A Continuous Time Model of Product Usage: Measuring the Effect of Product Design and Rewards in Online Games

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Why Study Product Usage?

- Product usage dominates consumers’ lives:
  - Examples: using Facebook - 1 workday/month, watching TV - 2 months/year, driving a car - 5 years/lifetime.

- Consumers who *use* products generate advertising revenues, repeat purchases, and favorable word-of-mouth.

- *Big Data* - availability of product usage data:
  - Dataset examples: TV watching, e-book reading, online game playing.
Research Questions

- How important are the following drivers for consumer product usage decisions (Holbrook and Hirschman, 1982; Laibson, 2001)?
  - intrinsic preferences,
  - extrinsic rewards,
  - habit.

- How can the firm influence product usage and consumer engagement?
  - change product design;
  - implement alternative rewards schedule;
  - remind consumers about the product.
Propose an empirical structural model that explains two consumer product usage decisions in continuous time: (1) Should I use a product? and (2) For how long?

Key model features:

- Usage decision incidence is stochastic and its rate is estimated;
- Utility is driven by intrinsic preferences, extrinsic rewards, and habit;

Extend the methodology of estimating dynamic discrete choice models in continuous time (Arcidiacono et al, 2011; Doraszelski and Judd, 2010) to allow for an unobserved state - habit.
Contribution - Substantive - Online Games

- **Consumer Behavior**
  - Consumer segments - 1 in 5 gamers is a “Content Enthusiast”, 4 in 5 gamers are “Reward Seekers”;
  - “Content Enthusiasts” are especially prone to habit formation.

- **Managerial Insights**
  - Product Design - change in time required to access new content;
  - Reward Scheduling - change the timing and the amount of rewards.
The Game of *World of Warcraft*

- Revenue model - subscription.
- 7 million subscribers in September 2006.
- Role-playing game with 60 consecutive levels.
- Product Design:
  - Time/effort requirements to access new content.
- Rewards Scheduling:
  - Virtual goods offered at certain progression points.
Data

- Data Collection - Every 10 min, a computer program records presence of users on the game server and their levels.
- Sample Size - 956 gamers observed for 6 months.
Model - Decision Incidence in Continuous Time

- Consumer decision at time $t$ - should I use or should I not use the product?
- When do consumer decisions occur?

<table>
<thead>
<tr>
<th>State</th>
<th>Decision Prompt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not using the product</td>
<td><em>Contextual usage cue</em> (Wood and Neal, 2009; Laibson, 2001)</td>
</tr>
<tr>
<td>Using the product</td>
<td><em>End of Flow</em> (Csíkszentmihályi, 1992)</td>
</tr>
</tbody>
</table>
Model - Consumer Utility Structure

\[ U_{\text{intr}}^\tau = \int_0^\tau e^{-tp}[\alpha_1 + \alpha_2 f_l(\text{level}) + \alpha_3 f_h(\text{habit})] \, dt \]

\[ U_{\text{extr}} = \beta_0 + \beta_1 g(\text{Reward}) \]
Value of Product Usage

- The value of using the product at level \( l \):

\[
V(s) = E_{\tau(s)} \left[ \int_{0}^{\tau(s)} e^{-\rho t} U_{\text{intr}}(s) dt \right] + E_{\tau(s)} \left[ e^{-\rho \tau(s)} \left( \pi_l(s) \left[ U_{\text{extr}}(s) + V(s') \right] + \pi_a(s) \max_{a \in A(s)} (U_{a}(s) + e_{a} + v_{a}(s)) \right) \right]
\]

\[
\text{intrinsic utility of usage over duration } \tau
\]

\[
\text{total value of leveling up}
\]

\[
\text{value of usage decision}
\]
Estimation Strategy

- The three processes - usage, habit formation, and levels progression - form a tri-variate continuous time Markov chain.
- MPEC approach - maximize the transition density of the observed process subject to the consumer value function using AMPL/Knitro (Dubé et al., 2011).
## Results - Utility Estimates

<table>
<thead>
<tr>
<th></th>
<th>Segment 1</th>
<th>Segment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intrinsic Utility</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td>2.023*</td>
<td>5.970*</td>
</tr>
<tr>
<td>Additional per Level</td>
<td>0.066*</td>
<td>0.018*</td>
</tr>
<tr>
<td>Habit “Bump”</td>
<td>0.035*</td>
<td>0.420*</td>
</tr>
<tr>
<td><strong>Extrinsic Rewards</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base</td>
<td>724.950*</td>
<td>251.349*</td>
</tr>
<tr>
<td>Every 10th Level</td>
<td>77.465*</td>
<td>93.172*</td>
</tr>
<tr>
<td><strong>Segment Size</strong></td>
<td>0.783**</td>
<td>0.217**</td>
</tr>
</tbody>
</table>

* - significant at 5%, ** - significant at 2.5%.

**Reward**  
*Seekers*

**Content**  
*Enthusiasts*
## Results - Decision Making Incidence

<table>
<thead>
<tr>
<th>Usage Decisions Prompts</th>
<th>Estimated Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Not using the product - Contextual Cues</strong></td>
<td></td>
</tr>
<tr>
<td>with habit</td>
<td>every 7 hours</td>
</tr>
<tr>
<td>without habit</td>
<td>every 65 hours</td>
</tr>
<tr>
<td><strong>Using the product - State of Flow Ends</strong></td>
<td></td>
</tr>
<tr>
<td>with habit</td>
<td>every 11 min</td>
</tr>
<tr>
<td>without habit</td>
<td>every 9 min</td>
</tr>
</tbody>
</table>
Managerial Decision: “Reminders”

- Frequency of usage cues is increased by 30%.
Managerial Decision: Complexity

- A 2-fold increase in time needed to get to use additional features and content.
Managerial Decision: Reward Scheduling

- Remove a large reward (e.g., virtual goods and benefits) obtained at level 10.

Removal of Extrinsic Rewards from Level 10
Results in Larger Drop-Outs from Earlier Levels
Conclusion and Future Research

- Proposed an empirical model of product usage in continuous time and explained usage of the online game.
- Future research - How do the *social* component and product *training* effect product usage?
- The *Big Data* trend will bring more product usage data that have never been available before.
Thank you!
Results: Habit

- Upon a cue arrival consumer makes a usage decision.
- If consumer decides not to use the product, the habit will go away with probability 0.606.
The Impact of Innovation on Product Usage: A Dynamic Model with Progression in Content Consumption (with Paulo Albuquerque)

- Research Question
  - How often should a firm innovate / issue product updates to keep mature consumers engaged?

- Methodology
  - Estimate dynamic structural model of video game content consumption in discrete time.

- Under review at Marketing Science.
Consumer Information Asymmetry in Online Product Reviews

- Research Question
  - Can the firm selling a product online profit by providing information about consumer tastes heterogeneity?

- Methodology
  - Dynamic model of the firm selecting an optimal price for its product and simulations.