# Peer-to-Peer Trading of Usage Quotas


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Driven to Discover℠

Initiative on the Sharing Economy

# Quota Based Business Models


Software as a service

NETJETS

YOUR OWN PRIVATE AIRLINE

fractional ownership of private jets

CLASSPASS

access to various gyms and fitness classes


KarmaGo, a WiFi provider, allows users to share their quota


Event tickets:
Access to a particular seat during the event

Vacatia

fractional ownership of vacation houses

# Mobile Hotspot Sharing

- Developed by MIT Media Lab in 2013
- “ Air Mobs creates a local mobile community to allow users to freely share internet access. ”


**Challenge**

“ There is a good chance that Verizon, AT&T, and other stakeholders would come in and shut it down.”

# China Mobile Hong Kong 2cm Platform


A trading platform for unused capacity.

- 2cm, started 2013

Two plans

- 1GB of data
- 5GB of data

"Many users who subscribe to a 5-GB monthly plan may not use all the data. 2cm data exchange platform would give them the chance to trade capacity."

– China Mobile Hong Kong chairman Tiger Lin Zhenhui

# Firm Initiated Capacity Sharing

Some firms not only allow peer-to-peer trading, but also provide infrastructure to facilitate peer-to-peer capacity trading.




Share your Ford car using **Ford car sharing** platform

**Toyota keyless system**: unlock doors and start cars with a smartphones

# Research Questions

**Is allowing customers to share their excess capacity beneficial?**

- How is the service provider's profit affected?
- How is the customers' surplus affected?
  - Individual
  - Aggregate
- What will happen to aggregate consumption?
- How is social welfare affected?
- What is the optimal contract design in the presence of peer-to-peer trading?

# Related Literature

## Secondary market for used durable goods

— *value enhancement* vs. *market cannibalization*

— **Common wisdom**: the secondary markets improves social welfare by increasing allocation efficiency and negatively affects provider's profit

Waldman (2003), Chen et al. (2013), Chevalier and Goolsbee (2009), Hendel et al. 2005), Johnson 2011, Leslie and Sorensen 2013

## Peer-to-peer product sharing

Lee and Whang (2002), Cui et al. (2014), Benjaafar et al. (2016), Jiang and Tian (2016), Fraiberg and Sundarajan (2016), Bellos et al. (2017) , Angelus (2011), Huang et al. (2001)

# Model Setup

**Service Provider**

**Low plan**

$\mathbf{m_1} = (q_1, p_1)$

$\mathbf{m_2} = (q_2, p_2)$

**High plan**

**Customers**

- Two quota plans
- Risk- neutral monopolist
- Service cost $c$ per unit of usage

**Assumptions**

**A1**: Full market coverage

**A2**: Full plan coverage

- Continuum of customers
- Types, denoted by $\theta$, are uniformly distributed on $[0, 1]$.
- Type-dependent consumption such that consumption is either $H$ or $L$ with

$$\mathbb{P}(x = H) = \theta$$

$$\mathbb{P}(x = L) = 1 - \theta$$

# Without Trading vs. with Trading

The service provider decides on the contract terms

Customers select a contract

Each customer learns his own demand

Customers use the platform to buy/sell data at price $\boldsymbol{\pi}$

**without trading**

**with trading**

## Customers' surplus

$$u_n(q,\theta) = r\mathbb{E}(x|x \le q) - p$$

$$u_t(q,\theta) = u_n(q,\theta) + \underbrace{\boldsymbol{\alpha}\,\pi\,\mathbb{E}(q-x|x \le q)}_{\textbf{Overage}} + \underbrace{\boldsymbol{\beta}(r-\pi)\mathbb{E}(x-q|x>q)}_{\textbf{Underage}}$$

$$\alpha = \min\left\{\frac{\text{total demand}}{\text{total supply}}, 1\right\} \quad \beta = \min\left\{\frac{\text{total supply}}{\text{total demand}}, 1\right\}$$

$$\beta = 1 \Rightarrow \alpha \le 1$$

$$\alpha = 1 \Rightarrow \beta \le 1$$

# Equilibrium

There exists a unique equilibrium in the form of a switching strategy

$$\theta_n = \frac{\delta}{r}\ , \qquad \theta_t = \begin{cases} \frac{\delta}{\delta+\pi} & if \quad \delta \le \pi \le r \\ \frac{r-\pi}{2r-(\delta+\pi)} & if \quad 0 \le \pi \le \delta \end{cases} \qquad \text{with } \delta = \frac{p_2 - p_1}{q_2 - q_1}$$


