A hybrid mode choice model to account for the dynamic effect of inertia over time

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The influence of habit/inertia in the choice process is not a new problem. The first studies date back to the end of the 70s. Since then, researches have always shown interest for this issue, though with different intensity.

Recently, it has received another boost, and some interesting advances have been produced.

But still, many different methods are used to account for inertia. *There is not a unique “accepted” paradigm.*

The reason is that “inertia” is a complex phenomenon.
**Background**

Habit related with the tendency to repeat a decision without thinking again about the reasons why we behave in such way.

leads to

Inertia related with a resistance to changing behaviour.

Many factors
Inertia in (transport) literature

In the (transport) literature *inertia* has been measured as the effect that preferences experienced in previous periods have on the current choice.

To properly account for inertia, the current choice needs to be explicitly related with the previous ones, and for this panel data are required:

(1) Data collected before and after a change in the conditions:
   (a) long panel data, where information from the same individual are gathered at “separate” times;
   (b) mixed revealed and stated preference (RP/SP) data.

(2) Data collected in stable conditions:
   (a) short panel data, gathered over a “continuous” period of time
Inertia in (transport) literature

**Inertia** as the effect the experience in previous periods have on the current choice:

It is usually assumed that in each time period individuals make a trade-off

\[ V^{(t)} = \sum_k \beta_k X_k^{(t)} \]

Evidence of inertia is provided assuming that it is a function of:

- the choices made in previous periods
  \[ I^{(t)} = \text{Indicator}(\text{choice}^{(t-1)}) + \ldots \]
- the value of some attributes in previous periods
  \[ I^{(t)} = f(X^{(t-1)}) + \ldots \]
- the evaluation of alternatives in previous periods
  \[ I^{(t)} = f(V^{(t-1)}) + \ldots \]
- cumulative weighted evaluation of previous periods
  \[ I^{(t)} = f(\prod_t V^{(t-1)}) + \ldots \]
Inertia in the psychological literature

Here, the standard measure of habit is the frequency with which a given behaviour has been performed in the past.

Psychologists have found that frequency of past behaviour:

- is the best predictor of future behaviour,
- tends to explain most of the variance in intention (or behaviour), thus often rendering as not significant most other predictors.

It is recognised that the role of past behaviour is more likely to be mediated by conscious and reasoned decision making processes. But:

- Observed behaviour is not affected by the characteristics of the alternatives available, which is crucial for transport policies.
- No measures of the individual level of satisfaction are used.
In the transport literature frequency of past behaviour has been used:

- in cross-sectional mode choice models; i.e. the *number of trips* per week have been typically used as indicators of habit.

- in continuous panel data *the number of times the same tour has been made in previous days* of the same week, has been tested to measure the “strength” of habit.

But: These attributes have been simply added to the typical utility function. They provide an indication of the history of the individual experience, *They do not explain what causes inertia*

Critized and abandoned in favour of panel estimation.
Objective

To measure the effect of habitual behaviour in the mode choice, using the frequency as a measure of the past history.

Try to distinguish between:

- *tendency to stick with the same alternative*, measured through lagged variables that link the current choice with the previous trip.
- *individual propensity to undertake habitual behaviour*, measured through the latent variable.

Test if these effects change over time.
Effect of habitual behaviour

Cherchi, Meloni and Ortuzar (2012 -> 2013) estimate a hybrid choice model to account for habitual behaviour in the revealed preference choices.

Following this work we assumed that:

- habit is revealed by the frequency of past behaviour (according to the psychological literature) but we recognise that frequency is only an indicator of a habitual behaviour
- the true process behind the formation of habitual behaviour is a latent one

Latent Habitual behaviour

Characteristics of:
- Alternatives (LOS) (before time $t$)

Characteristics of:
- Individuals (SE)
- Activities/Trips (A)

Characteristics of:
- Alternatives (LOS) ($time \ t$)

Trip Frequency (before time $t$)

Habit ($LV$)

Utility ($time \ t$)

Revealed choices ($time \ t$)

Time $t$
\( T = \{1, \ldots, T_w\} \)

Dynamic effect

Characteristics of:
- Alternatives (LOS) \((t \text{ime } t)\)

Characteristics of:
- Individuals (SE)
- Activities/Trips (A)

Utility \((t \text{ime } t)\)

Revealed choices \((p\ell\text{an panel } t)\)

Trip Frequency \((w\text{eek 1})\)

Habit \((L\text{V})\)

Characteristics of:
- Alternatives (LOS) \((t \text{ime } t+1)\)

Characteristics of:
- Individuals (SE)
- Activities/Trips (A)

Utility \((t \text{ime } t+1)\)

Revealed choices \((p\ell\text{an panel } t+1)\)

Trip Frequency \((w\text{eek 2})\)

Habit \((L\text{V})\)

Characteristics of:
- Alternatives (LOS) \((t \text{ime } t+2)\)

Characteristics of:
- Individuals (SE)
- Activities/Trips (A)

