MONASH
University

Public Transport Planning
New Zealand Transport Agency
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Demand Forecasting (Short)

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PTRG PUBLIC TRANSPORT RESEARCH GROUP

GROUP OF EIGHT AUSTRALIA

MONASH INSTITUTE OF TRANSPORT STUDIES

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Introduction

Overview

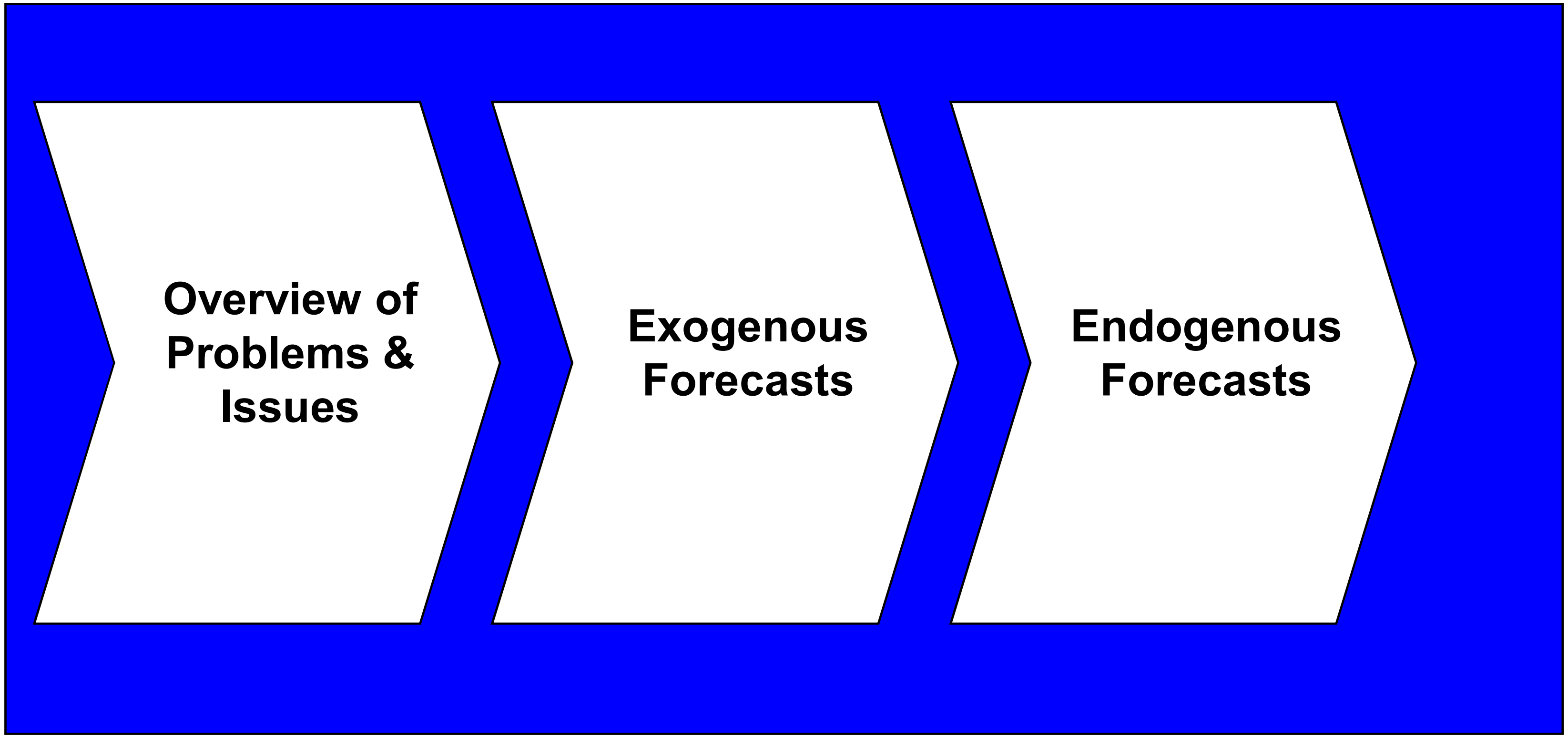
Exogenous Forecasting

Endogenous Forecasting

This session aims to provide tools to undertake PT demand forecasting at an individual route level

- Emphasis is on readily to use ‘raw’ approaches rather than rocket science
- However we will refer to some of the more complex approaches
- Selected references are included in this documentation plus a list of references for wider reading if desired
- Emphasis on :
  - endogenous (things we change) forecasting rather than
  - exogenous (socio-economic changes affecting the market)

…and is structured as follows



Overview of Problems & Issues

Exogenous Forecasts

Endogenous Forecasts

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Introduction

Overview

Exogenous Forecasting

Endogenous Forecasting

Demand forecasting is an inexact art – particularly in public transport

- Sydney airport railway – revenue and demand substantially below forecast - consortium running the railway went bankrupt

- Brisbane airport railway – revenue and demand substantially below forecast – operator is struggling

It has a poor image within industry and also the community

However the process in outline is really quite simple

<u>Existing Situation</u>
(Base Case)
Where you start from

<u>Future Situation</u>
(Project Case)
Where you might be heading

1. Understand Base Case

2. Understand Project Case

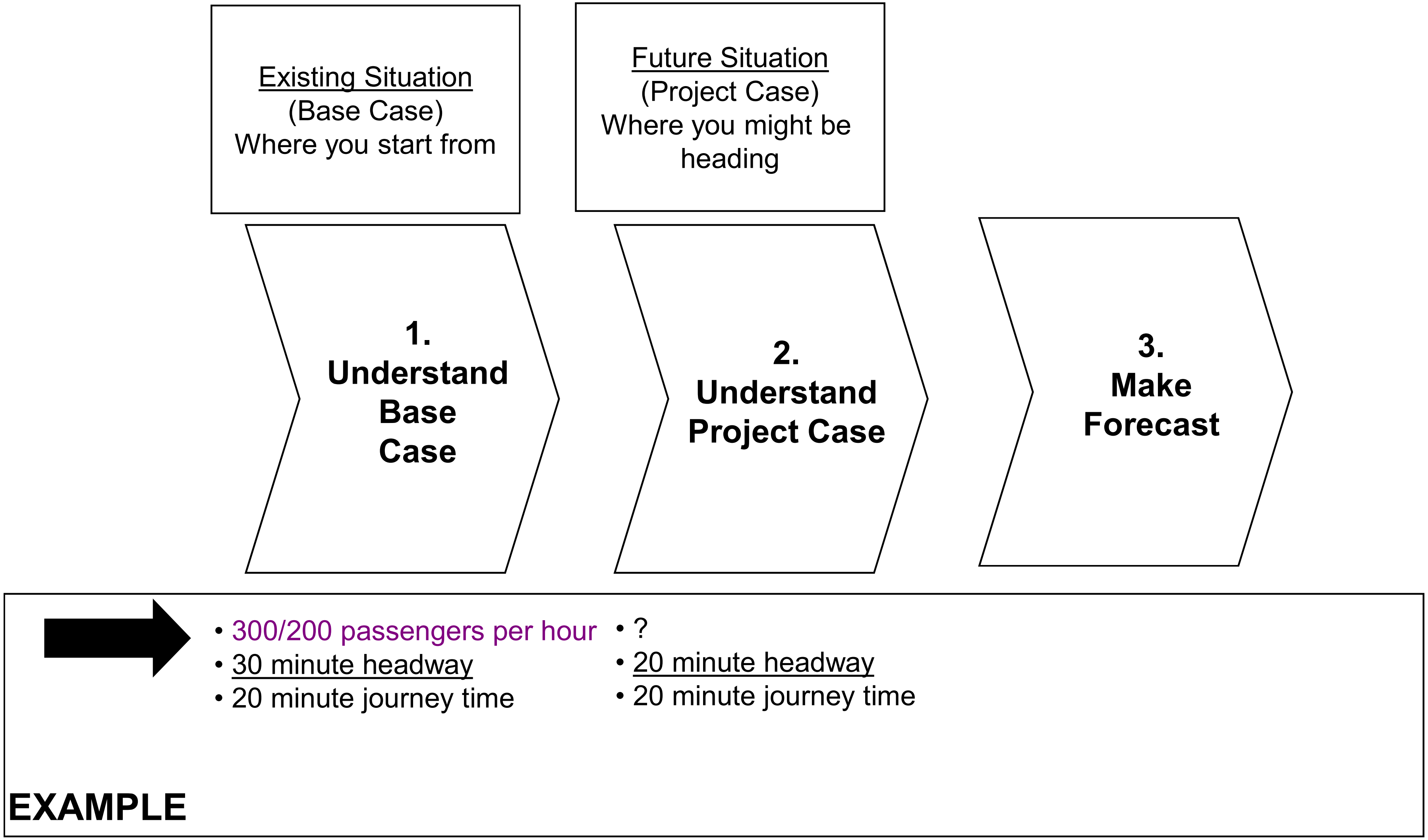
3. Make Forecast

- 300 passengers per hour
- <u>30 minute headway</u>
- 20 minute journey time

- ?
- <u>20 minute headway</u>
- 20 minute journey time

EXAMPLE

If we make a mistake then the forecast will be wrong



Existing Situation
(Base Case)
Where you start from

Future Situation
(Project Case)
Where you might be heading

1. Understand Base Case

2. Understand Project Case

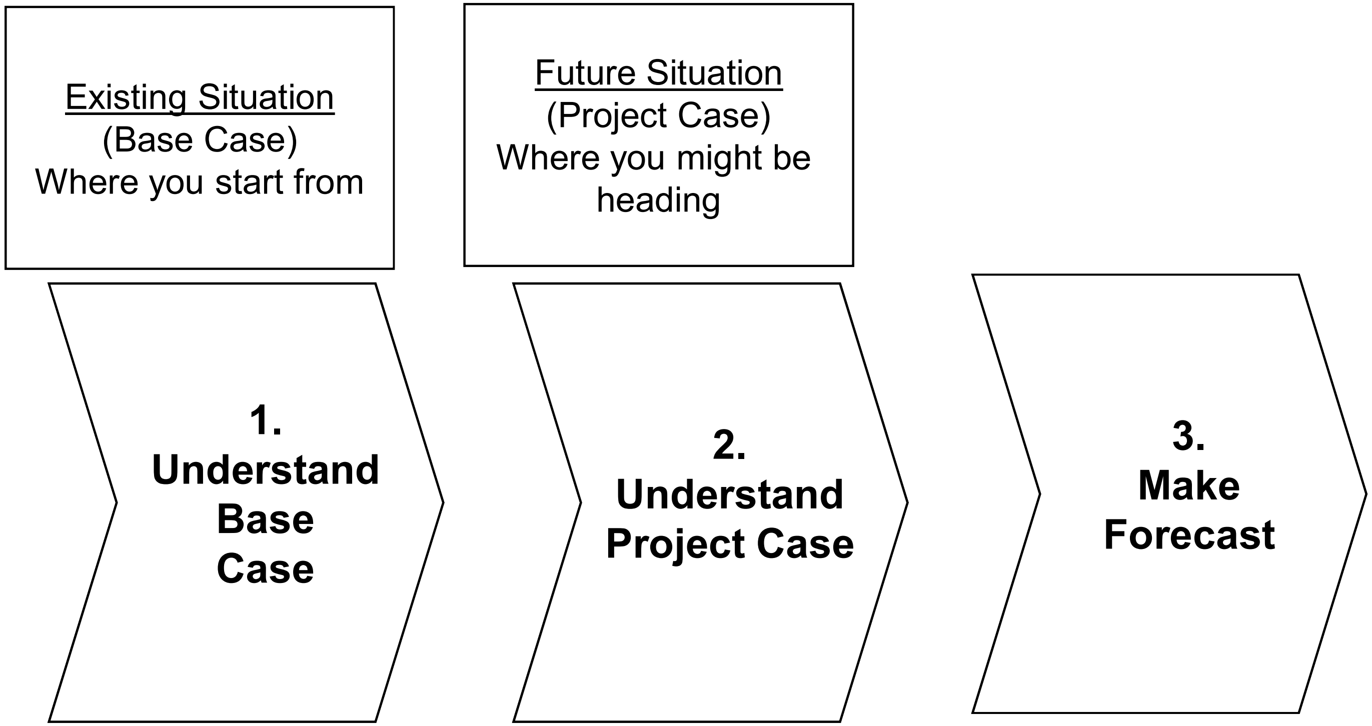
3. Make Forecast

- 300/200 passengers per hour
- 30 minute headway
- 20 minute journey time

- ?
- 20 minute headway
- 20 minute journey time

EXAMPLE

If we make an omission then the forecast will be wrong



<u>Existing Situation</u>
(Base Case)
Where you start from

<u>Future Situation</u>
(Project Case)
Where you might be heading

1. Understand Base Case

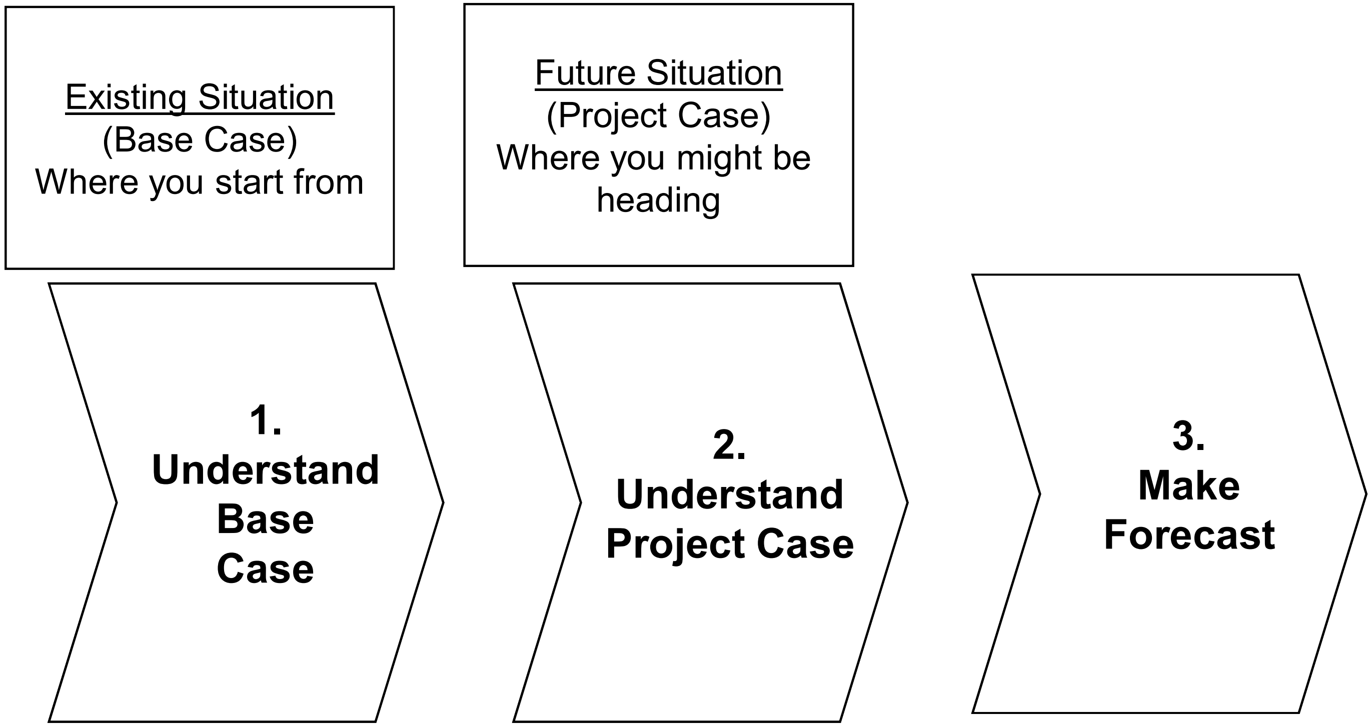
2. Understand Project Case

3. Make Forecast

EXAMPLE

• 300 passengers per hour	• ?
• <u>30 minute headway</u>	• <u>20 minute headway</u>
• 20 minute journey time	• 20 minute journey time
• No parrallel freeway	• New parallel freeway built

Forecasts are made in relation to an understanding of existing markets (demand) and how supply to those markets will change



Existing Situation
(Base Case)
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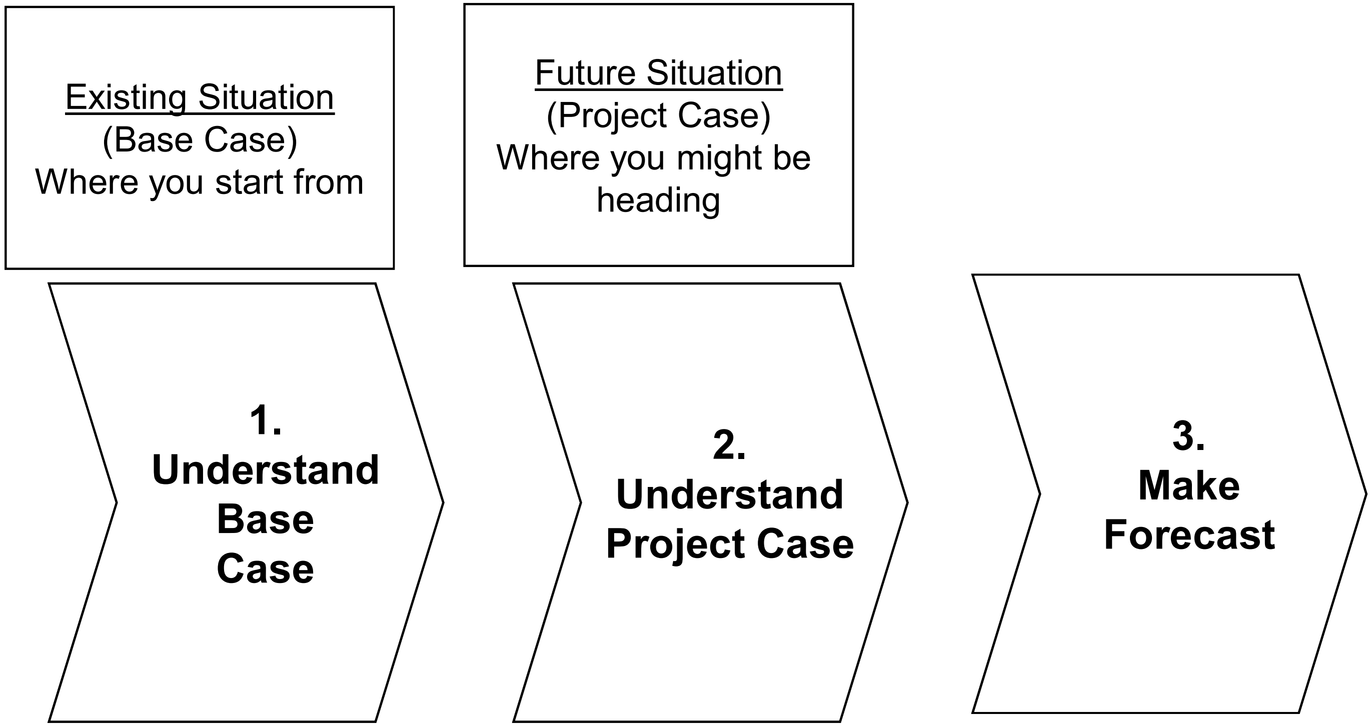
	Existing Situation	Future Situation
Demand	300 passengers per hour	?
Supply	30 minute headway 20 minute journey time	20 minute headway 20 minute journey time

