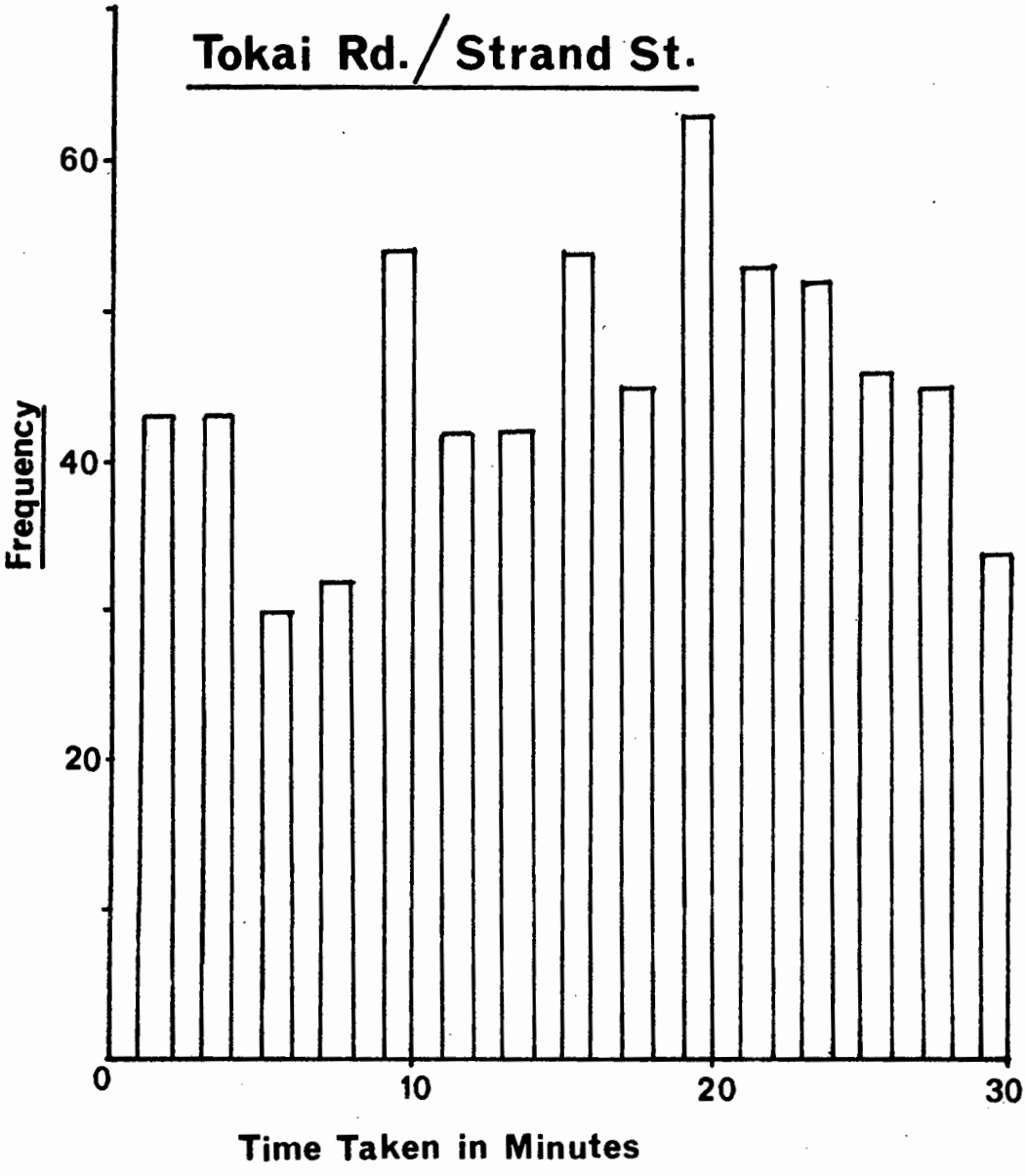
PLOTS OF FREQUENCY OF CAR TIMES FROM O-D STUDY

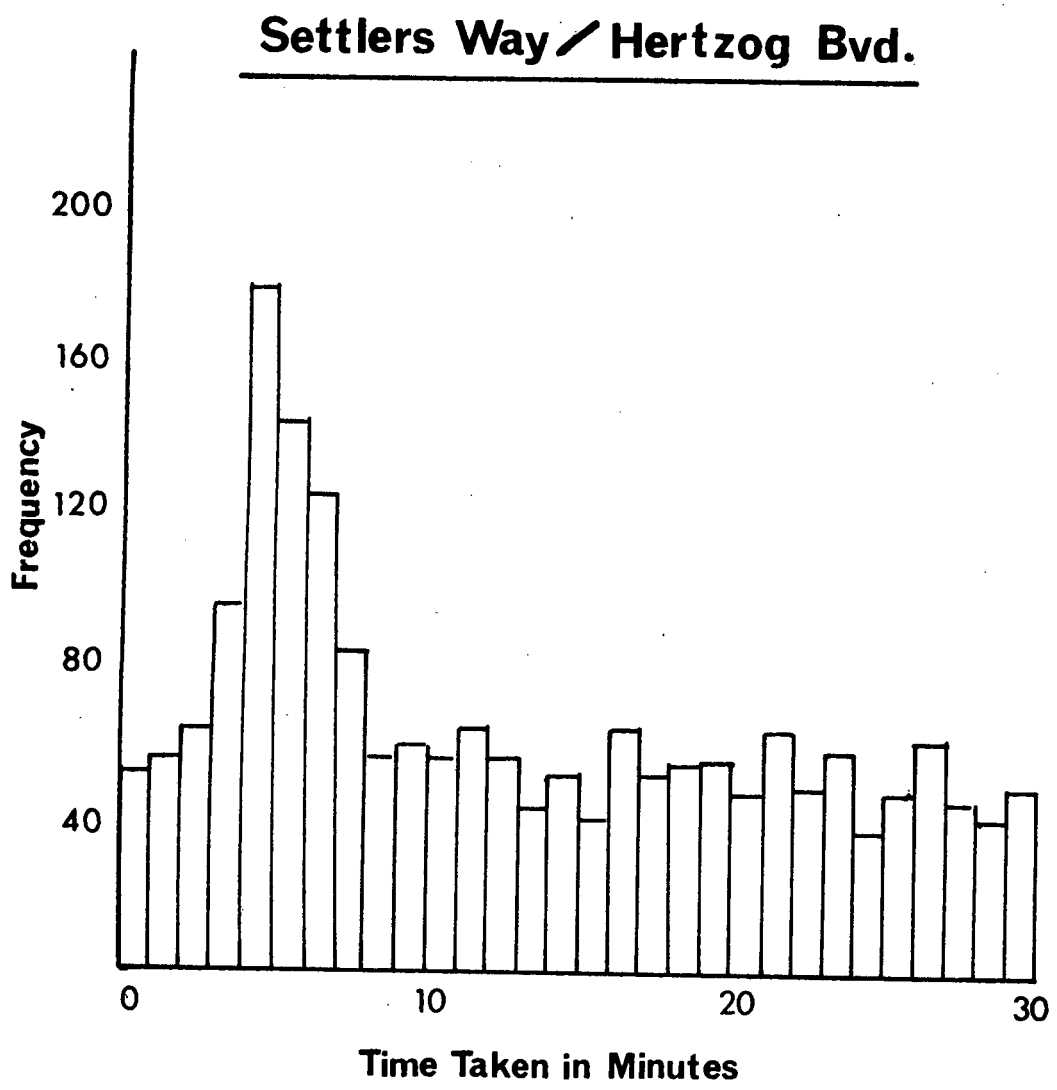
The following are a sample of plots of the frequencies of all calculated times for cars matched in the O-D survey. The modal value was found to approximate the actual times between the origin and destination.

This method was only useful for O-D pairs which had large traffic volumes. Page A.3.6.4 shows a plot for an origin at Tokai Road. The mode value is not well defined as there was a relatively small volume of traffic between Tokai Road and the CBD when compared with all the other influent vehicles not accounted for.


Woolsack/Strand St.
80
70
60
50
40
30
20
10
Frequency
0
10
20
30
Time Taken in Minutes


Princess Anne / Strand St.
Frequency
100
80
60
40
20
0
10
20
30
Time Taken in Minutes


Tokai Rd./Strand St.
Frequency
60
40
20
0
10
20
30
Time Taken in Minutes


Settlers Way / Hertzog Bvd.
Frequency
200
160
120
80
40
0
10
20
30
Time Taken in Minutes

APPENDIX 3.7

ORIGIN-DESTINATION TIME STUDY

LOCATION OF SURVEY STATIONS

O-D CODE : LO indicates an origin
LD indicates a destination

SURVEYOR CODE :

LO1	=	R.H. STEELE	LD1	=	O. BEYERS
LO2	=	D.G. ROWAN	LD2	=	J. HEEGER
LO3	=	K. STERNE	LD3	=	N. STANGER

The above surveyor codes were kept the same throughout the survey. The figure after the surveyor code indicates the day on which the survey was carried out. The letter indicates the morning or evening survey period.

EXAMPLE : LO1 3P indicates that R.H. Steele did the survey on the third day during the afternoon.

DAY	O-D CODE	SURVEY STATION	SURVEYOR CODE
1A	LO1	TOKAI ROAD, ON RAMP V.D.S.F.*	LO1 1A
	LO2	LADIES MILE, ON RAMP V.D.S.F.	LO2 1A
	LO3	MAIN ROAD/LADIES MILE	LO3 1A
	LD1	STRAND STREET EXTENSION	LD1 1A
	LD2	HERTZOG BOULEVARD	LD2 1A
	LD3	ROELAND STREET	LD3 1A
1P	LO1	HERTZOG BOULEVARD	LD1 1P
	LO2	STRAND STREET EXTENSION	LD2 1P
	LO3	ROELAND STREET	LD3 1P
	LD1	LADIES MILE, OFF RAMP V.D.S.F.	LO1 1P
	LD2	TOKAI ROAD, OFF RAMP V.D.S.F.	LO2 1P
	LD3	MAIN ROAD/LADIES MILE	LO3 1P
2A	LO1	CONSTANTIA ROAD, ON RAMP V.D.S.F.	LO1 2A

* V.D.S.F. = Van Der Stel Freeway

DAY	O-D CODE	SURVEY STATION	SURVEYOR CODE
2A	LO2	KENDAL ROAD, ON RAMP V.D.S.F.	LO2 2A
	LO3	VICTORIA ROAD, PLUMSTEAD	LO3 2A
	LD1	HERTZOG BOULEVARD	LD1 2A
	LD2	STRAND STREET EXTENSION	LD2 2A
	LD3	ROELAND STREET	LD3 2A
2P	LO1	STRAND STREET EXTENSION	LD1 2P
	LO2	HERTZOG BOULEVARD	LD2 2P
	LO3	ROELAND STREET	LD3 2P
	LD1	CONSTANTIA ROAD, OFF RAMP V.D.S.F.	LO1 2P
	LD2	KENDAL ROAD, OFF RAMP V.D.S.F.	LO2 2P
	LD3	VICTORIA ROAD, PLUMSTEAD	LO3 2P
3A	LO1	NOT AVAILABLE	LD1 3A
	LO2	WETTON ROAD	LD2 3A
	LO3	TROVATO LINK, ON RAMP	LD3 3A
	LD1	HERTZOG BOULEVARD	LO1 3A
	LD2	STRAND STREET EXTENSION	LO2 3A
	LD3	ROELAND STREET	LO3 3A
3P	LO1	MILL STREET	LD1 3P
	LO2	STRAND STREET EXTENSION	LO2 3P
	LO3	HERTZOG BOULEVARD	LO1 3P
	LO4	ROELAND STREET	LO3 3P
	LD1	WETTON ROAD	LD2 3P
	LD2	TROVATO LINK, OFF RAMP	LD3 3P
4A	LO1	NEWLANDS ROAD, NEWLANDS	LD1 4A
	LO2	WETTON ROAD	LD2 4A
	LO3	TROVATO LINK, ON RAMP	LD3 4A
	LD1	STRAND STREET EXTENSION	LO1 4A
	LD2	HERTZOG BOULEVARD	LO2 4A
	LD3	ROELAND STREET	LO3 4A
4P	LO1	STRAND STREET EXTENSION	LO1 4P
	LO2	HERTZOG BOULEVARD	LO2 4P
	LO3	ROELAND STREET	LO3 4P

DAY	O-D CODE	SURVEY STATION	SURVEYOR CODE
4P	LD1	NEWLANDS ROAD, NEWLANDS	LD1 4P
	LD2	LANSDOWNE ROAD/PALMYRA ROAD	LD2 4P
	LD3	TROVATO LINK, OFF RAMP	LD3 4P
5A	LO1	RHODES AVENUE, NEWLANDS	LD1 5A
	LO2	LANSDOWNE ROAD/PALMYRA ROAD	LO2 5A
	LO3	TROVATO LINK, ON RAMP	LD3 5A
	LD1	HERTZOG BOULEVARD	LO1 5A
	LD2	STRAND STREET EXTENSION	LO2 5A
	LD3	ROELAND STREET	LO3 5A
5P	LO1	HERTZOG BOULEVARD	LO1 5P
	LO2	STRAND STREET EXTENSION	LO2 5P
	LO3	ROELAND STREET	LO3 5P
	LO4	MILL STREET	LD3 5P
	LD1	RHODES AVENUE, NEWLANDS	LD1 5P
	LD2	RHODEBOSCH FOUNTAIN	LD2 5P
6A	LO1	RONDEBOSCH FOUNTAIN	LD2 6A
	LO2	WOOLSACK DRIVE, ON RAMP D.W.D.*	LO2 6A
	LO3	PRINCESS ANNE, ON RAMP D.W.D.	LO3 6A
	LD1	HERTZOG BOULEVARD	LO1 6A
	LD2	STRAND STREET EXTENSION	LD1 6A
	LD3	MILL STREET	LD3 6A
6P	LO1	STRAND STREET EXTENSION	LD1 6P
	LO2	HERTZOG BOULEVARD	LO1 6P
	LO3	MILL STREET	LD3 6P
	LD1	PRINCESS ANNE, OFF RAMP D.W.D.	LO3 6P
	LD2	WOOLSACK DRIVE, OFF RAMP D.W.D.	LO2 6P
	LD3	NOT AVAILABLE	LD2 6P
7A	LO1	LIESBEEK PARK/SETTLERS WAY	LO1 7A
	LO2	PINELANDS/SETTLERS WAY	LO2 7A
	LO3	BLACK RIVER/SETTLERS WAY	LO3 7A
	LD1	STRAND STREET EXTENSION	LD1 7A
	LD2	HERTZOG BOULEVARD	LD2 7A

* D.W.D. = De Waal Drive

DAY	O-D CODE	SURVEY STATION	SURVEYOR CODE
7A	LD3	ROELAND STREET	LD3 7A
7P	LO1	STRAND STREET EXTENSION	LD1 7P
	LO2	HERTZOG BOULEVARD	LD2 7P
	LO3	ROELAND STREET	LD3 7P
	LD1	SETTLERS WAY/LIESBEEK PARK	LO1 7P
	LD2	SETTLERS WAY/PINELANDS	LO2 7P
	LD3	SETTLERS WAY/BLACK RIVER	LO3 7P
8A	LO1	WOODSTOCK/EASTERN BOULEVARD	LO1 8A
	LO2	MILNER ROAD/SETTLERS WAY	LD2 8A
	LO3	NOT AVAILABLE	LO3 8A
	LD1	STRAND STREET EXTENSION	LD1 8A
	LD2	HERTZOG BOULEVARD	LO2 8A
	LD3	ROELAND STREET	LD3 8A
8P	LO1	ROELAND STREET	LD3 8P
	LO2	HERTZOG BOULEVARD	LO2 8P
	LO3	STRAND STREET EXTENSION	LO3 8P
	LD1	WOODSTOCK/EASTERN BOULEVARD	LO1 8P
	LD2	MILNER ROAD/SETTLERS WAY	LD2 8P
	LD3	NOT AVAILABLE	LD1 8P
9A	LO1	TROVATO/RHODES AVENUE	LO1 9A
	LO2	TOKAI ROAD, ON RAMP V.D.S.F.	LO2 9A
	LO3	PRINCESS ANNE, ON RAMP D.W.D.	LO3 9A
	LD1	STRAND STREET EXTENSION	LD3 9A
	LD2	HERTZOG BOULEVARD	LD2 9A
	LD3	NOT AVAILABLE	LD1 9A

APPENDIX 3.12

FORMULAE FOR LEVEL OF SERVICE INDICES

Below is a list of some of the LOS formulae used in previous studies.