Utility \((t \text{ime } t+2)\)

Revealed choices \((p\ell\text{an panel } t+2)\)

Trip Frequency \((w\text{eek } N)\)

Short panel data
Hybrid choice model

**Discrete choice**

\[ U_{qj}^{t+1} = V_{qj}^{t+1} + f(LV(\omega_q), I_{qj}^t) + \varepsilon_{qj}^{t+1} \]

\[ \varepsilon_{qj}^t \approx EV1 \]

**Structural model**

\[ y_{qj}^{t+1} = \begin{cases} 1, & \text{if } U_{qj}^{t+1} = \max_i \{U_{qi}^{t+1}\} \\ 0, & \text{otherwise} \end{cases} \]

**Measurement model**

w=wave; t=trip

**Latent habitual behaviour**

\[ LV_q = f(SE_q, LOS_{jq}, A_q; \beta) + \omega_q \]

\[ \omega_q \approx D(0, \sigma^2_\omega) \]

**Structural model**

\[ I_{kq}^w = f_1(LV_q; \delta_k) + \nu_{kq}^w \]

(K=3)

\[ \nu_{kq} \approx D(0, \sigma^2_{\omega_k}) \]

**Measurement model**
The Case of Habit/Inertia

\[ U_{jqt} = f(LOS_{jqt} , SE_q , A_{jqt} ; \theta_j , \lambda_p ) + \]

\[ i_{q\psi(r-1)} \times (\beta_{\text{lagT}} + \beta_{LV_j} LV_q ) + i_{qp(u-1)} \times (\beta_{\text{lagP}} + \beta_{LV_j} LV_q ) + \epsilon_{jqt} \]

\[ U_{jqt} = (...) + \beta^t_{LV_j} LV_q + \epsilon_{jqt} \]

Lagged variables:

- \( i_{qp(r-1)} \) is defined with respect to the purpose. It takes value one if the mode chosen for trip \( t \) is the same as that chosen in the previous tour made with the same purpose.

- \( i_{q\xi(u-1)} \) is defined with respect to the time period in which the tour starts. It takes value one if the mode chosen for trip \( t \) is the same as that chosen for the previous tour made in the same time period as the trip \( t \).
Panel data on a mode choice context

*Thurgau panel data:* a six-week travel diary

Final sample used to estimate our model contains:
- 16101 trips, 187 individual and 99 families

6 Waves: each week a wave

3 Time-of-week periods:
- peak period during week days (morning 5:45am-8:30am and evening 15:45-16:30)
- off-peak period during week days
- the weekend

4 Purposes: commuting, business, leisure, shopping.

5 Alternatives: car driver, car passenger, public transport, motorbike, slow modes.
Panel data on a mode choice context

Attributes included:

- Travel time, Travel cost
- Walking time, Headway
- Ticket discount, National season ticket (only PT)
- Time of the day: Peak period
- Fix working hours
- When the travel was planned: right now, during the day, routine
- SE characteristics (income, employment status, age, gender, car components)
- Distance, Purpose

Indicators for habitual behaviour:

(i) the number of trips in the previous week starting in the same time category as the current trip
(ii) the number of trips in the previous week with the same purpose as the current trip
(iii) the number of trips in the previous weeks made with the same mode as the current trip
Modelling results

Full Model
126 coefficients estimated
31762 observations
RP/SP joint estimation

Model with LV
45 coefficients estimated
12214 observations
9991 observations (weeks 2-6)
RP data only

Indicators:
- All the indicators are highly significant in revealing the latent effect of habitual behaviour.
- The frequency of the trips made with the same mode has the strongest effect.

Latent inertia:
- People younger than 19 years show less habitual behaviour
- Male are more habitual than female
Modelling results

<table>
<thead>
<tr>
<th>Lagged Variables</th>
<th>DCM with LV</th>
<th>DCM without LV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimates</td>
<td>t-test</td>
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<tr>
<td>Purpose (Car driver)</td>
<td>-0.486</td>
<td>-5.59</td>
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<tr>
<td></td>
<td>0.554</td>
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<td></td>
<td>-0.167</td>
<td>-1.46</td>
</tr>
</tbody>
</table>

Latent Inertia variable

| (Car driver) | 1.900 | 23.22 |
| (Car passenger) | -0.183 | -1.60 |
| (Public transport) | 0.291 | 1.78 |
| (Slowmodes) | 0.305 | 3.76 |

Lagged effects:
The lagged effect strongly varies among individuals and it has a bigger impact on the utility for those individuals who show stronger habitual behaviours.

For some mode the habitual behaviour is prevalent over the pure lagged effect.

Preliminary results show that: The dynamic effect over time of the LV is positive but diminishing.
Conclusions

The proposed model allows to:

- account for the effect of the frequency as an indicator of habitual behaviour.
- distinguish the effect of habitual behaviour from other sources of inertia
- account for dynamic effect of inertia over time.
Many thanks