2. TRANSPORT DEMAND ELASTICITY

Readings for Lecture 2

Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., ... & White, P. (2006). The demand for public transport: The effects of fares, quality of service, income and car ownership. Transport Policy, 13(4), 295-306.

Learning Outcomes

- The importance of an understanding of elasticity of demand
- Three main types of elasticity of demand
- The major determinants of price elasticity

2.1 Elasticities

Main demand factors

Increase in Demand from $D_T(p_T)$ to $D_T''(p_T)$ Due to:	Decrease in Demand from $D_T(p_T)$ to $D_T'(p_T)$ Due to:
Increase in income	Decrease in income
Increase in population	Decrease in population
Decrease in price of complements	Increase in price of complements
Increase in price of substitutes	Decrease in price of substitutes
Decrease in taxes on T	Increase in taxes on T
Increase in preferences for T	Decrease in preferences for T

Elasticity

Elasticity of demand is the responsiveness of demand to a change in one of its determinants

Price elasticity

$$\text{Price elasticity of demand} = \frac{\text{Percentage Change in Quantity Demanded}}{\text{Percentage Change in Price}}$$

Determinants of price elasticity

- The number and closeness of alternative modes of travel (substitutes)
- Proportion of disposable income spent on the mode of travel
- Time dimension

Price elasticity of demand estimates of passenger transport

	Elasticities	
	Peak	*Off Peak*
Car	0.10–0.70	0.20–1.10
Bus	0.10–0.70	0.10–1.10
Railway	0.20–0.40	≤ 1.00
	Leisure	*Non-leisure*
Airlines	1.10–2.70	0.40–1.20
Railway	1.40–1.60	0.60–0.70