EXAMPLE

Now I would like you to make a forecast based on the information below



Existing Situation
(Base Case)
Where you start from

Future Situation
(Project Case)
Where you might be heading

1. Understand Base Case

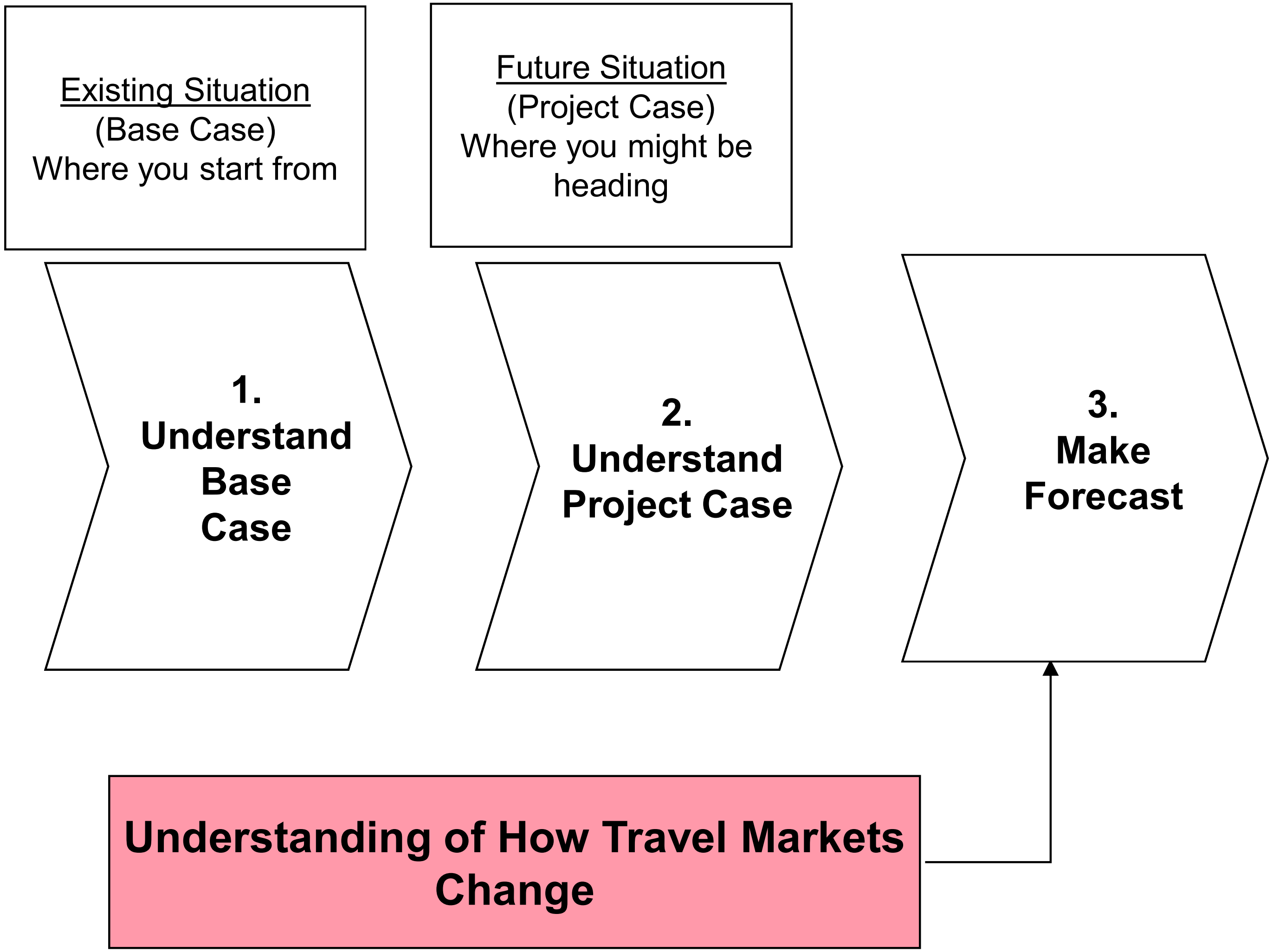
2. Understand Project Case

3. Make Forecast

Demand	300 passengers per hour	?
Supply	30 minute headway	20 minute headway
	20 minute journey time	20 minute journey time

EXAMPLE

In making forecasts it is useful to understand how and why travel markets change



Existing Situation
(Base Case)
Where you start from

Future Situation
(Project Case)
Where you might be heading

1. Understand Base Case

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Understanding of How Travel Markets Change

Where does the demand come from when a new public transport service is introduced

Travel Behaviour Change Affecting Public Transport

Source of Demand	Key Points

Where does the demand come from when a new public transport service is introduced

Travel Behaviour Change Affecting Public Transport

Source of Demand	Key Points
Generation (New Trips)	• New travel not currently made • E.g. entertainment travel (Off Peak) • Not Work Travel (Peak) • Includes induced demand
Diversion	• Existing Public Transport Users using new service rather than existing service • Needs to be spatially adjacent • Needs to be more attractive than existing
Mode Shift	• Stop using car and use bus (very important to differentiate car drivers from car pax) • Go from walking to using the tram
Redistribution	• People change where they live and work • Very long term affect

Example : The Transit Authority is introducing two extra tram trips per hour on a half hour service within the inner city – what share will the possible sources of demand have in the use of these services

Travel Behaviour Change Affecting Public Transport

Source of Demand	Key Points
Generation (New Trips)	• New travel not currently made • E.g. entertainment travel (Off Peak) • Not Work Travel (Peak) • Includes induced demand
Diversion	• Existing Public Transport Users using new service rather than existing service • Needs to be spatially adjacent • Needs to be more attractive than existing
Mode Shift	• Stop using car and use bus (very important to differentiate car drivers from car pax) • Go from walking to using the tram
Redistribution	• People change where they live and work • Very long term affect

Example : The Transit Authority is introducing a new cross corridor railway in the suburbs connecting two regional shopping centres – what share will the possible sources of demand have in the use of the service

Travel Behaviour Change Affecting Public Transport

Source of Demand	Key Points
Generation (New Trips)	• New travel not currently made • E.g. entertainment travel (Off Peak) • Not Work Travel (Peak) • Includes induced demand
Diversion	• Existing Public Transport Users using new service rather than existing service • Needs to be spatially adjacent • Needs to be more attractive than existing
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Redistribution	• People change where they live and work • Very long term affect

Actual Selected Evidence

Travel Behaviour Change Affecting Public Transport – Evidence

Source of Demand	Adelaide Transit Link Bus	Adelaide OBahn	LRT Manchester	Perth NS Rail	Rail Merseyside
Generation (New Trips)	8%	9%	15%	10%	24%
Diversion	78%	67%	75%	64%	56%
Mode Shift	13%	19%	10%	25%	20%
Redistribution	1%	0%	0%	1%	0%

Source: Anlezark, A., Crouch, B. and Currie, G.V. 'Trade Offs In The Redesign Of Public Transport Networks, Line Haul, Express And Transit Link Service Patterns' Australasian Transport Research Forum 1994

Introduction

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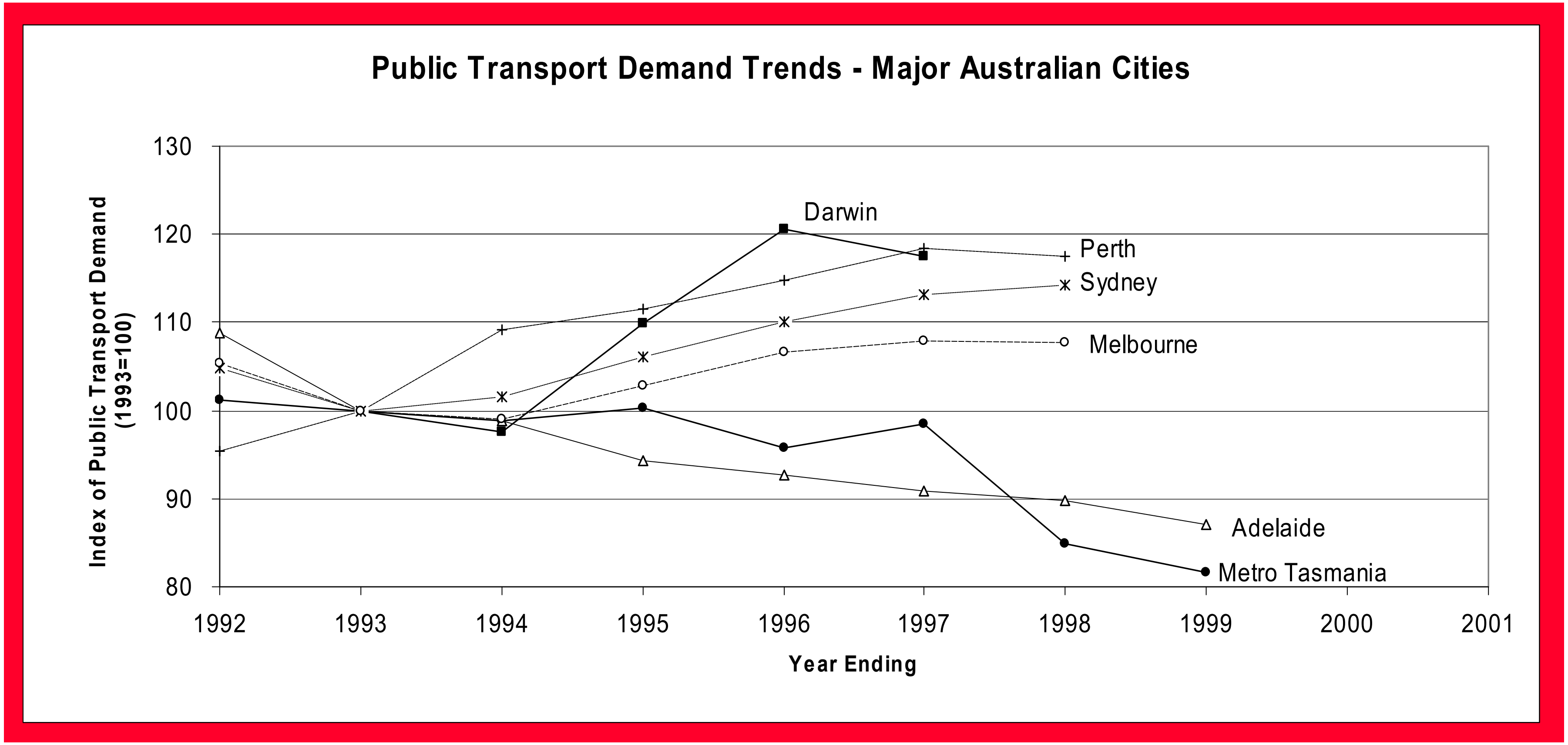
Exogenous Forecasting

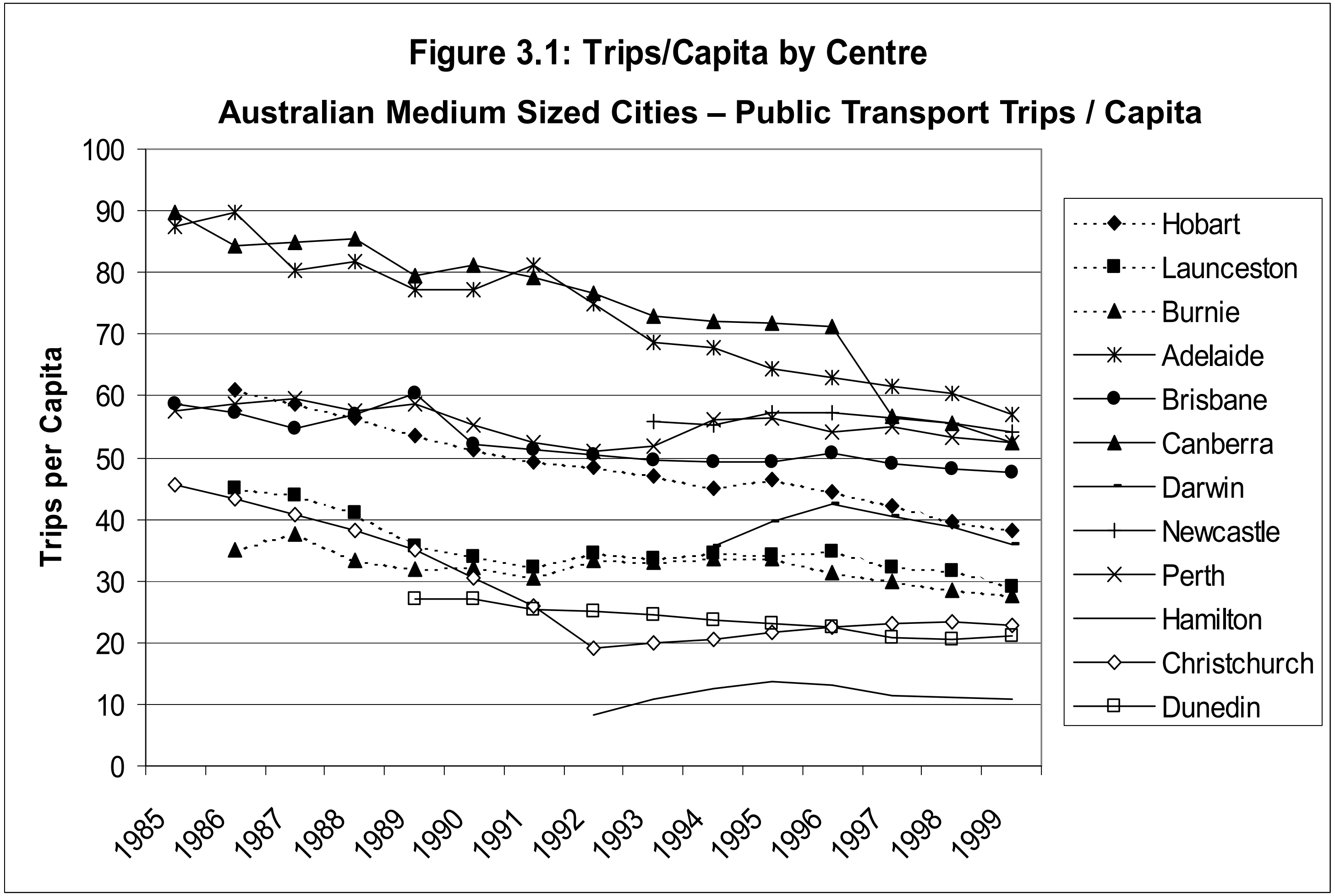
Endogenous Forecasting

Exogenous forecasting concentrates on understanding long term trends in markets and the wider influences which cause these trends



Note indexing of demand undertaken in this analysis (1993 = 100)

Population growth can obscure important trends – understanding trip rates on a per capita basis is a far more interesting way of examining exogenous demand trends



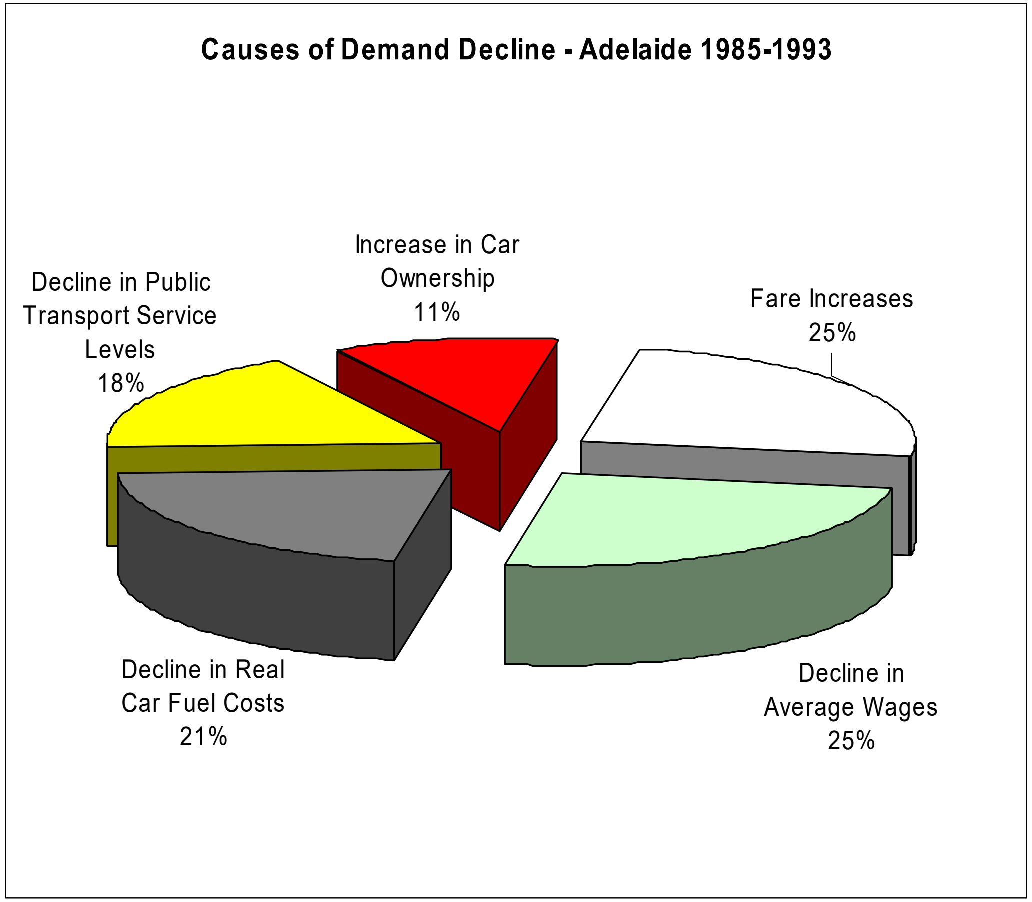
Note Adelaide demand decline

We enclose a paper by Willis (94) exploring the reasons for demand decline in Adelaide. Here are the key results.

