The Value of Knowing Drivers’ Opportunity Cost in Ride Hailing Systems

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Research Purpose
A ride hailing platform has knowledge about potential drivers’ outside opportunities. How is this knowledge beneficial? Can its value be quantified?

Understanding this is crucial for designing bonus programs and maintaining drivers’ commitment towards the platform.

The Motivating Discrete Model
Imagine a city with many potential drivers, differing in their opportunity cost (OC). Drivers choose whether to work for the platform based on expected revenue (rev.) rate.

The platform sets a matching policy subject to a pickup-time constraint.

- **1.** The city is modeled as the unit interval with a total of \( N \) participating drivers
- **2.** Two types of drivers, type \( L \) and type \( H \), with different OC, \( \kappa_L < \kappa_H \)
- **3.** Drivers can be busy or available
- **4.** Passengers arrive at random locations
- **5.** A passenger at \( x \) must be matched with an available driver within \( x - \delta \)
- **6.** A matched driver becomes busy for \( \tau \) units of time
- **7.** If no available drivers are in \( x - \delta \) the ride is lost

Drivers choose whether to work for the platform based on expected revenue (rev.) rate. The platform sets a matching policy subject to a pickup-time constraint.

- **MinRev:** Driver’s score = accumulated rev. by time \( t \)
- **MinWeightRev:** Driver’s score = accumulated rev. by time \( t \) divided by OC

Which policy performs better in Equilibrium?

In equilibrium (eq.) : Each driver participates if it’s profitable to them (compared to OC).

In this example (Fig 2), MinWeightRev attracts \( \times 2 \) more drivers in eq. relative to MinRev, and increases the matching rate by roughly \( \times 2 \).

The Mean Field Model
We analyze two mean field (m.f.) systems, one for each policy, corresponding to a large market of drivers \( (N \to \infty) \)

The formulation builds on the intuition that when \( N \) and \( t \) are large:

- Drivers’ scaled locations along the city form a Spatial Poisson process (Fig 3)
- Long-run revenue rates of all drivers coincide under MinRev (Fig 4), and the same holds for all drivers of the same type under MinWeightRev.

Key Findings – Improvement Bounds
Equilibrium participation profile of drivers is unique for each policy.

- **MinWeightRev** eq. is always better than MinRev eq. in terms of drivers’ participation rates and effective matching rate.
- **MinWeightRev** increases eq. total participation by up to \( \times 2 \) relative to MinRev.
- **MinWeightRev** improves eq. matching rate by up to \( \times 2 \) relative to MinRev.

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