Assessing demand-side behaviour in long-term energy modelling: The case of Romanian Social MARKAL

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Social MARKAL
Case: residential lighting in city of Nyon

Social TIMES Romania

- three sectors: residential, transports, others
- only demand side modeled in detail
- supply side: virtual imports
- start 2010, 6 time slices, 7 periods until 2026

### Final energy
- Electricity
- Coal
- Light fuel
- Heavy fuel
- Natural gas
- Petroleum
- Biomass
- Low Temp Heat
- Solar thermal
- Solar electric

### Demand devices (Residential)
- Incandescent bulbs
- EFL bulbs
- LED bulbs
- Petroleum lamps
- Coal heating stove
- Wood heating stove
- Natural gas heating stove
- Electric heating stove
- Petroleum heating stove
- LTH radiators
- Solar warm water
- Electric cooking
- Wood cooking
- Natural gas cooking
- ...
Residential Lighting

- Old technology
- Information forced tech.
- Economy driven tech.
- Bulb technology

- Usual behaviour
- Information triggered savings
- Energy conscious behaviour
- Behaviour virtual technology
Residential heating

- Building before renovation
- Heating before renovation
- Usual behaviour

- Information forced renovation
- Information forced renovation
- Information triggered savings

- Economy driven renovation
- Economy driven renovation
- Energy conscious behaviour


Proceedings of the Energy for Sustainability Multidisciplinary Conference EfS 2013, 8-10 September 2013 - Energy for Sustainability Initiative, University of Coimbra, Portugal
Behaviour models

- VBN: Value – Belief – Norm
- TPB: Theory of Planned Behaviour
- HB: Habitual Behaviour
- ABC: Attitude – Behaviour – Context
- IPB: Theory of Interpersonal Behaviour
- MOA: Motivation – Opportunity – Ability
Theory of Habitual Behaviour

Up to 95% of household energy behaviour is a form of habitual behaviour.

Source: Wagenaar, 1992

To break the habitual loop: removing incentives to habitual behaviour, making consumers aware of their habits, enable to control the outcomes

Source: Egmond and Bruel, 2007

Social MARKAL Behavioural Model

![Diagram](image)

What to measure

Bounds on technologies - share of people who:
• Already do have the information and behave rationally
• Do not have the information but once better informed, they will change their behaviour
• Will never change because of extra-economic reasons

Efficiencies, cost of virtual process technology “infocampaign”:
• Part of people for whom the information campaign is the principal vector of behavioural change - yield
• Part of people who denote a medium as the most efficient one – cost mix
How to measure

Q6: How many light bulbs do you have in your home?
[exact number, -10, -20, -30, -40, 40+, do not know]

Q7: How many of them are low-consumption bulbs?
[none, ¼, ½, ¾, all, don’t know]

Q8: During the last two years, how many incandescent bulbs (conventional bulbs) have you replaced with low consumption bulbs?
[exact number, none, ¼, ½, ¾, all, do not know]
How to measure (2)

Q10: Do you know that low consumption bulbs can consume 5 times less energy than incandescent bulbs? [yes, no]

Q11: Do you know that low consumption bulbs have a lifespan of up to 10 times superior to incandescent bulbs? [yes, no]

Q12: Were you better informed about economic advantages of the low-consumption bulbs, would you be ready to abandon the incandescent bulbs? [yes, no]

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Q13: Did you know that a household where half of all incandescent bulbs are replaced by low-consumption bulbs can realise a saving up to 200 Frs per year? [yes, no]

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<td>393 (100%)</td>
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Q14: Based on this information, would you change at least the half of your bulbs? [yes, no, already did]

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<td>71 (18.1%)</td>
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<td>393 (100%)</td>
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<td>407 (100%)</td>
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How to measure (4)

Q15: Your electricity consumption would be susceptible to change following a:
15.1 opinion or advice of a close person (neighbour, family member, colleague)
15.2 information campaign in medias, advertisements
15.3 request from your children
15.4 modification of your revenue
15.5 important electricity price increase
15.6 nothing could change my current behaviour

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A hybrid simulation-optimisation model

Results: Reference Case (Percentage of Vehicle Sales)

- TIMES model investments follow 'winner takes all' phenomenon (in this conceptual model, there are no market constraints).