An Example of Exogenous Demand Analysis – Explanation of Historical Trends

	Change in Variable 1985 - 1993	Quantified Elasticity of Demand	Explained Change in Demand Caused by Variable	% Total Demand Decline Explained
Fare Increases	27%	-0.25	-7%	25%
Decline in Average Wages	-7%	1.10	-7%	25%
Decline in Real Car Fuel Costs	-15%	0.44	-6%	21%
Decline in Public Transport Service Levels	-6%	0.81	-5%	18%
Increase in Car Ownership	1%	-2.94	-3%	11%
Increase in Unemplyment	14%	0.01	0%	0%
		Total	-28%	100%

Source : Based on an analysis of data and findings in Willis (99)



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We will cover 4 areas in relation to endogenous forecasting

BENCHMARKING

ELASTICITIES

GENERALISED COST MODELS

ADVANCED METHODS

BENCHMARKING

ELASTICITIES

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ADVANCED METHODS

The principle is remarkably simple

Existing Situation
(Base Case)
Where you start from

Future Situation
(Project Case)
Where you might be heading

1. Understand Base Case

- Establish Vkms operated
- Establish boardings output
- Calculate BVK

2. Understand Project Case

- Establish Proposed new Vkms to be operated

3. Make Forecast

- Apply BVK benchmark to make forecast

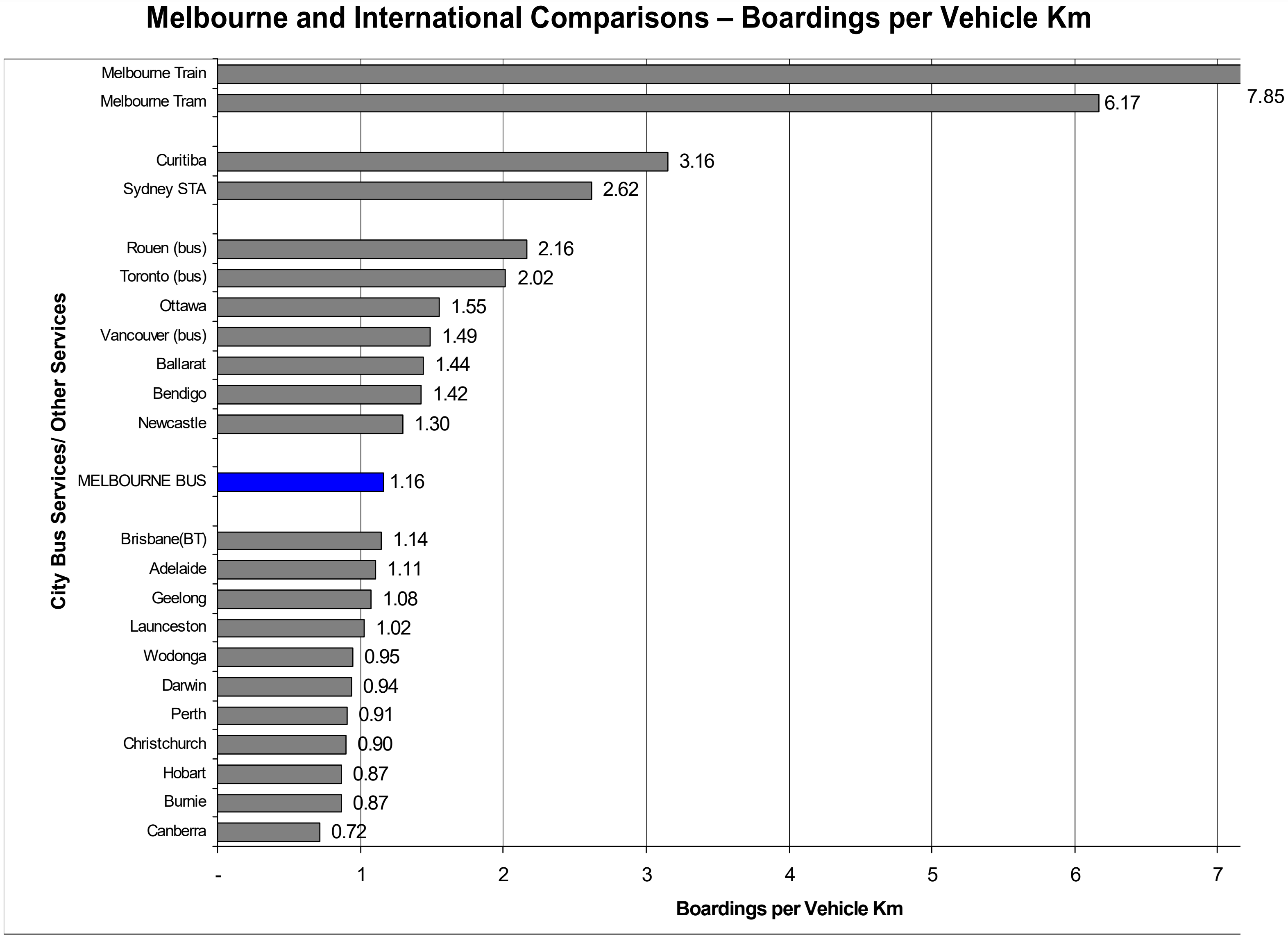
BVK,BPH or BPR measures are only applicable to service level changes – they are best applied to specific (or disaggregated) situations

- Does not forecast fare impacts or changes in travel time etc.
- It is a ‘service quantum’ measure
- The more specific (or disaggregated) you can make the forecast the better e.g. :
    - BVK for bus services in out areas
    - BVK on weekday nights
    - BVK for outer area services on Sundays

Their major weakness is that they are very ‘broad brush’. The specifics of some service change proposals can often affect demand

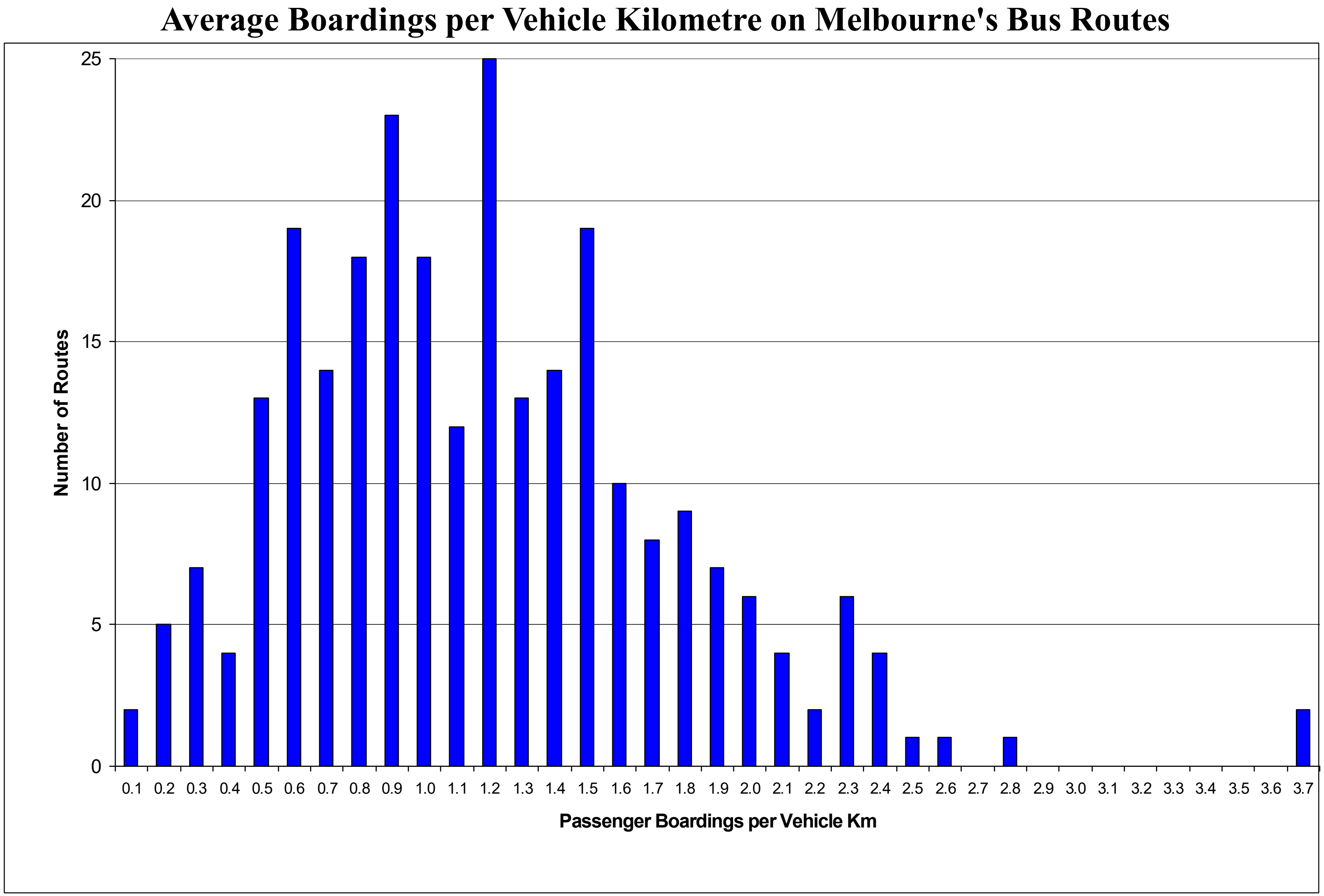
- A major assumption is that existing circumstances and usage on one service will be applicable to another service which is proposed
- In reality every tram bus and rail service is unique
- Nevertheless this is a very simple and powerful tool

Some BVK examples



Source: Melbourne Train and Tram (DoI Annual Report 2000-2001), Melbourne Bus – Route Demand and Supply Databases (2001), Interstate Data – Annual Reports 1998-99 Task B.2 (4) Best Practice Bus Cities
Note: Train kms uses set kms rather that total carriage kms such that the values are comparable with bus services

Some BVK examples



Average Boardings per Vehicle Kilometre on Melbourne's Bus Routes

Source : Route Demand and Supply Database

Endogenous Forecasting Agenda

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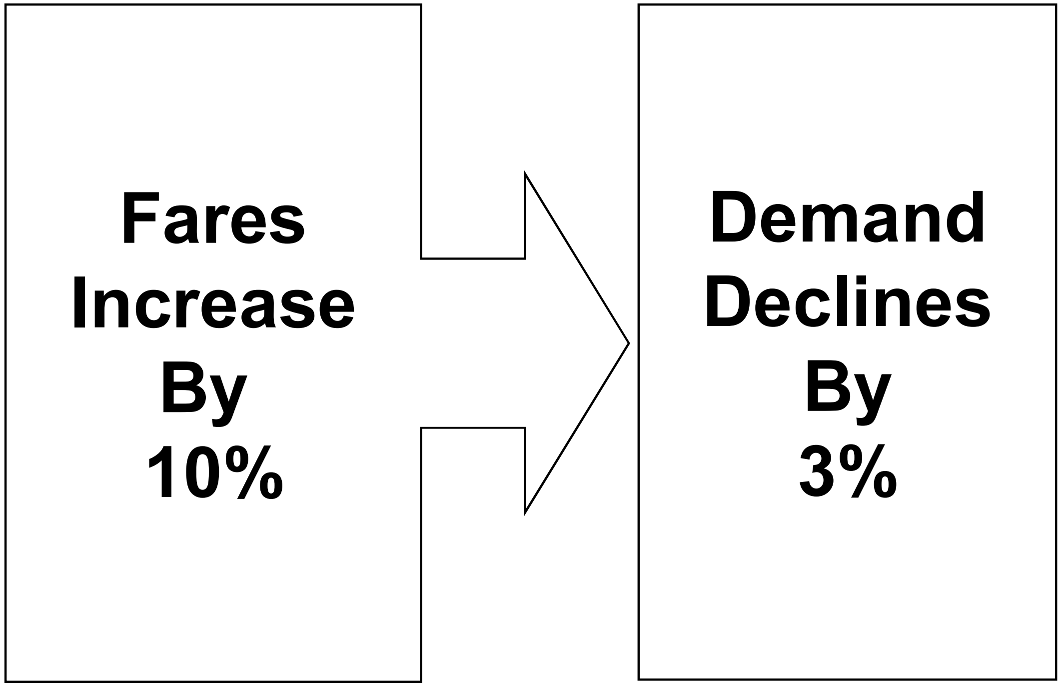
Elasticity is the response of demand resulting from a change in a factor causing that response



Fares Increase By 10%

Demand Declines By 3%

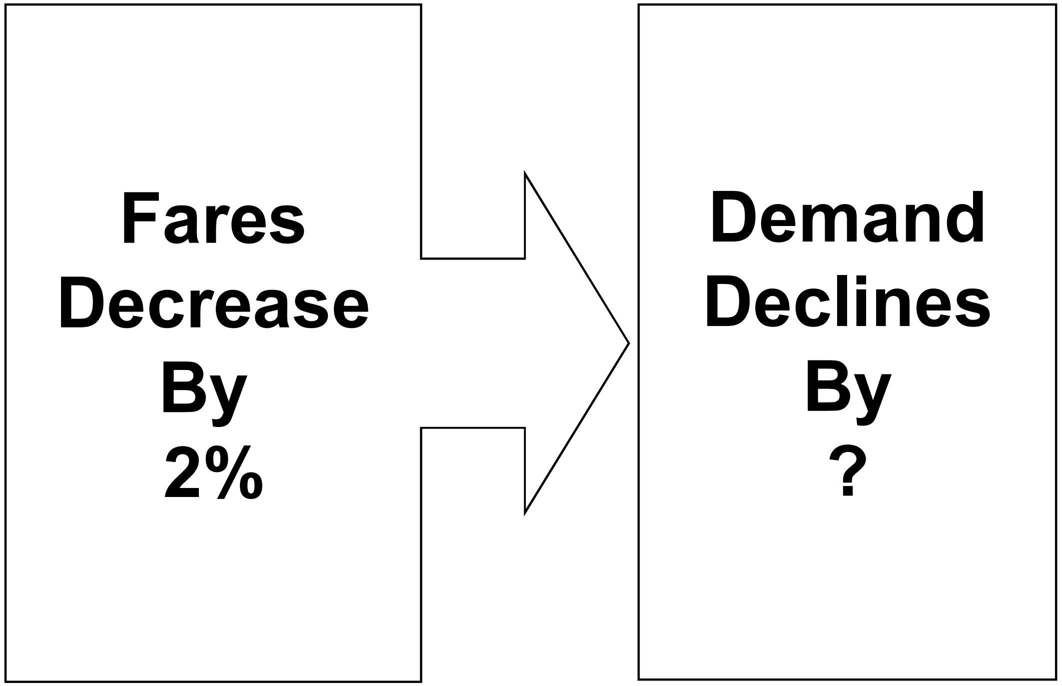
Simple Elasticity is:

$$E = \frac{\%\text{Change in Demand}}{\%\text{Change in Fares}}$$

$$E = \frac{-3\%}{+10\%}$$

$$E = -0.3$$

Its application for forecasting is also very simple



Fares Decrease By 2%

Demand Declines By ?

Simple Elasticity is:

%Change in Demand = E * %Change in Fares

%D = - 0.3 * -2%

%D = + 0.6%

The form of the elasticity value is important and says much about market responsiveness to demand

- A negative elasticity implies the inverse change in demand to change in the elasticity factor e.g. Fare elasticity of -0.3 means demand will increase if fares decrease
- An example of a positive elasticity would be one for public transport service level e.g. Elasticity to change in service levels = +0.4. This means an increase in the quantity of service provided would also increase demand i.e. in the same direction
- Low elasticity values mean demand wont change much for a given change in the factor being measured e.g. -0.02 means a 1% increase in demand for a 50% decline in the variable. This is termed *inelastic*
- High elasticity values mean demand is very responsive to changes in the variable e.g. Elasticity = +1.5. This means a 20% increase in the factor results in a 30% increase in demand. This is termed *elastic*
- Note that technically elasticities work in both directions and measure demand responsiveness equally in both directions

We enclose a full report on current passenger travel demand elasticity evidence from Transfund NZ (2003). This identifies important industry average values.

