A Choice Modeling Framework for Service Time Windows

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Customer Flexibility and Operational Cost

For on-demand and appointment service providers, managing the time slots capacity is important. To reduce the service cost, some service providers offer long and overlapping time windows with reward to gain some flexibility (Figure 1 left). *How do these overlapping windows affect customer choices and what is the value of them?*

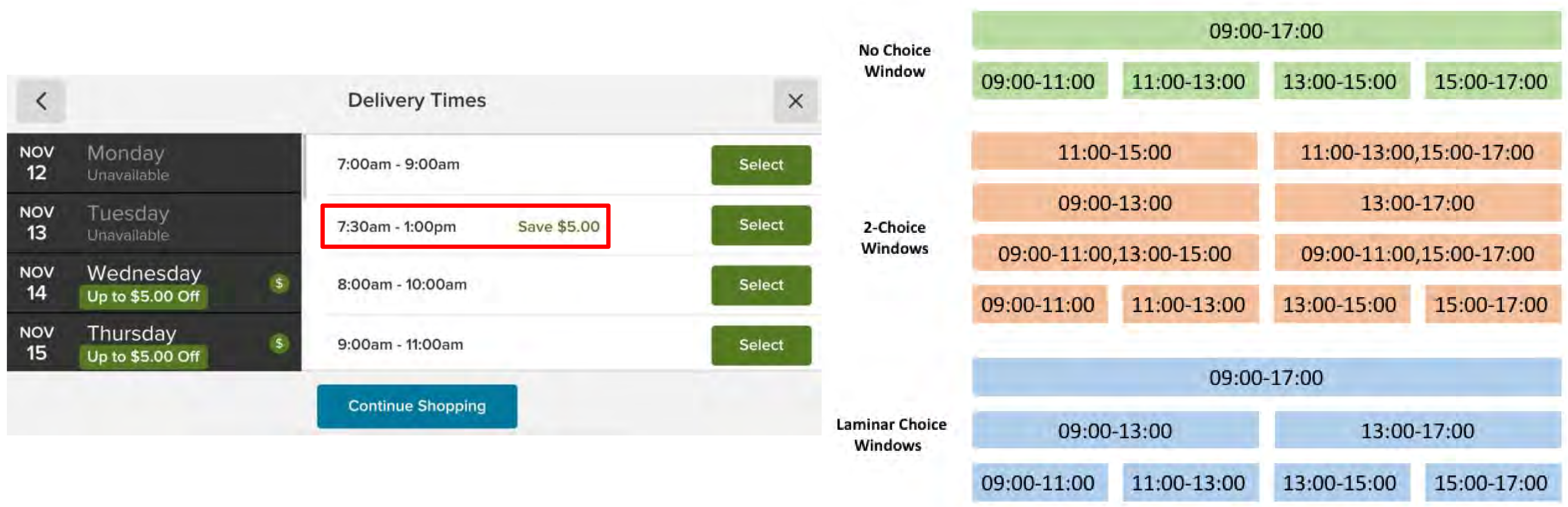

Figure 1. Screenshot from a grocery website (left) and the structure of time window investigated in this work (right)

Modeling Customer Choice Behavior

We assume that there are N disjoint base windows. For window i, it has cost c_i, and customers have random utility U_i. For those who choose an overlapping window, they will receive a reward δ, and expect to receive their service in the most unfavorable base window. When U_i follows Generalized Extreme Value (GEV) model, we could compute the choice probability by the linear combination of choice probability without overlapping windows.

