The Price of Travel Time for Household Activities: A Theoretical Insight

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The value of travel time is one of the main elements in determining investments decisions in transport infrastructure, and the main element of congestion costs. It accounts for 40-50% of total costs in the decision to invest in transport infrastructure, and 70-80% of total congestion costs.

Various studies have developed estimates of travel time: different users and travel conditions, waiting as well as actual travel.

The general consent is that people have fixed travel time budgets. However, there is no simple answer on how to measure travel time.

The value of travel time: 40-50% of the average wage
The question: *Pricing Travel Time*

- **Method**
  - Revealed preferences
  - Discrete choice modelling
  - Meta-analysis of elasticities

- **Links**
  - Labour supply theory
  - Prospect theory

- **Main message**
Travel Time in Non-market Activities

- Assume that the Supply of Transport Infrastructure is Fixed
- Assume that the supply of labour time to market activities is fixed

- The modes of travelling are:
  - time-intensive and
  - capital-intensive commodities
    - The market and the household supply of time- and capital-intensive commodities for travelling is fixed

- The price is given by the determinants of Demand
Given the consumers’ fixed budget of time (and income) constraints
- Demand for time-intensive and capital-intensive commodities

Disaggregate Demand between high- and low- skilled consumers
- Expect high-skilled consumers to increase consumption of capital-intensive commodities
  - Time-intensive commuting decreases relative to capital-intensive commuting
Expect their share of expenditures on travelling (commuting) to decrease relative to total expenditures (and income)
- Price elasticity of demand
- Income elasticity of Demand

If not then time dispersion affects price and income elasticities
- purchasing power decreases relative to the market
  - the value of time and money decreases relative to the market
  - Implications for measuring the willingness to pay
- Model to be tested
Estimates of Travel Time for Women
Melbourne, 1991-2006

Travel time for household activities increased by 2.02 hours.
Some labour supply Elasticities

- For Australia, we have estimates for the *uncompensated* wage elasticities.
  - the own-wage elasticities of labour supply, which also represent the uncompensated demand for goods and services.

- For single women, the estimate is of about + 0.34,
- for married women, the estimates range from + 0.23 to + 0.55
- For women high-income earners: + 0.20 and + 0.39
- and for low-income women: + 0.25 to + 0.55

- This means that their labour supply is (price) inelastic: there is little change in hours of work for a given change in the wage rate.
Transport elasticities

- Elasticities are functions with several possible variables, including the type of market, type of consumer and time period.
- In general, narrowly defined transport is more elastic than broadly defined transport, because consumers have more alternatives.
- Most individual price components are considered inelastic because they each represent a small portion of users total costs.

- For example: The elasticity of vehicle travel with respect to fuel price depends on
  - the type of trip (commercial, commute, recreational, etc.),
  - the type of motorist (rich, poor, young, old, etc.),
  - travel conditions (rural, urban, peak, off-peak),
  - and the time period being considered (short-, medium- or long-run).
  - Generally between 0 and 1
Method

- **Demand**

Utility is a function of a minimum quantity of time consumed in travelling for household activities and a minimum amount of income to buy travel time.

- **The model:**

\[ U_i = (X_i + C)^a Y_i^\beta, \quad i = 1,\ldots,n \quad a, \beta > 0 \]

- \( X_i \) is the individual i’s demand of time for household commodities (including travelling),
- \( Y_i \) is the demand for market commuting commodities
- \( C \) is a shift parameter and is positive.
  - \( C \) can either represent i) the constant ratio of total time to travel time (time-budget for household activities)
    - at the recreation-endowment point (given the fixed supply of transport infrastructure);
  - or ii) a constant cost-share of net earnings.
- Substitution between household and market commodities is limited.
Income elasticity

- Y is a necessary good for all individuals
  - As education (income) rises, Y becomes less of a necessary good, but will remain a necessary good for all individuals

- The income elasticity for market commuting commodities Y is < 1: necessity
  - The effect of increasing education (income) is positive

- X is a luxury

- The income elasticity for household commodities X (including travelling) is a luxury by all individuals
Income elasticity of demand for travel time
Price elasticity

- In the usual Cobb-Douglas specification, the price elasticity of demand for commuting would be unity.
- Here, the price elasticity of demand for $X > 0$.
  - The demand for household commodities (including commuting) is elastic.
  - This feature of demand drives the results.
The demand for household commodities X (including commuting) is price elastic for all individuals regardless of income level.