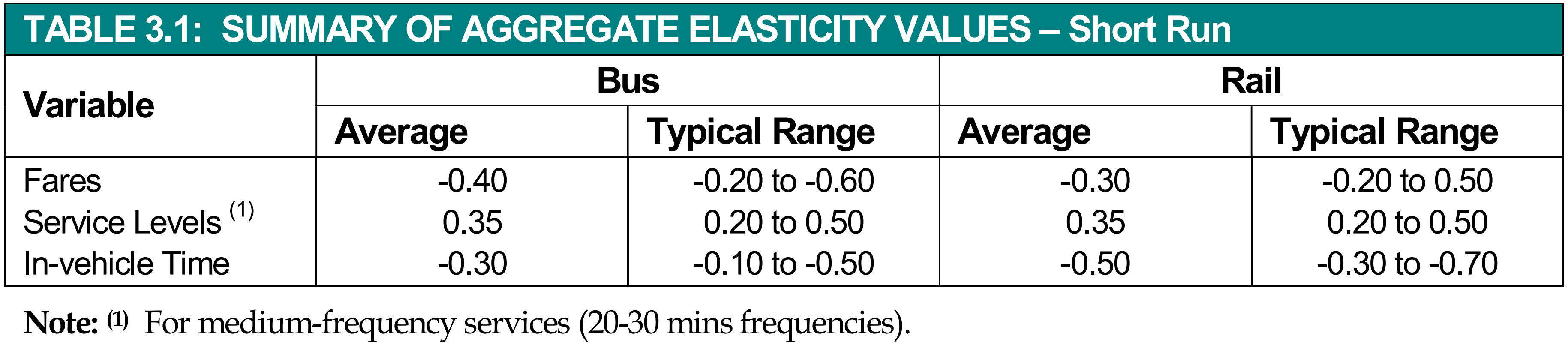


TABLE 3.1: SUMMARY OF AGGREGATE ELASTICITY VALUES – Short Run

Variable	Bus		Rail	
	Average	**Typical Range**	**Average**	**Typical Range**
Fares	-0.40	-0.20 to -0.60	-0.30	-0.20 to 0.50
Service Levels (1)	0.35	0.20 to 0.50	0.35	0.20 to 0.50
In-vehicle Time	-0.30	-0.10 to -0.50	-0.50	-0.30 to -0.70

Note: (1) For medium-frequency services (20-30 mins frequencies).

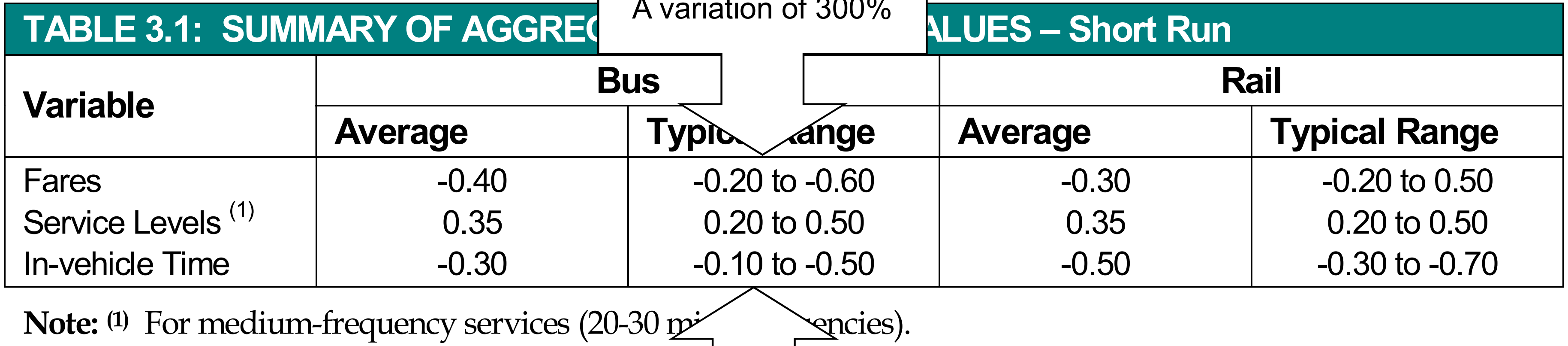
Source: Transfund NZ (1990)

Some simple working examples show how they may be applied

PROBLEM	**SOLUTION**
Proposal: Fares **are to be increased by 10%** **WHAT WILL HAPPEN TO REVENUE?**	**E = -0.3** **Change in Demand = E * Change in Fare** **%D = -0.3 * +10%** **%D = -3%**
Proposal: **Tram** Services Levels **are to be cut from 1.0M Vkms p.a. to 0.8M vkms p.a.**	**E = 0.35** **Change in Demand = E * Change in Service Level** **%D = 0.35 * -20%** **%D = -7%**
Proposal: **Bus** Running Times **are to increase as a result of traffic growth. It is expected that running time will, increase by 10%.**	**E = -0.30** **Change in Demand = E * Change in in-vehicle travel time** **%D = -0.30 * +10%** **%D = -3%**

An important issue with elasticities is that they can vary quite a lot according to the circumstances being considered

A 20% fare increase can reduce demand by between 4% and 12%. A variation of 300%



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Service Levels (1)	0.35	0.20 to 0.50	0.35	0.20 to 0.50
In-vehicle Time	-0.30	-0.10 to -0.50	-0.50	-0.30 to -0.70

Note: (1) For medium-frequency services (20-30 mi encies).

A 30% reduction in in-vehicle travel time can increase demand by Between 1% and 5%. A variation of 500%.

Source: Transfund NZ (1990)

Some important factors affect elasticities in various ways

Importance of Attribute to Journey

- If In Vehicle Travel is Long its elasticity value will increase
- If fares are (relatively) very high then their elasticity value will be larger

Strength of Competition

- If close substitutes to a given travel option are available elasticity values increase
- E.g. ‘captive’ travelers have low elasticity values
- E.g. If walking is an option rather than tram the elasticity value will be high

Opportunities for Trip Generation (or Suppression) and Trip Redistribution

- Providing services in new areas or areas with high levels of population growth or where new facilities are provided
- Elasticities will be higher

Passenger Characteristics

- Some groups are very price sensitive (low income) these groups will have higher elasticities
- Others will be busy people wanting to get from A to B quickly e.g. a businessman (high elasticities)

These are the rationale behind the variation in elasticities in the real world

TABLE 3.2: SUMMARY OF DISAGGREGATE ELASTICITY EVIDENCE

Aspect	Fares	Service Levels (1)	In-vehicle Time
Time horizon	Long run typically double (range 1.5 to 3.0) short run.	Long run typically about double short run.	Very limited evidence: indicates long run 1.5 to 2.0 times short run.
Trip purpose/time period	Off-peak/non-work typically twice peak/work; weekend most elastic.	Off-peak/non-work typically c. twice peak/work; weekend most elastic (may be partly frequency differences).	Inconclusive re relative elasticities; although most evidence is that off-peak is more elastic than peak.
Trip distance	Highest at very short distances (walk alternative); lowest at short/medium distances; then some increase and then decrease for longest distances (beyond urban area).	Highest at short distances (walk alternative).	Limited evidence – longest trips more elastic than short/medium distance trips.
City size	Lower in larger cities (over 1 million population) – USA evidence.	Higher in larger cities - EU evidence.	No evidence.
Base level of variable	Elasticities broadly proportional to the base fare level (based on recent UK study – otherwise limited evidence).	Elasticities increase with headways (broadly proportional up to c. 60 mins headway).	No firm evidence – although expect elasticities to increase with proportion of total trip (generalised costs) spent in vehicle.
Magnitude of change	No significant variation in elasticities with magnitude of change (majority of studies).	No evidence	No evidence
Direction of change	No significant differences for fare increases and decreases (majority of studies)	No evidence	No evidence

There is much debate about the time scale effects of elasticities – longer run elasticies are higher

- Longer term elasticities are thought be larger:
  - Short Run – 6-12 months
  - Medium Run – 2-7 years
  - Long Run – 8 years and over
- Weight of evidence if that long run elasticities are between 1.5 to 3 times larger than short run
- BUT it is almost impossible to ‘hold’ a particular variable constant in the long term to show how its affect worked in the long term. Many other factors (including exogenous influences) have impacts. So long run elasticities are a little less reliable

An interested reader should peruse Transfund NZ (2003) further to cover a range of wider issues

- Other Issues covered in Transfund NZ (2003)
  - Cross modal effects (cross elasticities)
  - Private Transport Elasticities
    - -Fuel Prices
    - -Vehicle Operating Costs
    - -Toll impacts
    - -Parking Charges
    - -In Vehicle Travel Time
  - Elasticity meaures
    - -Shrinkage Ratio
    - -Arc Elasticity
    - -Point Elasticity

SOME WORKING EXAMPLE TESTS - ELASTICITIES

Working Example No. 1

PROBLEM	**SOLUTION**
Proposal: **A fare increase of 20% has been called for peak (white collar) passengers. What will the demand and revenue implications be.** Existing Service Raw Data: **Total demand is 200M boardings p.a.** **Current average peak fare per boarding is $1.20**	

SOME WORKING EXAMPLE TESTS - ELASTICITIES

Working Example No. 2

PROBLEM	**SOLUTION**
Proposal: The tram operator has had a vehicle returned to service after a road accident. They can deploy it on either route 777 or route 999. They want to deploy it where demand impacts will be greatest. Which route should they put it on? Existing Service Raw Data: Route 777: Current dedicated fleet = 4 trams/hr Base demand is 4M p.a. Route 999: Current dedicated fleet = 10 trams/hr Base demand is 30M p.a.	

SOME WORKING EXAMPLE TESTS - ELASTICITIES

Working Example No. 3

PROBLEM	**SOLUTION**
Proposal: The Government has been forced to increase fares by 20%. As recompense, at the cost of $4M, the operator has been allowed to increase service levels by 10%. Does this make economic sense? Existing Service Raw Data: Total demand is 30M boardings p.a. Current average fare per boarding is $1.00	

Endogenous Forecasting Agenda

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Total generalised cost (TGC) modelling is simple and powerful tool with wider application than benchmarking and elasticities

- Generalised cost modelling is the basis of all more complex forms of travel demand model
- It can be applied in more specific situations
- It is adaptable to enable forecasting of all the various trip attributes which may be changes in public transport service planning
- It can also be used for estimating the impacts of ‘soft variables’ e.g. passenger amenity, safety, comfort and information factors

TGC is the total 'perceived' cost of travel to the user including fares and all aspects of travel valued in dollar terms

	Actual Time (mins)	Perceptual Weightings[2]	Percieved Time (mins)	Total Generalised Cost ($)
Access Walk	5 Mins	2.0	10 Mins	
Expected Wait	10 Mins	2.0	20 Mins	
Unexpected Wait	1 Mins	5.0	5 Mins	
In-Vehicle Travel 1	10 Mins	1.0	10 Mins	
Transfer Time [1]	8 Mins	2.0 plus a 10 min transfer penalty	26 Mins	Apply a Value of Time of $10.00/hour[3] (16.67c/ minute)
In-Vehicle Travel 2	5 Mins	1.0	5 Mins	
Egress Walk	5 Mins	2.0	10 Mins	
Total Time	**44 Mins**		**86 Mins**	**$14.33**
			Fare	**$ 1.84**
				$ 16.18

Note: [1] Includes a walk and wait

[2] See TransFund NZ June 2000

[3] June 2004 DoI Guideline on economic, social and environmental cost-benefit analysis 2005

TGC modelling involves (yet again) three quite simple steps

Existing Situation
(Base Case)
Where you start from

Future Situation
(Project Case)
Where you might be heading

1. Understand Base Case

- Measure existing average total generalised cost of travel (TGC)
- Measure demand

2. Understand Project Case

- Establish proposed changes to TGC in the project case

3. Make Forecast

- Apply a TGC elasticity

Lets take an example; a 10% increase in in vehicle travel time
THE BASE CASE   TGC = $16.18

	Actual Time (mins)	Perceptual Weightings[2]	Percieved Time (mins)	Total Generalised Cost ($)
Access Walk	5 Mins	2.0	10 Mins	
Expected Wait	10 Mins	2.0	20 Mins	
Unexpected Wait	1 Mins	5.0	5 Mins	
In-Vehicle Travel 1	10 Mins	1.0	10 Mins	
Transfer Time [1]	8 Mins	2.0 plus a 10 min transfer penalty	26 Mins	Apply a Value of Time of $10.00/hour[3] (16.67c/ minute)
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[2] See TransFund NZ June 2000

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Lets take an example; a 10% increase in in vehicle travel time
THE PROJECT CASE   TGC = $16.43

	Actual Time (mins)	Perceptual Weightings[2]	Percieved Time (mins)	Total Generalised Cost ($)
Access Walk	5 Mins	2.0	10 Mins	
Expected Wait	10 Mins	2.0	20 Mins	
Unexpected Wait	1 Mins	5.0	5 Mins	
In-Vehicle Travel 1	11 Mins	1.0	11 Mins	
Transfer Time [1]	8 Mins	2.0 plus a 10 min transfer penalty	26 Mins	Apply a Value of Time of $10.00/hour[3] (16.67c/ minute)
In-Vehicle Travel 2	5.5 Mins	1.0	5.5 Mins	
Egress Walk	5 Mins	2.0	10 Mins	
Total Time	45.5 Mins		87.5 Mins	$14.59
			Fare	$ 1.84
				$ 16.43

Note: [1] *Includes a walk and wait*

[2] *See TransFund NZ June 2000*

[3] *June 2004 DoI Guideline on economic, social and environmental cost-benefit analysis 2005*

The forecast is made by applying a simple TGC elasticity

1. Understand Base Case

TGC = $16.18

2. Understand Project Case

TGC = $16.43

+1.5%

3. Make Forecast

TGC = -1.0

%D = E * %change TGC

%D = -1.0 *+1.5%

%D = -1.5%

Now lets take a more complex case – a halving of service headways

- In the example we have been using, average wait time is 10 minutes
- A good rule of thumb is that wait time is on average half headway
- Hence it implies average service headways are around 20mins in the Base Case
- If the project case has half service headways then it implies that they will go from 20 mins to 10 minutes
- Based on the wait time = half headway rule, this means wait times will fall from 10 minutes to 5 minutes

Halving of service headways
THE BASE CASE TGC = $16.18

	Actual Time (mins)	Perceptual Weightings[2]	Percieved Time (mins)	Total Generalised Cost ($)
Access Walk	5 Mins	2.0	10 Mins	
Expected Wait	10 Mins	2.0	20 Mins	
Unexpected Wait	1 Mins	5.0	5 Mins	
In-Vehicle Travel 1	10 Mins	1.0	10 Mins	
Transfer Time [1]	8 Mins	2.0 plus a 10 min transfer penalty	26 Mins	Apply a Value of Time of $10.00/hour[3] (16.67c/ minute)
In-Vehicle Travel 2	5 Mins	1.0	5 Mins	
Egress Walk	5 Mins	2.0	10 Mins	
Total Time	44 Mins		86 Mins	$14.33
			Fare	$ 1.84
				$ 16.18

Note: [1] *Includes a walk and wait*

[2] *See TransFund NZ June 2000*

[3] *June 2004 DoI Guideline on economic, social and environmental cost-benefit analysis 2005*

Halving of service headways
THE PROJECT CASE TGC = $14.51

	Actual Time (mins)	Perceptual Weightings[2]	Percieved Time (mins)	Total Generalised Cost ($)
Access Walk	5 Mins	2.0	10 Mins	
Expected Wait	5 Mins	2.0	10 Mins	
Unexpected Wait	1 Mins	5.0	5 Mins	
In-Vehicle Travel 1	10 Mins	1.0	10 Mins	
Transfer Time [1]	8 Mins	2.0 plus a 10 min transfer penalty	26 Mins	Apply a Value of Time of $10.00/hour[3] (16.67c/ minute)
In-Vehicle Travel 2	5 Mins	1.0	5 Mins	
Egress Walk	5 Mins	2.0	10 Mins	
Total Time	39 Mins		76 Mins	$12.67
			Fare	$ 1.84
				$ 14.51

Note: [1] Includes a walk and wait

[2] See TransFund NZ June 2000

[3] June 2004 DoI Guideline on economic, social and environmental cost-benefit analysis 2005

