Do Consumers Shift from Private to Shared Ownership?

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Problem setting

• Starting questions
  o How many goods do we own? For how long do we use them? And, what about our neighbours?
    Vacuum cleaners; drills
    Internet connection
    Private cars
  o Wouldn’t it be more convenient to organise and make a common purchase and share utilisation?
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• **Research questions**
  o Do consumers shift from individual consumption and ownership to shared consumption and shared ownership?
  o Under which conditions/characteristics/preferences?
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  o Do consumers shift from individual consumption and ownership to shared consumption and shared ownership?
  o Under which conditions/characteristics/preferences?

• Policy implication
  o Unequal access to essential goods (too expensive for individual purchase): internet, transport, energy
  o Reduce not-sustainable individual consumption and ownership
More equal model in sharing economy

<table>
<thead>
<tr>
<th>Sharing Economy</th>
<th>Fractional Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increase access</td>
</tr>
<tr>
<td></td>
<td>Sustainable consumption</td>
</tr>
<tr>
<td>“consumers granting each other temporary access to under-utilized physical assets (‘idle capacity’), possibly for money” (Frenken &amp; Schor, 2017)</td>
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<tr>
<td>Ownership</td>
<td>Individual</td>
</tr>
<tr>
<td>Consumption</td>
<td>Access-based (payment - short rental)</td>
</tr>
<tr>
<td>Coordination</td>
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<tr>
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</tr>
<tr>
<td></td>
<td>Right of exclusion</td>
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<td>Increases power concentration</td>
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More equal model in sharing economy

<table>
<thead>
<tr>
<th>Ownership</th>
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<tr>
<td>Consumption</td>
<td>Access-based (payment - short rental)</td>
<td>Access-based (group coordination)</td>
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<tr>
<td>Coordination</td>
<td>Market-based</td>
<td>Social rules</td>
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<tr>
<td>Good</td>
<td>Anti-common, Right of exclusion, Increases power concentration</td>
<td>Common-pool resource, Shared good (not private, not public), Luxury goods (exclusive by nature)</td>
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</tbody>
</table>

Increase access
Sustainable consumption

“consumers granting each other temporary access to under-utilized physical assets (‘idle capacity’), possibly for money” (Frenken & Schor, 2017)

True sharing: “bottom-up community-led initiatives for shared consumption and ownership, to increase affordable access to goods for essential services” (Pasimeni, 2021)
Agent-Based Model

Evolutionary game theory of coalition formation with the “best reply” type of adjustment dynamic
Agent-Based Model


*Evolutionary game theory of coalition formation with the “best reply” type of adjustment dynamic*

\( t = 0 \): Agents satisfy their demand: 1) rely on the service from a general provider

2) buy and use a good individually
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\[ t = 0: \text{Agents satisfy their demand: } 1) \text{ rely on the service from a general provider} \\
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\[ t > 0: \text{A third option is available: } 3) \text{ purchase commonly a good and share ownership and consumption} \]
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• Agents interact to form a stable sharing groups:
  - Agents tie links, communicate, evaluate options, establish stable groups and share
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- Agents interact to form a stable sharing groups:
  - Agents tie links, communicate, evaluate options, establish stable groups and share
  - Stability of sharing groups is necessary condition (purchase and share common good)
    - Agents establish a group when they reach stability (Pareto optimal)
      - all agents in group maximize individual utility (compared to other 2 options)
      - none of them has the incentive to move to another group or to purchase alone
      - no other agent wants to enter in this sharing group
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- Once the group is established, the decision to adopt the shared good is taken
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• Once the group is established, the decision to adopt the shared good is taken

• Replacement after certain period of time-use
The utility functions (Cobb-Douglas)

1) Public provider (no purchase)

\[ U_{i1} = [e_i - d_i p_1]^{\theta_i} (d_i * K)^{1-\theta_i} \]

1) Preference for income  
2) Preference for consumption

2) Individual purchase:

