Moving towards modal shift in TIMES

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Overview

• Motivation
  – Transport modelling & mode choice
• Conceptual model for modal shift
  – Spreadsheet model
  – Modal shift framework in TIMES
• Preliminary results
• Discussion & next steps

Motivation

• The transport problem
• Urban: Public transport vs. auto
• Regional: High speed rail vs. aviation
Motivation

• Urban congestion
  – frustration
  – longer travel times
  – lost productivity
  – accidents/insurance
  – fuel consumption
  – freight costs
  – air quality

Mode Choice

• Regional congestion
  – regional economic development
  – national productivity
  – competitiveness
  – environmental quality

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Motivation

Mode Choice

- Trip length →
- Mode choice →
- Occupancy →
- Technology →

Mobility

Person kilometers

Car PKT, Bus PKT, Train PKT

Car VKT, Bus VKT, Train VKT

Fuel/Vehicle CO₂, Fuel/Vehicle CO₂, Fuel/Vehicle CO₂
Motivation

Current TIMES structure

Fuel Input (e.g. Diesel)

Road Car Short Distance [PKT]

Road Car Long Distance [PKT]

Road Bus Urban [PKT]

Road Bus Intercity [PKT]

Train Passenger Heavy [PKT]

Train Passenger Light [PKT]

Motivation

Mode Choice

Trip length →

Mode choice →

Occupancy →

Technology →

Mobility

Person kilometers

Car PKT

Bus PKT

Train PKT

Car VKT

Bus VKT

Train VKT

Fuel CO₂

Fuel CO₂

Fuel CO₂
Transport modelling  Factors of mode choice

• Household composition
• Working/living location
• Gender and age
• Socio-economic status
• Education
• Quality and reliability of PT
• Travel time
• Availability

Conceptual model  Overview

• Exogenous Urban and Regional Passenger Kilometres Travelled (PKT) - D
• Cost of Time added to objective equation:
  – TTIME commodity an auxiliary input
  – Speed of each technology (s, in VKT/hr)
  – Value of time (€/hr)
• Disaggregate by income groups to give mode choice
• Travel Time Budget (TTB) for each income group a limiting “availability” of TTIME: 1.1 hr/day
Conceptual model

Formulation

Minimize

\[ C = \sum_{i,m} \text{PKT}_{i,m} \cdot c_{i,m} \]

such that

\[ \sum_{i,m} \text{PKT}_{i,m} = D ; \]

\[ \sum_{m} s_{m} \cdot \text{PKT}_{i,m} = TTB_{i} \]

\( i \) – income group  \( m \) – mode
\( C \) – overall cost
\( c_{i,m} \) – fuel, investment & time cost per PKT
\( s_{m} \) – speed by mode, hrs/pkm
\( D \) – overall PKT travel demand (modelled exogenously)
\( TTB_{i} \) – travel time budget (hrs)

Cost per PKT

- Cost per PKT: \( c_{i,m} = f c_{m} \cdot i c_{m} \cdot tc_{i} \)
  - Fuel cost: fuel price * fuel intensity / load factor
    \[ \frac{\text{\euro}}{\text{PKT}} = \frac{\text{\euro}}{\text{MJ}} \cdot \frac{\text{MJ}/\text{PKT}}{\text{VKT}/\text{VKT}} \]
  - Investment cost: Cost of vehicle / lifetime VKT / load
    \[ \frac{\text{\euro}}{\text{PKT}} = \frac{\text{\euro}}{\text{vehicle}} \cdot \frac{1}{\text{life VKT}/\text{VKT}} \]
  - Time cost: Time value / speed
    \[ \frac{\text{\euro}}{\text{PKT}} = \frac{\text{\euro}}{\text{hour}} \cdot \frac{\text{hours}/\text{PKT}}{\text{VKT}/\text{VKT}} \]
**Conceptual model**  Value of Time (VoT)

- Estimate that willingness to pay for time saving is 40% * hourly wage
  - Irish VoT by income deciles:

<table>
<thead>
<tr>
<th>Income deciles</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekly income (€)</td>
<td>165.3</td>
<td>243.7</td>
<td>285.9</td>
<td>338.8</td>
<td>412.2</td>
<td>483.7</td>
<td>582.7</td>
<td>688.2</td>
<td>864.2</td>
<td>1460.9</td>
</tr>
<tr>
<td>Hourly wage (€)</td>
<td>4.4</td>
<td>6.4</td>
<td>7.5</td>
<td>8.9</td>
<td>10.9</td>
<td>12.7</td>
<td>15.3</td>
<td>18.1</td>
<td>22.7</td>
<td>38.4</td>
</tr>
<tr>
<td>Value of Time (wage * 40%)</td>
<td>1.7</td>
<td>2.6</td>
<td>3.0</td>
<td>3.6</td>
<td>4.3</td>
<td>5.1</td>
<td>6.1</td>
<td>7.2</td>
<td>9.1</td>
<td>15.4</td>
</tr>
</tbody>
</table>

- California VoT by income quintiles:

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Lowest fifth</th>
<th>Second fifth</th>
<th>Third fifth</th>
<th>Fourth fifth</th>
<th>Highest fifth</th>
<th>Top 5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of Time ($/hr)</td>
<td>0.75</td>
<td>1.94</td>
<td>3.34</td>
<td>6.18</td>
<td>13.25</td>
<td>22.48</td>
</tr>
</tbody>
</table>

**Conceptual model**  TIMES structure
**Conceptual model**

To calculate the cost per PKT for each mode, income decile

**Scenarios:**

- **Existing capacity** (fuel + time cost)
- **Added capacity** (+ investment cost)
- **Scenario 1: Car investment** (Car speeds and annual distance increases by 20%)
- **Scenario 2: Bus and rail investment** (Speed, occupancy and annual distance increases by 50%)

**Spreadsheet Results**

![Graphs showing cost per PKT for different scenarios](image-url)
Spreadsheet Results

**California**

Existing Capacity (at fuel price $3.8 per gallon)

New Capacity (at fuel price $3.8 per gallon)

**Scenario 1: Car Investment** (at fuel price $3.8 per gallon)

**Scenario 2: Bus Investment** (at fuel price $3.8 per gallon)

Spreadsheet Results

Ireland

New capacity: By Fuel Type (median income group)
Spreadsheet Results  

- Source of travel costs for “Added capacity”

- Median income group, m€20/PJ fuel cost

TIMES Model  

- Implemented simple models for Ireland and California, populated with data from each TIMES model
- One fuel input (Diesel/gasoline)
- One travel demand – PKT/PMT
- 3 competing modes - pass car, bus, train
  - Characterised by
    - Efficiency (mVKT/PJ)
    - Investment cost
    - Speed
TIMES Model  Results: No TC, no TTB

• One optimum mode chosen

TIMES Model  Results: No TC, TTB

• Equilibrium reached immediately
TIMES Model Results: TC & TTB imposed

- New train and new car investment

TIMES Model Results: TC Sensitivity

Increased time cost by 50%: More investment in cars (more expensive fuel cost is recovered in time cost savings)

Decreasing time cost by 50%: Same technology selection, since time budget is limiting slower modes.
TIMES Model

Results: TTB Sensitivity

TTB decreased to 0.8 hrs/day: Total investment into cars (fastest mode)

TTB increased to 1.5hrs/day: Investment into cheaper, slower mode (Train)

Discussion

• Model does show modal competition, but
  – Calibration needed to replicate base year and simulate to the future
  – Issues with VoT/disaggregated income approach:
    – “Time availability”? 
  – Income groups travel differently
  – Access
    • Public transport: 95% urban and 51% rural
    • Car ownership
Discussion Next steps

• Issues
  – Competition between high speed rail & aviation
  – Cycling

• Approaches
  – More detailed technologies
  – Short vs. long, Urban vs. regional travel.
  – Transport within energy systems model

Next steps

• Next next steps
  – The role of Infrastructure: Bus lanes, space availability
  – The role of Space: constraints and costs
  – Feasibility study of using logit model (or other) for mode share: non-linear probability equations
    => code change would be needed.
• Thank you for your attention

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