Again the forecast is made by applying a simple TGC elasticity

1. Understand Base Case

TGC = $16.18

2. Understand Project Case

TGC = $14.51

-10.3%

3. Make Forecast

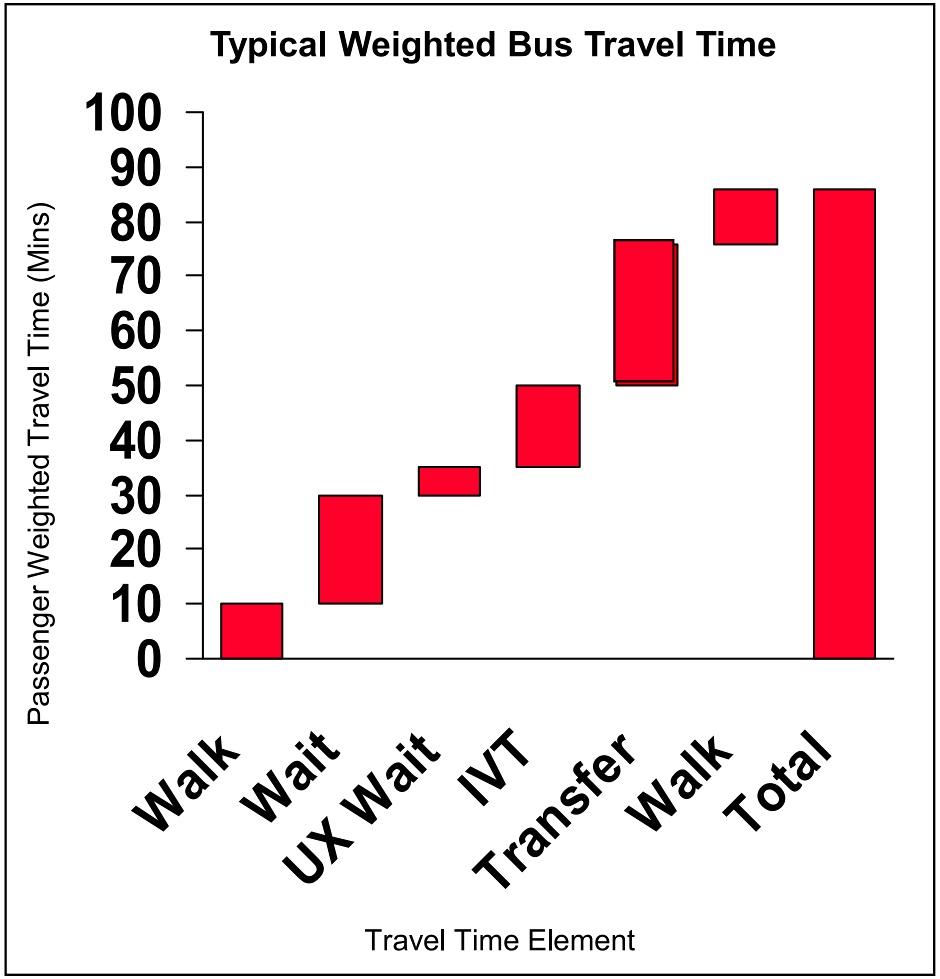
TGC = -1.0

%D = E * %change TGC

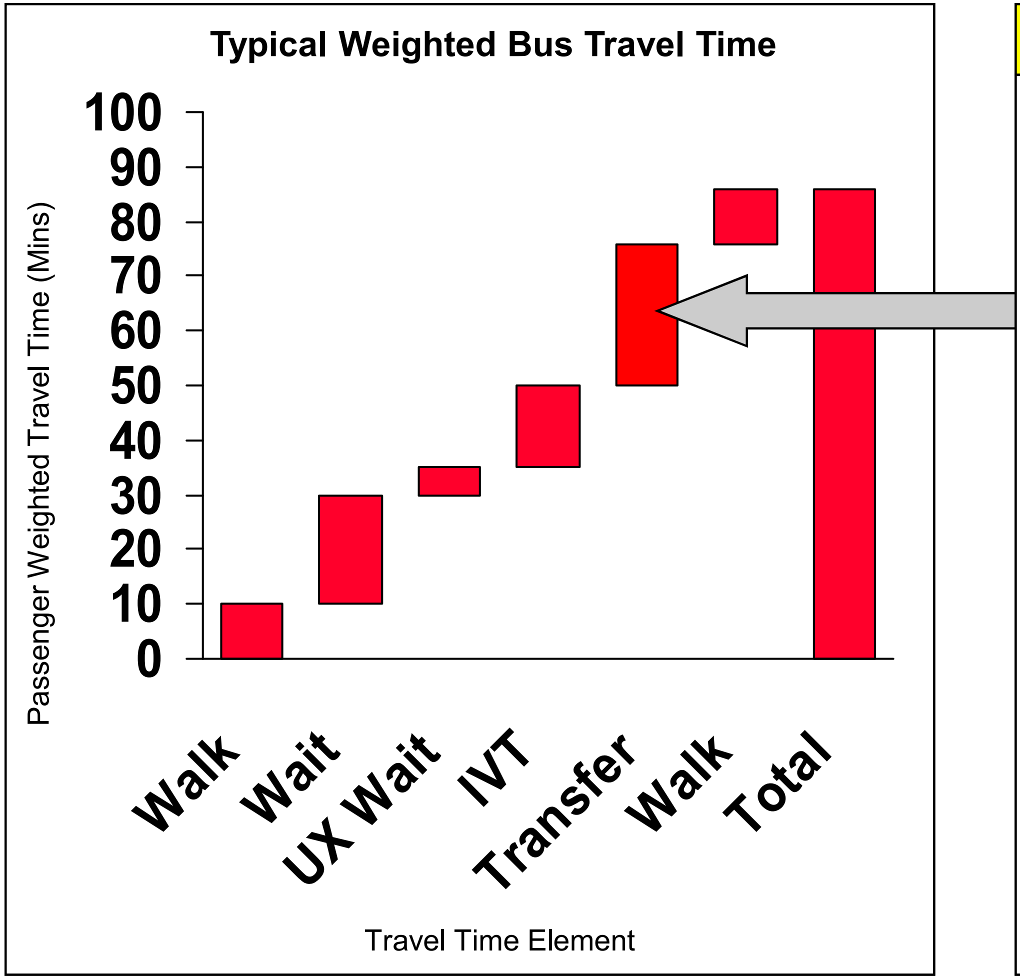
%D = -1.0 *-10.3%

%D = +10.3%

It is worth digressing for a moment to understand the relative importance of various PT travel time components.



This illustrates that transfers are a significant deterrent to PT travel



Transfer Issues

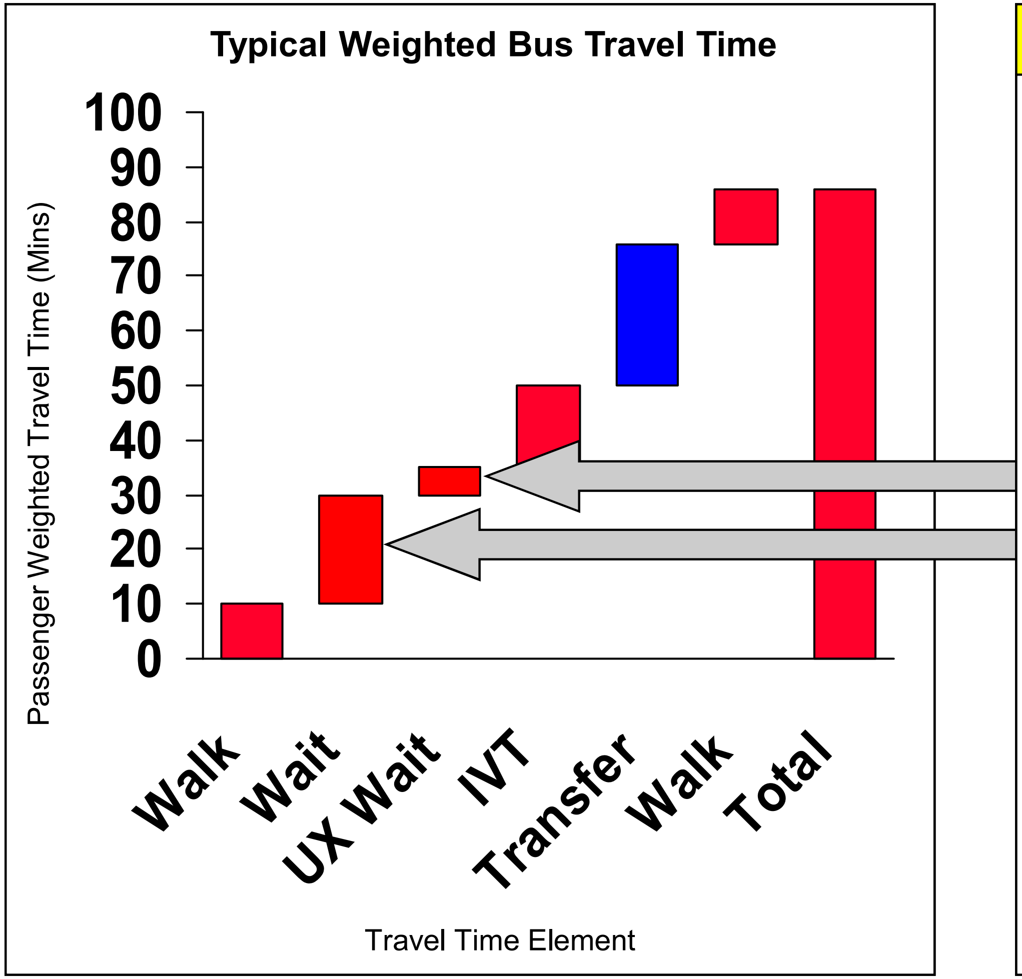
- **Represents over 30% of total perceived travel time**
- **Evidence shows transfer penalties can vary considerably with quality of the**

Unprotected Area, Open Air, Uncoordinated Transfer, Low Frequency	**Protected Area, Covered, Coordinated Transfer, High Frequency**
32 Minutes	4 Minutes

- **This is a direct PT infrastructure issue**
- **BUT Not everyone transfers**

(Source: Currie and Willis (98) Australasian Transport Research Forum)

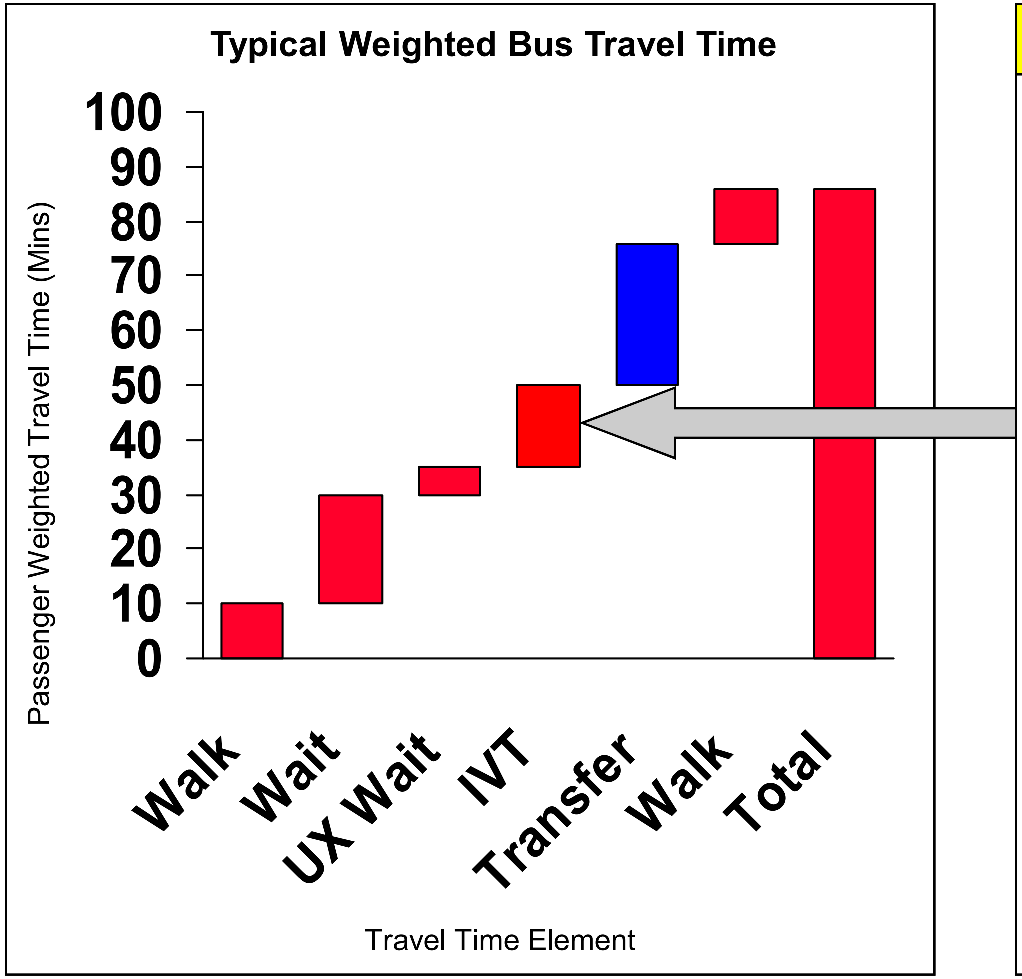
Wait times are almost as significant – but for a non-transfer trip they almost dominate the journey



Wait Time Issues

- **Represents almost 30% of total perceived travel time in this case**
- **If the trip did not include a transfer then it would represent as much as 40%**
- **Infrastructure related elements of wait time are:**
  - Quality of stop environment
  - Provision of real time information to ease the uncertainties associated with unexpected wait time
  - Infrastructure to reduce unexpected wait time i.e. bus priority measures to improve reliability

A key conclusion is that time in the vehicle is not particularly important

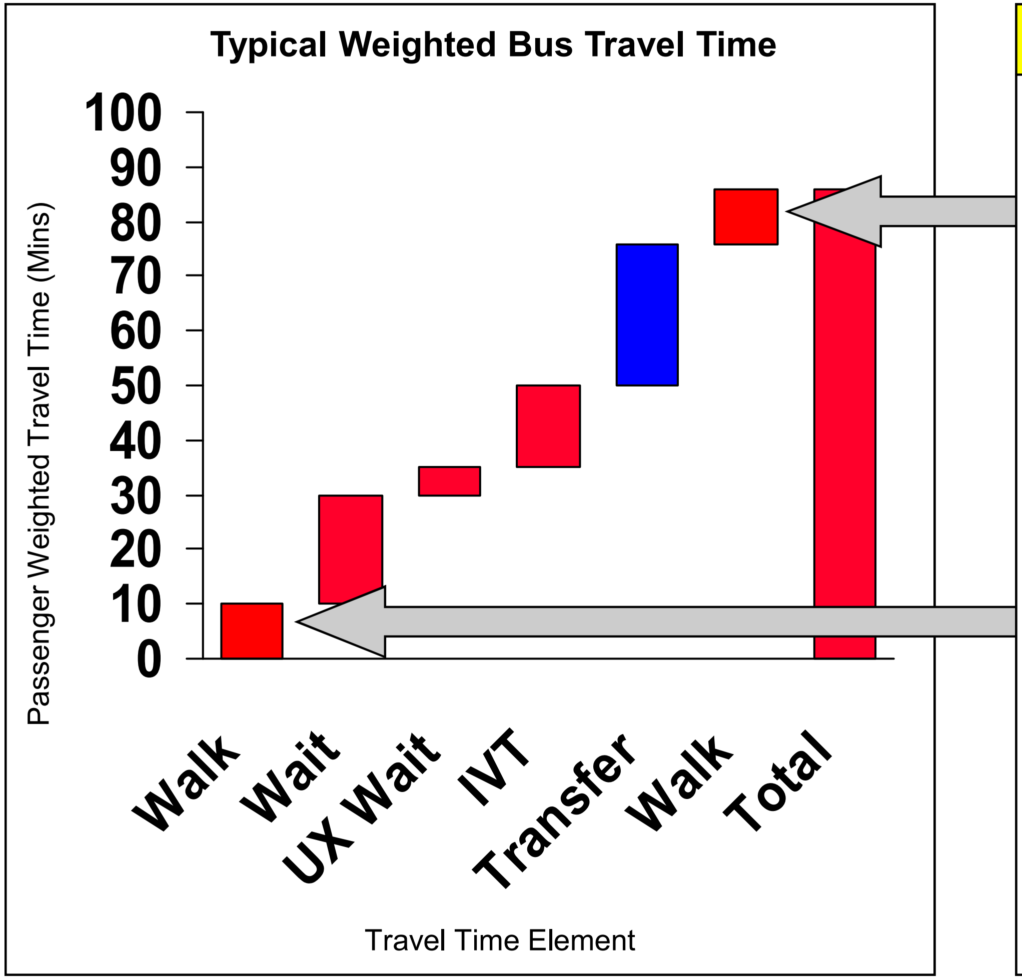

Typical Weighted Bus Travel Time

In Vehicle Travel Time Issues

- **Represents only 17% of total perceived travel time**
- **It is interesting to contrast the travel time reductions which are feasible with bus priority with the potential benefits of reduces unexpected waiting time. Tackling unreliable arrival times is far more important however most bus priority schemes tend to emphasise bus travel time savings**

Note: The low importance of in-vehicle time changes if passengers have to stand. Evidence shows they value standing at twice in vehicle time. Recent work on a rail service in Melbourne has shown management of standing time dominates aspects of passenger benefits in designing peak rail services

The ‘hidden factor’ is the importance of walk access/egress



Walk Access/Egress Time Issues

- Represents only 23% of total perceived travel time
- Increases to 42% (as important as wait time) for non transfer trips
- Yet little infrastructure investment surrounds this issue
- Jurisdictional boundary problems is a major issue here

A few more points about TGC – TGC elasticities

- The Transfund NZ (2003) review suggests:
  - The weight of international evidence is that TGC elasticities lie in the range -0.6 to -1.8
  - Although a narrower range -0.8 to 1.5 is suggested from experimental data
  - The review suggests an average value of -1.0 is appropriate.
  - Perhaps -1.5 for inter-peak applications

The Transfund ‘Valuation of Public Transport Attributes’ review presents a summary of international evidence on specific TGC elements – We will review some of these here

TRANSFER PENALTIES

MODE SPECIFIC FACTORS

SOFT VARIABLES

Source : Transfund NZ ‘ Valuation of Public Transport Attributes’ Booz Allen Hamilton for Transfund NZ June 2000

Transfer penalties vary with the quality of the transfer environment

- British Rail (NSE) 10 to 14 mins IVTT
- London Transport 3.5 mins (LUL/LUL)

  5.0 mins (LUL/NSE)
- Perth 6.0 mins (bus-rail)

  8 to 9 mins (bus-bus)
- The PT Attributes research recommends:
  - Bus-bus 10 mins IVTT
  - Fixed track 8 mins IVTT
  - Sensitivity testing of + and - 50% of values to understand impacts