3) Shared purchase:
The utility functions (Cobb-Douglas)

1) Public provider (no purchase)

\[ U_{i1} = [c_i - d_i p_1]^{\theta_i} (d_i * K)^{1-\theta_i} \]

\[ K = 1 - \frac{1 - k}{1 + e^{-r(\frac{A_1 t - 1}{z} - g)}} \]

1) Preference for income
2) Preference for consumption

2) Individual purchase:

3) Shared purchase:
The utility functions (Cobb-Douglas)

1) Public provider (no purchase)

2) Individual purchase:

\[ U_{i2} = [e_i - (d_i p_2 + \frac{I}{L_2})]^{\theta_i} (d)^{1-\theta_i} \]

3) Shared purchase:
The utility functions (Cobb-Douglas)

1) Public provider (no purchase)

2) Individual purchase:
   \[ U_{i2} = \left[ e_i - (d_i p_2 + \frac{I}{L_2}) \right]^{\theta_i} (d)^{1-\theta_i}; \quad L_2 = \frac{S}{d_i} \text{ and } d_i \leq S \]

3) Shared purchase:
The utility functions (Cobb-Douglas)

1) Public provider (no purchase)

2) Individual purchase:

3) Shared purchase: 

\[ U_{i3} = \left[ e_i - (d_ip_3 + x_i) \right]^{\theta_i} \left\{ (d_i + D_{-i}) \left[ \frac{\alpha_id_i}{d_i + D_{-i}} + (1 - \alpha_i) \left( \frac{\beta_ix_i}{x_i + X_{-i}} + \frac{1 - \beta_i}{N} \right) \right] \right\}^{1-\theta_i} \]

1) Preference for income
2) Preference for consumption (in group)
The utility functions (Cobb-Douglas)

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   (no purchase)

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1) Preference for income
2) Preference for consumption (in group)
   a. Proportional division rule based on agent’s demand
   b. Proportional division rule based on agent’s monetary contribution
   c. Equal shared division rule based on group size
The utility functions (Cobb-Douglas)

1) Public provider (no purchase)

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3) Shared purchase: \[ U_{i3} = [e_i - (d_ip_3 + x_i)]^{\theta_i} \left\{ \left[ \left( d_i + D_{-i} \right) \frac{\alpha_idx_d}{d_i + D_{-i}} + \left( 1 - \alpha_i \right) \frac{\beta_idx_i}{x_i + X_{-i}} + \frac{1 - \beta_i}{N} \right] \right\}^{1-\theta_i} \]

- **1) Preference for income**
- **2) Preference for consumption (in group)**
  - a. Proportional division rule based on agent’s demand
  - b. Proportional division rule based on agent’s monetary contribution
  - c. Equal shared division rule based on group size

\[ \sum d_i \leq S \quad \text{and} \quad L_3 = \frac{S}{\sum d_i} \quad \text{and} \quad \frac{I}{L_3} \leq \sum x_i \leq \frac{I}{L_3} \times 1.1 \]
# Model initialisation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product features</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacity</td>
<td>$S=S_2=S_3$</td>
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<tr>
<td>Investment</td>
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<tr>
<td><strong>Consumer features</strong></td>
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<tr>
<td>Demand</td>
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<tr>
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<td><strong>Public service features</strong></td>
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<tr>
<td>Lowest value of $K$</td>
<td>$k$</td>
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<tr>
<td>Steepness</td>
<td>$r$</td>
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<tr>
<td>Sigmoid midpoint</td>
<td>$g$</td>
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</tr>
<tr>
<td>General provider capacity</td>
<td>$Z$</td>
<td>0.75</td>
</tr>
</tbody>
</table>

200 heterogenous agents

$d_{\text{mean}}$ : average demand in population

$d_{\text{delta}}$ : distance between min and max values of demand in the population