Source: Oum, *et al.* (1990)
Note: All the figures are negative

Price elasticities

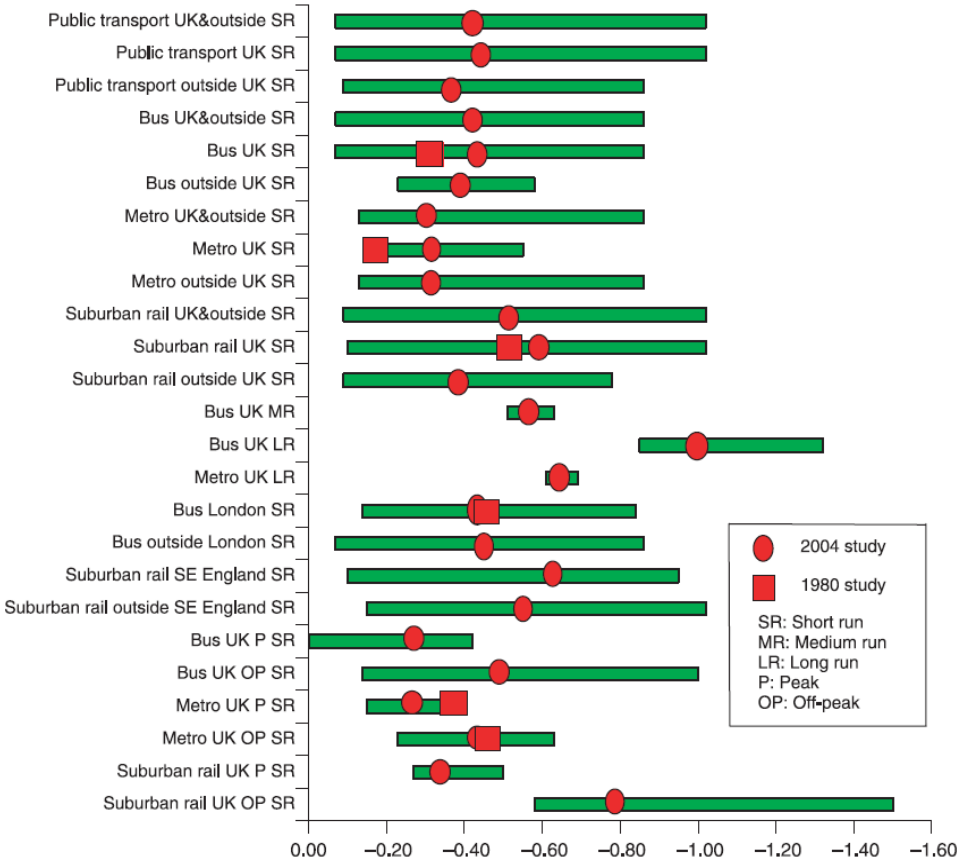

Fig. 1. Summary of mean values and ranges of fare elasticities.

Cross price elasticity

Cross price elasticity = Percentage change in quantity demanded of service A/Percentage change in price of service B

Cross price elasticities intercity passenger transport demand in Canada, mid range values, Oum and Gillen (1983)

Mode	*Air*	*Bus*	*Rail*
Air	–	−0.015	0.025
Bus	−0.085	–	−0.340
Rail	0.295	−0.675	–

Source: Adapted from Oum *et al.* (1990)
Note (again) that quantity A is shown on the rows.

Estimates of cross-elasticities of transport demand

Modes	*Cross-elasticity*
Rail-Truck (freight)	–0.18 to +0.50
Truck-Rail (freight)	–0.62 to +0.84
Rail-Waterway (freight)	+0.15 to +0.20
Waterway-Rail (freight)	+0.61 to +0.86
Air-Bus (passenger)	–0.02 to –0.01
Bus-Air (passenger)	–0.12 to –0.05
Air-Rail (passenger)	+0.01 to +0.04
Rail-Air (passenger)	+0.08 to +0.51
Bus-Rail (passenger)	–0.47 to –0.21
Rail-Bus (passenger)	–1.18 to –0.17

Data source: Oum, *et al.* (1990)

Income elasticity

Income elasticity = Percentage change in quantity demanded/Percentage change in income

South East Britain income rail elasticities (2002)

Area	*Income elasticity*
South East to London	2.07
London to South East	1.90
South East Non London	0.89
Non London	0.11

Source: ATOC (2002)