As education (income) rises, the price elasticity of demand for commuting decreases (in absolute value).

- The demand for travel time of high-skilled (high-income) individuals is price inelastic relative to the demand for travel time of low-skilled (low-income) individuals.

The price elasticity of D for Y is -1
- Does not vary with education (income)
Price elasticity of demand for household travelling (commodities)
Summary

- Demand for X is price elastic (luxury)
  - Income elasticity >1
    - as income (education) increases the effect on income is negative
    - From > 1 to 1

- Demand of time for Y is price inelastic
  - The income elasticity of Y is < 1
    - as income rises Y becomes less of a necessity but still unit-elastic

- Rising time inequality
  - lowers the price elasticity of Y (in absolute value)
    - high-income earners are assumed to get richer in terms of money and time.
    - As a result, the equilibrium price rises.
An increase in dispersion increases the equilibrium price of X.
Dispersion decreases the aggregate demand of time for X and increases the aggregate demand of income for Y.

With increasing time inequality, in the aggregate, fewer people are able to meet, simultaneously, both the minimum time and money requirements.

This means that only by holding i) the (quantity of) services from transport infrastructure constant, and ii) the quantity of hours at work constant, the price of Y equals the price of X:
- travel time for household travelling = market travelling
- Only then purchasing power holds
Conclusion

- I focus on high- and low- skilled women to investigate how a change in the ratio of labour endowment to actual labour supply affects the demand of time for commuting.
  - The general increase in the average hours of work in the market, increase inequalities in the distribution of time (and income) for household activities, including travel time.

- The inequality of the distribution of time affects the price elasticity of demand for travel time, and therefore equilibrium price.

- As inequality (time) rises, the market demand for travel time becomes less price elastic.
  - If for high-income earners the demand of travel time for household activities is price-inelastic, time for paid work will not decrease for every increase in the wage rate.

- To price travel time we need to consider the price as well as income elasticity of demand.
While we generally believed that the excess demand for travel time (and hence for transport infrastructure and modes), is the result of a sub-optimal equilibrium market price
- and hence, that either the price should be higher, or that taxes should be introduce to reallocate the costs,

- in this paper I argue that this ‘excess’ demand is the result of a price inelastic demand (negative income)
  
  - A decreased value (purchasing power) of the consumers’ travel time budget relative to the market value of the budget,
  - as we do not include travel time and recreation time as a necessity.
  - This lack of acknowledgment leads to an underestimation of the costs (relative to the benefits) for consumers.
Thank you
To note also that in this paper I distinguished between the gross- and the net-demand for travel time.

That is, I considered the net demand of consumers, given by high- and low-skilled consumers.

However, the gross demand would also include producers (or sellers) of time.

Future research will extend this analysis to focus on the effect of ‘sellers’ on the price of travel time.
Demand

Net Demand

Gross Supply

Net Supply

ND

X

P

(a)

P

S

D

ω

α

Gross Demand

X

P

NS

X

(b)

(c)
The symbol $\alpha$ signifies the efficient price (of services) given the endowment of infrastructure and of time to work and to travel (budget).

That is, $\alpha$ on the net demand curve signifies the willingness to buy.

- Not in the literature
- Implications for
  - Price elasticities and
    - Cross-price: time-intensive and capital-intensive commodities
    - Luxuries, necessities and normal goods
    - Incentives .... excess demand
- It is the maximum price at which the consumer is willing to pay in order to buy services.
While α on the net supply curve signifies the willingness to sell.

It is the minimum price the consumer is willing to sell his/her services (time) for work.

The gross demand represents total expenditures (work and non-work).

