Transportation demand management in a deprived territory: A case study in the North of France

Hakim Hammadou and Aurélie Mahieux

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Outline

1) Aim of the study
2) Methodology
3) Available Data
4) Analysis of the results
5) Conclusions
1) Aim of the study

• Analysis of the transport demand in the ex coal-mining area of the Pas-de-Calais area in the North of France
  => Is there potential for up scaling public transport services to decrease the share of private car? If so, which strategy to implement?
  – Construction and analysis of the estimated parameters of a modal choice model
  – Simulation of an improvement on the transport network
  – Analysis of the induced modal shifts

• Particular context:
  – Deprived area
  – Private car is the dominant transport mode for commuting (around 70%)
  – Low share of public transport (3%)
  – Urban structure resulting from the mining history which influences mobility behaviors
  – Regeneration strategy focusing on urban projects and a new public transport infrastructure e.g. a Bus with a High Level of Service (BHLS)
1) Aim of the study

The SMT Artois-Gohelle area in the Nord-Pas-de-Calais Region

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1) Aim of the study

Literature overview

• **Determinants of modal choice and travel behaviours**
  – (De Witte et al., 2013): socioeconomic variables, spatial indicators and journey characteristic indicators are the key determinants
  – (Meurs and Haaijer, 2001): land-use environment influences both mobility behavior and mode choice

• **Determinants of public transport demand**
  – (Paulley et al., 2006): fares, quality of service and car ownership strongly influence public transport demand
  – (Ubillos and Sainz, 2004): for university students in Spain, more frequent underground and train services, and lower fares for bus should attract new public transport users

• **Impacts of network improvement or a new transport infrastructure on modal choice**
  – (Hensher and Rose, 2007): modal choice in Sydney for commuter and non-commuter to assess different public infrastructure alternative projects
  – (Shen et al., 2009): study how environmental deterioration and network improvement should have an impact on modal choice
2) Methodology

Theoretical framework

• Mode choice modeling is used to analyze transport demand on disaggregated data.
  – Based on the discrete choice theory (Mac Fadden, 1974) (Ben-Akiva and Lerman, 1985)
  – Assumes the existence of a random utility function

  +

  • Individuals maximize this random utility function
  • For the same given choice, two individuals may have different preferences
  • Taste difference is found in the error term
  • Choice of the distribution of the residuals leads to two sort of models: a probit model in the case of a normal distribution or a logit model in the case of a Gumbel distribution
2) Methodology
Structure of the multinomial logit tree

Mode choice

- Car driver
- Car passenger
- Public transport
- Bike
- Walking
3) Available data
Presentation of the database

• Two Household Travel Surveys (HTS):
  – Béthune-Bruay-Noeux in 2005
  – Lens-Liévin-Hénin-Carvin in 2006
    • Representative sample of 15,628 trips within the whole studied urban transport perimeter on 1,195 zones

• These surveys are based on revealed preferences
  – Socioeconomic characteristics of travelers
  – Characteristics of observed trips
    • For the other alternative modes, trips are reconstructed with some GIS softwares
  – Location of trips
    • Land use occupation from the SIGALE® base from the Nord-Pas-de-Calais Region level to our scale of investigation
3) Available data
Descriptive statistics of the sample

Mode split

- Walking: 21.02%
- Public transport: 3.15%
- Car driver: 48.40%
- Car passenger: 21.02%
- Bike: 2.37%

Income distribution

- Less than 10,000€: 18.83%
- Between 10 and 20,000€: 41.65%
- Between 20 and 30,000€: 22.22%
- Between 30 and 40,000€: 10.69%
- Between 40 and 60,000€: 5.46%
- More than 60,000€: 1.14%
3) Available data
Descriptive statistics of the sample

Occupation

- Farmers: 23.96%
- Artisans: 9.95%
- Liberal profession: 11.50%
- Intermediate profession: 2.22%
- Employees: 0.33%
- Workers: 5.19%
- Inactive people: 2.56%
- Scholars: 21.65%
- Students: 22.63%