Historical income and price elasticities

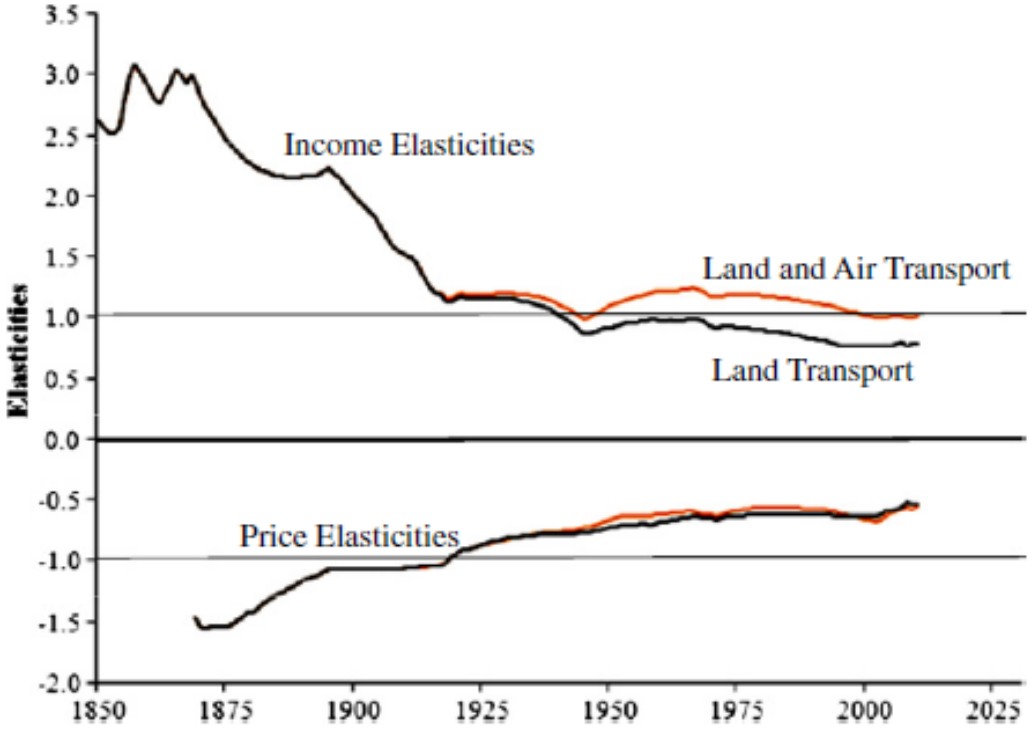

Fig. 5. Income and price elasticities for passenger transport demand, 1850–2010.

Fouquet, R. (2012). Trends in income and price elasticities of transport demand (1850–2010). *Energy Policy*, *50*, 62-71.

2.2 Exercises

Basics

1. Is the price elasticity of demand for airline industry in short-haul markets more or less than long-haul markets? Why?
2. What are the factors that influence the elasticity of demand for pilots?
3. Suppose the income elasticity of demand for good is -4. Is this good a normal good or an inferior good? If it is a normal good, then is it a luxury or a necessity? Why?
4. With changes in fuel prices what kind of effects should we see in the market for travel?

Elasticity values

1. Various studies indicate that the price elasticity of demand for automobile usage lies above –0.5 (that is, below 0.5 in absolute value). What does this say about the potential success of policies designed to reduce urban congestion by monetary disincentives?

2. The price elasticity of demand for Amtrak, the US rail passenger service, among vacation travellers has been estimated as –1.20. Given that Amtrak faces the market demand for rail passenger trips, what effect will a 15% increase in fares have upon market demand? What effect will the fare increase have upon revenues?

Demand estimations

According to demand theory, the market demand curve for transportation is downward-sloping.

- You are a transportation economist for rail operator and you are asked to estimate the price elasticity of demand for rail services. Describe in some detail what steps you would follow to obtain the price elasticity of demand.
- Suppose that your analysis found that the price elasticity of demand for rail services was –0.78. What impact would a 10% increase in price have upon the quantity of Amtrak services demanded? Do you know whether revenues would rise or fall?

Logit model

Suppose, in a binary logit model, that the “own-” and “cross-” price elasticities of demand for mode “a” are –0.34 and +0.15 respectively. Interpret these numbers.

1. What is the effect on the demand for mode “a” of a 15% increase in its price? Does this represent a change in demand or a change in quantity demanded?
2. What is the effect on the demand for a mode “a” when the price of mode “b” increases by 15%? Does this represent a change in demand or a change in quantity demanded?

Advanced exercise (1)

This is a totally artificial exercise; however, it is designed to try to get you to think about own price, cross price and income elasticities. Presented below are some completely hypothetical passenger figures for public transport services in a hypothetical city somewhere near you!

Advanced exercise (2)

Transport mode:	Rail	Bus	Underground	Total
Annual usage (millions):	38	90	23	151

For this hypothetical public transport market, the following elasticities apply:

		Rail	*Bus*	*Underground*
Income elasticity of demand:		0.41	–0.50	0.32
			Price	
Own & cross price elasticities		*Rail*	*Bus*	*Underground*
Quantity	Rail	–0.45	–0.40	–0.30
	Bus	0.08	–0.40	0.10
	Underground	0.02	0.05	–0.20

Note: modes listed on rows relate to the quantity change in demand, those listed in columns relate to change in price

Advanced exercise (3)

Using all of these values you should be able to answer the following questions – as a side note, if you have the necessary skills you may find a spreadsheet useful to assist with this exercise.

1. If there is a 5 per cent rise in income, what would be the new daily modal splits and the new total daily usage?
2. Using your answer for the new total daily usage from part (a), what is the overall income elasticity to travel?
3. How does your answer from part (b) compare with the results presented in Case study 3.1 in Chapter 3 and what might be the reason for any such differences? (Hint: you will need to calculate a rough elasticity from the values presented in the case study.)