1. KAIN, J.F.[11]

LOS (transit) for zone j

$$= \frac{\text{number of coach miles/24 hrs. in zone j}}{\text{area of zone j in acres}}$$

2. ADAMS, W.T.[9]

$$\text{Transit Service Ratio Factor} = \frac{(V^{1,0})\ S_R}{(P^{1,5})\ (M^{0,25})}$$

where V = equivalent revenue vehicle miles operated per weekday.

M = urbanized land area in square miles.

S_R = ratio of the square root of the average vehicle speed of competing modes of travel.

P = population above 5 years of age in 10000's.

3. WILSON, F.R.[1]

Service index for zone j = (No. miles of bus routes in zone j)(No. peak hour buses)(No. seats per bus)/(Labour force in zone j)

4. BOWEN, W.[10]

Service Index zone j

$$= \sum_{i=1}^{N} \frac{(\text{No. of trains stopping in peak hour in j})^{0,5}}{(\text{Area zone j})^{0,5}}$$

where N = Number of stations in zone j.

APPENDIX 4.1

MODAL SPLIT RESULTS FOR EACH WORKPLACE

Figures are given for the mode use for commuters at each workplace. Percentage modal split results are listed for the CBD and non-CBD commuters as well as the global figures.

Finally Cape Town City Tramways have been excluded from the non-CBD results. This has been done to test the effect of the free use of buses which C.T.C. Tramways employees enjoy on the overall results. It can be seen that there is a significant reduction in the percentage bus use and a consequent increase in the train usage when compared with the non-CBD percentages.

MODAL SPLIT RESULTS*

	CAR	PASSENGER	MOTOR CYCLE	BUS	TRAIN	BICYCLE	WALK	DRIVE TO BUS/TRAIN
Safmarine	10	1	0	1	8	0	1	3
Mobil House	38	12	0	14	39	0	3	14
C.T.C. Engnr.	141	33	2	29	93	0	16	14
ESCOM	30	25	2	5	38	0	3	3
Freight S'vces	24	9	0	12	16	0	1	1
Nico Malan	31	7	1	6	3	0	4	0
Norwich Gen.	5	0	0	2	3	0	0	3
Borckenhagen & Louw	12	2	1	1	2	0	0	1
L'berg & Stander	37	7	1	2	7	0	2	0
Norwich Life	13	8	0	7	15	0	0	1
Ninham Shand	69	12	5	14	30	0	3	3
Caltex	35	9	0	10	27	0	5	5
Davidson & Ewing	12	2	0	1	6	0	0	0
CBD TOTAL	457	126	12	104	287	0	38	48
CBD %	42,7	11,7	1,1	9,8	26,7	0,0	3,5	4,4
S.A. Mutual	87	25	0	6	49	0	5	6
Southern Life	109	37	1	12	26	1	15	1
R. & Coleman	57	11	0	1	16	0	5	1
C.T.C. T'ways	44	6	0	43	2	0	1	2
Reids S/River	6	3	0	1	0	0	1	0
Reids Obs.	13	1	0	3	0	0	0	0
Mobil R'bosch	37	2	0	0	3	0	0	3
F. S'vces Obs.	3	3	0	0	0	0	0	0
NON-CBD TOTAL	357	88	1	66	96	1	27	13
NON-CBD %	55,0	13,6	0,2	10,2	14,7	0,2	4,1	2,0
GLOBAL TOTAL	814	214	13	170	383	1	65	61
GLOBAL %	47,3	12,4	0,8	10,0	22,2	0,06	3,8	3,5
NON-CBD - C.T.C.T. % †	56,8	14,9	0,2	4,2	17,1	0,2	4,7	2,0

* Non-CBD figures with C.T. City Tramways excluded.

† The taxi mode has been deleted as the percentage usage was nil.

TRANSFER ANALYSIS FOR EACH WORKPLACE

WORKPLACE	FIRM USES FLEXI TIME	CAR OWNERS WHO DO NOT USE CARS	CAR USERS
		Av. No. of Transfers per person	Av. No. of Transfers per person*
City Engineers Dept.	No	0,02	0,21
Mobil House	No	0,02	0,39
ESCOM	No	0,05	0,21
Safmarine	No	0,11	0,00
Freight Services	No	0,00	0,35
Nico Malan	No	0,00	0,48
Norwich General	No	0,00	0,60
Borckenhagen & Louw	No	0,00	0,58
Liebenberg & Stander	No	0,13	0,35
Ninham Shand	Partly	0,03	0,21
Norwich Life	Yes	0,00	0,00
Caltex	No	0,05	0,14
Davidson & Ewing	No	0,00	0,16
CBD AVERAGE		0,03	0,26
S.A. Mutual	No	0,28	0,95
Southern Life	Yes	0,03	0,84
Reckitt & Coleman	No	0,08	1,46
C.T.C. Tramways	No	0,32	0,76
Reids Salt River	No	0,00	-
Mobil Rondebosch	No	0,14	0,89
Freight Services Obs.	No	-	1,00
Reids Observatory	No	-	1,85
NON-CBD AVERAGE		0,20	1,01
GLOBAL AVERAGE		0,07	0,59

* This is the number of transfers car users estimate they would have to make if they used public transport.

INCONVENIENCE FACTORS RELATING TO PUBLIC TRANSPORT NON CAR OWNERS CBD and NON-CBD

WORKPLACE	SAMPLE SIZE	INCONVENIENCE FACTORS								
		1	2	3	4	5	6	7	8	9
Caltex	18	7	5	5	3	3	0	1	0	0
Nico Malan	15	5	7	4	2	2	0	1	2	0
Davidson & Ewing	6	2	2	2	2	1	0	0	0	0
Freight S'vces	27	8	9	9	3	5	2	5	2	0
B'hagen & Louw	2	0	1	0	0	2	0	0	0	0
Norwich Life	22	3	6	3	2	3	1	3	1	0
Safmarine	6	1	2	3	1	2	0	2	1	0
Mobil House	18	3	6	4	1	5	0	5	0	0
City Park	89	23	26	18	12	16	3	13	11	0
ESCOM	37	8	9	17	6	8	1	10	1	1
Ninham Shand	34	13	9	10	5	4	0	5	1	0
L'berg & Stander	11	4	2	2	2	0	0	3	1	0
Norwich Gen.	2	0	2	1	0	0	0	0	0	0
CBD TOTAL	287	77	86	78	39	51	7	48	20	1
P.P.R. (CBD)		18,9	21,1	19,2	9,6	12,5	1,7	11,8	5,1	0,3
Reids Obs.	4	2	4	1	1	2	2	0	0	0
S.A. Mutual	55	13	16	7	6	12	20	9	4	0
Southern Life	65	11	34	8	4	14	12	1	11	0
Mobil R'Bosch	2	1	1	0	0	0	0	0	1	0
R. & Coleman	25	4	15	1	1	10	11	3	3	0
C.T.C. T'ways	36	4	16	6	4	5	5	1	1	3
NON-CBD TOTAL	187	35	86	23	16	43	50	14	20	3
P.P.R. (NON-CBD)		12,2	46,0	8,0	5,6	15,0	17,4	4,9	7,0	1,0
GLOBAL TOTAL	474	112	172	101	55	94	57	60	41	4
P.P.R. (GLOBAL)		16,1	24,8	14,5	7,9	13,5	8,2	8,6	5,9	0,6

1. Distance to walk to or from station or stop.
2. Waiting for public transport.
3. Seat Availability.
4. Shelter Provision at stop or station
5. P.T. arrives too early or late for work.
6. Having to transfer vehicles.
7. P.T. is generally inconvenient.
8. Others.
9. P.T. is not inconvenient.

REASONS FOR NOT USING OWN CAR FOR THE WORK JOURNEY

CAR OWNERS - NOT USING OWN CARS

WORKPLACE	SAMPLE SIZE	REASONS								
		1	2	3	4	5	6	7	8	9
City Park	101	45	5	7	12	42	41	5	2	0
Mobil House	64	23	2	8	9	25	22	4	1	1
ESCOM	40	21	4	2	6	14	12	1	1	3
Safmarine	9	2	0	2	3	5	4	1	0	0
Freight S'vces	13	5	0	2	1	6	3	1	1	0
Nico Malan	6	0	0	0	0	0	2	0	1	4
Norwich Gen.	6	1	1	1	1	4	0	0	0	0
B'hagen & Louw	5	0	2	2	2	1	0	0	0	0
L'berg & Stander	8	4	0	4	4	5	1	0	0	2
Norwich Life	9	1	3	0	0	5	6	2	0	1
Ninham Shand	34	12	4	4	4	13	3	1	1	0
Caltex	36	10	4	9	9	17	8	2	2	1
Davidson & Ewing	3	1	0	0	0	2	0	0	0	0
CBD TOTALS	334	125	25	38	51	139	102	17	11	12
P.P.R. (CBD)		23,9	4,8	7,3	9,8	26,7	19,8	3,3	2,1	2,3
S.A. Mutual	39	13	6	3	5	11	1	2	0	7
Southern Life	29	7	4	5	2	8	0	0	2	6
R. & Coleman	12	1	2	3	1	1	0	1	0	2
C.T.C. T'ways	21	7	4	3	2	5	11	1	1	0
Reids S/River	2	0	0	0	0	0	0	0	1	0
Mobil R'Bosch	7	2	2	0	0	0	0	1	1	0
NON-CBD TOTALS	110	30	18	14	10	25	12	5	5	15
NON-CBD P.P.R.		22,3	13,4	10,4	7,5	18,7	8,9	3,7	3,7	11,2
GLOBAL TOTALS	444	155	43	52	61	164	114	22	16	27
GLOBAL P.P.R.		23,7	6,6	8,0	9,3	25,1	17,4	3,4	2,4	4,1

1. Car Trip is too expensive.
2. Other family member uses car.
3. Wife uses car for shopping.
4. Wife uses car for other reasons.
5. Roads are too congested.
6. No suitable parking available.
7. Car trip takes too long.
8. Car being serviced.
9. Travel by car pool.

REASONS FOR USING OWN CAR FOR WORK JOURNEY CAR USERS

WORKPLACE	SAMPLE SIZE	REASONS								
		1	2	3	4	5	6	7	8	9
City Park	139	3	14	48	5	11	13	93	22	15
Mobil House	38	3	5	23	2	7	11	3	16	4
ESCOM	29	2	3	17	2	5	4	4	10	1
Safmarine	10	0	1	6	0	2	4	3	3	1
Freight S'vces	23	0	3	13	1	1	2	12	3	4
Nico Malan	31	5	3	20	2	7	2	2	9	4
Norwich Gen.	5	0	0	3	0	0	0	3	1	0
B'hagen & Louw	12	0	1	7	0	2	1	3	3	4
L'berg & Stander	37	1	2	25	1	5	7	22	14	5
Norwich Life	13	1	2	5	0	4	3	0	7	0
Ninham Shand	68	4	8	43	5	15	10	18	19	9
Caltex	35	2	2	18	3	6	4	8	9	11
Davidson & Ewing	12	1	0	5	0	0	1	7	3	1
CBD TOTALS	452	22	44	233	21	65	62	178	119	59
P.P.R. (CBD)		2,8	5,6	28,3	2,6	8,0	7,6	22,2	14,7	7,3
Mobil R'Bosch	37	0	3	22	7	0	7	17	7	5
C.T.C. T'ways	46	2	2	28	7	8	3	19	6	5
R. & Coleman	59	6	5	41	15	10	17	16	10	13
Southern Life	108	5	23	76	18	20	30	19	16	21
Reids Obs.	13	1	3	9	7	4	1	3	3	3
F. S'vces Obs.	3	0	0	1	2	0	0	1	1	2
S.A. Mutual	83	8	14	47	18	20	14	12	24	14
Reids S/River	8	1	1	5	1	1	1	0	4	3
NON-CBD TOTALS	357	23	51	229	75	63	73	87	71	65
P.P.R. NON-CBD		3,1	6,9	31,1	10,02	8,5	9,9	11,8	9,7	8,8
GLOBAL TOTALS	809	46	96	464	96	128	135	269	190	124
P.P.R. (GLOBAL)		2,98	6,2	30,0	6,2	8,3	8,7	17,3	12,2	8,0

1. No P.T. available.
2. Car Trip is cheaper.
3. Car trip is quicker.
4. Would have to transfer.
5. Too far to walk for P.T.
6. Too long to wait for P.T.
7. Uses car during/directly after working hours.
8. P.T. is generally inconvenient.
9. Take children to school.