Transfer Penalty research evidence

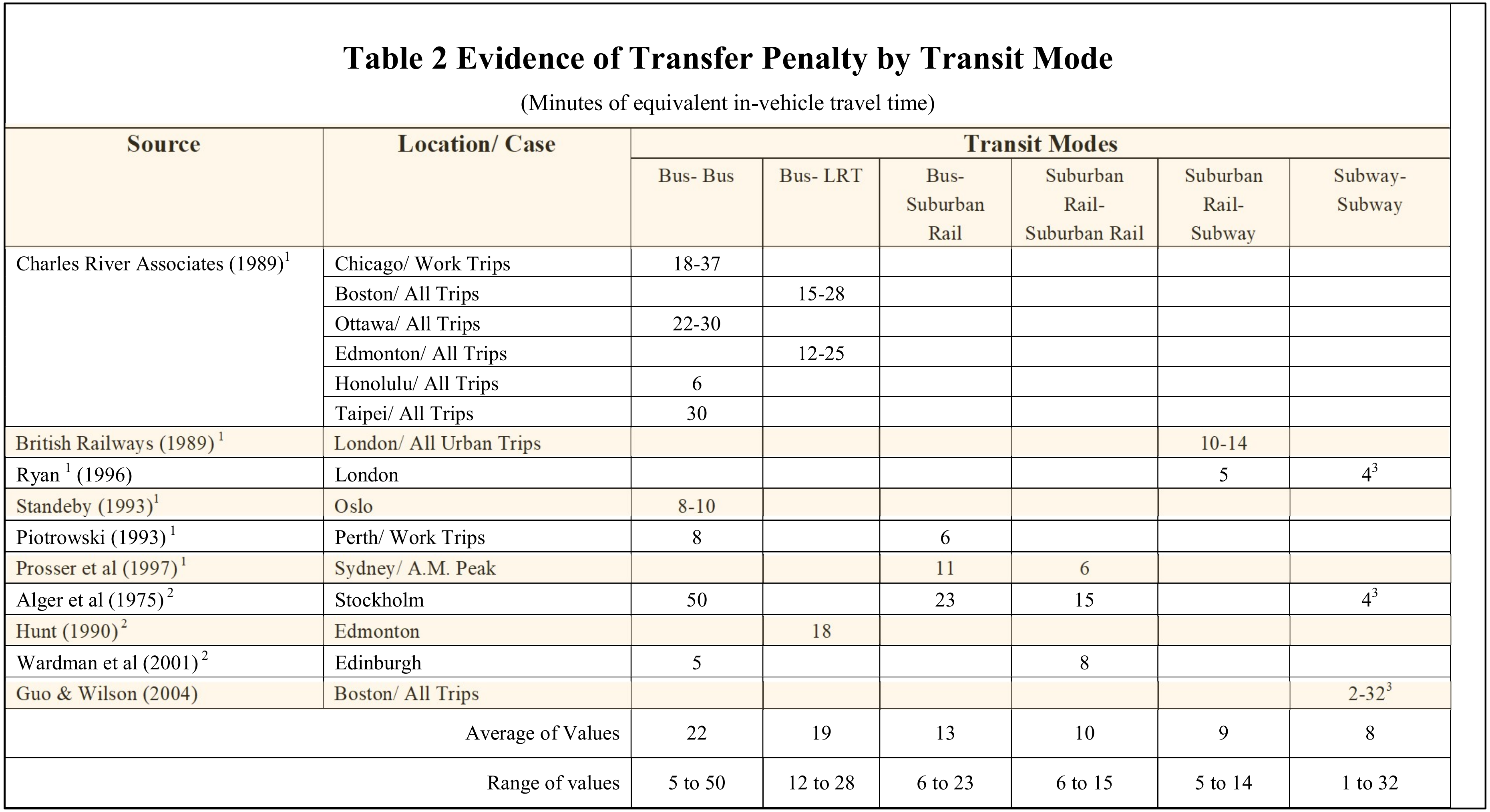


Table 2 Evidence of Transfer Penalty by Transit Mode

(Minutes of equivalent in-vehicle travel time)

Source	Location/ Case	Transit Modes					
		Bus- Bus	Bus- LRT	Bus-Suburban Rail	Suburban Rail-Suburban Rail	Suburban Rail-Subway	Subway-Subway
Charles River Associates (1989)[1]	Chicago/ Work Trips	18-37					
	Boston/ All Trips		15-28				
	Ottawa/ All Trips	22-30					
	Edmonton/ All Trips		12-25				
	Honolulu/ All Trips	6					
	Taipei/ All Trips	30					
British Railways (1989) [1]	London/ All Urban Trips					10-14	
Ryan [1] (1996)	London					5	4[3]
Standeby (1993)[1]	Oslo	8-10					
Piotrowski (1993) [1]	Perth/ Work Trips	8		6			
Prosser et al (1997) [1]	Sydney/ A.M. Peak			11	6		
Alger et al (1975) [2]	Stockholm	50		23	15		4[3]
Hunt (1990) [2]	Edmonton		18				
Wardman et al (2001) [2]	Edinburgh	5			8		
Guo & Wilson (2004)	Boston/ All Trips						2-32[3]
Average of Values		22	19	13	10	9	8
Range of values		5 to 50	12 to 28	6 to 23	6 to 15	5 to 14	1 to 32

Source: Currie G (2005) 'The Demand Performance of BRT' Journal of Public Transportation Vol 8 No 1, 2005 – available at : http://www.nctr.usf.edu/jpt/journalfulltext.htm

New discovery – Transfer Penalties vary with the weather

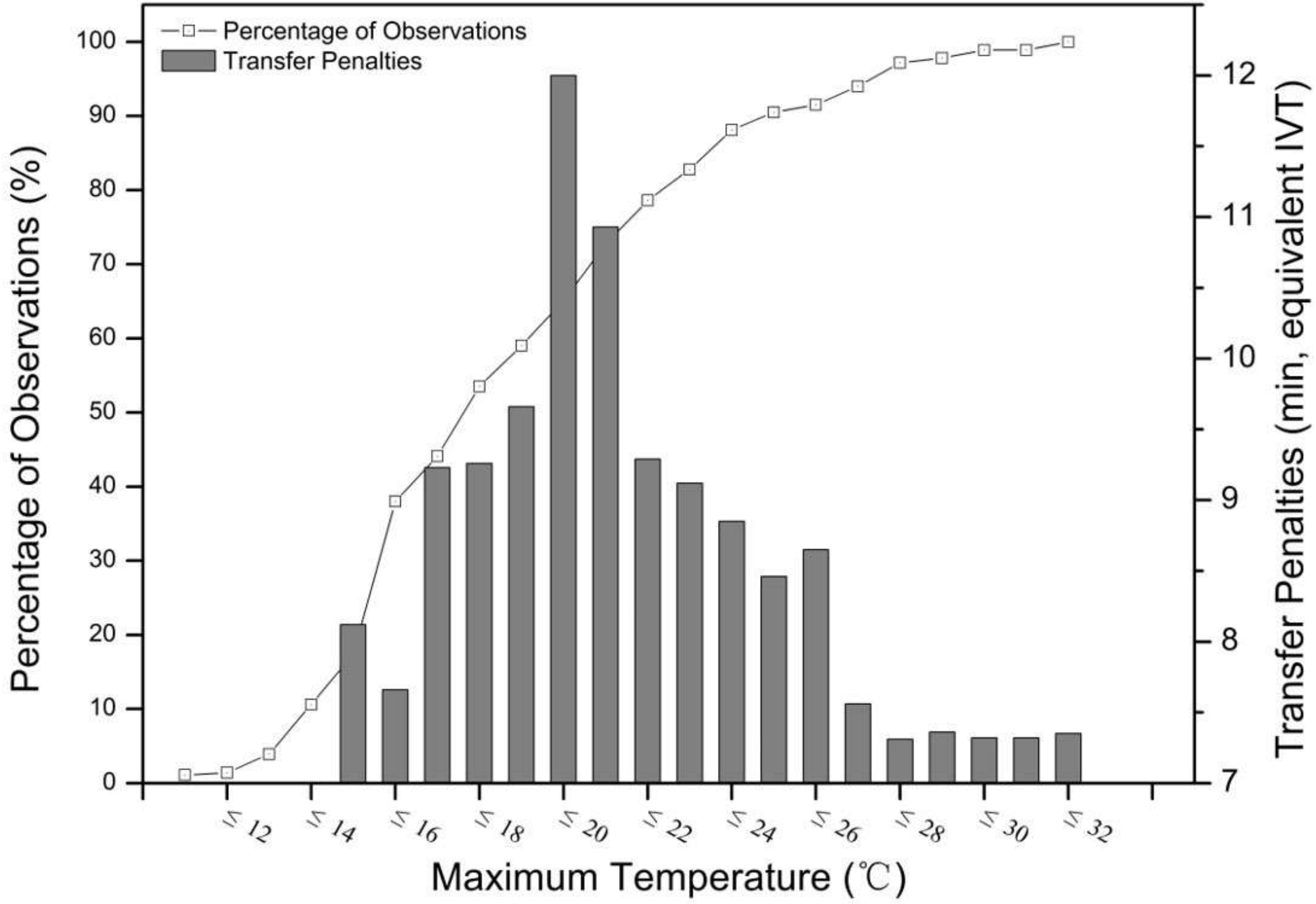


Fig. 1. Rail Feeder Transfer Penalty Variation by Groups of Maximum Temperature

Source: Gong X, Currie G Liu Z and Guo X (2017) ‘A Disaggregate Study of Rail Feeder Transfer Penalties Including Weather Effects’ TRANSPORTATION

Mode Specific Factors (MSF) identify how passengers value the relative features of bus, light & heavy rail

- A $ value is placed on travel by bus vs light rail vs heavy rail
- It can be a negative value in some cases
- It represents how passengers would value the relative features of each transit mode
- It is added to the TGC in each case and is critical in understanding how people decide to travel by bus vs tram vs train
- The Valuation of PT Attributes’ research is the critical source of all evidence in this area
- Often Stated Preference research is used to value the MSF

MSF research evidence

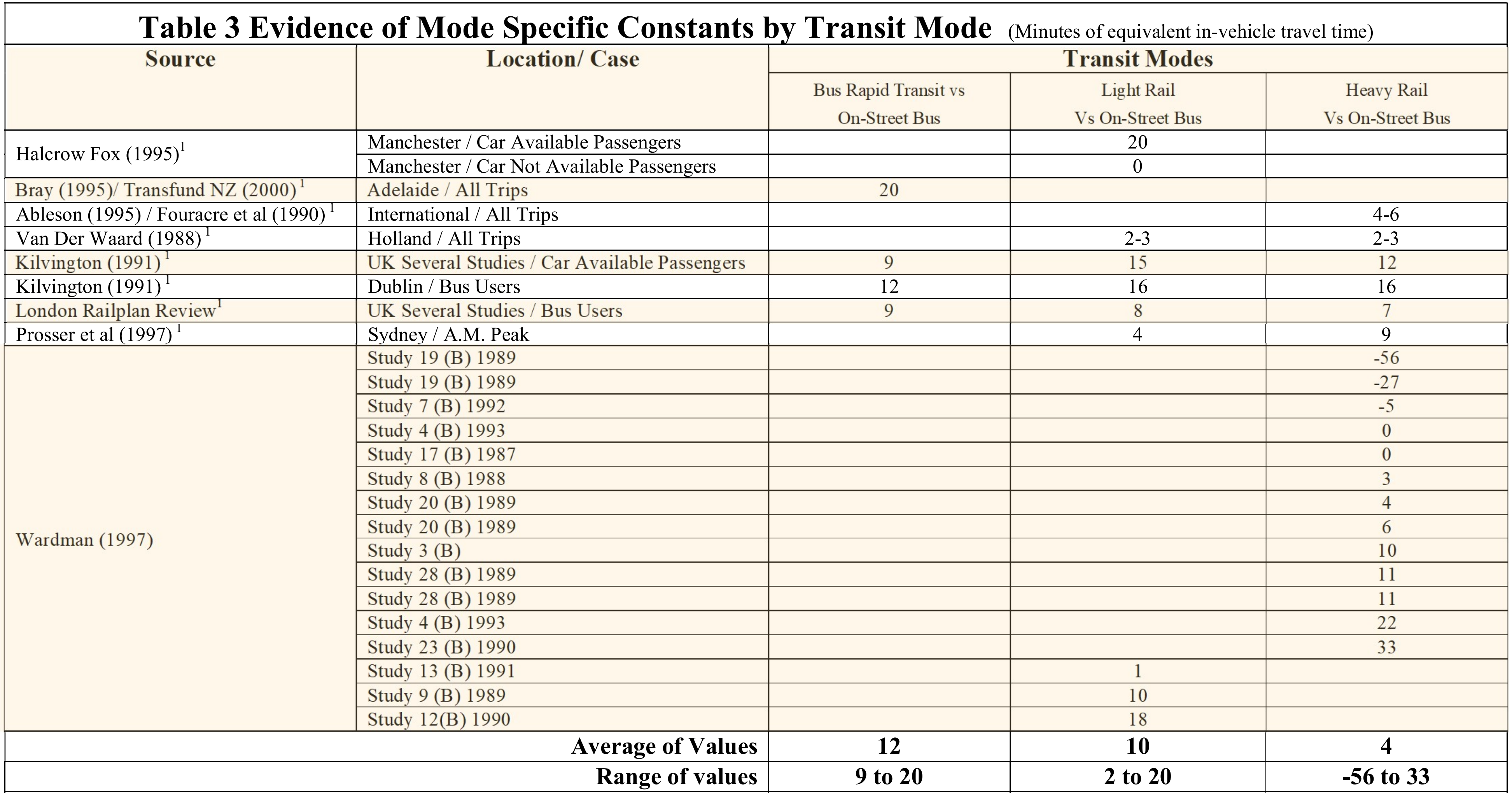
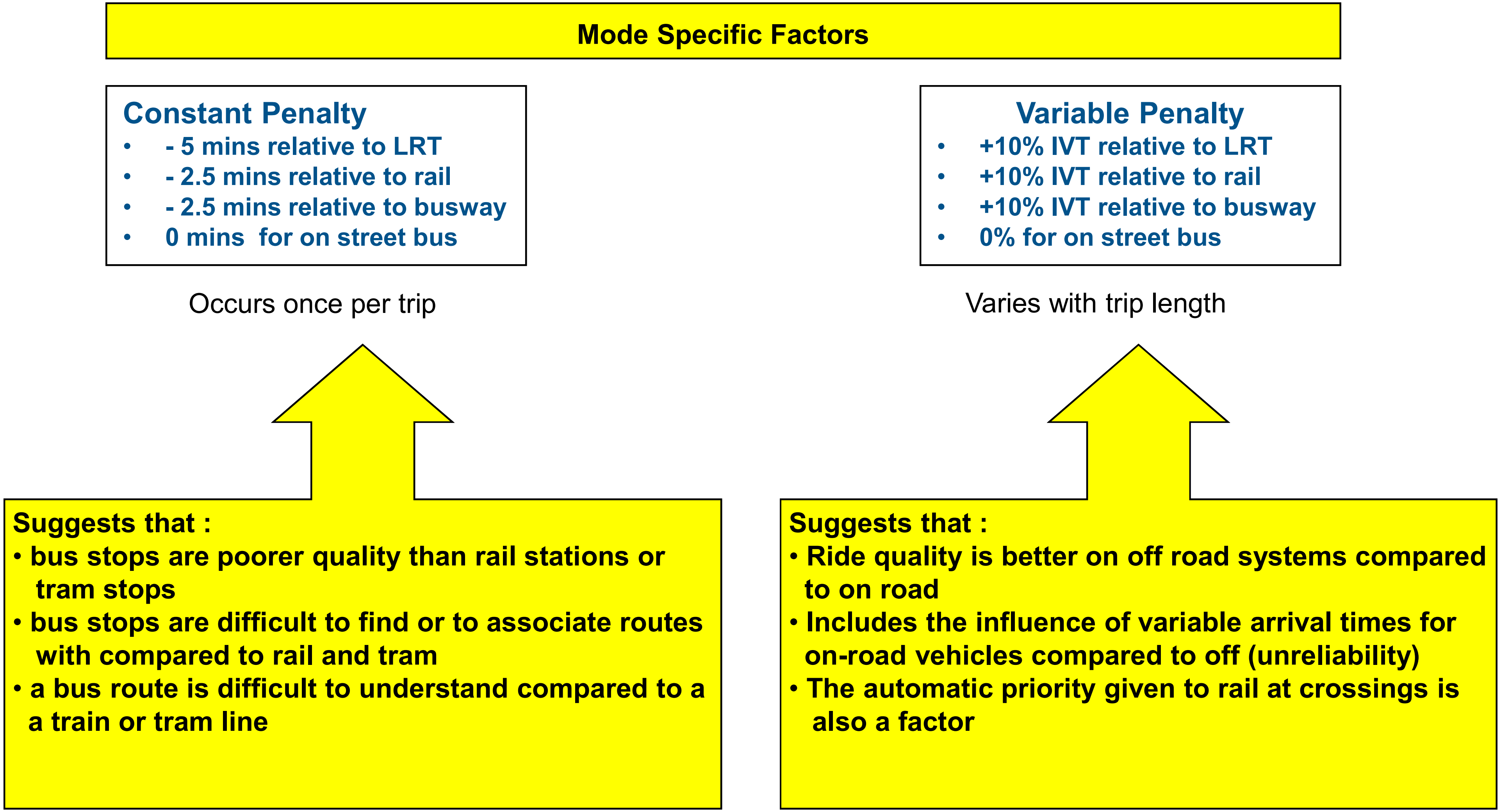


Table 3 Evidence of Mode Specific Constants by Transit Mode (Minutes of equivalent in-vehicle travel time)

Source	Location/ Case	Transit Modes		
		Bus Rapid Transit vs On-Street Bus	Light Rail Vs On-Street Bus	Heavy Rail Vs On-Street Bus
Halcrow Fox (1995)[1]	Manchester / Car Available Passengers		20	
	Manchester / Car Not Available Passengers		0	
Bray (1995)/ Transfund NZ (2000)[1]	Adelaide / All Trips	20		
Ableson (1995) / Fouracre et al (1990)[1]	International / All Trips			4-6
Van Der Waard (1988)[1]	Holland / All Trips		2-3	2-3
Kilvington (1991)[1]	UK Several Studies / Car Available Passengers	9	15	12
Kilvington (1991)[1]	Dublin / Bus Users	12	16	16
London Railplan Review[1]	UK Several Studies / Bus Users	9	8	7
Prosser et al (1997)[1]	Sydney / A.M. Peak		4	9
Wardman (1997)	Study 19 (B) 1989			-56
	Study 19 (B) 1989			-27
	Study 7 (B) 1992			-5
	Study 4 (B) 1993			0
	Study 17 (B) 1987			0
	Study 8 (B) 1988			3
	Study 20 (B) 1989			4
	Study 20 (B) 1989			6
	Study 3 (B)			10
	Study 28 (B) 1989			11
	Study 28 (B) 1989			11
	Study 4 (B) 1993			22
	Study 23 (B) 1990			33
	Study 13 (B) 1991		1	
	Study 9 (B) 1989		10	
	Study 12(B) 1990		18	
	Average of Values	**12**	**10**	**4**
	Range of values	**9 to 20**	**2 to 20**	**-56 to 33**

Source: Currie G (2005) 'The Demand Performance of BRT' Journal of Public Transportation Vol 8 No 1, 2005 – available at : http://www.nctr.usf.edu/jpt/journalfulltext.htm

The MSF's include a constant and a variable element



Mode Specific Factors

Constant Penalty

- - 5 mins relative to LRT
- - 2.5 mins relative to rail
- - 2.5 mins relative to busway
- 0 mins for on street bus

Occurs once per trip

Variable Penalty

- +10% IVT relative to LRT
- +10% IVT relative to rail
- +10% IVT relative to busway
- 0% for on street bus

Varies with trip length

Suggests that :

- **bus stops are poorer quality than rail stations or tram stops**
- **bus stops are difficult to find or to associate routes with compared to rail and tram**
- **a bus route is difficult to understand compared to a a train or tram line**

Suggests that :

- **Ride quality is better on off road systems compared to on road**
- **Includes the influence of variable arrival times for on-road vehicles compared to off (unreliability)**
- **The automatic priority given to rail at crossings is also a factor**

MSF’s can be used to answer part of the ultimate question; is LRT better than bus (on street)

	ON STREET BUS			LIGHT RAIL		
	Actual Time (mins)	Perceptual Weightings	Perceived Time (mins)	Actual Time (mins)	Perceptual Weightings	Perceived Time (mins)
Access Walk	5 Mins	2.0	10 Mins	5 Mins	2.0	10 Mins
Expected Wait	10Mins	2.0	20 Mins	10Mins	2.0	20 Mins
Unexpected Wait	1 Mins	5.0	5 Mins	1 Mins	5.0	5 Mins
In-Vehicle Travel	10Mins	1.0	10 Mins	10Mins	0.9	9 Mins
Egress Walk	5 Mins	2.0	10 Mins	5 Mins	2.0	10 Mins
Mode Specific Constant		0.0	0 Mins		-10mins	-10Mins
		Total	55 Mins		Total	44 Mins
Fare			$1.50			$1.50
		Total Generalised Cost	$10.67		Total Generalised Cost	$8.83 -17%

A real world example: Should we run a shuttle train from Richmond Station to a new Station at the MCG during the footy?