- The gross supply represents the total earnings (income).
Consumers as buyers, to be better off, their consumption of X must be to the right of the endowment point

- They must remain net buyers (ND) of X
Firstly, it is because an increase in inequality has the direct effect of lowering income levels for some people. Specifically, for those who met the minimum income requirement marginally, a decrease in income to less than the requirement will mean that they can no longer afford to consume time in recreation and market time saving goods. Secondly, an increase in inequality increases the equilibrium price of time for household activities relative to market activities, which also increases the minimum income and time requirements. This is an indirect effect that exacerbates the problem just described. With fewer people able to meet the minimum requirements, aggregate demand of time for household activities will decrease.
If the average hours of travel time for household activities increases while the time allocated to household activities (and recreation), decreases, then the value of the initial budget of travel time decreases relative to the market value of time ($w_0 < w_i$). As $w_0$ represents also the value of travel time in the market, at the given supply of transport infrastructure (services), then the value of travel time for household activities is also decreasing relative to the market value of time. Hence, the value of time from consuming capital intensive commodities decreases relative to the market value of goods. The market value of time intensive commodities decreases with respect to the market value of time. The commodity X becomes more (than expected) capital expensive, as the value of time decreases relative to the price of market goods; and Y becomes more (than expected) time expensive, relative to the market price of time.
As high-skills consumers allocate more time to work, relative to household work, than low-skills people, their income is high, but their quantity budget of time for travelling is lower relative to their income. However, as time-saving goods become more expensive, their demand for those (time) becomes price inelastic (time for travelling becomes a necessity). Low-skills individuals, allocate more time to household work, relative to market work, but the value of their budget decreases relative to the market value of time, so that their price elasticity of demand for time is also price inelastic (the money-budget for travelling becomes a necessity). Both cases display a negative income elasticity of demand for commuting.
Endowment of Infrastructure and of time services is fixed at $\omega$.

- 2 goods to consume
  - Public good and modes

Consumers’ WTP is at $\alpha$

- Where the consumer decides to be a net buyer or a net seller of X
Preferences represent the willingness to pay.
- Utility is a way to describe preferences.

The marginal rate of substitution is where the consumer’s marginal willingness to pay equals the market exchange rate.
- the wage rate, or the marginal rate of substitution between leisure and consumption.

If we consider it a discrete choice, we can see that their consumption
The consumption ratio approaches the Cobb-Douglas ratio
In this paper I want to show that the elasticity is low even for necessity.

But only if there is a budget:
- Value input and value output
- MC supply of inputs: expenditures to produce output: commuting and speed (commodities) and purchasing power
- Hence: revealed preferences
- WTP value of the endowment

An endowment and hence substitution of time and money between consumption and ... leisure is limited.

Hence question the MRS

How to argue for an endowment?

Elasticities: ... but no income elasticity

In labour supply: ... everyone worse off

This is the reason why I re-consider the WTP and distinguish it between ...
The value of travel time is one of the main elements in determining investments decisions in transport infrastructure, and the main element of congestion costs. It accounts for 40-50% of total costs in the decision to invest in transport infrastructure, and 70-80% of total congestion costs.

Various studies have developed estimates of travel time: different users and travel conditions, waiting as well as actual travel.

The general consent is that people have fixed travel time budgets. However, there is no simple answer on how to measure travel time.
The Equilibrium point between Fixed Gross Supply and Aggregate Demand represents the Willingness to Pay

- Demand in the presence of an endowment (Varian, 1996)
- Given that Leisure is a normal good

We need to Investigate only the determinants of the Net Demand for Non-Market Travel Time
The consumers’ willingness to pay reflects the value assigned to non-market travel time.

It includes the costs of personal (unpaid) time spent travelling.

Personal travel time (unpaid private travel time) is valued at 40% of seasonally adjusted full time average weekly earnings for Australia, assuming a 38 hour week.

- Full time ordinary time earning in 2008 in Australia were about $29.00 per hour assuming a 38 hour week.
- 40% of $29.00 per hour is about $12.00/person-hr.
- Used in the valuation of private car travel to and from work, recreational travel, motor cycle travel, bicycle travel, pedestrian travel, waiting time, public transit passenger travel and tourist/recreational travel.
The cost of travel is assumed to be a small proportion of income; hence, it is price inelastic. However, a necessity has also a price inelastic demand. Can luxury become a necessity?

1) It depends on the assumptions made about the endowment of time and money for commuting.

2) And the position of consumers on the aggregate demand for commuting.
Married women according to types of jobs: full-timers the elasticity is between + 0.05 and + 0.13; in the presence of children: + 0.25 and + 0.33; with older dependent children: + 0.32. For part-time married women with no children is + 0.56, with young children + 0.86 to + 1.05, with older children + 0.13