CAR POOL AND PARKING AVAILABILITY FOR EACH WORKPLACE

WORKPLACE	CAR OWNERS WHO DO NOT USE CARS		CAR USERS	
	Free Parking Available (%)	Members of Car Pool (%)	Free Parking Available (%)	Members of Car Pool (%)
City Park	19,8	0,0	48,9	1,4
Mobil House	4,7	1,1	10,5	5,3
ESCOM	10,0	4,7	6,9	6,9
Safmarine	0,0	0,0	20,0	20,0
Freight S'vces	23,0	0,0	34,8	4,4
Nico Malan	50,0	57,0	90,3	3,2
Norwich Gen.	16,6	0,0	80,0	0,0
B'hagen & Louw	60,0	0,0	33,3	8,3
L'berg & Stander	12,5	11,1	8,1	2,7
Ninham Shand	47,0	5,6	13,2	2,9
Norwich Life	0,0	0,0	0,0	0,0
Caltex	19,4	1,7	2,9	2,9
Davidson & Ewing	33,3	0,0	8,3	0,0
CBD AVERAGE %	14,0	2,3	29,6	3,5
S.A. Mutual	100,0	14,6	92,8	7,2
Sthn. Life	100,0	17,6	56,5	8,3
R. & Coleman	100,0	18,8	100,0	6,8
C.T.C. T'ways	27,3	0,0	45,7	0,0
Reids S/River	100,0	0,0	-	-
Mobil R'Bosch	85,8	0,0	27,0	0,0
Reids Obs.	-	-	53,8	0,0
F. S'vces. Obs.	-	-	33,3	0,0
NON-CBD AV. %	85,5	11,2	67,6	5,4
GLOBAL AV. %	31,7	5,8	46,1	4,3

APPENDIX 4.1

LISTING OF THE PROGRAMME MD2

On the following pages is the listing of the programme which determines the modal split versus the direct distance from the workplace. The data has been corrected by use of the array ZCOM as described in Section 4.10 of the text.

```
      DIMENSION  KK(2000,11),KZ(147,10),KCW(1000,2),
     1KZW(21,2),KCH(2000,2),DHW(2000),RK(20),
     2DT(20),CD(20),CP(20),CY(20),BS(20),TR(20),
     3AMODE(20,10),R(20),AH(2000,2),AW(2000,2),
     4ZCOM(88),ST(20),BC(20),WK(20),CAMODE(20,10),
     5A(20,10)
      READ(8,1) N,M
    1 FORMAT(2I5)
      WRITE(5,1)N,M
    4 FORMAT(2I4,I6,4I4)
C
C   READ IN THE COMMUTER DATA
C
      READ(8,3) ((KK(I,J),J=1,11),I=1,1719)
    3 FORMAT(I2,I3,6I2,I3,I4,I2)
C
C   READ IN THE ZONAL DATA
C
      READ(8,7)((KZW(I,J),J=1,2),I=1,M)
      READ(8,4)((KZ(I,J),J=1,7),I=1,147)
C
C   READ IN THE CORRECTION ARRAY
C
      READ(8,2)(ZCOM(I),I=1,88)
    2 FORMAT(F5.3)
    7 FORMAT(2I4)
      DO 5 J=1,M
      DO6 I=1,N
      IF(KK(I,1).EQ.J) GO TO 8
      GO TO 6
    8 KCW(I,1)=KZW(J,1)
      KCW(I,2)=KZW(J,2)
    6 CONTINUE
    5 CONTINUE
      WRITE(5,1) KCW(1,1),KCW(20,2)
      DO 9 J=1,88
      DO10 I=1,N
      IF(KK(I,10).EQ.J) GO TO 11
      GO TO 10
   11 KCH(I,1)=KZ(J,6)
      KCH(I,2)=KZ(J,7)
   10 CONTINUE
    9 CONTINUE
      K=0
C
C  CALCULATE THE DISTANCE FROM
C    ZONE TO THE WORKPLACE
C
      DO 12 I=1,N
      IF(KCH(I,1).EQ.0)GO TO 13
      AH(I,1)=FLOAT(KCH(I,1))
      AH(I,2)=FLOAT(KCH(I,2))
      AW(I,1)=FLOAT(KCW(I,1))
      AW(I,2)=FLOAT(KCW(I,2))
      DX2=(AH(I,1)-AW(I,1))**2.0
      DY2=(AH(I,2)-AW(I,2))**2.0
      DHW(I)=SQRT(DX2+DY2)
      GO TO 12
   13 K=K+1
   12 CONTINUE
      DMAX=0.0
```

```
C
C    CALCULATE THE MAXIMUM AND THE
C          MINIMUM DISTANCES
C
        DO 14 I=1,N
        IF(DHW(I).EQ.0.0)GO TO 14
        I+(DMAX-DHW(I))15,15,14
   15   DMAX=DHW(I)
   14   CONTINUE
        DMIN=100000.0
        DO 16 I=1,N
        IF(DHW(I).EQ.0.0)GO TO 16
        IF(DMIN-DHW(I))16,17,17
   17   DMIN=DHW(I)
   16   CONTINUE
C
C    THE RANGE OF DISTANCES IS BROKEN
C         UP INTO 20 INCREMENTS
C
        DINC=(DMAX-DMIN)/20.000
        WRITE(5,877) DMAX,DMIN,DINC
  877   FORMAT(3F10.3)
        DO 18 J=1,20
        B(J)=0.0
   18   CONTINUE
        DO 90 J=1,20
        DO 19 K=1,10
        AMODE(J,K)=0.0
        A(J,K)=0.0
   19   CONTINUE
   90   CONTINUE
C
C    THE MODAL SPLIT FOR EACH DISTANCE
C    INCREMENT IS CALCULATED AND IS
C    STORED IN THE ARRAY AMODE AND THE
C    CORRECTED VERSION IS STORED IN
C    THE ARRAY CAMODE. THE PERCENTAGE
C    MODAL SPLIT IS STORED IN THE ARRAY A
C
        DO 21 J=1,20
        IF(J.EQ.1) GO TO 22
        GO TO 23
   22   D1=DMIN
        GO TO 24
   23   D1=(J-1)*DINC+DMIN
   24   D2=J*DINC+DMIN
        AMODE(J,1)=(D2+D1)/2.0
        WRITE(5,917)D1,D2
  917   FORMAT(2F8.3)
   21   CONTINUE
```

```
      DO 223 I=1,N
      DO 222 J=1,20
      DO 26 K=2,10
      DO 224 KM=1,88
      L=K-1
      ZU=AMODE(J,1)+DINC/2.0
      ZL=AMODE(J,1)-DINC/2.0
      IF(KK(I,7).EQ.L)GO TO 515
      GO TO 26
  515 IF(KK(I,10).EQ.KM)GO TO 27
      GO TO 224
   27 IF(DHW(I).GE.ZL.AND.DHW(I).LT.ZU) GO TO 102
      GO TO 222
  102 AMODE(J,K)= AMODE(J,K)+1.0
      B(J)=B(J)+1.0
      CAMODE(J,K)=AMODE(J,K)/ZCOM(KM)
  224 CONTINUE
  26  CONTINUE
  222 CONTINUE
  223 CONTINUE
      WRITE(5,100)(B(J),J=1,20)
  100 FORMAT(10F6.1)
      WRITE(5,30)
      DO 620I=1,20
      ST(I)=0.0
  620 CONTINUE
C
      DO 621 I=1,20
      DO 622 J=1,9
      ST(I)=ST(I)+CAMODE(I,J)
  622 CONTINUE
  621 CONTINUE
      DO 908 J=1,20
      DO 909 K=2,10
      IF(B(J).EQ.0.0)GO TO 908
      A(J,K)=(CAMODE(J,K)*100.0)/ST(J)
  909 CONTINUE
  908 CONTINUE
      DO 28 J=1,20
      WRITE(5,29)(AMODE(J,K),K=1,10)
      WRITE(5,29)(CAMODE(J,K),K=1,10)
      WRITE(5,29)(A(J,K),K=1,10)
   28 CONTINUE
   29 FORMAT(10F6.3)
   30 FORMAT(1H1,10X,'LISTING OF INCREMENTAL MEAN',
     11X,'DISTANCES VS. PERCENTAGE MODE USE')
      STOP
      END
```

APPENDIX 4.5.

LISTING OF COMPUTER PROGRAMME RTCCBD.

```
      DIMENSION KK(1720,13),ODDM(147,21),ZONE(88,15),
     1KT(88),KFM(88),KTR(88),DIST(88),CD(88),C(88),
     2T(88),E(88),F(88),FM(88),TR(88),KJ(88),CO(88),
     3K(88),KF(88),RTCBD(88,11)
C.....................................
C   READ IN THE QUESTIONNAIRE DATA,(KK), AND
C   THE DISTANCES FROM HOME TO WORK ARRAY,(ODDM),
C   AND THE SUPPLEMENTARY DATA FOR EACH ZONE
C            IN ARRAY (ZONE).
C.....................................
      READ(8,1)((KK(I,J),J=1,13),I=1,1719)
    1 FORMAT(I2,I3,6I2,I3,I4,2I2,I4)
      READ(8,2)((ODDM(I,J),J=1,21),I=1,88)
    2 FORMAT(7F8.3)
      READ(8,4)((ZONE(I,J),J=1,11),I=1,88)
    4 FORMAT(2F4.0,F6.0,7F5.0,F5.1)
      DO 8 I=1,88
      K(I)=0
      KF(I)=0
      KJ(I)=0
      DIST(I)=0.0
      CD(I)=0.0
      C(I)=0.0
      KFM(I)=0
      KTR(I)=0
      CO(I)=0.0
      DO 9 J=1,11
      RTCBD(I,J)=0.0
    9 CONTINUE
C.....................................
C   THE FOLLOWING SERIES OF IF STATEMENTS
C   CHECK IF THE COMMUTER IS A TRAIN OR A
C   CAR USER AND IF HE WORKS IN THE CBD.
C.....................................
    8 CONTINUE
      DO 5 I=1,1719
      DO 6 J=17,88
      IF(KK(I,7).EQ.1.OR.KK(I,7).EQ.5)GO TO 11
      IF(KK(I,7).EQ.9)GO TO 11
      GO TO 5
   11 IF(KK(I,10).LE.16.OR.KK(I,10).GE.89)GO TO 5
      IF(KK(I,1).EQ.1.OR.KK(I,1).EQ.3) GO TO 5
      IF(KK(I,1).EQ.5.OR.KK(I,1).EQ.6) GO TO 5
      IF(KK(I,1).EQ.11.OR.KK(I,1).EQ.14) GO TO 5
      IF(KK(I,1).EQ.16.OR.KK(I,1).EQ.20) GO TO 5
      IF(KK(I,10).EQ.J) GO TO 12
      GO TO 6
```

```
   12 IF(ZONE(J,4).EQ.0.0.OR.ZONE(J,8).EQ.0.0)GO TO 5
      KW=KK(I,1)
      KH=KK(I,10)
      IF(KH.GE.147.OR.KW.GE.22) GO TO 5
      KT(J)=KT(J)+1
      IF(KK(I,4).EQ.1)CO(J)=CO(J)+1.0
      K(J)=K(J)+(KK(I,11)*2000)/(KK(I,6)+2)
      IF(KK(I,3).EQ.1.OR.KK(I,3).EQ.5)GO TO 13
      KF(J)=KF(J)+(KK(I,6)+1)
      GO TO 30
   13 KF(J)=KF(J)+(KK(I,6)+2)
   30 IF(KK(I,3).GE.4)KFM(J)=KFM(J)+1
      DIST(J)=DIST(J)+ODDM(KH,KW)
      IF(KK(I,7).EQ.5.OR.KK(I,7).EQ.9)KTR(J)=KTR(J)+1
      IF(KK(I,7).EQ.1)GO TO 80
      GO TO 5
   80 CO(J)=CO(J)+1.0
      C(J)=C(J)+(ODDM(KH,KW)*1.48+0.096)*4.4+KK(I,13)/2.0

C.....................................
C  THE ABOVE EXPRESSION REPRESENTS THE
C   CALCULATION OF THE MOTORISTS TRIP
C       FOR EACH COMMUTER.
C.....................................
    6 CONTINUE
    5 CONTINUE
      DO 14 J=17,88
      T(J)=FLOAT(KT(J))
      E(J)=FLOAT(K(J))
      F(J)=FLOAT(KF(J))
      FM(J)=FLOAT(KFM(J))
      TR(J)=FLOAT(KTR(J))
   14 CONTINUE
C.....................................
C   THE ARRAY RTCBD IS NOW SET UP FOR
C   USE IN THE REGRESSION ANALYSES TO
C  FOLLOW. IT IS THEN WRITTEN INTO A
C   DATA FILE FOR EASY ACCESS.
C.....................................
      DO 15 I=17,88
      IF(T(I).EQ.0.0)GO TO 15
      IF(CO(I).EQ.0.0)GO TO 15
      RTCBD(I,1)=((TR(I)/T(I))*100.0)
      RTCBD(I,2)=DIST(I)/T(I)
      RTCBD(I,3)=(FM(I)/T(I))*100.0
      RTCBD(I,4)=ZONE(I,4)
      RTCBD(I,5)=ZONE(I,8)
      RTCBD(I,6)=ZONE(I,9)
      RTCBD(I,7)=ZONE(I,11)
      RTCBD(I,8)=C(I)/CO(I)
      RTCBD(I,9)=E(I)/T(I)
      RTCBD(I,10)=F(I)/T(I)
      RTCBD(I,11)=(T(I)-CO(I))*100.0/T(I)
   15 CONTINUE
      WRITE(5,121)(T(I),I=17,88)
  121 FORMAT(11F5.0)
      WRITE(5,81)((RTCBD(I,J),J=1,11),I=17,88)
      WRITE(17,81)((RTCBD(I,J),J=1,11),I=17,88)
   81 FORMAT(8F6.2,F8.2,2F5.2)
      STOP
      END
```

APPENDIX 4.6

MEASUREMENT OF PERCEIVED AND ACTUAL TIMES

Sterne[12], using data from the questionnaire survey, attempted to discover a relationship between the time a person said he took to come to work by train and the actual time it takes to make the trip by train. Figure A.4.6.1 shows a plot of the actual versus the perceived times for a random selection of train commuters.