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4) Analysis of the results
Multinomial logit regression results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Walk</th>
<th>Public transport</th>
<th>Car driver</th>
<th>Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>(t-stat)</td>
<td>Coefficient</td>
<td>(t-stat)</td>
</tr>
<tr>
<td>Age</td>
<td>0.0118 ***</td>
<td>2.85</td>
<td>-0.019 *</td>
<td>-1.86</td>
</tr>
<tr>
<td>Male</td>
<td>1.18 ***</td>
<td>12.04</td>
<td>0.107</td>
<td>0.51</td>
</tr>
<tr>
<td>Travel cost</td>
<td>-0.18 ***</td>
<td>-48</td>
<td>-6 ***</td>
<td>-21.31</td>
</tr>
<tr>
<td>In-vehicle travel time</td>
<td>-0.18 ***</td>
<td>-48</td>
<td>-0.0589 ***</td>
<td>-16.59</td>
</tr>
<tr>
<td>Parking time</td>
<td></td>
<td></td>
<td>8.65</td>
<td>0.35</td>
</tr>
<tr>
<td>Walking time to and from stops</td>
<td>-0.0426 ***</td>
<td>-14.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Occupation (ref. employers)**

| Pupils                          | -0.918 *** | -4.7     | -2.48 ***   | -4.73    | -2.88 ***     | -13.55   | -2.91 ***     | -6.31    |
| Students                        | 0.291      | 0.81     | -2.53 ***   | -3.08    | -0.526 ***    | -2.7     | -1.04         | -1.06    |
| Intermediate profession         | 0.265      | 1.41     | -0.887      | -1.39    | 0.288 ***     | 2.52     | -0.118        | -0.27    |
| Liberal profession              | 1.35 ***   | 5.39     | -5.28 ***   | -3.84    | 0.546 ***     | 2.93     | -4.63 ***     | -4.76    |
| Workers                         | -0.483 *** | -3.24    | -0.901 **   | -2.33    | -0.395 ***    | -4.26    | -0.635 *      | -1.89    |
| Inactive people                 | -0.496 *** | -2.91    | -1.42 ***   | -3.01    | -1.21 ***     | -11.85   | 0.273         | 0.65     |
4) Analysis of the results
Multinomial logit regression results

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<tr>
<td></td>
<td>Coefficient</td>
<td>(t-stat)</td>
<td>Coefficient</td>
<td>(t-stat)</td>
<td>Coefficient</td>
<td>(t-stat)</td>
<td>Coefficient</td>
</tr>
<tr>
<td><strong>Travel motive (ref. recreational purpose)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Work purpose</td>
<td>0,761 ***</td>
<td>4,01</td>
<td>2,54 ***</td>
<td>6,38</td>
<td>0,67 ***</td>
<td>5,88</td>
<td>2,21 ***</td>
</tr>
<tr>
<td>School purpose</td>
<td>0,855 ***</td>
<td>5,65</td>
<td>3,15 ***</td>
<td>10,6</td>
<td>-0,743 **</td>
<td>-2,34</td>
<td>0,164</td>
</tr>
<tr>
<td>Shopping purpose</td>
<td>-0,229 *</td>
<td>-1,89</td>
<td>0,227</td>
<td>0,62</td>
<td>-0,0898</td>
<td>-1,09</td>
<td>1,22 ***</td>
</tr>
<tr>
<td><strong>Household composition (ref. single person)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Couple without children</td>
<td>-0,63 ***</td>
<td>-3,14</td>
<td>-0,761 *</td>
<td>-1,66</td>
<td>-1,34 ***</td>
<td>-9,09</td>
<td>-1,99 ***</td>
</tr>
<tr>
<td>Couple with 1 or 2 children</td>
<td>-0,361 *</td>
<td>-1,71</td>
<td>-0,64</td>
<td>-1,45</td>
<td>-0,634 ***</td>
<td>-4,12</td>
<td>-1,26 ***</td>
</tr>
<tr>
<td>Large family</td>
<td>-0,0228</td>
<td>-0,1</td>
<td>-0,317</td>
<td>-0,68</td>
<td>-0,367 **</td>
<td>-2,18</td>
<td>-3,18 ***</td>
</tr>
<tr>
<td>Lone parents with 1 or 2 children</td>
<td>-0,125</td>
<td>-0,52</td>
<td>-3,39 ***</td>
<td>-6,37</td>
<td>0,206</td>
<td>1,1</td>
<td>-1,06 **</td>
</tr>
<tr>
<td>Lone parents with more than 2 children</td>
<td>0,485</td>
<td>1,6</td>
<td>1,32 ***</td>
<td>2,55</td>
<td>0,594 **</td>
<td>2,05</td>
<td>0,232</td>
</tr>
<tr>
<td><strong>Annual income (ref. more than 40 000€)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 10 000€</td>
<td>-0,262 *</td>
<td>-1,66</td>
<td>0,763 ***</td>
<td>2,53</td>
<td>-0,278 **</td>
<td>-2,3</td>
<td>-1,57 ***</td>
</tr>
<tr>
<td>Between 10 and 20 000€</td>
<td>0,34 ***</td>
<td>2,93</td>
<td>-0,1</td>
<td>-0,38</td>
<td>-0,116</td>
<td>-1,38</td>
<td>0,755 ***</td>
</tr>
<tr>
<td>Between 20 and 30 000€</td>
<td>-0,108</td>
<td>-0,79</td>
<td>0,967 ***</td>
<td>3,41</td>
<td>-0,0194</td>
<td>-0,21</td>
<td>-0,378</td>
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<tr>
<td>Between 30 and 40 000€</td>
<td>-0,0668</td>
<td>-0,38</td>
<td>-0,0304</td>
<td>-0,07</td>
<td>0,00614</td>
<td>0,05</td>
<td>-1,18 **</td>
</tr>
</tbody>
</table>