A real world example: Should we run a shuttle train from Richmond Station to a new Station at the MCG during the footy?

Shuttle Train from Richmond Station

	Actual Time (mins)	**Perceptual Weightings**	**Perceived Time (mins)**
Access Walk	2 Mins	2.0	
Expected Wait	4 Mins	2.0	
Transfer Time[1]		5 min transfer penalty	
In-Vehicle Travel	2 Mins	1.0	
Egress Walk	3 Mins	2.0	

Total **Mins**

Total Generalised Cost **$**

Direct Walk

Actual Time (mins)	**Perceptual Weightings**	**Perceived Time (mins)**
10 Mins	2.0	

Total **Mins**

Total Generalised Cost **$**

Note: [1]Includes transfer penalty only

‘Soft Variables’ is an interesting new approach using a TGC framework to estimate the impacts of improving passenger amenities

- See the ‘Valuation of Public Transport Attributes’ research review for a good coverage of this interesting subject area
- Other good references are the British Railways ‘Passenger Demand Forecasting Handbook’
- The general premise is that
  - using Stated Preference style research you can get passenger to put a value on to amenities such as customer information, the provision of seats at bus stops, provision of weather protection canopies at rail stations etc
  - To estimate passenger impacts of providing new amenities the value can be added to TGC in the project case
  - The change in TGC can used to forecast demand using a standard TGC elasticity

Example transit ‘Soft Variable’ valuations

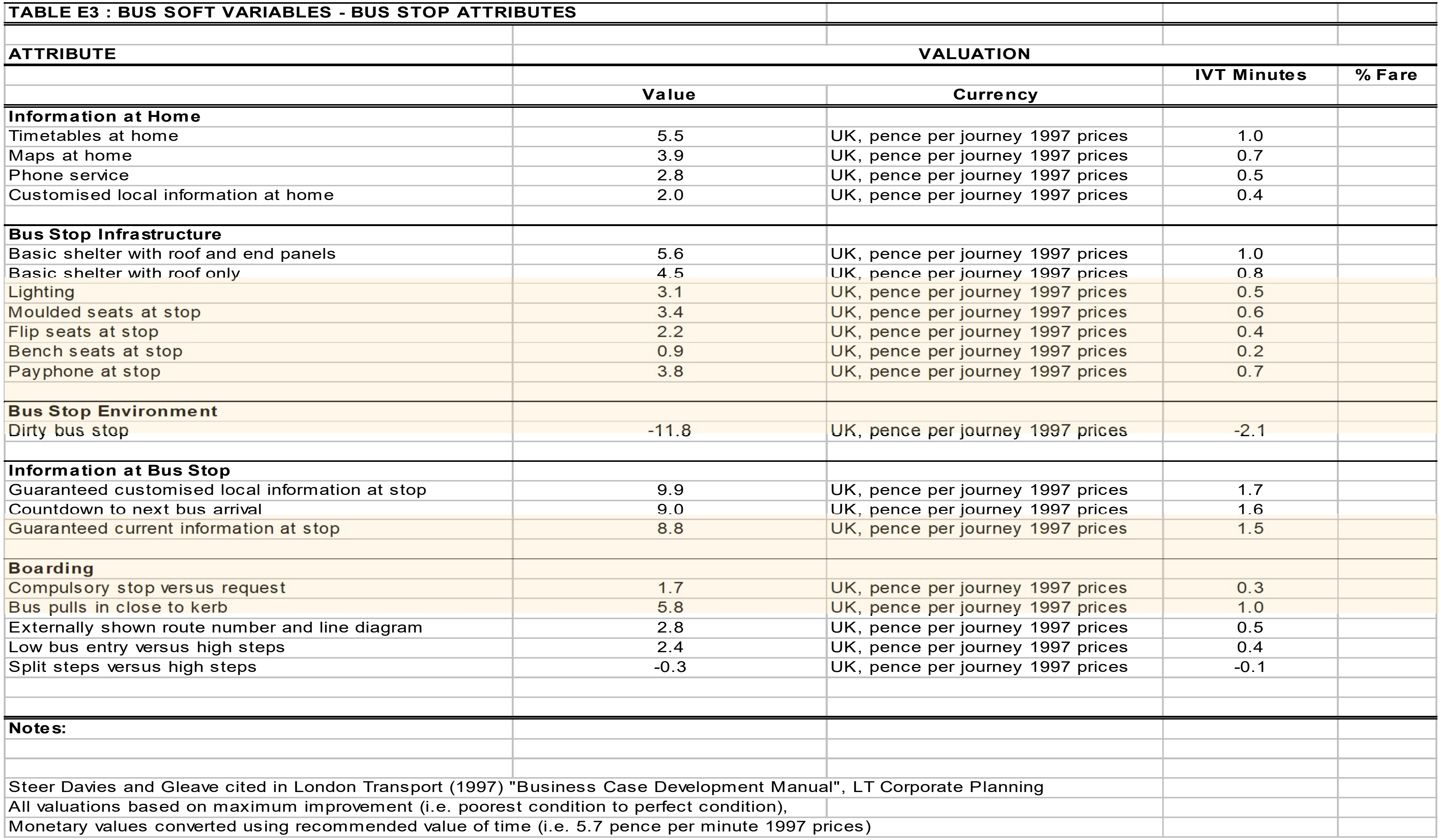


TABLE E3 : BUS SOFT VARIABLES - BUS STOP ATTRIBUTES

ATTRIBUTE	VALUATION			
			IVT Minutes	% Fare
	Value	Currency		
Information at Home				
Timetables at home	5.5	UK, pence per journey 1997 prices	1.0	
Maps at home	3.9	UK, pence per journey 1997 prices	0.7	
Phone service	2.8	UK, pence per journey 1997 prices	0.5	
Customised local information at home	2.0	UK, pence per journey 1997 prices	0.4	
Bus Stop Infrastructure				
Basic shelter with roof and end panels	5.6	UK, pence per journey 1997 prices	1.0	
Basic shelter with roof only	4.5	UK, pence per journey 1997 prices	0.8	
Lighting	3.1	UK, pence per journey 1997 prices	0.5	
Moulded seats at stop	3.4	UK, pence per journey 1997 prices	0.6	
Flip seats at stop	2.2	UK, pence per journey 1997 prices	0.4	
Bench seats at stop	0.9	UK, pence per journey 1997 prices	0.2	
Payphone at stop	3.8	UK, pence per journey 1997 prices	0.7	
Bus Stop Environment				
Dirty bus stop	-11.8	UK, pence per journey 1997 prices	-2.1	
Information at Bus Stop				
Guaranteed customised local information at stop	9.9	UK, pence per journey 1997 prices	1.7	
Countdown to next bus arrival	9.0	UK, pence per journey 1997 prices	1.6	
Guaranteed current information at stop	8.8	UK, pence per journey 1997 prices	1.5	
Boarding				
Compulsory stop versus request	1.7	UK, pence per journey 1997 prices	0.3	
Bus pulls in close to kerb	5.8	UK, pence per journey 1997 prices	1.0	
Externally shown route number and line diagram	2.8	UK, pence per journey 1997 prices	0.5	
Low bus entry versus high steps	2.4	UK, pence per journey 1997 prices	0.4	
Split steps versus high steps	-0.3	UK, pence per journey 1997 prices	-0.1	

Notes:

Steer Davies and Gleave cited in London Transport (1997) "Business Case Development Manual", LT Corporate Planning

All valuations based on maximum improvement (i.e. poorest condition to perfect condition),

Monetary values converted using recommended value of time (i.e. 5.7 pence per minute 1997 prices)

Example transit ‘Soft Variable’ valuations

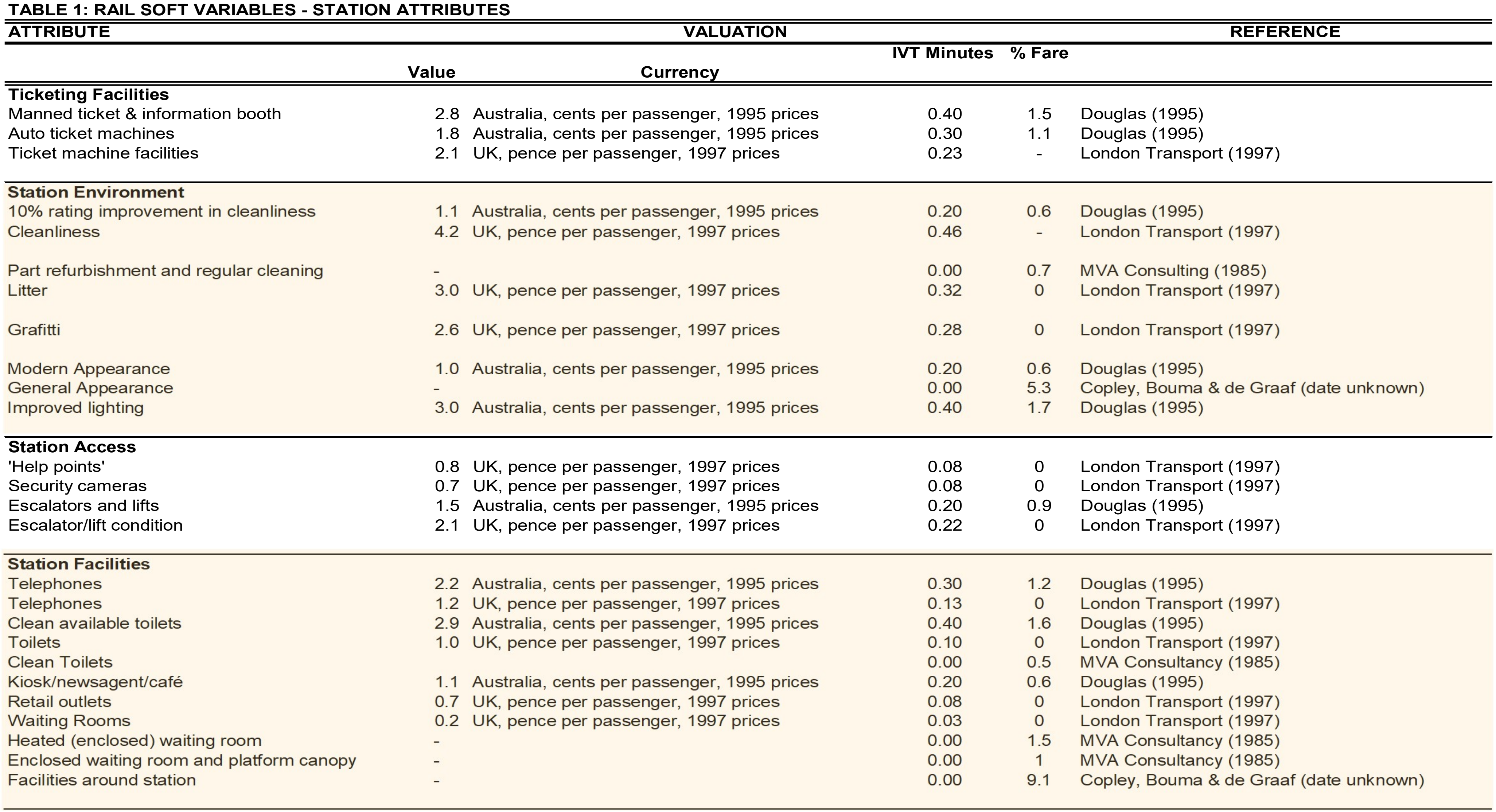


TABLE 1: RAIL SOFT VARIABLES - STATION ATTRIBUTES

ATTRIBUTE	VALUATION				REFERENCE
			IVT Minutes	% Fare	
	Value	Currency			
Ticketing Facilities					
Manned ticket & information booth	2.8	Australia, cents per passenger, 1995 prices	0.40	1.5	Douglas (1995)
Auto ticket machines	1.8	Australia, cents per passenger, 1995 prices	0.30	1.1	Douglas (1995)
Ticket machine facilities	2.1	UK, pence per passenger, 1997 prices	0.23	-	London Transport (1997)
Station Environment					
10% rating improvement in cleanliness	1.1	Australia, cents per passenger, 1995 prices	0.20	0.6	Douglas (1995)
Cleanliness	4.2	UK, pence per passenger, 1997 prices	0.46	-	London Transport (1997)
Part refurbishment and regular cleaning	-		0.00	0.7	MVA Consulting (1985)
Litter	3.0	UK, pence per passenger, 1997 prices	0.32	0	London Transport (1997)
Grafitti	2.6	UK, pence per passenger, 1997 prices	0.28	0	London Transport (1997)
Modern Appearance	1.0	Australia, cents per passenger, 1995 prices	0.20	0.6	Douglas (1995)
General Appearance	-		0.00	5.3	Copley, Bouma & de Graaf (date unknown)
Improved lighting	3.0	Australia, cents per passenger, 1995 prices	0.40	1.7	Douglas (1995)
Station Access					
'Help points'	0.8	UK, pence per passenger, 1997 prices	0.08	0	London Transport (1997)
Security cameras	0.7	UK, pence per passenger, 1997 prices	0.08	0	London Transport (1997)
Escalators and lifts	1.5	Australia, cents per passenger, 1995 prices	0.20	0.9	Douglas (1995)
Escalator/lift condition	2.1	UK, pence per passenger, 1997 prices	0.22	0	London Transport (1997)
Station Facilities					
Telephones	2.2	Australia, cents per passenger, 1995 prices	0.30	1.2	Douglas (1995)
Telephones	1.2	UK, pence per passenger, 1997 prices	0.13	0	London Transport (1997)
Clean available toilets	2.9	Australia, cents per passenger, 1995 prices	0.40	1.6	Douglas (1995)
Toilets	1.0	UK, pence per passenger, 1997 prices	0.10	0	London Transport (1997)
Clean Toilets			0.00	0.5	MVA Consultancy (1985)
Kiosk/newsagent/café	1.1	Australia, cents per passenger, 1995 prices	0.20	0.6	Douglas (1995)
Retail outlets	0.7	UK, pence per passenger, 1997 prices	0.08	0	London Transport (1997)
Waiting Rooms	0.2	UK, pence per passenger, 1997 prices	0.03	0	London Transport (1997)
Heated (enclosed) waiting room	-		0.00	1.5	MVA Consultancy (1985)
Enclosed waiting room and platform canopy	-		0.00	1	MVA Consultancy (1985)
Facilities around station	-		0.00	9.1	Copley, Bouma & de Graaf (date unknown)

WORKING EXAMPLE TESTS – TGC Soft Variables

Working Example No. 1

Av. Existing Rail Traveller

	Actual Time (mins)	Perceptual Weightings	Perceived Time (mins)
Access Walk	5 Mins	2.0	
Expected Wait	5 Mins	2.0	
In-Vehicle Travel	50 Mins	1.0	
Egress Walk	3 Mins	2.0	
		Total	Mins
Fare			$2.50

Total Generalised Cost $

Research Question

- 5.6 Million passengers use Uglyville station each year
- Uglyville is appropriately named because it's a very dirty station
- The transit authority are thinking of spending $80,000 p.a. on a cleaning contractor to ensure the station is clear at all times
- What would the demand impact of this be?
- Is it a financially sensible thing to do?

