The Economics of Peer-to-Peer Car Sharing

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Sharing Economy: P2P Car Sharing

car sharing has become an increasingly popular trend

Share it

Car renter
Rent great cars from people nearby
Unlock 1,000's of cars from $5/hour.

Car owner
Share your car. Earn $10,000 per year.
Potential Benefits

- Reduce car ownership
- Reduce car usage
- Reduce affiliated resources, such as parking space, congestion
Research Questions

• How does sharing economy affect ownership and usage of resources?

• Does collaborative consumption always lead to greater sustainability (i.e., leads to lower ownership, lower usage, or both)?

• Who benefits most from collaborative consumption, those who own, those who rent, or the platform that matches owners and renters?
Literature Review

• Two sided market
Rochet and Tirole 2006; Parker and van Alstyne 2005; Eisenmann et al. 2006; and Mongell and Roth. 1991

• On-demand mobility systems
Schuijbroek et al. 2013; Raviv and Kolka 2013; Shu et al. 2013

• Lease v.s. Buying
Desai and Purohit 1998; Hendel and Lizzeri 2002; Johnson and Waldman 2003

• Social sharing of information goods
Bakos et al. 1999; Galbreth et al. 2012; Conner and Rumelt 1991; Takeyama 1994; Shy and Thisse 1999; Varian 2005
Main Features

- A consumer has exogenous usage type $\xi$ and chooses to be either owner or renter.
- A renter pays price rate $p$ for each unit of usage, and an owner pays commission $\gamma p$ to the platform.
- An owner can always use their own car and will be able to rent out the car with probability $\beta$ when the car is not in use.
- A renter will successfully rent a car with probability $\alpha$. 
Peer-to-Peer Car Sharing

Car Owner:
- Car purchasing cost $c$
- Commission fee $py$ to platform
- Moral hazard cost of renting out a car $w$

Car Renter:
- Price rate $p$ to car owner
- Inconvenience cost $d$
Basic Model

- **Car Renter**  \[ \pi_r(\xi) = (u(\xi) - p\xi - d\xi)\beta \]

- **Car Owner**  \[ \pi_o(\xi) = u(\xi) - \alpha(1 - \xi)((1 - \gamma)p - w) - c \]

Car Renter  \[ \pi_r(\xi) \geq \pi_o(\xi) \]

Car Owner  \[ \pi_r(\xi) \leq \pi_o(\xi) \]

\[ \pi_r(\theta) = \pi_o(\theta) \]
Matching Supply with Demand

• Supply
  \[ D(\theta) = \int_{[0,\theta]} \xi f(\xi) d\xi \]

• Demand
  \[ S(\theta) = \int_{[\theta,1]} (1 - \xi) f(\xi) d\xi \]

Balance supply with demand

\[ \alpha S(\theta) = \beta D(\theta) \]

Measure of car utilization

\[ \rho(\theta) = \frac{D(\theta)}{S(\theta)} \]

Estimate \( \alpha \) and \( \beta \) from \( \rho(\theta) \)

Then find the fixed point of

\[ \pi_r(\theta) = \pi_o(\theta) \]

\[ \alpha S(\theta) = \beta D(\theta) \]
Multi-server loss queueing system

G/G/S/S Queue Approximation

\[ \alpha = \frac{\rho(\theta)}{1+\rho(\theta)} \]
the probability of renting a car out for an owner

\[ \beta = \frac{1}{1+\rho(\theta)} \]
the probability of finding a car available for a renter
Exogenous Price: Equilibrium Results

- Ownership $\omega^* = 1 - \theta^*$
- Usage $q^* = \frac{1-\alpha^*\theta^*^2}{2}$

Increases with:
- price
- inconvenience cost

Decreases with:
- commission,
- fixed ownership cost
- moral hazard
Ownership is higher under collaborative consumption when $p$ is large.

Ownership is higher under Collaborative consumption when $p$ is high.

The threshold $p_w$ decreases with $c$. 
Usage is higher under collaborative consumption when \( p \) is large

\[
c = 0.3
\]

\[
c = 0.7
\]

Usage is higher under Collaborative consumption when \( p \) is high

The threshold \( p_q \) decreases with \( c \)
When is it more sustainable?

Higher ownership, higher usage

Lower ownership, lower usage

Price, $\rho$

Ownership cost, $\sigma$
Endogenous Price: private platform’s problem

\[ \max_{p, \gamma} \pi(p) = \gamma p \alpha S(\theta) \]

subject to: \( \pi_o(\theta) = \pi_r(\theta) \)

\[ \alpha = \frac{D(\theta)}{D(\theta) + S(\theta)} \]

\( \pi_o(\xi) \geq \pi_r(\xi) \) for \( \xi \geq \theta \)
\( \pi_o(\xi) \leq \pi_r(\xi) \) for \( \xi \leq \theta \)
\( \pi_o(\xi) \geq 0 \) for \( \xi \geq \theta \)
\( \pi_r(\xi) \geq 0 \) for \( 0 \leq \xi \leq \theta \)
When is it more sustainable?
Endogenous Price: Social Welfare and Public Platform

\[
\max_{p, \gamma} \pi(p) = \text{total social welfare}
\]

subject to: \( \pi_o(\theta) = \pi_r(\theta) \)

\[
\alpha = \frac{D(\theta)}{D(\theta) + S(\theta)}
\]

\( \pi_o(\xi) \geq \pi_r(\xi) \text{ for } \xi \geq \theta \)

\( \pi_o(\xi) \leq \pi_r(\xi) \text{ for } \xi \leq \theta \)

\( \pi_o(\xi) \geq 0 \text{ for } \xi \geq \theta \)

\( \pi_r(\xi) \geq 0 \text{ for } 0 \leq \xi \leq \theta \)
Comparison: Public and Private Platform

Private platforms induce more ownership than public platforms.
Comparison: Public and Private Platform

Private platform charges a higher price $\rho$

![Graph showing the comparison between private and public platform prices. The graph indicates a higher price for the private platform as the fixed ownership cost, $c$, increases.](image)
Can Public Platform Implement Social Optimal?

• There exists $\bar{\gamma}(c)$ such that the public platform can implemental social optimal if

$$\gamma \leq \bar{\gamma}(c) = \frac{(1-\theta^s)^2}{\theta^s(2\theta^{s^2} - 2\theta^s + 1)}$$

$$p = \frac{\theta^s}{(1 - \gamma \theta^s)(2\theta^{s^2} - 2\theta^s + 1)}$$
Numerical Analysis: Monotonicity with $d$

- Both Social welfare and private platforms’ profit decrease with inconvenience cost $d$.

- Platform’s incentive to reduce inconvenience cost align with social welfare.
Numerical Analysis: Non-monotonicity with $w$

Social welfare decrease with moral hazard $w$.

Private platform’s profit decrease with moral hazard $w$ when $c$ is large.

Private platform’s profit is non-monotone with moral hazard $w$ when $c$ is small.

Social planer’s incentive to reduce moral hazard does not align with private platforms’!
Conclusion

• Collaborative consumption can induce higher ownership and higher usage and thus less sustainability.

• Public platform leads to lower ownership and usage than private platform, and can implement social optimal.

• The incentive of reducing moral hazard by a private platform is not aligned with social planner.