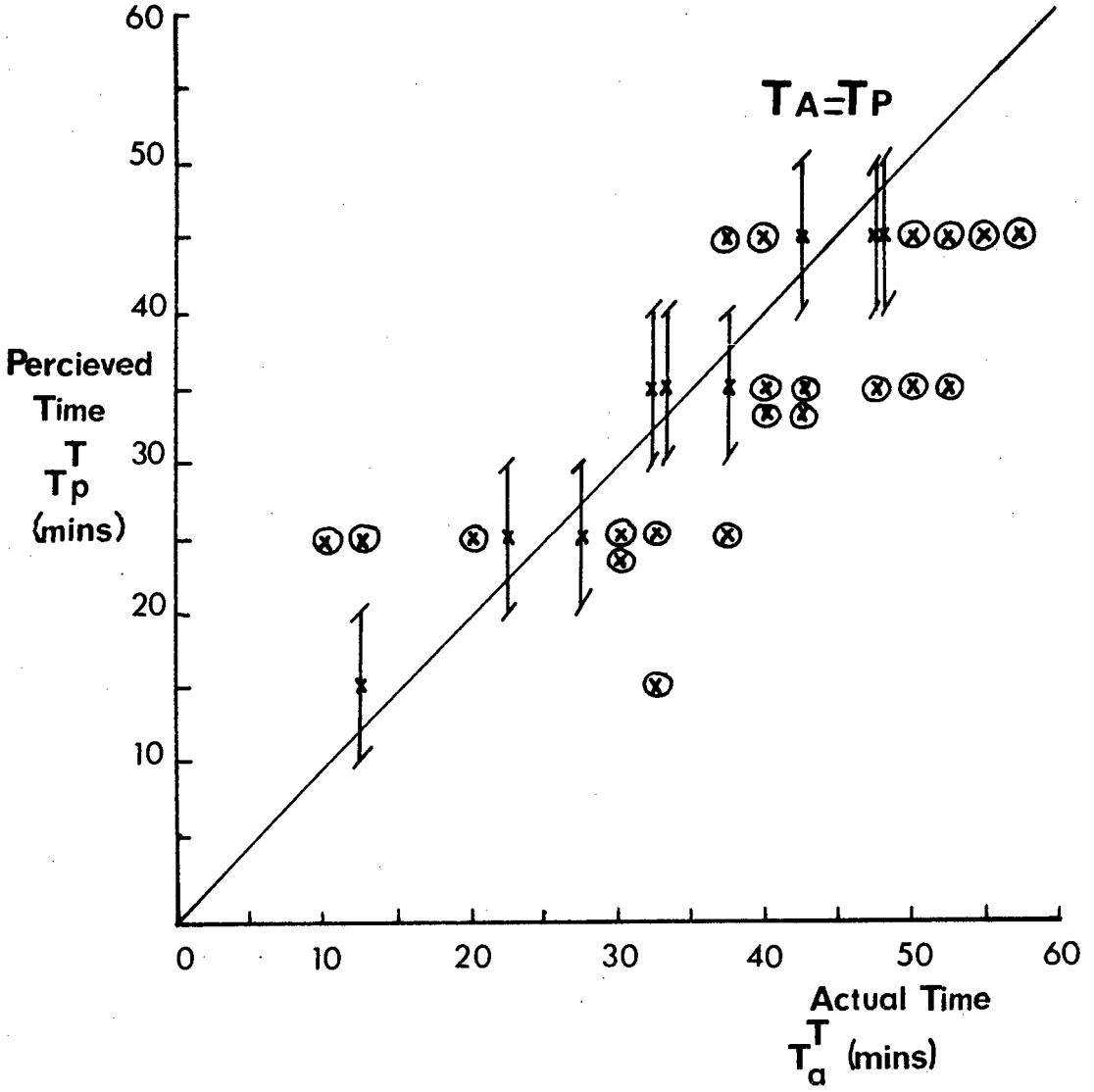


Fig A 4.6.1. **Selection of Train users' Perceptions of Travel Time**

The points tend to be grouped in horizontal bands. This is due to the "box type" questions used in the survey and it illustrates the problem of the structured question mentioned in Chapter 3. A range of ten minutes was allowed for each answer to "the time taken to come to work" question; and where this ten minute interval intersects the $T_A = T_P$ line the point is marked with a cross and the ten minute interval is marked as a line about this point. The points which are ringed are more than a half interval away from the $T_A = T_P$ line. It is noticed that almost 75% of these circled points fall below the $T_A = T_P$ line. In other words the train commuters tended to underestimate their travel times.

Steele[13] investigated car users' perceptions of travel times by car and applied a linear regression analysis to the variables of perceived time (T_P^C) and actual times (T_A^C). The resultant equation was

$$T_P^C = 1{,}89 + 0{,}811\ T_A^C \qquad \text{(A.6.1)}$$
$$(r = 0{,}565)$$

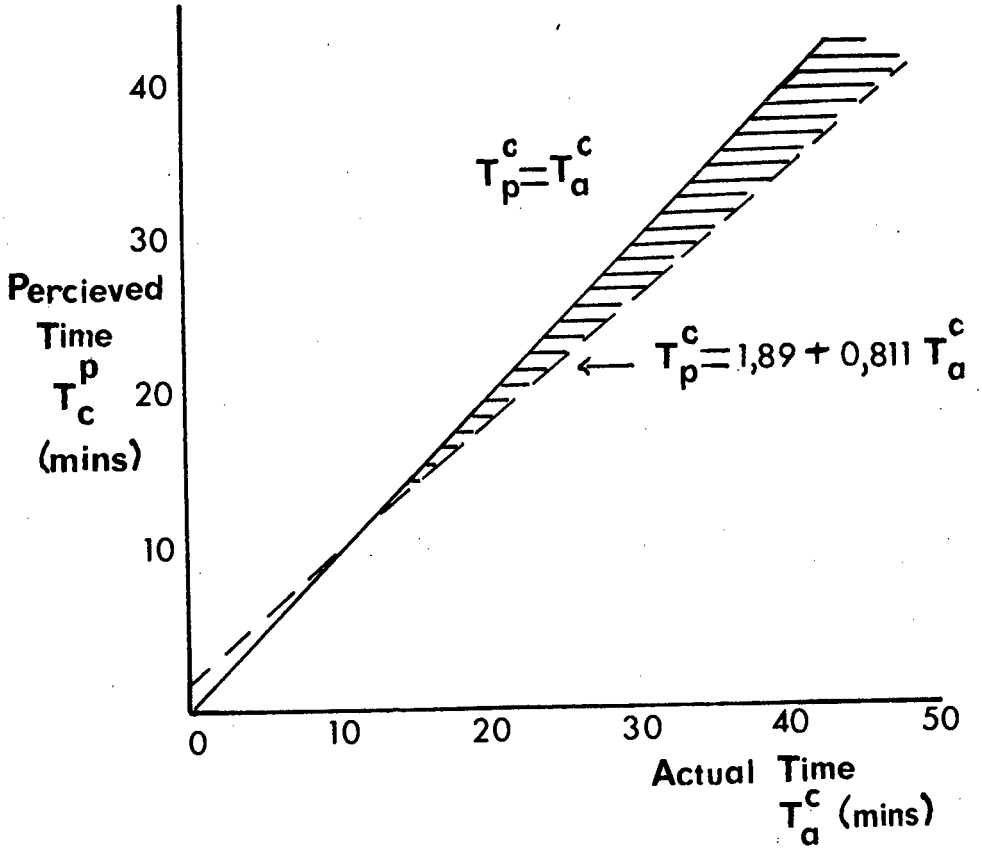
where r = the coefficient of linear correlation. This line is plotted in Figure A.4.6.2 together with the line $T_A^C = T_P^C$.

The car user tends to underestimate his time, above a trip time of ten minutes, as shown by the shaded area in the figure below. It appears that the magnitude of the difference between the perceived and actual times is related to the trip length.

Unfortunately, the questions relating to the perception of times for alternative modes were poorly answered. Many

Car users' Perceptions of Travel Time

Fig A.4.6.2.



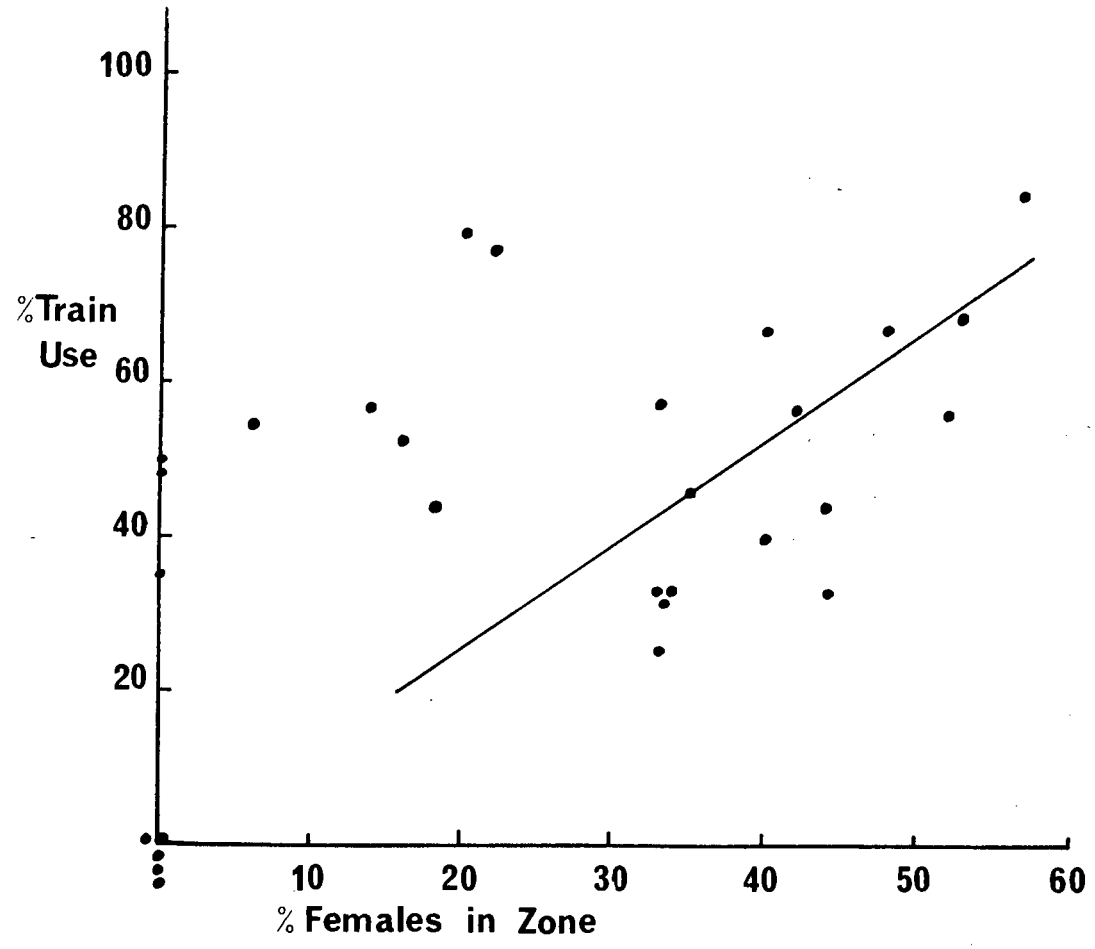
respondents noted that they "had no idea" of alternative times. This probably is justification for the hypothesis that modal choice decisions are not based on actual time differences between modes but the perceived difference in times. There still remains the major problem of measuring these perceived values.

APPENDIX 4.7.