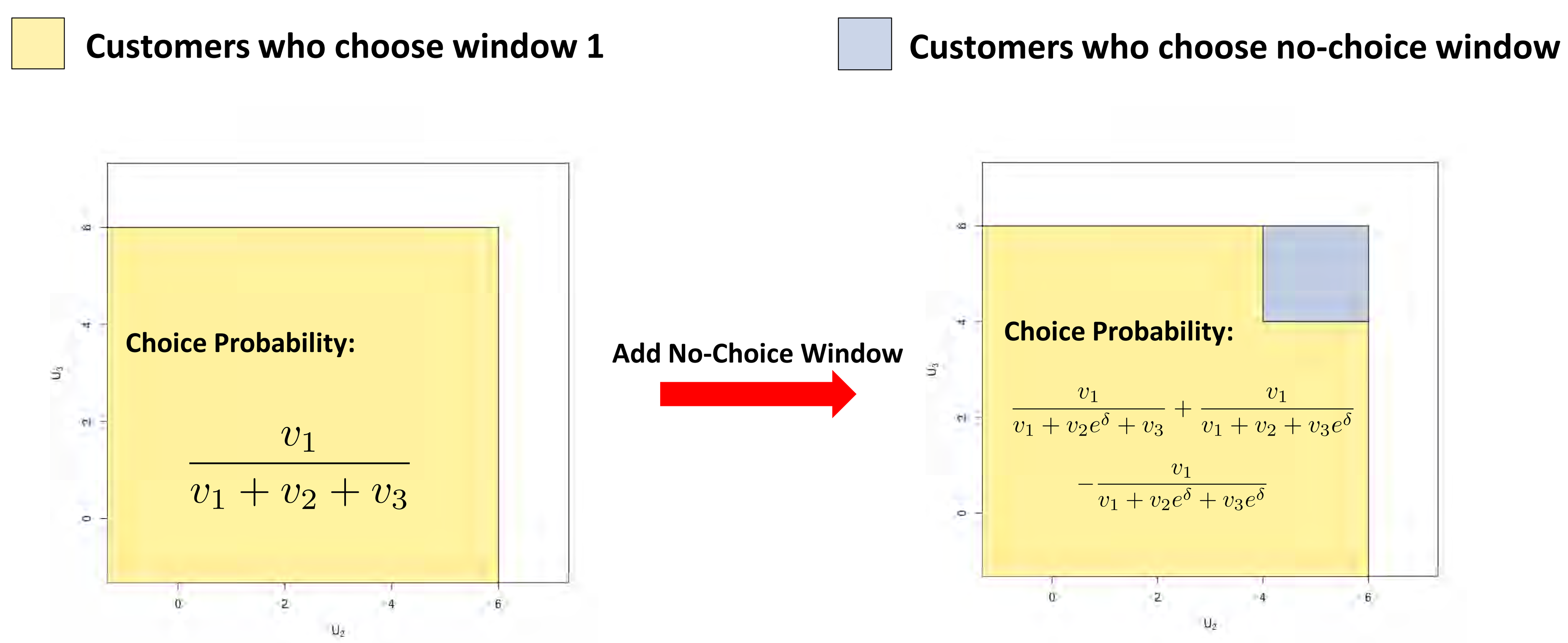

Figure 2. When N=3, conditional valuation space for $U_1 = 6$, without overlapping window (left), and with a no-choice window that gives $2 reward (right)

Cost Saving Effect of Overlapping Windows

For those who choose the overlapping windows, the seller will assign them to the cheapest window. The seller needs to choose the optimal reward δ^* by optimizing the following cost function:

$$C(\delta) = \sum_{i=1}^{N} c_i \pi(i, \mathbf{v}, \delta) + (c_{\min} + \delta)(1 - \sum_{i=1}^{N} \pi(i, \mathbf{v}, \delta))$$

It turns out that, δ^* is always strictly positive, i.e., it is always beneficial to add overlapping windows under two general conditions:

a) *The choice probability for the underlying GEV model is strictly positive for all i. (For MNL, $v_i > 0$.)*

b) *The costs c_i are not all the same.*

Power of Overlapping Windows

For 2-base-window case, adding a no-choice window could reach 60% of the best possible savings, when $c_1 > 1.5c_2$. For 4-base window case, 2-choice window works much better than no-choice and Laminar choice window, because it segments the customers into many groups based on their first two preferences, and each group faces a 2-base-window case, which has shown to be effective.

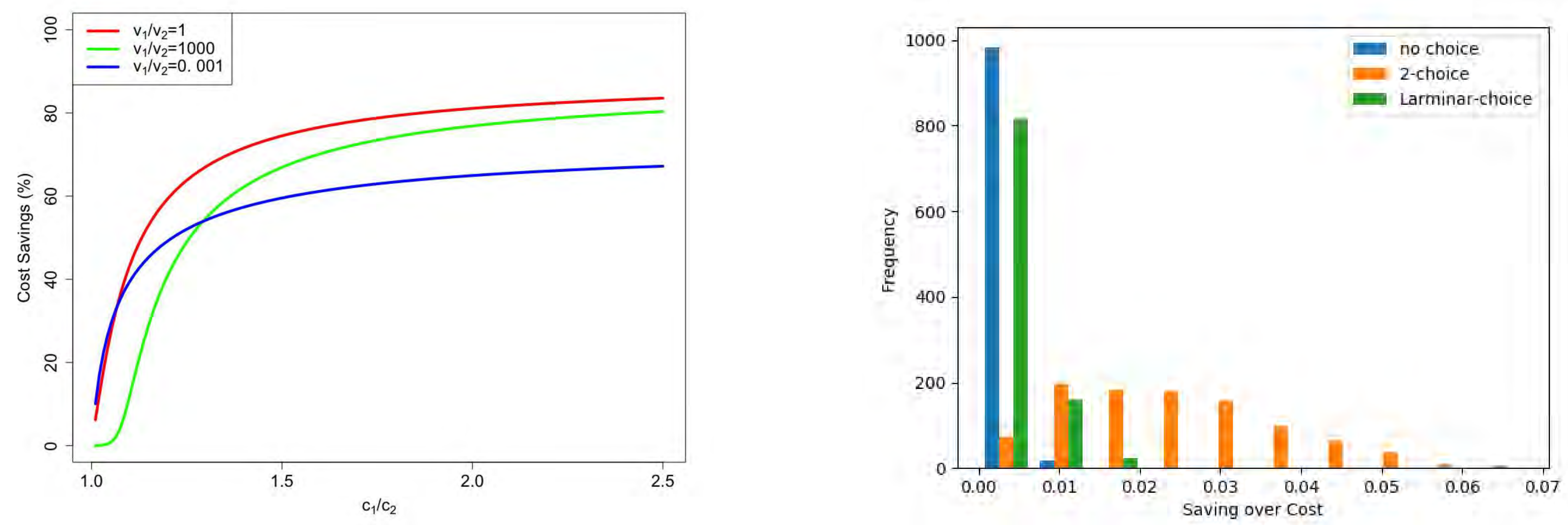

Figure 3. Saving effect in terms of best possible saving (left)
Comparison of three types of overlapping windows (right)

Future Research

Overlapping windows with vehicle routing problem, dynamic assortment/rewards in practice, efficient pricing algorithms…