Optimal match recommendations in two-sided marketplaces with endogenous prices

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Overview

Context: Lead-generation platforms that use responses to platform questionnaires to connect each customer with a few service providers.

- Examples: Amazon Home Services, Angi, HomeAdvisor, Jia.com (齐家), TaskRabbit, Thumbtack, To8to (土巴兔), …

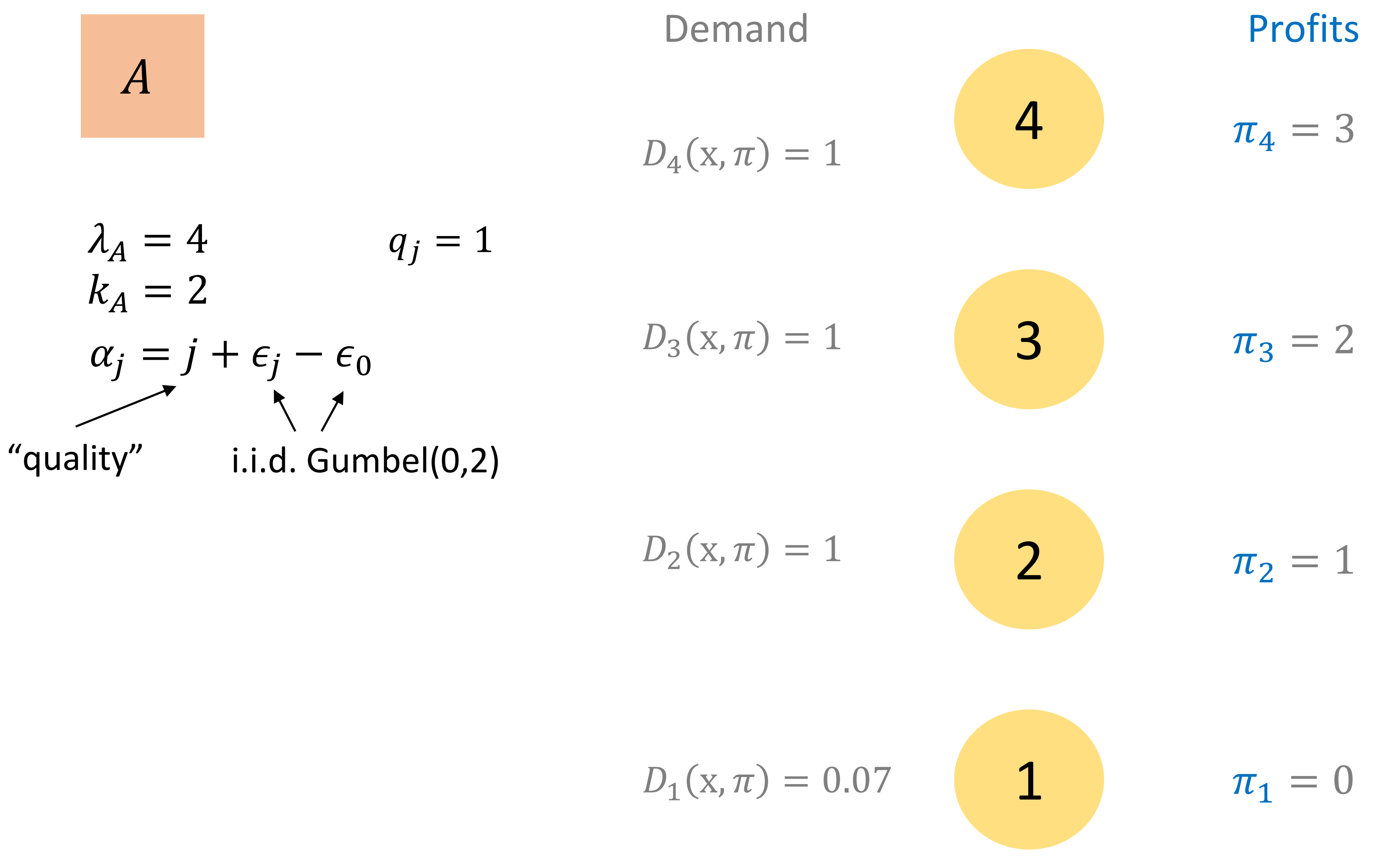
Research question: How to best recommend matches to maximize social welfare?

Literature on optimizing match recommendations: Does not account for price endogeneity (i.e. service providers set their own prices outside of the platform's control). Moreover, optimal solutions are complex and intractable to compute.

Contributions: In optimizing match recommendations, accounting for price endogeneity

1. simplifies the structure of optimal solutions, so that they are tractable to compute;
2. results in higher social welfare.

Illustration: 1 segment, 4 providers, MNL preferences



Optimal Policy:
recommend a subset of cardinality 2 s.t.

$\mathbb{P}(4 \in S) = 0.65$
$\mathbb{P}(3 \in S) = 0.65$
$\mathbb{P}(2 \in S) = 0.65$
$\mathbb{P}(1 \in S) = 0.05$

Impression probabilities

Customer surplus: 11.66
Provider surplus: 6.00
Social welfare: 17.66

Model

Set I of customer segments:

- λ_i: arrival rate;
- k_i: max # of recommendations;
- F_i: continuous prob. measure on $\mathbb{R}^n$.

Set J of n providers:

- q_j: capacity;
- π_j: profit per job (endogenous)

Policy x
x_{iS}: prob. of recommending S to a segment i customer.

Matched with j iff $\alpha_j - \pi_j \geq 0$ and $j \in \arg\max_{j' \in S}\{\alpha_{j'} - \pi_{j'}\}$.

Objective: choose recommendation policy x to maximize the social welfare.

Results

$$\underbrace{\alpha_j = \gamma_{ij}}_{\text{average surplus}} + \underbrace{\epsilon_j}_{\text{Idiosyncratic surplus}} - \underbrace{\delta}_{\text{outside option}}$$

$\epsilon_j \sim G_i$
$\delta \sim H_i$
Arbitrary segment-dependent distributions

Theorem: Under the above assumption on preferences,

a) A policy x is optimal if and only if under an equilibrium π, $x_{iS} > 0$ implies
$$S \subseteq \{\text{top } k_i \text{ providers with highest } \gamma_{ij} - \pi_j\}$$
i.e. always recommend those with the highest predicted attractiveness;

b) Optimal policy x can be encoded simply as **impression probabilities.**

c) Optimal (x, π) can be tractably computed via stochastic subgradient descent.

d) Social welfare is strictly higher than the case in which the platform assumes an exogenous profit vector and repeated re-optimizes.

Full paper available on SSRN.