- COCHIN-TIMES investment decisions are far diverse, mainly dominated by gasoline cars, followed by gasoline hybrids and gasoline plug-in cars in the later years.

- No Supply restrictions: Faster penetration of plug-in hybrids since currently there are no manufacturer supply limitations in the model.

Source: K. Ramea et al., Incorporation of Consumer Demand in Energy Systems Models and their Implications for Climate Policy Analysis, IEW Paris, IEA 19-21 June 2013

Share of Choice - Research setup

Share-of-Choice MARKAL

\[
\begin{align*}
\text{Respondent} & \quad k = 1 \ldots K. \\
\text{Period} & \quad t = 1 \ldots T. \\
\text{Campaign level} & \quad j = 0, 1. 1 \text{ if campaign and } 0 \text{ otherwise.} \\
\text{Subsidies level} & \quad l \geq 0.
\end{align*}
\]

\[
u(k, j) = \begin{cases} 1 & \text{if } l_0(k, j) = 0 \\ -l_0(k, j) & \text{otherwise.} \end{cases}
\]

part-worths for the low consumption bulb

\[
\begin{align*}
d(t) & \quad \text{forecasted demand for bulbs} \\
c_q & \quad \text{cost of the campaign} \\
\lambda & \quad \text{cost of the subsides}
\end{align*}
\]

\[
\begin{align*}
z_1(t) & \quad \text{installed capacity of incandescent bulbs} \\
z_2(t) & \quad \text{installed capacity of low consumption bulbs} \\
q & \quad \text{campaign configuration: 1 if campaign and 0 otherwise.} \\
l & \quad \text{subside level - amount of subside per bulb} \\
p(k) & \quad \text{preference for respondent } k: 1 \text{ if respondent becomes a new client 0 otherwise.} \\
x & = (y, z) & \text{the variable describing the activities in the classical model (i.e. investment in each technology, etc.)}
\end{align*}
\]

\[
\min_{x, p, q, l} c \cdot x + c_q \cdot q + \lambda \cdot l
\]

\[
A \cdot x \geq b.
\]

\[
\begin{align*}
k = 1 \ldots K \\
u(k, 0) \cdot (1 - q) + u(k, 1) \cdot q + l & \geq (p(k) - 1) \cdot M, \\
u(k, 0) \cdot (1 - q) + u(k, 1) \cdot q + l & \leq p(k) \cdot M,
\end{align*}
\]

\[
P = \frac{1}{K} \sum_{k=1}^{K} p(k) \quad \text{proportion of low consumption bulbs}
\]

\[
\begin{align*}
z_1(t) & = d(t) \cdot (1 - P), \\
z_2(t) & = d(t) \cdot P
\end{align*}
\]
Share of Choice - Results

Proceedings of the 53rd Meeting of the Euro Working Group on Commodities and Financial Modelling (EWGCFM) and 2nd International Conference of the Research Centre for Energy Management (RCEM), 22-24 May 2014, Chania, Crete

Proceedings of the 14th Informatics in Economy International Conference, 30 April - 2 May 2015, Bucharest, Romania

A comparison of the approaches

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Research project

• Swiss Enlargement Contribution in the framework of the Romanian-Swiss Research Program

• Swiss National Fund of Scientific Research Grant IZERZ0_142217

• Research team:
  – Geneva: Emmanuel Fragnière, Francesco Moresino, Roman Kanala
  – Bucharest: Ion Smeureanu, Marian Dardala, Andrea Reveiu, Emilia Titan, Felix Furtuna