$d_i \in \text{UNIFORM} \ (d_{\text{min}} \ ; \ d_{\text{max}})$

\[
d_{\text{min}} = (d_{\text{mean}} - \frac{d_{\text{delta}}}{2})
\]

\[
d_{\text{max}} = (d_{\text{mean}} + \frac{d_{\text{delta}}}{2})
\]
Finding the niche in the economy

1. Global sensitivity analysis (full parameter space) (Dosi et al., 2018)
Finding the niche in the economy

1. Global sensitivity analysis (full parameter space) (Dosi et al., 2018)
   a. Elementary effect (EE) One-At-a-Time (OAT)
      o Identify the parameters most relevant to model output
   b. Near Orthogonal Latin Hypercube (NOLH) DoE
      o Optimise the number of model sampling points to be observed for the selected parameters
   c. Kirging meta-model estimation
      o Spatial interpolation method study the parameter space in which the number of sharing consumers is maximised
   d. Sobol decomposition
      o Evaluate the individual and interaction effects of parameters on the variance of the model output.

2. Global sensitivity analysis (small parameter space)
   a. NOLH DoE
   b. meta model
   c. decomposition

3. Transition from individual ownership to shared ownership
   o Model configuration that produces the highest number of sharing consumers
   o Which consumers drive it and to what extent it leads to a more sustainable model of consumption

4. Policy intervention
   o Unit price of the service/good
   o Size and cost of the good
   o Finding the niche in the economy
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## Model initialisation (1/4) – EE (180 sim)

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<thead>
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<th>Symbol</th>
<th>Benchmark</th>
<th>Min.</th>
<th>Max.</th>
<th>OAT EE</th>
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**Elementary Effect**

\( \sigma \): Provides an estimate of the interaction effects with the other parameters (non-linear and non-additive effects of each parameter).

\( \mu \text{.star} \): The overall effect of each parameter on the model outcome (shared purchase).
Elementary Effect

**sigma:**
Provides an estimate of the interaction effects with the other parameters (non-linear and non-additive effects of each parameter)

**mu.star:**
The overall effect of each parameter on the model outcome (shared purchase)
### Model initialisation (2/4) – NOLH (562 sim)

<table>
<thead>
<tr>
<th>Parameter</th>
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Few agents opt for shared purchase

- Only a niche group of consumers chooses the shared purchase option
- Higher demand
- Medium-low average preference for income
- Small good are shared

➢ Best three simulations to reduce the space
# Model initialisation (3/4) – NOLH small (562 sim)

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<th>Parameter</th>
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<th>Max (d)</th>
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</table>
High shared purchase in the smaller space

- Shared purchasers is significantly different from zero
- Mid-low preferences for income
- Mid-low preferences for the demand division rule
- Low good capacity (80% variance)

➤ Best simulation is the niche
## Model initialisation (4/4) - Niche

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Transition to Shared Purchase in the niche

From individual to shared purchase
Transition to Shared Purchase in the niche

From individual to shared purchase

-7.5% goods purchased yearly
Transition to Shared Purchase in the niche

-7.5% goods purchased yearly

From individual to shared purchase

| Demand (d) | High | Low | High |
| Income (e) | Mid-low | High | Low |
| Pref. Income (θ) | Mid-high | Low | High |
Policy Intervention

(a) $p_1$

(b) $p_2$

(c) $p_3$
Policy Intervention

(a) $p_1$

(b) $p_2$

(c) $p_3$

(a) Shared_Purchase

(b) Individual_Purchase

(c) Public_Service

(d)
Conclusions

**Contribution**
- Modelling transition from individual to shared ownership
- Evolutionary model of coalition formation and diffusion
- Apply advanced method of sensitivity analysis in ABM (and find niche in the economy)
Conclusions

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Findings
- Only a niche decides to shift
- High demand and low-mid income, buy smaller goods
- Fractional ownership allows doing more with less (SDGs) – with not sustainability concerns
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Transportation sector (reduces individual ownership, private cars)
Opportunities for expensive goods with high capacity (autonomous or driverless vehicles?)
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Applications
- Transportation sector (reduces individual ownership, private cars)
- Opportunities for expensive goods with high capacity (autonomous or driverless vehicles?)