GRAPHS OF RELATIONSHIPS BETWEEN

INDEPENDENT AND DEPENDENT VARIABLES

fig A.4.7.1 % Train use vs % Females in Zone



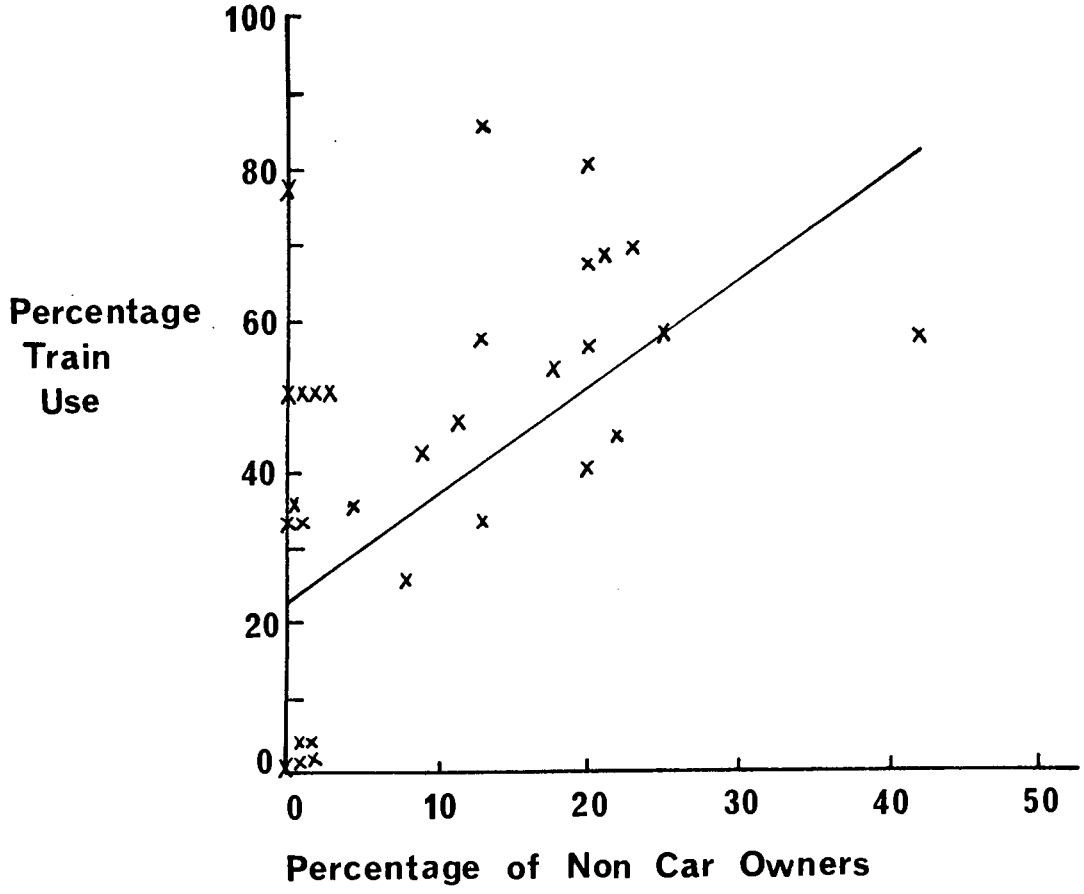


fig. A 4.7.2 % Train use vs % Non Car Owners

fig.A4.7.3. % Train use vs Average Economic Index

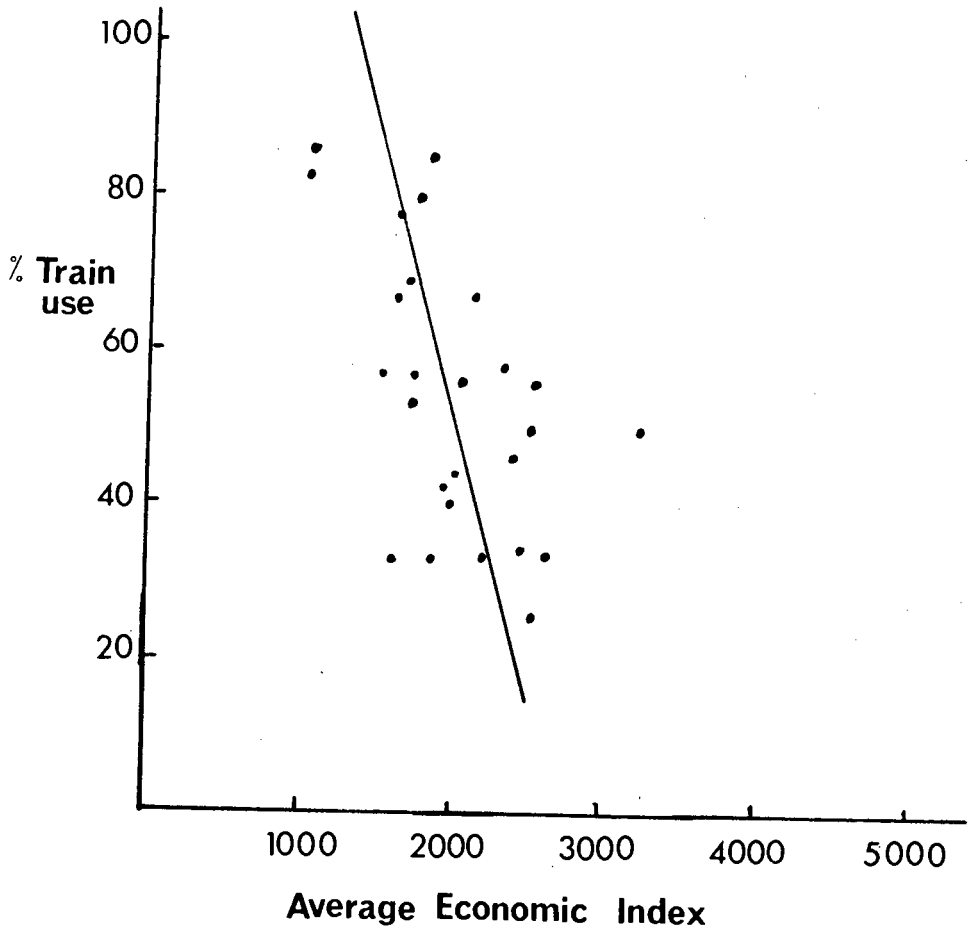


fig.A.4.7.4 % Train use vs Time Difference

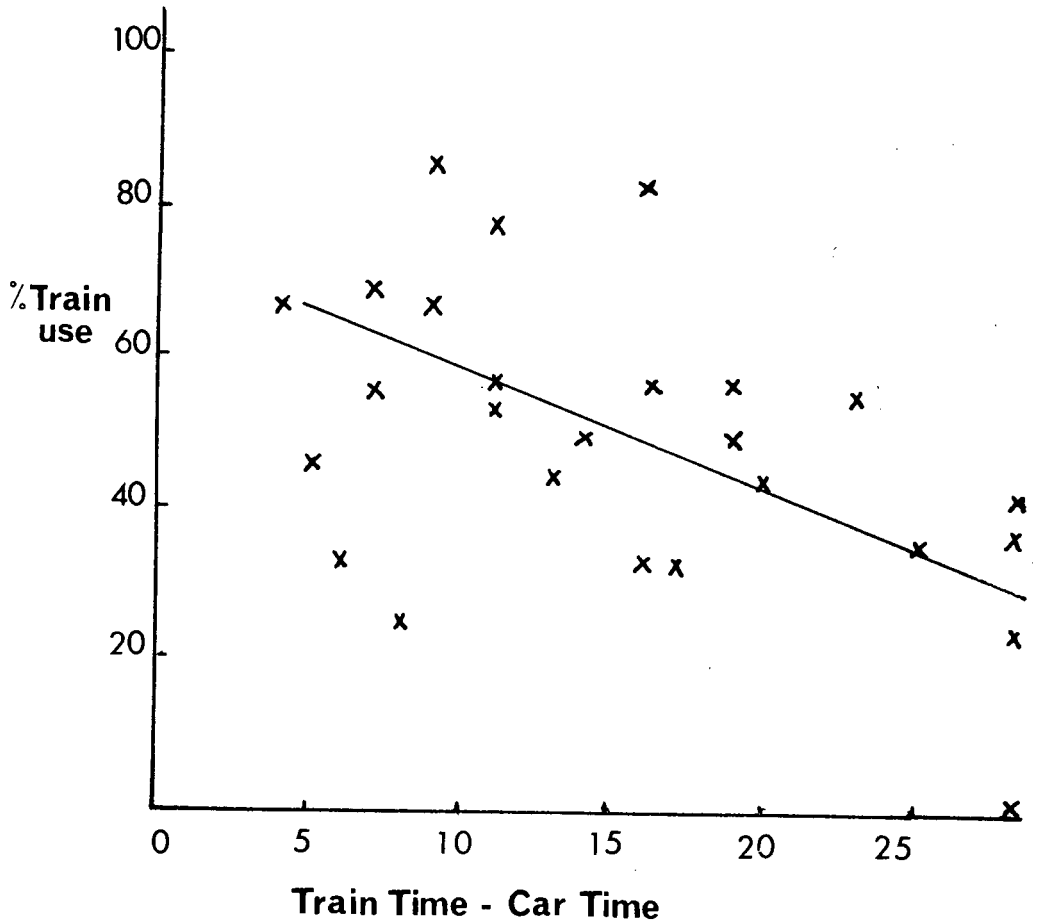


fig A4.7.5. % Train use vs Cost Difference

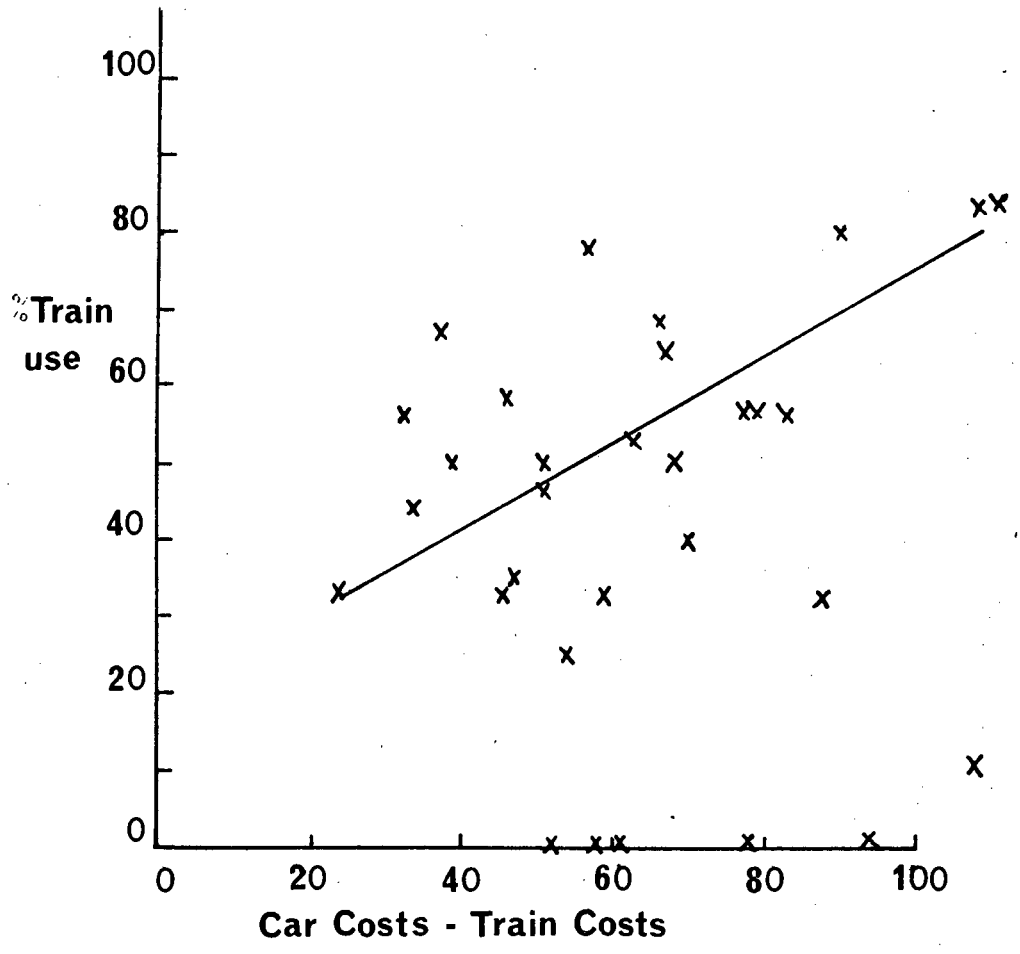
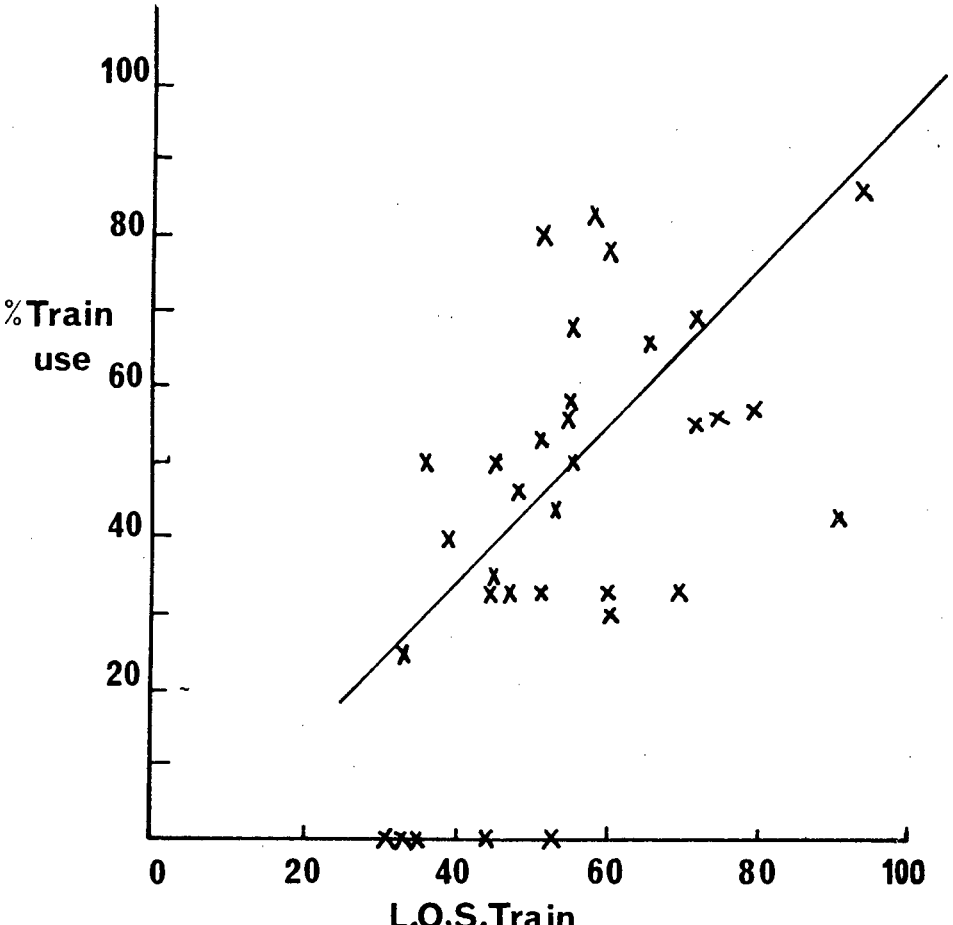


fig. A4.7.6. % Train use vs Train L.O.S.



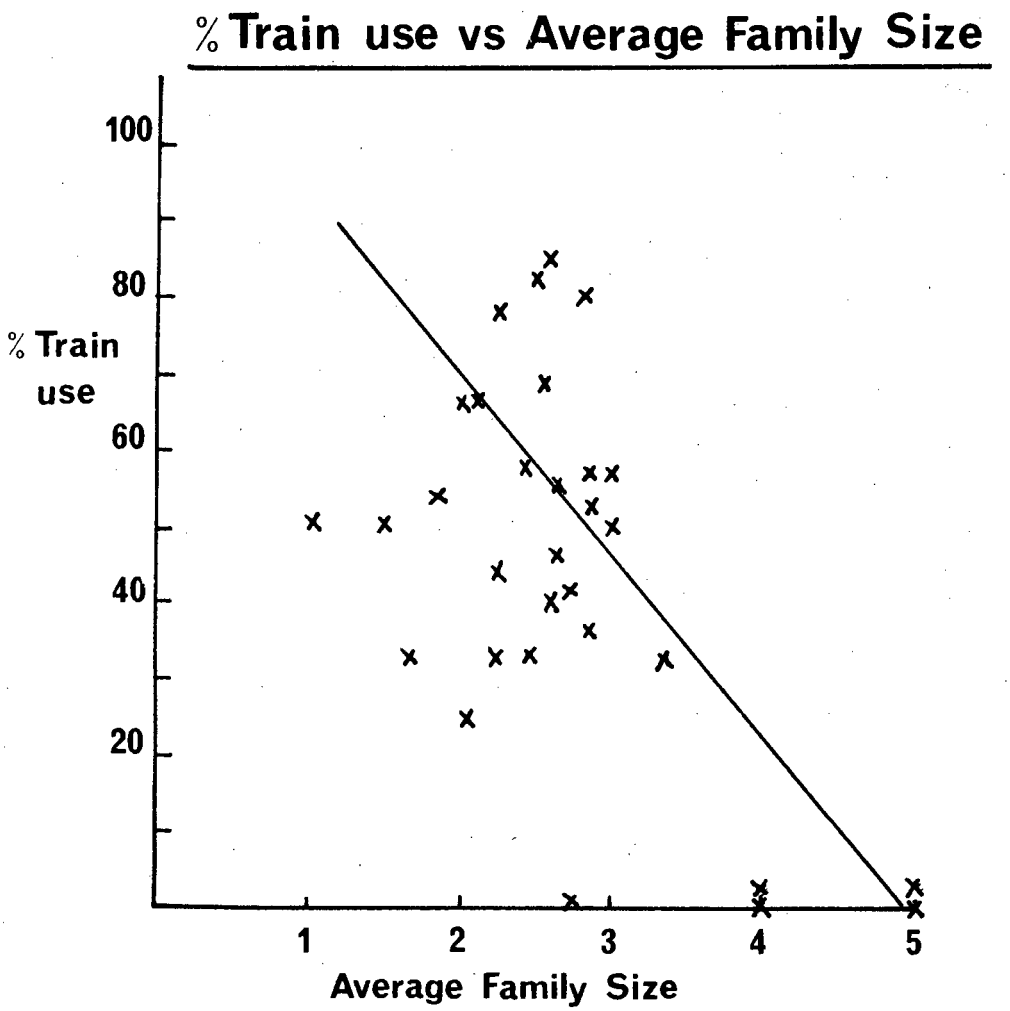

% Train use vs Average Family Size
100
80
60
40
20
% Train use
1
2
3
4
5
Average Family Size

fig. A.4.7.7

APPENDIX 4.8

LISTING OF THE DATAFILE RDAT

The datafile RDAT contained the input variables for the BMDO2R programme. The listing is given on the following page. The columns each represent the observed values of the variables in each zone. The variables are listed below.