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4) Analysis of the results
Multinomial logit regression results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Walk Coefficient</th>
<th>Walk (t-stat)</th>
<th>Public transport Coefficient</th>
<th>Public transport (t-stat)</th>
<th>Car driver Coefficient</th>
<th>Car driver (t-stat)</th>
<th>Bike Coefficient</th>
<th>Bike (t-stat)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accessibility</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bus frequency (origin)</strong></td>
<td>-0.00667</td>
<td>***</td>
<td>-7.25</td>
<td>0.00122</td>
<td>0.73</td>
<td>-0.00727</td>
<td>***</td>
<td>-4.13</td>
</tr>
<tr>
<td><strong>Number of bus stops at 5 minutes (destination)</strong></td>
<td>-0.443</td>
<td>***</td>
<td>-7.52</td>
<td>1.21</td>
<td>10.71</td>
<td>0.149</td>
<td>***</td>
<td>3.59</td>
</tr>
<tr>
<td><strong>Number of bus stops at 5 minutes (origin)</strong></td>
<td>-0.259</td>
<td>***</td>
<td>-4.6</td>
<td>-0.0215</td>
<td>-0.18</td>
<td>-0.0612</td>
<td>-1.52</td>
<td>-0.269</td>
</tr>
<tr>
<td><strong>Land-use characteristics (ref. residential area)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dense urban area</td>
<td>-0.569</td>
<td>**</td>
<td>-2.28</td>
<td>0.363</td>
<td>0.56</td>
<td>-0.184</td>
<td>-1</td>
<td>2.1</td>
</tr>
<tr>
<td>Commercial area</td>
<td>-1.83</td>
<td></td>
<td>-1.57</td>
<td>-0.159</td>
<td>-0.09</td>
<td>-0.709</td>
<td>**</td>
<td>-1.93</td>
</tr>
<tr>
<td>School / university area</td>
<td>-0.428</td>
<td></td>
<td>-0.92</td>
<td>3.72</td>
<td>5.98</td>
<td>1.9</td>
<td>***</td>
<td>4.08</td>
</tr>
<tr>
<td>Industrial area</td>
<td>-1.01</td>
<td>*</td>
<td>-1.91</td>
<td>-0.409</td>
<td>-0.39</td>
<td>-0.0989</td>
<td>-0.36</td>
<td>1.57</td>
</tr>
<tr>
<td>Constant</td>
<td>4.38</td>
<td>***</td>
<td>12.75</td>
<td>-1.42</td>
<td>-1.66</td>
<td>1.43</td>
<td>***</td>
<td>6.41</td>
</tr>
</tbody>
</table>

Final log-likelihood = -9083.607  
McFadden’s Pseudo-$R^2 = 0.541$ 
% prévisions correctes = 83%
4) Analysis of the results

