DYNAMIC MODELLING APPROACHES
AND
EMPIRICAL EVIDENCE

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Why Dynamic Modelling?
Response to changes in transport supply, prices, policy and socio-economic factors is not instantaneous but occurs over time.

Adjustment possibilities limited in the short run
• costs of adjustment
• imperfect information & expectations
• current circumstances & commitments
• habit & resistance to change

Greater flexibility in the long run, so the response will build up over time

Long-run effects > short-run effects

Advantages of Dynamic Modelling
• describes changes in travel behaviour
• captures both short- & long-run relationships
• gives information about the time scale of effects
• can analyse effects of factors which vary little at one point in time - e.g. prices
• can accommodate asymmetry, the influence of habit, or expectations
Dynamic Modelling Approaches

Basic requirements:
• model must relate current demand to past or future values of explanatory variables

Commonly used models:
• Partial adjustment model: relates demand to explanatory variables and demand in previous period
• Error-correction model: relates change in demand to changes in explanatory variables and levels of all variables in previous period

Partial Adjustment Model

Long-run (desired) demand: \( Q^* = \beta x \)

Assume: a proportion (\( \delta \)) of the difference between actual and desired demand is closed each period

\( Q - Q_{-1} = \delta (Q^* - Q_{-1}) \)

Solving for \( Q \) and substituting for long-run demand

\( Q = \delta \beta x + (1 - \delta) Q_{-1} \)

Short-run effect: \( \delta \beta \)
Long-run effect: \( \beta \)

Error Correction Model

Long-run demand: \( Q^* = \beta x \)

Assume: change in \( Q \) depends on change in \( X \) (impact effect) and the deviation from equilibrium in the previous period (error correction mechanism)

\( Q - Q_{-1} = \gamma (X - X_{-1}) + \phi (Q_{-1} - Q^*) \)

Substituting for long-run demand

\( Q - Q_{-1} = \gamma (X - X_{-1}) + \phi Q_{-1} - \phi \beta x \)

Short-run effect: \( \gamma \)
Long-run effect: \( \beta \)
Choice of Model

Partial adjustment model:
• requires stationary variables, otherwise estimates inconsistent
• the response to all variables has the same lag structure

Error correction model:
• does not require stationary variables
• more general lag structure
In many cases, little difference between PAM & ECM

Data for Dynamic Transport Modelling

Longitudinal Data
- Panel Surveys
  - British Household Panel Survey
  - European Community Household Panel
- Aggregate Time-Series
  - National
  - Regional
- Repeated Cross-Section
  - Family Expenditure Survey
  - National Travel Survey

Empirical Evidence

Aggregate time-series (pooled cs-ts data)
- demand for local bus services

Repeated cross-section data (pseudo-panel)
- car ownership

Panel data
- choice of commuting mode
Local Bus Travel - Data

STATS100A - bus operator data provided to DfT
- vehicle miles, passenger journeys & receipts
- aggregated into 46 English counties
- 10 years: 1987 to 1996

Regional Statistics
- population
- disposable income

National Statistics
- motoring costs
- retail prices

Local Bus Travel: Model

- Pooled cross-section time-series model
- Dependent variable: bus journeys per capita
- Independent variables:
  - income per capita
  - service: bus kms per capita
  - bus fare: passenger receipts per journey
  - motoring costs
- Dynamics
  - PAM (ECM also used, results similar)
- County specific fixed effects

Local Bus Travel: Estimated Elasticities

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<th>LR</th>
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<tr>
<td>Income</td>
<td>-0.39</td>
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<td>Fare</td>
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<td>Service (Vkm)</td>
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<td>1.03</td>
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<tr>
<td>Time for 95% of LR effect</td>
<td>4.5 years</td>
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Car Ownership - Data

Family Expenditure Survey
- cars, socio-economic & demographic variables
- 14 years: 1982 to 1995
- 16 cohorts by year of birth of household head in 5-year bands

National Statistics
- car purchase costs
- car running costs
- public transport fares
- retail prices

Car Ownership: Model

- Pseudo-panel model
- Dependent variable: cars per HH (cohort mean)
- Independent variables:
  - household income (cohort mean)
  - number of adults & children (cohort mean)
  - % in rural/urban areas (cohort mean)
  - car purchase & running costs
  - public transport fares
- Dynamics: PAM
- Weighting: observations in each cohort-year
- Random effects & autocorrelated errors

Car Ownership: Estimated Elasticities

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<tbody>
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<td>Car purchase costs</td>
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<td>Car running costs</td>
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<td>Public transport fares(VKm)</td>
<td>(0.09)</td>
<td>(0.24)</td>
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<tr>
<td>Time for 95% of LR effect</td>
<td>6.3 years</td>
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elasticities calculated at middle income
Commuting Mode - Data

British Household Panel Survey
- individuals who travel to work in at least 2 consecutive years
- 11 years: 1991 to 2001
- over 37,000 observations
- 10,000 individuals
- average of 4 years per individual

National Statistics
- car purchase prices
- fuel prices
- retail prices

Commuting Mode: Model

- Binary Probit model
- Dependent variable = 1 if car; = 0 otherwise
- Independent variables:
  - socio-economic & geographic
  - company car
  - car purchase costs & motor-fuel prices
- Differences between men & women
- Dynamics (state dependence)
  - lagged dependent variable
- Unobserved heterogeneity
  - random effects for individuals
- Correction for attrition

Commuting Mode: Estimated Elasticities

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<tbody>
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<td>Income</td>
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<td>Car purchase costs</td>
<td>-0.20</td>
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<td>Fuel price</td>
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<td>Time for 95% of LR effect</td>
<td>6 years</td>
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Conclusions

• Significant dynamic effects in all empirical studies
• Long-run elasticity more than 2x short-run
• Adjustment is slow: 95% of total effect takes between 4 and 6 years
• Use of static elasticity will either under- or over-estimate effects of changes in prices etc at a given point in time
• Forecasts based on static demand model will be inaccurate

References

Commuting mode

Bus Travel

Car ownership