Advanced exercise (4)

4. Calculate the effect on modal splits and the new monthly usage of the impact of the following factors (each should be considered on its own) and from your answers highlight which modal fare has the largest impact on the overall demand for travel in this city.
    a) a 15 per cent increase in the level of rail fares
    b) a 15 per cent increase in the level of bus fares
    c) a 15 per cent increase in the level of underground fares
5. What might be expected to happen to the cross price elasticity of the train across all other modes if the level of rail travel was to significantly increase? Why would this happen?
6. Roughly speaking, why have we got the answers that we have got for part c and what does this underline with regard to own and cross price elasticities of public transport services?

2.3. The demand for gasoline

based on McCarthy (2001); Chapter 3

Background

- 94% of all motor vehicle trips in USA were taken in private transportation
- 80,7 % of total intercity travel was done in passenger cars
- 45,7 % of all petroleum consumption is by personal cars

Research question

- Given the dominance of motor vehicle travel in the USA, are consumers sensitive to changes in its price?
- In the 1993 national budget discussions, there was a considerable interest in raising the gasoline tax, both for its effect on deficit reduction and for its potential in reducing urban congestion and pollution.
- Holding all else constant, an increase in the federal gasoline tax is expected to reduce the quantity of gasoline consumed. But by how much? Is the demand for gasoline price elastic or price inelastic?

Research question

- A related question concerns governmental policy that alters the manner in which gasoline is allocated.
- By the mid-1970s, price controls on oil were still in effect.
- Because price controls prevent the monetary price of gasoline from rising, what impact did the price controls have on the opportunity cost of gasoline when the 1973-4 oil crisis hit?

The demand for gasoline in California

To answer these questions, the demand for gasoline must be estimated. In a study on monthly gasoline demands and automobile travel in California, Lee (1980) assumed the market demand for gasoline in California, G_t, to be:

$$G_t^0 = \beta_0 + \beta_1(\text{Real Gas Price})_t + \beta_2(\text{Real Income})_t +$$
$$+ \beta_3(\text{Population})_t + \sum_{t=1}^{11} \psi_i S_{ti} + \tau_1 \text{DEC73} +$$
$$+ \tau_2 \text{JAN74} + \tau_3 \text{FEB74} + \tau_4 \text{MAR74} + \tau_5 \text{APR74} + \varepsilon_t$$

Hypotheses

(1) By the law of demand β_1 is expected to be negative

(2) Each of the gasoline crisis variables reduces the consumption of gasoline, all else hold constant

(3) Estimated effect of gasoline crisis on the opportunity costs of gasoline is positive

(4) Gasoline is a normal good $\rightarrow \beta_2 > 0$

(5) $\beta_3 > 0$

Estimation results

Dependent variable – average daily consumption of gasoline per month ('000s)

Explanatory Variable	Coefficient Estimate	*t*-statistic
Constant	–25,193.1	–3.38
Real Gasoline Price ($)	–18,552.8	–5.34
Real Income (billion $)	277.3	6.29
Population (millions)	1,567.9	2.92
DEC73	–1,801.5	–2.84
JAN74	–1,629.7	–2.57
FEB74	–2,313.1	–3.60
MAR74	–2,524.1	–3.88
APR74	162.7	0.25
$R^2 = 0.92$		

Source: Lee (1980), table 2, p. 40. Lee did not report the coefficient estimates for the seasonal dummy variables

Demand curve

Hypothesis 1

- Estimated coefficient for β_1 is negative and significant → downward slope of demand curve.
- 95 % confidence interval for β_1 is (-25,8; -11,3)

Hypothesis 2

Because of the increased time cost, brought on by the gasoline crisis, average daily consumption fell by 1,8 million gallons.

Change in the demand

Hypothesis 3

Given that average daily consumption was approximately 25 million gallons, the results indicate that in march 1974, the gasoline crisis resulted in a 10% reduction in gasoline consumption.