Elasticities

<table>
<thead>
<tr>
<th>Elasticities</th>
<th>Walking</th>
<th>Car</th>
<th>Public transport</th>
<th>Bike</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price elasticity</td>
<td>-</td>
<td>-0,22</td>
<td>-5,3</td>
<td>-</td>
</tr>
<tr>
<td>Time elasticity</td>
<td>-9,9</td>
<td>-0,84</td>
<td>-1,58</td>
<td>-11,74</td>
</tr>
<tr>
<td>Frequency elasticity</td>
<td>-</td>
<td>-</td>
<td>0,05</td>
<td>-</td>
</tr>
</tbody>
</table>

- People are more sensible to the time spent in public transport than in car.
  => Confirms the lack of public transport mobility culture in this territory.
- People are more sensible to the cost of public transport than to the frequency or the time spent in a bus
  => Preferable to implement policies which have an impact on the cost of the public transport use. Public transport fares seem to be a key variable.
4) Analysis of the results

Simulations

<table>
<thead>
<tr>
<th>Transport modes</th>
<th>Initial modal split</th>
<th>Free public transport (1)</th>
<th>Higher frequency of public transport (2)</th>
<th>Higher frequency of public transport (3)</th>
<th>(1) + (3)</th>
<th>Longer car travel times (4)</th>
<th>(3) + (4)</th>
<th>(1) + (3) + (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>24.00%</td>
<td>19.98% (-0.16)</td>
<td>23.84% (+0.16)</td>
<td>23.41% (-0.59)</td>
<td>19.17% (-4.83)</td>
<td>24.82% (+0.82)</td>
<td>24.34% (-0.41)</td>
<td>19.82% (-14.18)</td>
</tr>
<tr>
<td>Public transport</td>
<td>2.83% (+11.59)</td>
<td>14.42% (+0.06)</td>
<td>2.89% (+0.06)</td>
<td>15.27% (+12.44)</td>
<td>2.98% (+0.15)</td>
<td>3.06% (+0.23)</td>
<td>16.72% (+13.89)</td>
<td></td>
</tr>
<tr>
<td>Car driver</td>
<td>56.17% (-3.56)</td>
<td>52.61% (+0.08)</td>
<td>56.25% (+0.08)</td>
<td>52.38% (-3.79)</td>
<td>55.45% (-0.72)</td>
<td>55.48% (-0.69)</td>
<td>50.81% (-5.36)</td>
<td></td>
</tr>
<tr>
<td>Car passenger</td>
<td>15.06% (-3.65)</td>
<td>11.41% (+0.40)</td>
<td>15.46% (+0.40)</td>
<td>11.56% (-3.50)</td>
<td>14.65% (-0.41)</td>
<td>14.99% (-0.07)</td>
<td>10.92% (-4.14)</td>
<td></td>
</tr>
<tr>
<td>Bike</td>
<td>1.95% (-0.37)</td>
<td>1.58% (+0.05)</td>
<td>2.00% (+0.05)</td>
<td>1.63% (+0.32)</td>
<td>2.10% (+0.15)</td>
<td>2.13% (+0.18)</td>
<td>1.73% (-0.25)</td>
<td></td>
</tr>
</tbody>
</table>

- (1) + (3): strong transport policy which encourage the public transport use
- (1) + (3) + (4): combination of one policy in favour of public transit ((1)+(3)) and one discouraging the use of the car (4)
- (3) + (4): BHLS scenario
5) Conclusions

Main findings

• Walking time to and from bus stops has a positive impact on public transport demand.
• Frequency of bus has no influence on public transport demand but has a negative influence for all the other transport modes.
• Parking time has no influence on demand for car.
• People are less sensible to change in cost of using car or car travel times than to change in bus ticket price or bus travel times.

=> Real opportunities to increase public transport share
=> Changes have to be extreme to lead to a significant impact on car demand.
5) Conclusions

Main findings

• More frequencies and faster travel times will have little effect on public transport demand.

• Strong inertia in car driver use

• Conventional economic instruments (travel times, travel cost) are not sufficient
5) Conclusions

Research agenda

• Robustness check on the model by using a nested logit estimation
  – Nested logit is expected to better reproduced travel behaviors by introducing correlation among alternatives

• Comparison of a similar model on a different territory in the same Region
Thank you for your attention

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