Column No.	Variable	
1	Percentage of commuters using train.	PCTTRN
2.	Average Direct Distance of zone CBD firm.	DISTHW
3.	Percentage females in zone.	PCTFEM
4.	Train LOS for zone.	TRNLOS
5.	Train Times for zone.	TTIMES
6.	Car Times for zone.	CTIMES
7.	Train Costs for zone.	TCOSTS
8.	Car Costs for zone.	CCOSTS
9.	Average Zonal Economic Index	EINDEX
10.	Average Zonal Family Size.	FMSIZE
11.	Percentage of non car owners in zone.	PERNCO

1	2	3	4	5	6	7	8	9	10	11
33.33	4.43	33.33	60.00	18.33	12.00	7.60	31.42	1599.93	2.4713.33	
56.00	5.72	52.00	74.00	20.31	13.00	9.30	82.38	2041.32	1.8420.00	
44.44	6.00	38.88	52.38	27.00	14.33	2.30	83.33	2.29.56	2.2222.22	
50.00	6.00	50.00	65.00	30.30	16.00	10.00	89.63	2500.00	1.30 0.00	
66.67	6.00	58.33	65.00	25.33	16.00	10.20	97.18	2162.20	2.0020.00	
39.78	7.91	0.00	75.00	42.30	17.00	10.20	58.98	2494.13	2.87 4.35	
50.33	6.78	25.33	55.00	33.33	17.00	10.80	56.44	2333.25	2.4225.00	
46.43	8.36	35.71	53.03	50.00	25.00	15.40	61.12	2463.60	2.5410.71	
33.33	7.14	44.44	72.22	36.36	19.00	11.60	57.84	2111.11	2.22 0.00	
0.00	9.05	0.00	82.00	50.00	31.00	15.50	63.14	3241.34	2.71 0.00	
25.00	9.32	33.33	60.00	81.20	22.00	12.40	68.12	2555.50	2.08 8.33	
67.57	9.29	48.65	56.00	53.00	29.00	12.40	79.08	1657.62	2.1421.62	
51.50	9.02	0.00	65.51	41.30	22.00	13.20	64.07	3250.00	3.00 0.00	
0.00	9.96	0.00	50.00	40.00	25.00	14.20	75.29	2000.00	5.00 0.00	
77.78	10.91	22.22	60.00	33.33	27.00	15.20	71.60	1581.99	2.22 0.00	
0.00	11.05	0.00	66.66	45.21	32.00	15.20	72.35	1000.00	4.00 0.00	
40.00	11.77	40.00	50.00	56.01	25.00	13.60	64.96	2000.00	2.5020.00	
62.23	11.91	53.33	71.00	34.00	29.00	14.60	80.32	1717.92	2.5423.38	
53.33	12.56	16.67	51.00	46.15	34.00	15.80	87.26	1702.17	2.8716.67	
57.14	13.20	42.86	22.50	44.00	32.00	15.70	74.28	1523.43	3.0042.86	
57.14	13.84	19.05	53.00	50.00	26.00	16.30	94.31	1719.29	2.5419.29	
0.00	14.39	0.00	50.00	70.00	27.00	15.70	96.29	5000.00	1.50 0.00	
0.00	13.80	0.00	53.10	70.01	28.00	16.20	85.31	2000.00	4.00 0.00	
55.56	14.70	5.56	71.00	54.00	23.00	17.00	90.97	2533.28	2.67 0.00	
33.33	14.15	33.33	51.11	46.30	29.00	17.00	85.43	1858.67	3.33 0.00	
0.00	15.20	0.00	51.11	80.00	34.00	18.40	112.46	1650.00	5.30 0.00	
33.33	15.55	33.33	64.00	32.00	26.00	19.20	73.75	2666.67	1.67 0.00	
50.00	16.00	20.00	51.00	60.00	30.00	18.60	108.72	1766.60	2.9020.00	
33.33	15.15	33.33	53.00	43.33	32.00	20.40	130.54	1066.67	2.5066.67	
54.71	21.00	47.14	93.00	51.00	40.00	21.90	150.00	1785.71	2.5714.29	
42.42	23.40	15.15	91.00	65.00	45.00	23.20	150.48	1960.58	2.73 9.09	

APPENDIX 5.1

TECHNIQUE OF MINIMUM LEAST SQUARES

The minimum least squares method involves fitting a surface to a number of points distributed in space so that the sum of the squares of the distances from each point in space to the surface is a minimum. In two dimensions, that is for one independent variable, the situation can be considered as shown in figure 5.1.1.

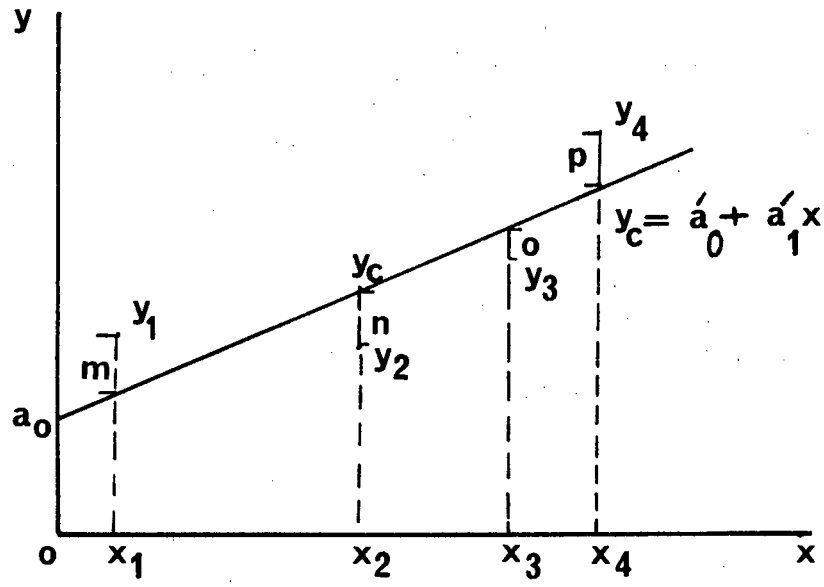


Fig A 5.1.1. Least Squares Regression

In figure A.5.1.1, m, n, o and p are the deviations from the observed points (X_i, Y_i) to the computed trend line, $Y_c = a_0' + a_1'X$. The criterion for this line to be the "best" fit to these observed points is that the sum of the squares of the deviations be a minimum, i.e.

$$m^2 + n^2 + o^2 + p^2 = \text{minimum} \qquad (5.1.1)$$

If the computed equation is:

$$Y_c = a' + a'X \tag{5.1.2}$$

then the parameters a' and a' can be found by solving the following set of equations:

$$\begin{aligned} \Sigma Y &= na_0' + a_1'\Sigma X \\ \Sigma XY &= a_0' X + a_1'\Sigma X^2 \end{aligned} \tag{5.1.3}$$

where

n = the number of observed points.

These are termed the normal equations. Similarly for m independent variables the corresponding (m+1) parameters of the equation to the hyper-plane in (m+1) dimensional space (equation two) are found by solving the following set of normal equations:

$$\begin{aligned} a_0'n + a_1'\Sigma X_1 + a_2'\Sigma X_2 + \ldots + a_m'\Sigma X_m &= \Sigma Y \\ a_0'\Sigma X_1 + a_1'\Sigma X_1^2 + a_2'\Sigma X_1X_2 + \ldots + a_m'\Sigma X_1X_m &= \Sigma X_1Y \\ a_0'\Sigma X_m + a_1'\Sigma X_mX_1 + a_2'\Sigma X_mX_2 + \ldots + a_m'\Sigma X_m^2 &= \Sigma X_mY \end{aligned} \tag{A.5.1.4}$$

APPENDIX 5.2

INPUT REQUIREMENTS FOR BMDO2R

The order of cards in the job deck of the programme is:

1. System Cards.
2. Problem Card.
3.* Transgeneration Card(s).
4.* Labels Card(s).
5. F-Type Variable Format Cards.
6. Data Input Cards
   (or " ADD DATAFILE." statement).
7. Sub Problem Card(s).
8.* Control-Delete Cards.
9.* Index Plot Cards.

(* These cards are optional.)

The system cards are the usual cards required to commence a computer run. The Problem card contains information specific to that run, including the number of variables, the number of transgenerated variables and the number of sub-problems in the run. The transgeneration cards are optional cards which specify which independent variables are to be transgenerated. A list of transgeneration options available is provided in the manual. The labels card allows the user to attach a six column alphanumeric name to all or some of the variables.

The variable format cards specify the format in which the input data is to be read. This input data must be in

F-type or floating point format.

The sub-problem cards note which variable is designated as the dependent variable and what F-value* is specified for the deletion or the inclusion of the variable of each step of the programme. This F level is more fully discussed in section 5.3.

The control-delete card designates the variables which are not required to enter the regression or which are to be forced into the regression irrespective of their F-value. Finally the index plot card allows the user to specify for which variables he wishes to have the residuals plotted.

All these specification cards were stored in an element of a programme file and the execution of the programme simply required the following control statements:

1. @RUN RUNID, ACCOUNT No., PROJECT NAME, TIME, PAGES
2. @ASG,AXZ RDAT. (RDAT is the data file containing the observations for each variable.)
3. @ASG,AXZ BMR1. (BMR1 is the programme file containing all the statements listed earlier.)
4. @ASG,AXZ BMD*NEWABS (BMD*NEWABS is the package routine which contains BMDO2R.)
5. @XQT BMD*NEWABS.BMDO2R
6. @ADD BMR1.ELT'n'
7. @FIN

Different versions of the regression problem can be

---

* The B.M.D. manual[5] terms this the F-level and notes that 0,01 will be the default level if no level is stated. In fact, the F-value needs to be included as the calculations and output indicate that the F-value is used not the F-level which is purely a significance level.

stored in various elements of the file BMR1 and only the 'n' on card number 6 needs to be altered for different runs.

APPENDIX 5.3

STATISTICAL TESTS IN REGRESSION ANALYSIS

A.5.3.1 STATISTICAL SIGNIFICANCE OF THE REGRESSION EQUATION

To test whether the regression equation is a result of regression in the population or is a result of chance only, the null hypothesis H_o is formulated as below:

$$H_o : a_1' = a_2' = a_3'' = 0$$

If the regression is significant one would expect the regression sum of squares S_R would be large relative to the residual sum of squares S_E. Thus the ratio for F, shown in equation (A.5.3.1) should be large if the regression is significant.

$$F = \frac{\frac{S_R}{\nu_1}}{\frac{S_E}{\nu_2}} = \frac{\frac{\Sigma (Y_c-\bar{Y})^2}{\nu_1}}{\frac{\Sigma (Y-Y_c)^2}{N-\nu_1-1}} = \frac{S_R'}{S_E'} \qquad \text{(A.5.3.1)}$$

where

ν_1 = the regression degrees of freedom,

ν_2 = the residual degrees of freedom,

N = the number of observations.

For the BMDO2R output the F ratio is calculated at each step (see Appendix 5.5). This F ratio is then compared with the ratios tabulated in tables of the F distribution[1]. If the F ratio is greater than the tabulated $F_{\nu_1, \nu_2, \gamma}$ (γ = level of significance chosen for the analysis) then the nul

hypothesis is rejected and the regression equation is said to be significant at the γ^{th} level of significance.

A.5.3.2 TEST FOR SIGNIFICANCE OF THE PARTIAL REGRESSION COEFFICIENTS

The null hypothesis for this test is usually stated as:

$$H_o : a_i = 0$$

and if the sign of the partial regression coefficient is unknown the test becomes a two tailed test with the alternative hypothesis H_1 expressed as:

$$H_1 : a_i \neq 0$$

The t statistic is used in this case and H_o is rejected if

$$t = \frac{(a_i - 0)}{S_{a_i}} > t_{\gamma/2, \nu_2} \qquad \text{(a.5.3.2)}$$

γ and ν_2 are defined earlier,

t = tabulated in tables of the "Students" t distribution,

S_{a_i} = standard error of the estimate of a_i.

If the null hypothesis is rejected then one can say that the partial regression coefficient is significantly different from zero at the γ level of significance. The BMDO2R output lists the values for the standard errors of the estimate for the partial correlation coefficients. Hence the t statistic can be readily calculated.

APPENDIX 5.4

THE SIMPLE CORRELATION MATRICES

An optional output facility with the BMDO2R programme is a listing of the simple correlation coefficients between each of the variables. These correlation matrices are provided in this appendix for the zonal and the person-level regressions. The listing provides an indication of possible causes of multi-collinearity between variables in the regression model.