Hypothesis 4

A 1 billion dollar increase in real personal income leads to a 277000 gallon increase in average daily gasoline consumption.

Hypothesis 5

Additional person increases daily demand by a bit more than one and half gallons per day.

Elasticities

The price elasticity of demand is defined as:

$$\frac{\Delta G/G}{\Delta RPG/RPG} = \frac{\Delta G}{\Delta RPG}\frac{RPG}{G} = \beta_1 \frac{RPG}{G}$$

- Replacing β_1 with 18,552 and RPG and G with their respective sample means, Lee calculated the gasoline price elasticity of demand to be –0.216 → the demand for gasoline is inelastic.
- The data are monthly, covering five year period, the rice elasticity is short run. Long run price elasticity of demand are considerably higher and have been estimated to be around -0.8.
- Employing a similar procedure, the income elasticity of the demand for gasoline was calculated to be 0.876 → gasoline is a normal good.

Queuing cost premia

- What was the queuing cost associated with the gasoline crisis?
- From estimation results, an estimate of queuing prices for each month of the crises can be obtained by dividing the month's coefficient by β_1.
- Table reports these estimates which are positive and consistent with hypothesis 3.
- The queuing cost represent a significant portion of the total opportunity cost.

	December 1973	January 1974	February 1974	March 1974	April 1974*
Monetary	31.3	32.4	32.6	35.7	36.7
Time price	9.7	8.8	12.5	13.4	–
Opportunity cost	41.0	41.2	45.1	49.1	36.7

* A time price for April 1974 was not calculated because the price shock coefficient for this month was not significantly different from zero.
Source: Lee (1980), table 4, p. 41

The demand for trips

Dependent variable – average daily trips during each month ('000s)

Explanatory Variable	Coefficient Estimate	*t*-statistic
Constant	–1,211.080	–7.51
Real Gasoline Price ($)	–370.235	–4.93
Real Income (billion $)	4,578.8	4.80
Population (millions)	65,660.1	5.66
DEC73	–20,744.1	–1.51
JAN74	–20,841.2	–1.52
FEB74	–51,063.3	–3.68
MAR74	–87,070.6	–6.19
APR74	–6,221.3	–0.44
$R^2 = 0.97$		

Source: Lee (1980), table 2, p. 40. Lee did not report the coefficient estimates for the seasonal dummy variables

The demand for gasoline x trips

- The impact of price, income and population was same and significant.
- However gasoline crisis variables were stronger in demand for gasoline than for trips. Why?
- We would expect demand for trips to be less responsive to gasoline price increases than for gasoline because, in the shirt run, there re more substitution opportunities for reducing fuel than for reducing the number of trips.

The 1993 gasoline tax increase

- According to the 1993 Deficit Reduction Bill, passed in late 1993, the federal gasoline tax increased by 4.3 cents per gallon. With average per gallon price equal to USD 1.06, this represents an approximate 4% increase in the 1993 real price of gasoline.
- The above results found price elasticity of demand for gasoline to be – 0.216 and for trips -0.236.
- The federal gasoline tax increase can be expected to have reduced the quantity of gasoline demanded by 0.86% and average daily trips by 0.94%.
- At the national level, this translates into a 1.74 million gallon daily reduction in the demand for gasoline and 5.68 fewer automobile trips per day.

Comments

- A potential deficiency of the model is the lack of information on relevant alternatives. Economic theory tells us that demand depends on price of substitutes.
- Is this important? Possibly, but not necessarily.

2.4 Summary

Summary

- Price elasticity = Percentage change in quantity demanded/Percentage change in price
- Cross price elasticity = Percentage change in quantity demanded of service A/Percentage change in price of service B
- Income elasticity = Percentage change in quantity demanded/Percentage change in income

Readings for Lecture 3

- Buehler, R., & Pucher, J. (2012). Demand for public transport in Germany and the USA: an analysis of rider characteristics. *Transport Reviews*, *32*(5), 541-567.