Endogenous Forecasting Agenda

BENCHMARKING

ELASTICITIES

GENERALISED COST MODELS

ADVANCED METHODS

Endogenous Forecasting Agenda

BENCHMARKING

ELASTICITIES

GENERALISED COST MODELS

ADVANCED METHODS

One problem which the previous approaches have is a lack of knowledge about competition from car/walk – multi-modal transport network models are the main approach used to address this issue

- Benchmarking, elasticity and TGC models all have to be based on factoring an existing market by a market change estimate
- This is not necessarily based on any knowledge of the quality of alternatives to transit e.g. quality and volume of road travelers
- In addition what happens if there is NO existing demand and this is an entirely new project. There will be no demand to factor? (The Herring Bay Problem)
- Multi-modal transport network models are the most common approach to this issue

A Multi-Modal Transport Network Model includes networks for each mode and a trip matrix for travel within the network

Zones – Travel From/To
Links – Travel Speed

Road Network

Zones – Travel From/To
Walk Links – Travel to/from stops/stations
Nodes – Bus stops/Stations
Link File – Transit Travel Time/ Fares
Route File – List of stops running to/
and Headway

Public Transport Network

From Zone – To Zone – No. Trips

Trip Matrix by Mode

Typically a 4 step process is followed

Trip Generation

- Take population data and work out number of trips from
- Take employment data and work out number of trips to

Trip Distribution

- Work out where trips go from and to
- E.g. Gravity Model

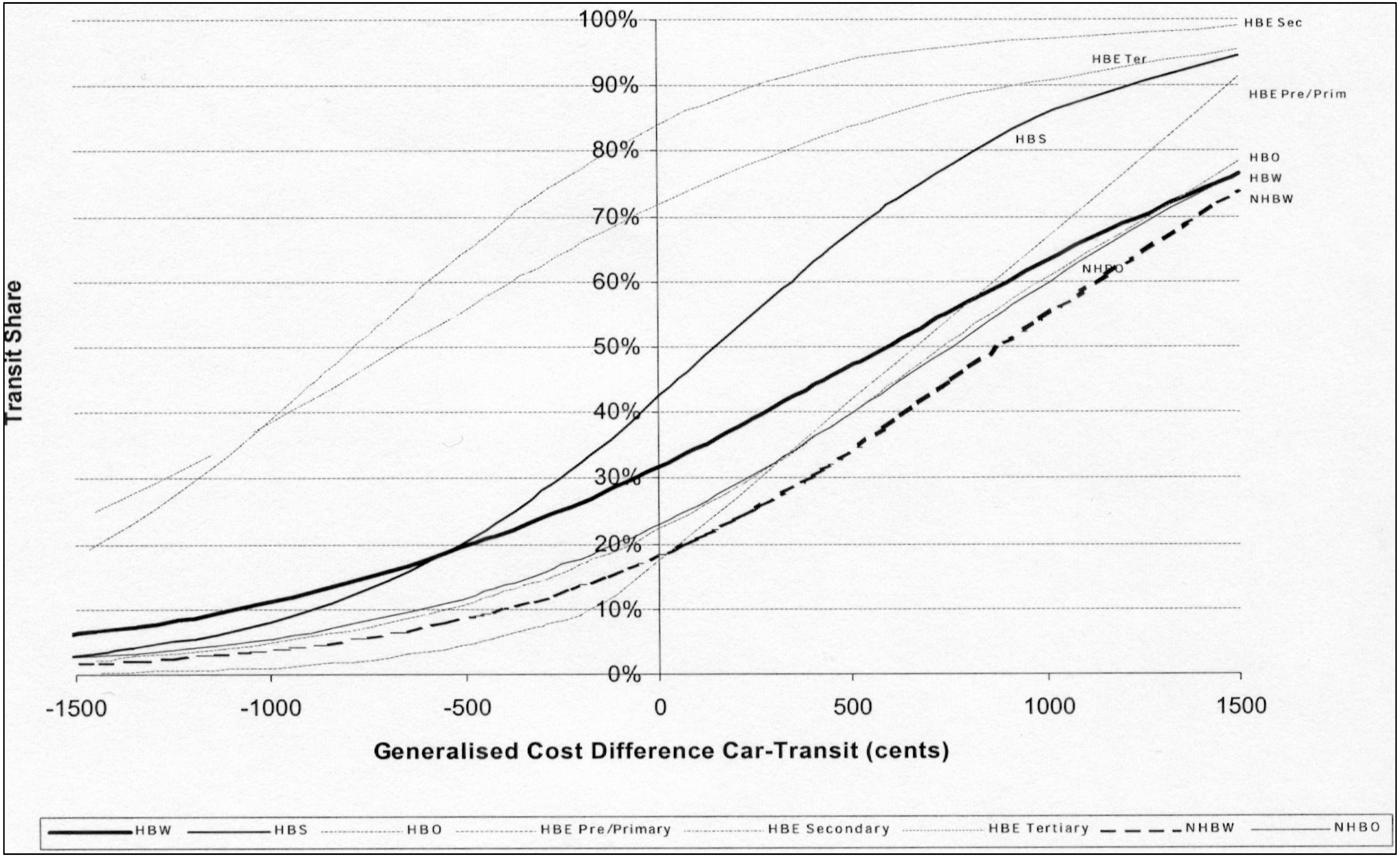
Mode Split

- Split trips into modes used using total generalised cost utilities or skims

Trip Assignment

- Allocate travel onto specific routes and services (or roads)

Whats called a logit curve in the Mode Split stage is the key driver of transit – other mode decision processes



Overview of Endogenous Forecasting Approaches

BENCHMARKING	• Use of Service Effectiveness Performance Measures e.g. BVK • Very Broad Brush – for changes in PT service quantum
ELASTICITIES	• Use of simple elasticity values • Covers a wide area of service issues (price, wait time, reliability, in vehicle travel time etc)
GENERALISED COST MODELS	• Valuation of passenger perceptions of travel including fare • Adoption of a TGC elasticity • Mode Specific Factors • Soft variables
ADVANCED METHODS	• Network modelling – 4 step models • Logic Curves

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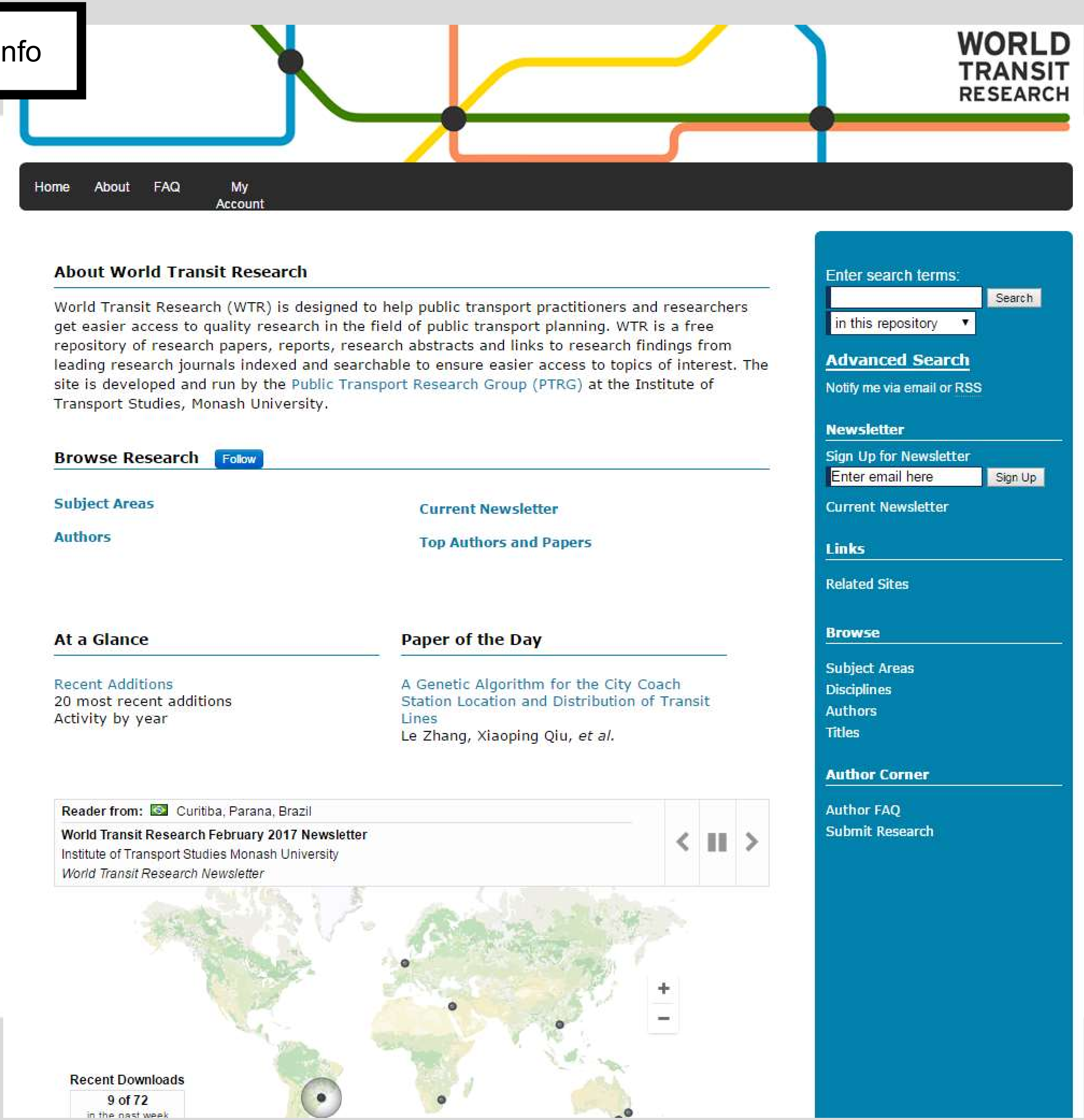

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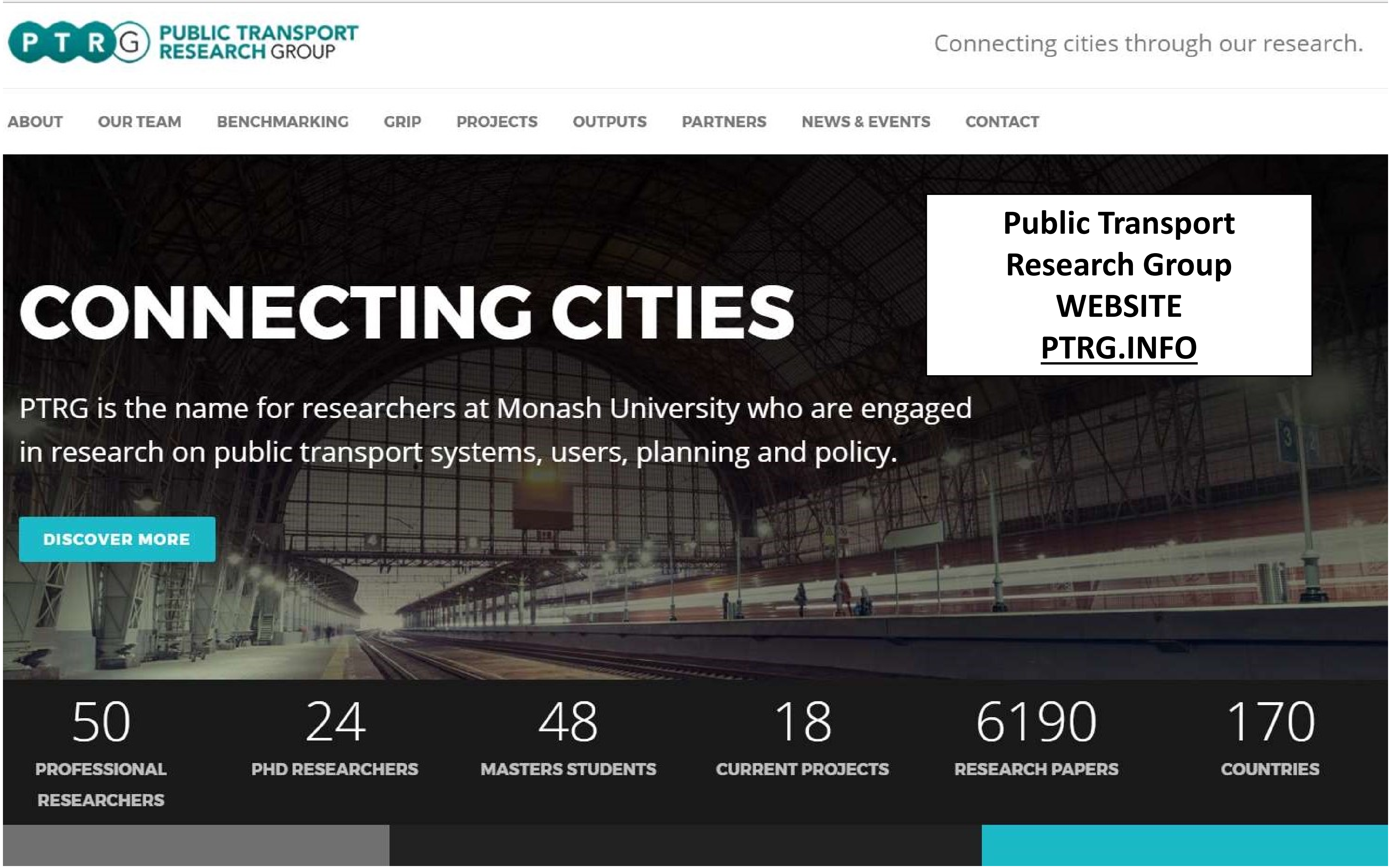

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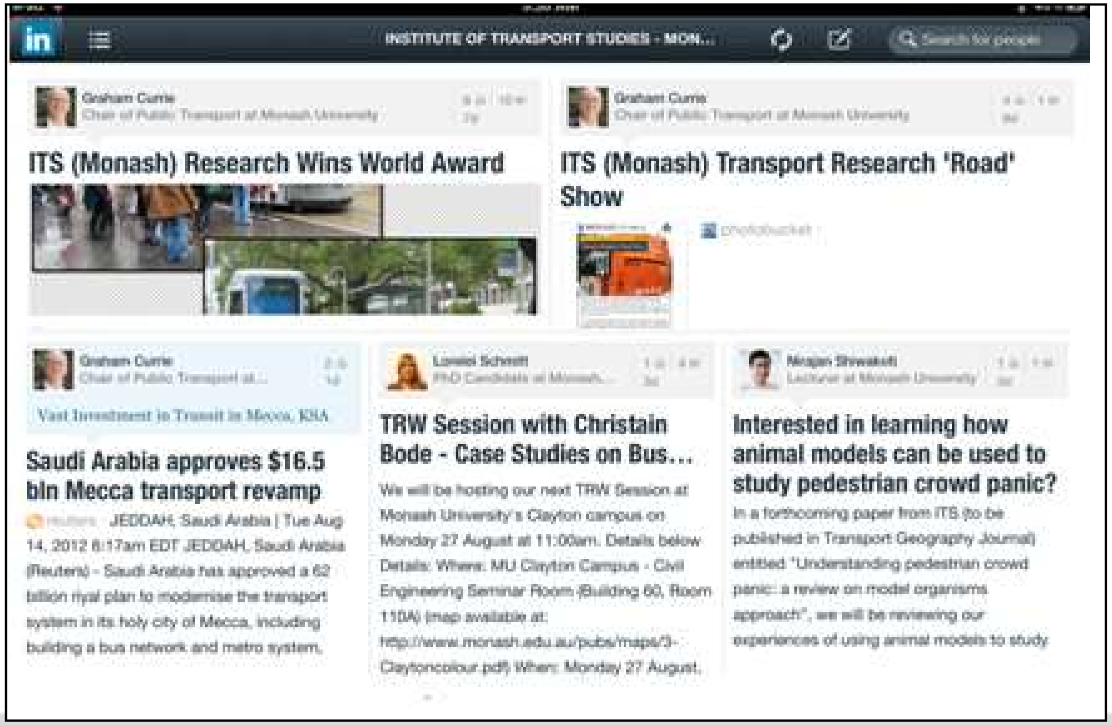
Join the **ITS (Monash)** LinkedIn group to keep informed of our activities



INSTITUTE OF TRANSPORT STUDIES - MON...

Graham Currie
Chair of Public Transport at Monash University

ITS (Monash) Research Wins World Award

Graham Currie
Chair of Public Transport at Monash University

ITS (Monash) Transport Research 'Road' Show

Graham Currie
Chair of Public Transport at...

Vast Investment in Transit in Mecca, KSA

Saudi Arabia approves $16.5 bln Mecca transport revamp

reuters · JEDDAH, Saudi Arabia | Tue Aug 14, 2012 8:17am EDT JEDDAH, Saudi Arabia (Reuters) - Saudi Arabia has approved a 62 billion riyal plan to modernise the transport system in its holy city of Mecca, including building a bus network and metro system.

Loreiei Schmitt
PhD Candidate at Monash...

TRW Session with Christain Bode - Case Studies on Bus...

We will be hosting our next TRW Session at Monash University's Clayton campus on Monday 27 August at 11:00am. Details below Details: Where: MU Clayton Campus - Civil Engineering Seminar Room (Building 60, Room 110A) (map available at: http://www.monash.edu.au/pubs/maps/3-Claytoncolour.pdf) When: Monday 27 August.

Nirajan Shiwakoti
Lecturer at Monash University

Interested in learning how animal models can be used to study pedestrian crowd panic?

In a forthcoming paper from ITS (to be published in Transport Geography Journal) entitled "Understanding pedestrian crowd panic: a review on model organisms approach", we will be reviewing our experiences of using animal models to study

INSTITUTE OF TRANSPORT...

Group Discussions

Graham Currie
Vast Investment in Transit in Mecca, KSA

Nirajan Shiwakoti
Interested in learning how animal models can be used to study pedestrian crowd...

Loreiei Schmitt
TRW Session with Christain Bode - Case Studies on Bus Priority

Graham Currie
ITS (Monash) Research Wins World Award

Graham Currie
ITS (Monash) Transport Research 'Road' Show

Alexa Delbosc
World Conference in Transport Research abstracts accepted

Graham Currie

Graham Currie
Chair of Public Transport at Monash University

ITS (Monash) Research in the New York Times

Guys I have made a direct attchment of Geoffs piece in the New York Times; Team - FYI linking a newspaper article directly improves its look on LinkedIn but can only be done on first post of the discussion, not commenting on an existing one.

ITS (Monash) Research in the New York Times

nytimes.com · AUSTIN, TEXAS - Kelly Hunka tried out an electric bicycle for the first time last week. Hours later, she was back for another ride. "These are so cool," Ms. Hunka, who works for an Austin technology company, said as she paced...