ZONAL LEVEL

CORRELATION MATRIX

VARIABLE NUMBER	1	2	3	4	5	6	7	8	9	10
1	1.000	.195	.553	.552	-.298	.056	.175	.207	-.111	-.571
2		1.000	-.110	.343	.721	.858	.990	.988	-.243	.330
3			1.000	.437	-.530	-.216	-.136	-.060	-.283	-.591
4				1.000	-.283	.260	.298	.343	-.274	-.372
5					1.000	.624	.747	.700	.094	.600
6						1.000	.870	.870	-.182	.319
7							1.000	.981	-.199	.339
8								1.000	-.244	.304
9									1.000	-.372
10										1.000

VARIABLE NUMBER	11	12	13	14	15	16	17	18	19	20
1	.563	-.410	-.406	-.336	.211	.188	.159	-.526	-.371	.381
2	.174	.381	.048	.392	.985	.836	.955	.352	-.111	.862
3	.552	-.535	-.440	-.494	-.049	-.017	-.143	-.607	-.617	.119
4	.324	-.516	-.591	-.462	.349	.238	.223	-.333	-.440	.740
5	-.226	.877	-.617	.331	.691	.601	.755	.583	.348	.355
6	.060	.172	-.214	.169	.867	.798	.890	.344	-.049	.757
7	.142	.407	.066	.416	.975	.811	.964	.354	-.070	.832
8	.219	.347	.020	.360	1.000	.892	.970	.325	-.119	.864
9	-.430	.230	.308	.197	-.249	-.240	-.192	-.398	.857	-.259
10	-.171	.561	.413	.514	.298	.260	.348	.992	.110	.034
11	1.000	-.322	-.336	-.259	.230	.279	.164	-.126	.521	.237
12		1.000	.910	.944	.338	.267	.404	.523	.468	-.018
13			1.000	.685	.013	-.008	.067	.369	.489	-.279
14				1.000	.351	.264	.404	.491	.434	.042
15					1.000	.901	.967	.320	-.126	.866
16						1.000	.915	.290	-.108	.716
17							1.000	.367	-.044	.772
18								1.000	.098	.072
19									1.000	-.242
20										1.000

PERSON LEVEL

CORRELATION MATRIX

VARIABLE NUMBER	1	2	3	4	5	6	7	8	9	10
1	1.000	.042	.209	.091	-.029	.033	.049	.136	-.184	-.069
2		1.000	-.099	.490	.860	.902	.994	.880	-.096	.170
3			1.000	.087	-.205	-.105	-.095	-.115	-.303	-.438
4				1.000	.093	.294	.479	.422	-.109	-.059
5					1.000	.798	.864	.769	.002	.225
6						1.000	.905	.804	-.105	.173
7							1.000	.880	-.094	.160
8								1.000	-.084	.128
9									1.000	-.283
10										1.000

VARIABLE NUMBER	11	12	13	14	15	16	17	18	19	20
1	-.356	-.081	-.103	-.089	.144	.201	.140	-.082	-.231	.042
2	.810	.442	-.069	.477	.852	.330	.820	.167	-.022	.939
3	-.486	-.221	-.180	-.237	-.115	-.103	-.134	-.467	-.547	-.060
4	-.036	-.158	-.322	-.054	.408	.079	.277	-.066	-.162	.733
5	.067	.776	.303	.748	.745	.327	.765	.224	.117	.689
6	.014	.238	-.315	.245	.779	.331	.793	.174	-.027	.804
7	.008	.444	-.078	.479	.851	.330	.830	.157	-.025	.925
8	.053	.398	-.054	.427	.998	.721	.964	.121	-.033	.827
9	.265	.112	.171	.114	-.081	-.032	-.069	-.244	.867	-.090
10	.230	.183	.093	.183	.122	.038	.138	.993	.191	.111
11	1.000	.093	.088	.091	.058	.093	.066	.237	.356	.013
12		1.000	.818	.948	.385	.180	.403	.179	.217	.267
13			1.000	.795	-.051	.011	-.042	.088	.238	-.169
14				1.000	.414	.179	.415	.177	.217	.342
15					1.000	.757	.965	.115	-.033	.801
16						1.000	.780	.032	-.015	.286
17							1.000	.134	-.006	.719
18								1.000	.237	.105
19									1.000	-.052
20										1.000

APPENDIX 5.5

TESTS FOR THE REGRESSION MODEL EQUATIONS

The listings for the regression equations at the zonal level and the person level are presented in this appendix. The statistical tests outlined in Appendix 5.3 are used to test the significance of these equations:

A.5.5.1 MODEL EQUATION AT THE ZONAL LEVEL

The equation developed at the zonal level which appears to provide "best" explanation of the observed data is shown below:

$$\underset{}{PCTTRN} = \underset{}{63,589} + \underset{(0,678)}{\overset{(a_1')}{1,749x_2}} - \underset{(3,650)}{\overset{(a_2')}{17,597x_{10}}} + \underset{(0,204)}{\overset{(a_3')}{0,678x_{11}}} \quad \text{(A.5.5.1)}$$

$R = 0,7988$ $\qquad$ F Ratio $= 15,869$

a) TEST FOR THE SIGNIFICANCE OF THE REGRESSION EQUATION

$H_o : a_1' = a_2' = a_3' = 0$

$\nu_1 = 3 : \nu_2 = 27$

$F = 15,869.$

From the tables for the F distribution,

$F_{3;\ 27;\ 0,01} = 4,60$

Therefore F Ratio $= 15,87 > F_{3;\ 27;\ 0,01} = 4,60.$

Thus the null hypothesis is rejected and the regression equation is significant at the 1% level of significance.

b) TEST FOR THE SIGNIFICANCE OF THE PARTIAL REGRESSION COEFFICIENTS

H_o : $a_i = 0$

H_a : $a_i \neq 0$ ($\therefore$ Two tail test)

i. For $a_1' = 1,749$

$\nu_2 = 27$: $S_{a_1} = 0,678$

t statistic $= \frac{1,749}{0,678} = 2,57$

From t distribution tables,

$t_{0,05;\ 27} = 1,703$

Thus $t > t_{0,05;\ 27}$

Therefore the null hypothesis is rejected. The partial correlation coefficient (a_1') is significantly different from zero at the 1% level.

ii. Similarly for $a_2' = -17,597$: $S_{a_2} = 3,650$

t statistic $= \frac{17,597}{3,650} = 4,82$

Again t statistic $> t_{0,05;\ 27}$

Therefore a_2' is significantly different from zero.

iii. For $a_3' = 0,678$: $S_{a_3} = 0,205$

t statistic $= \frac{0,678}{0,205} = 3,30$

Again t statistic $> t_{0,05;\ 27}$

Therefore a_3' is significantly different from zero.

Thus the equation (A.5.5.1) satisfies the criteria set out in section 5.4.

A.5.5.2 MODEL EQUATION AT THE PERSON LEVEL

The equation which again appeared to be the "best" model can be written as

$$\underset{}{PCCTRN} = \underset{}{0,38576} - \underset{(0,07130)}{\overset{(a_1')}{0,4587x_{11}}} + \underset{(0,10674)}{\overset{(a_2')}{0,36267x_{17}}} - \underset{(0,00002)}{\overset{(a_3')}{0,00004x_{19}}}$$

$R = 0,4057$ F Ratio = 24,625

a. TEST FOR THE SIGNIFICANCE OF THE REGRESSION EQUATION

As in section A.5.5.1,

$H_o : a_1' = a_2' = a_3' = 0$

$\nu_1 = 3 : \nu_2 = 375$

$F_{3;\ 375;\ 0,01} = 2,62$

$\therefore$ F Ratio $> F_{3;\ 375;\ 0,01}$

Thus the null hypothesis is rejected and the equation is considered significant at the 1% level.

b. TEST FOR THE SIGNIFICANCE OF THE PARTIAL REGRESSION COEFFICIENTS

$H_o : a_i = 0$

$H_a : a_i \neq 0$ (Two tail test)

i. For $a_1' = -0,4587$: $S_{a_1} = 0,07130$

$\nu_2 = 375$

$$t \text{ statistic} = \frac{0,36267}{0,10674} = 3,39$$

Again t statistic > $t_{0,05;\ 375}$

iii. For $a_3' = -0,00004$: $S_{a_3} = 0,00002$

$\nu_2 = 375$

$$t \text{ statistic} = \frac{0,00004}{0,00002} = 2,0$$

Again t statistic > $t_{0,05;\ 375}$

Thus for all the partial regression coefficients the null hypothesis can be rejected and these coefficients can all be regarded as significantly different from zero at the 1% level of significance.

Thus the person level equation also satisfies the criterion specified in section 5.4.

ZONAL LEVEL

BMD02R - STEPWISE REGRESSION - VERSION OF MAY 2, 1966
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE	RTCCBD
NUMBER OF CASES	31
NUMBER OF ORIGINAL VARIABLES	11
NUMBER OF VARIABLES ADDED	9
TOTAL NUMBER OF VARIABLES	20
NUMBER OF SUB-PROBLEMS	6

THE INPUT VARIABLE FORMAT IS (8F6.2,F8.2,2F5.2)

VARIABLE		MEAN	STANDARD DEVIATION
PCTTRN	1	44.65096	25.19649
DISTHW	2	11.56677	4.70599
PCTFEM	3	29.87064	25.86716
TRNLOS	4	55.67742	15.62132
TTIMES	5	44.74194	15.78811
CTIMES	6	25.60645	7.70463
TCOSTS	7	14.20645	3.79218
CCOSTS	8	81.00967	30.51738
EINDEX	9	2130.07764	741.06879
FNSIZE	10	2.68935	.87346
PERNCO	11	12.01645	14.91542
TIMEDF	12	18.93548	12.52181
TIMERO	13	1.76220	.46094
LOGTDF	14	1.18017	.30598
COSTDF	15	66.80322	26.80714
COSTRO	16	5.56026	.67837
LOGCDF	17	1.79178	.17387
ROOTFS	18	1.62001	.25899
NEWECI	19	3376.81671	1005.61276
NEWLOS	20	669.39285	442.87694

COVARIANCE MATRIX

VARIABLE NUMBER	1	2	3	4	5	6	7	8	9	10
1	634,863	23,158	360,321	217,163	-118,585	10,897	16,740	159,236	-2077,201	-12,562
2		22,146	-13,376	25,198	53,549	31,105	17,659	141,894	-846,121	1,357
3			669,110	176,473	-216,521	-43,113	-13,389	-47,216	-5423,179	-13,350
4				244,026	-69,686	31,235	17,632	163,612	-3170,479	-5,078
5					249,264	75,915	44,752	337,138	1099,763	8,278
6						59,361	25,425	204,465	-1038,451	2,146
7							14,381	113,534	-560,026	1,123
8								931,311	-5507,008	8,107
9									*********	-241,012
10										,763

VARIABLE NUMBER	11	12	13	14	15	16	17	18	19	20
1	211,551	-129,482	-4,710	-2,588	142,495	3,209	,695	-3,434	-9394,865	4251,167
2	12,237	22,443	,105	,565	124,235	2,668	,782	,429	-525,021	1795,859
3	212,871	-173,409	-5,244	-3,911	-33,827	-,290	-,644	-4,067	*********	1367,975
4	75,515	-100,922	-4,257	-2,209	145,979	2,522	,605	-1,346	-6915,936	5122,993
5	-53,214	173,349	4,492	4,015	292,386	6,440	2,072	2,383	5518,057	2484,608
6	6,936	16,554	-,759	,399	179,041	4,172	1,192	,686	-378,214	2584,505
7	8,015	19,327	,115	,483	-99,154	2,085	,635	-,347	-265,249	1396,512
8	99,858	132,673	,274	3,363	817,776	18,462	5,145	2,571	-3657,584	11682,603
9	-4757,229	2138,214	-105,186	44,579	-4946,982	-120,787	-24,734	-76,401	*********	*********
10	-2,228	6,133	,166	,138	6,964	,154	,053	,224	96,680	13,237
11	222,470	-60,152	-2,307	-1,180	91,843	2,828	,425	-,485	-7808,775	1562,529
12		156,796	5,251	3,616	113,346	2,268	,880	1,697	5896,271	-99,896
13			,212	,125	,159	-,003	,005	,044	226,859	-56,984
14				,094	2,880	,055	,021	,039	133,603	5,662
15					718,622	16,377	4,509	2,224	-3392,335	10286,091
16						,460	,108	,051	-73,711	215,171
17							,030	,017	-7,684	-59,440
18								,067	25,638	8,221
19									*********	*********
20										*********

SUB-PROBLEM 4
DEPENDENT VARIABLE 1
MAXIMUM NUMBER OF STEPS 40
F-LEVEL FOR INCLUSION 2.500000
F-LEVEL FOR DELETION 2.500000
TOLERANCE LEVEL .001000

STEP NUMBER 1
VARIABLE ENTERED 10

MULTIPLE R .5708
STD. ERROR OF EST. 21.0421

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
REGRESSION	1	6205.625	6205.625	14.016
RESIDUAL	29	12840.274	442.768	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	38.93416)		
FSIZE 10	-16.46611	4.39831	14.0155

VARIABLES NOT IN EQUATION

VARIABLE		PARTIAL CORR.	TOLERANCE	F TO ENTER
DISTHA	2	.49523	.8909	9.0986
PCTFEM	3	.32543	.6509	3.3165
TRNLOS	4	.44523	.8615	6.9228
TTIMES	5	.06787	.6396	.1296
CTIMES	6	.30601	.8983	2.8929
TCOSTS	7	.47736	.8850	8.2637
CCOSTS	8	.48670	.9075	8.6911
EINDEX	9	-.42488	.8614	6.1683
PERNCO	11	.57515	.9707	13.8406
TINEDF	12	-.13287	.6856	.5032
TINERO	13	-.22678	.8290	1.5181
LOGTDF	14	-.05974	.7353	.1003
COSTDF	15	.48642	.9110	8.6783
COSTRO	16	.42361	.9327	6.1233
LOGCDF	17	.46398	.8790	7.6815
ROOTFS	18	.38145	.0163	4.7678
NEWECI	19	-.37735	.9879	4.6490
NEWLOS	20	.48805	.9988	8.7549

STEP NUMBER 2
VARIABLE ENTERED 11

MULTIPLE R .7403
STD. ERROR OF EST. 17.5181

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
REGRESSION	2	10453.115	5226.557	17.031
RESIDUAL	28	8592.784	306.885	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	72.84496)		
FMSIZE 10	-14.10136	3.71649	14.3965
PERNCO 11	.80969	.21764	13.0407

VARIABLES NOT IN EQUATION

VARIABLE		PARTIAL CORR.	TOLERANCE	F TO ENTER
DISTHW	2	.44480	.8361	6.6595
PCTFEM	3	-.00127	.4414	.0000
TRNLOS	4	.35888	.7916	3.9916
TTIMES	5	.19540	.6240	1.0716
CTIMES	6	.28978	.8847	2.4751
TCOSTS	7	.44246	.8440	6.5724
CCOSTS	8	.40913	.8316	5.4280
EINDEX	9	-.16580	.6099	.7632
TIMEDF	12	.03381	.6329	.0309
TIMERO	13	-.07291	.7568	.1443
LOSTDF	14	.07044	.7053	.1346
COSTDF	15	.40313	.8299	5.2393
COSTRO	16	.29623	.8246	2.5973
LOGCDF	17	.40923	.8275	5.4313
ROOTFS	18	.23427	.0142	1.5679
NEWECI	19	-.11764	.7285	.3789
NEWLOS	20	.43698	.9383	6.3726

STEP NUMBER 3
VARIABLE ENTERED 2

MULTIPLE R .7988
STD. ERROR OF EST. 15.9776

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
REGRESSION	3	12153.197	4051.066	15.869
RESIDUAL	27	6892.702	255.285	

VARIABLES IN EQUATION				VARIABLES NOT IN EQUATION			
VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE	VARIABLE	PARTIAL CORR.	TOLERANCE	F TO ENTER
(CONSTANT	63.58861)						
DISTHW 2	1.74946	.67793	6.6595	PCTFEM 3	.01656	.4408	.0071
FMSIZE 10	-17.59745	3.65037	23.2394	TRNLOS 4	.17767	.5967	.8475
PERNCO 11	.67844	.20491	10.9620	TTIMES 5	-.24991	.2598	1.7320
				CTIMES 6	-.17725	.2556	.8433
				TCOSTS 7	.02124	.0199	.0117
				CCOSTS 8	-.20837	.0214	1.1801
				EINDEX 9	-.18360	.6099	.9070
				TIMEDF 12	-.14113	.5585	.5284
				TIMERO 13	-.06576	.7560	.1129
				LOGTDF 14	-.09739	.6225	.2490
				COSTDF 15	-.21563	.0265	1.2678
				COSTRO 16	-.12261	.2828	.3968
				LOGCDF 17	-.04042	.0864	.0425
				ROOTFS 18	.19836	.0140	1.0650
				NEWECI 19	-.11362	.7276	.3400
				NEWLOS 20	.09731	.1867	.2485