Policy interventions
- Incentives or lower tariffs to reduce unitary cost or increase prices for individual owners
- Define right capacity and cost for policy (improve efficiency and effectiveness)
Thank you!

Francesco Pasimeni: f.pasimeni@sussex.ac.uk
Back-up
The agent-based model (ABM)

• Extends previous model (Pasimeni and Ciarli, 2018)

• Sequential games of coalition formation with the “best reply” type of adjustment dynamic
  - (Bloch 1995; Bloch 1996; Mutuswami and Winter 2002)

• Utility function in the evolutionary game theory of coalition formation
  - (Axtell 1999, 2002)

• Co-evolution of coalition formation and diffusion of shared goods

Results

• Bigger coalition are formed to invest in very expensive common goods
  → less individual contribution, despite higher negotiation

• Connections increase rapidity of information flow
  → determine higher diffusion

• There is not 100% diffusion
  → not all agents are better off in coalition
## ABM extension

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<td></td>
<td>2) Individual purchase</td>
<td>2) Purchase in coalition</td>
</tr>
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<td></td>
<td>3) Shared purchase</td>
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The utility functions (Cobb-Douglas)

1) Public provider (no purchase)

\[ U_{i1} = [e_i - d_i p_1]^{\theta_i} (d_i * K)^{1-\theta_i} \]

- 1) Preference for income
- 2) Preference for consumption

2) Individual purchase:

\[ U_{i2} = [e_i - (d_i p_2 + \frac{I}{L_2})]^{\theta_i} (d)^{1-\theta_i} \]

- a. Proportional division rule based on agent’s demand
- b. Proportional division rule based on agent’s monetary contribution
- c. Equal shared division rule based on group size

3) Shared purchase:

\[ U_{i3} = [e_i - (d_i p_3 + x_i)]^{\theta_i} \left\{ (d_i + D_{-i}) \left[ \frac{\alpha_i d_i}{d_i + D_{-i}} + (1 - \alpha_i) \left( \frac{\beta_i x_i}{x_i + X_{-i}} + \frac{1 - \beta_i}{N} \right) \right] \right\}^{1-\theta_i} \]

- 1) Preference for income
- 2) Preference for consumption (in group)
- a. Proportional division rule based on agent’s demand
- b. Proportional division rule based on agent’s monetary contribution
- c. Equal shared division rule based on group size

\[ \sum d_i \leq S \quad \text{and} \quad L_3 = \frac{S}{\sum d_i} \quad \text{and} \quad \frac{I}{L_3} \leq \sum x_i \leq \frac{I}{L_3} * 1.1 \]
Coalition Formation & Diffusion

(a) *Initiator* (in black) in regular network structure

Initiators (strong motivation)
1. Tie links with others
2. Starts the process of group formation

Knowledge diffusion & Network formation
Coordination & Coalition evaluation

\[
W_t = \max[W_{t-1}; \min[1; Adv + (\text{Sharing Adopters}_{t-1})^\xi]]
\]
Group Formation – Evaluation and decision

1) No_Purchase

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<tr>
<th>Agent</th>
<th>d</th>
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<th>I3 L3</th>
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<th>U3</th>
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2) Individual_Purchase

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3) Shared_Purchase

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Agents’ utility

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Utility in sharing group

\[ U_{i3} = \left[ e_i - (d_i + p_3 + x_i) \right]^{\theta_i} \left\{ (d_i + D_{-i}) \left[ \frac{\alpha_i d_i}{d_i + D_{-i}} + (1 - \alpha_i)(\frac{\beta_i x_i}{x_i + X_{-i}} + \frac{1 - \beta_i}{N}) \right] \right\}^{1 - \theta_i} \]