F-LEVEL OR TOLERANCE INSUFFICIENT FOR FURTHER COMPUTATION

PERSONAL LEVEL

BMD02R - STEPWISE REGRESSION - VERSION OF NOVEMBER 12, 1964
HEALTH SCIENCES COMPUTING FACILITY, UCLA

PROBLEM CODE	RTCCBD
NUMBER OF CASES	379
NUMBER OF ORIGINAL VARIABLES	11
NUMBER OF VARIABLES ADDED	9
TOTAL NUMBER OF VARIABLES	20
NUMBER OF SUB-PROBLEMS	6

VARIABLE		MEAN	STANDARD DEVIATION
PCTTRN	1	.51979	.50027
DISTHW	2	10.92347	5.33524
PCTFEM	3	.32718	.46980
TPNLOS	4	61.28232	14.81604
TTIMES	5	38.86016	14.75313
CTIMES	6	25.30607	9.58290
TCOSTS	7	13.45302	4.28790
CCOSTS	8	81.75403	38.95242
EINDEX	9	2042.12810	973.23623
FNSIZE	10	2.44063	1.28217
PCPNCO	11	.85224	.35533
TIMEDF	12	13.55409	9.16250
TIMERO	13	1.58127	.38408
LOGTDF	14	1.03918	.28499
COSTDF	15	60.30101	35.23852
COSTRO	16	5.90495	1.64064
LOGCDF	17	1.77857	.22181
ROOTFS	18	1.50761	.41009
NEWECI	19	2981.40710	1413.48050
NEWLOS	20	708.05282	526.10425

COVARIANCE MATRIX

VARIABLE NUMBER	1	2	3	4	5	6	7	8	9	10
1	.250	.112	.049	.676	-.213	.158	.105	2.647	-89.592	-.044
2		28.465	-.249	38.739	67.717	46.095	22.727	182.906	-500.488	1.163
3			.221	.606	-1.422	-.471	-.192	-2.096	-138.511	-.264
4				219.515	20.368	41.810	30.411	243.402	-1576.035	-1.114
5					217.655	112.768	54.623	442.073	21.956	4.265
6						91.832	37.200	300.188	-975.979	2.121
7							18.382	146.957	-393.395	.881
8								1517.291	-3189.721	6.406
9									*********	-353.004
10										1.644

VARIABLE NUMBER	11	12	13	14	15	16	17	18	19	20
1	-.063	-.371	-.020	-.013	2.542	.165	.016	-.017	-163.162	11.169
2	.020	21.622	-.142	.725	160.179	2.892	.971	.365	-166.986	2636.742
3	-.081	-.952	-.032	-.032	-1.904	-.079	-.014	-.090	-363.218	-14.949
4	-.191	-21.443	-1.933	-.227	212.992	1.916	.911	-.403	-3394.331	5714.293
5	.350	104.887	1.719	3.144	387.450	7.912	2.504	1.358	2447.229	5344.579
6	.048	20.936	-1.159	.668	262.989	5.205	1.686	.686	-368.097	4055.679
7	.012	17.423	-.128	.585	128.575	2.322	.789	.276	-152.660	2085.799
8	.738	141.884	-.813	4.742	1370.334	46.108	8.330	1.939	-1796.651	16940.664
9	91.603	997.936	64.127	31.777	-2796.328	-51.605	-14.876	-97.594	*********	*********
10	.105	2.144	.046	.067	5.525	.080	.039	.522	345.310	74.567
11	.126	.302	.012	.009	.726	.054	.005	.035	178.762	2.516
12		83.951	2.878	2.476	124.461	2.707	.818	.672	2815.326	1288.899
13			.148	.087	-.685	.007	-.004	.014	129.384	-34.150
14				.081	4.157	.084	.026	.021	87.587	51.281
15					1241.758	43.786	7.541	1.664	-1643.992	14854.864
16						2.692	.284	.022	-35.546	247.116
17							.049	.012	-1.783	83.859
18								.168	137.559	22.729
19									*********	*********
20										*********

SUB-PROBLM 1
DEPENDENT VARIABLE 1
MAXIMUM NUMBER OF STEPS 40
F-LEVEL FOR INCLUSION 2.500000
F-LEVEL FOR DELETION 2.500000
TOLERANCE LEVEL .000000

STEP NUMBER 1
VARIABLE ENTERED 19

MULTIPLE R .2307
STD. ERROR OF EST. .4874

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
REGRESSION	1	5.037	5.037	21.201
RESIDUAL	377	89.565	.238	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	.76327 1		
NEWECI 19	-.00008	.00002	21.2009

VARIABLES NOT IN EQUATION

VARIABLE		PARTIAL CORR.	TOLERANCE	F TO ENTER
DISTHW	2	.03802	.9995	.5444
PCTEEM	3	.10134	.7008	3.9017
TRNLOS	4	.05598	.9737	1.1822
TTIMES	5	-.00182	.9862	.0012
CTIMES	6	.02743	.9993	.2830
TCOSTS	7	.04418	.9994	.7352
CCOSTS	8	.13192	.9989	6.6589
EINDEX	9	.03331	.2484	.4177
FMSIZE	10	-.02653	.9637	.2649
PERNCO	11	-.30072	.8733	37.3831
TIMEDF	12	-.03236	.9527	.3941
TIMERO	13	-.05097	.9432	.9793
LOGTDF	14	-.04086	.9527	.6287
COSTDF	15	.14044	.9989	7.5656
COSTRO	16	.20288	.9998	16.1398
LOGCDF	17	.14235	1.0000	7.7769
ROOTFS	18	-.02861	.9437	.3081
NEWLOS	20	.03143	.9973	.3717

STEP NUMBER 2
VARIABLE ENTERED 17

MULTIPLE R .2631
STD. ERROR OF EST. .4831

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
REGRESSION	2	6.852	3.426	14.679
RESIDUAL	376	87.750	.233	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	.20692)		
LOGCDF 17	.31240	.11202	7.7769
NEWECI 19	-.00008	.00002	21.4342

VARIABLES NOT IN EQUATION

VARIABLE		PARTIAL CORR.	TOLERANCE	F TO ENTER
DISTIW	2	-.13912	.3269	7.4010
PCTFEM	3	.12767	.6820	6.2134
TRNLOS	4	.01698	.8974	.1082
TTIMES	5	-.17712	.3997	12.1450
CTIMES	6	-.14189	.3704	7.7048
TCOSTS	7	-.13390	.3112	6.8458
CCOSTS	8	-.02053	.0698	.1582
EINDEX	9	.05254	.2443	1.0379
FMSIZE	10	-.04759	.9445	.8514
PERNCO	11	-.31519	.8686	41.3635
TIMEDF	12	-.10125	.7897	3.8844
TIMERO	13	-.04553	.9416	.7790
LOGTDF	14	-.11349	.7793	4.8930
COSTDF	15	.01181	.0685	.0523
COSTRO	16	.14830	.3908	8.4329
ROOTFS	18	-.04943	.9254	.9185
NEWLOS	20	-.10320	.4813	4.0368

STEP NUMBER 3
VARIABLE ENTERED 11

MULTIPLE R .4057
STD. ERROR OF EST. .4591

ANALYSIS OF VARIANCE

	DF	SUM OF SQUARES	MEAN SQUARE	F RATIO
REGRESSION	3	15.569	5.190	24.625
RESIDUAL	375	79.032	.211	

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	.38576)		
PERNCO 11	-.45857	.07130	41.3635
LOGCDF 17	.36267	.10674	11.5439
NEWECI 19	-.00004	.00002	5.0806

VARIABLES NOT IN EQUATION

VARIABLE	PARTIAL CORR.	TOLERANCE	F TO ENTER
DISTHW 2	-.17066	.3253	11.2188
PCTEEM 3	.01375	.5904	.0707
TRNLOS 4	.01884	.8974	.1328
TTIMES 5	-.20234	.3988	15.9656
CTIMES 6	-.16761	.3693	10.8107
TCOSTS 7	-.16705	.3093	10.7357
CCOSTS 8	-.02305	.0698	.1988
EINDEX 9	.02699	.2425	.2726
FMSIZE 10	.00607	.9175	.0138
TIMEDF 12	-.11165	.7895	4.7213
TIMERO 13	-.04574	.9415	.7840
LOGTDF 14	-.12551	.7790	5.9862
COSTDF 15	.01747	.0685	.1142
COSTRO 16	.18226	.3885	12.8506
ROOTFS 18	.00114	.9016	.0005
NEWLOS 20	-.11769	.4810	5.2532

APPENDIX 6.1

ELASTICITY OF DEMAND

The quantity of a good demanded is a function of the price of that good. The change in price of a good will therefore result in a corresponding change in the demand for it. This relationship between change in price and change in quantity demanded is known as the price elasticity of demand.

There are three measures of the elasticity of demand. The point elasticity (η_{pt}) assumes a knowledge of the shape of the demand curve. For a change in price (p) the point elasticity of demand (η_{pt}) at the point (p_1 q_1) *ceteris paribus*, is given by the equation below.

$$\eta_{pt} = \left(\frac{\partial q}{\partial p}\right)_{p_1} \cdot \frac{p}{q_1} \qquad (6.1.1)$$

where q is the quantity demanded.

The arc elasticity (η_{arc}) is calculated from two points on the damand curve (e.g. the quantity demanded before and after a price increase) and is defined as:

$$\eta_{arc} = \frac{\log q_1 - \log q_2}{\log p_1 - \log p_2} = \frac{\Delta \log q}{\Delta \log p} \qquad (6.1.2)$$

Finally, the shrinkage ratio or loss ratio (LR) is the most common form in use in transportation problems. It involves relating the changes in price (p) and quantity (q) to the values before the change (p_1, q_1). The loss ratio is defined as

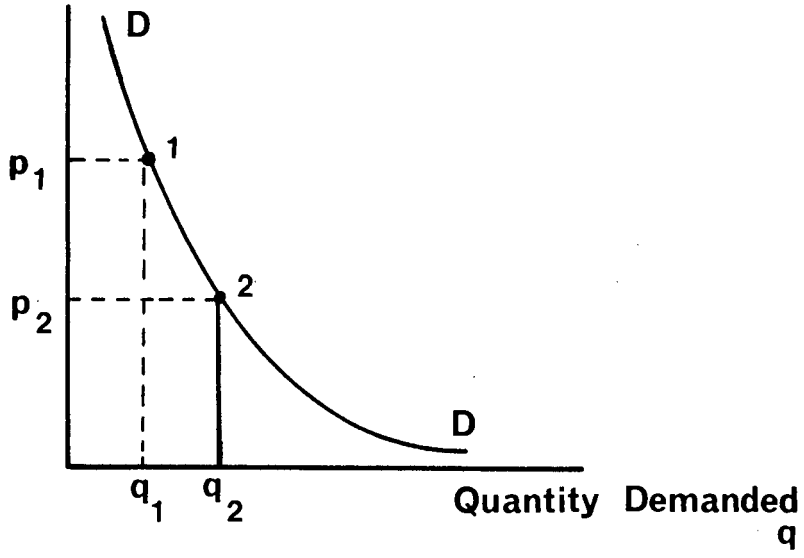
$$LR = \frac{\Delta q}{\Delta p} \cdot \frac{p_1}{q_1} \qquad (6.1.3)$$

These three definitions are illustrated in figs. A.6.1.1.

A Graphical Representation of Elasticity of Demand

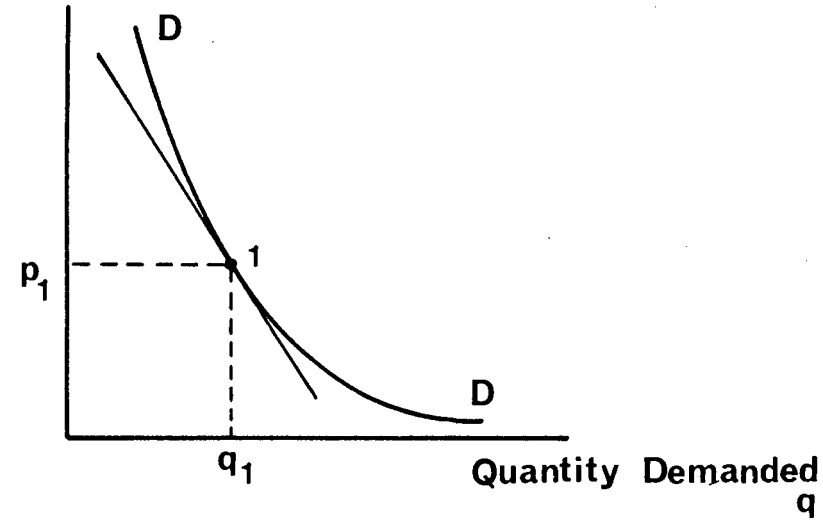
(1) Arc Elasticity

$$\eta^{D}_{arc} = \frac{\log q_1 - \log q_2}{\log p_1 - \log p_2}$$



(2) Point Elasticity

$$\eta^{D}_{pt} = \left(\frac{\partial q}{\partial p}\right)_{p_1} \cdot \frac{p_1}{q_1}$$



(3) Loss Ratio

$$LR = \left(\frac{q_1 - q_2}{p_1 - p_2}\right) \cdot \frac{p_1}{q_1}$$

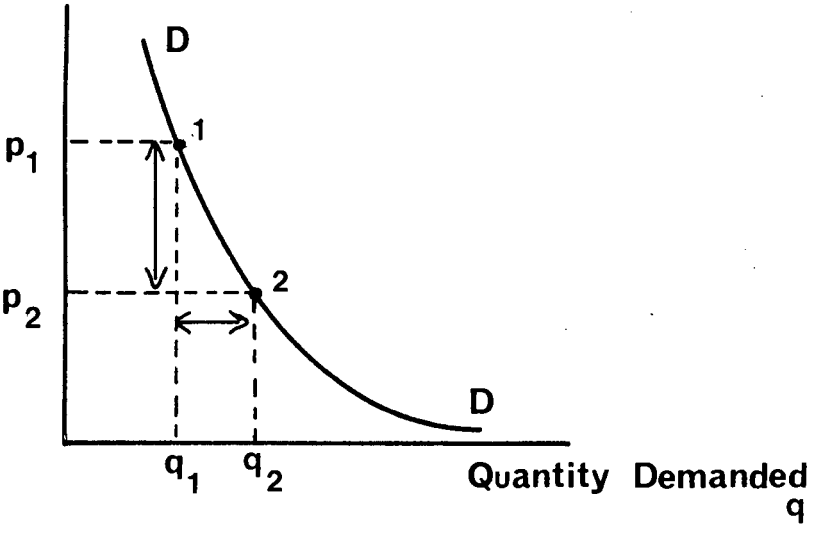


Fig.A 6.1.1 Elasticity of Demand