Let $\mathbf{m}_1^t = (L, p_1)$ and $\mathbf{m}_2^t = (H, p_2)$ , then the service provider solves

$$\max_{p_1^t, p_2^t} \quad p_1^t \theta_t + p_2^t (1 - \theta_t) - c\ \mathrm{P}_t$$

subject to

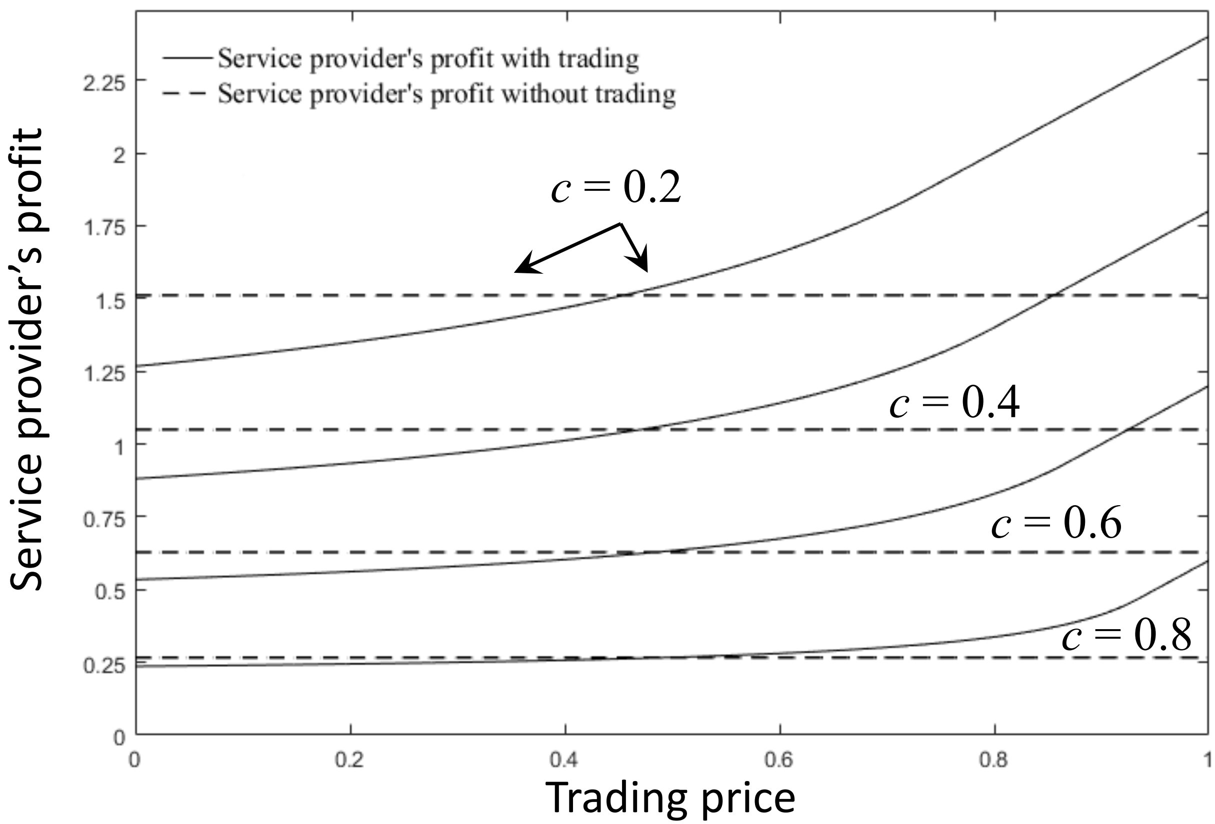
$$u_t(\hat{\theta}_1, \mathbf{m}_1^t) \ge u_t(\hat{\theta}_1, \mathbf{m}_2^t) \qquad \text{for some } \hat{\theta}_1 \in [0,1]$$

$$u_t(\hat{\theta}_2, \mathbf{m}_2^t) \ge u_t(\hat{\theta}_2 \mathbf{m}_1^t) \qquad \text{for some } \hat{\theta}_2 \in [0,1]$$

$$u_t(0, \widehat{\mathbf{m}}\ ) \ge 0 \qquad \text{for some } \widehat{\mathbf{m}} \in \{\mathbf{m}_1^t, \mathbf{m}_2^t\}$$

# The Service Provider’s Profit

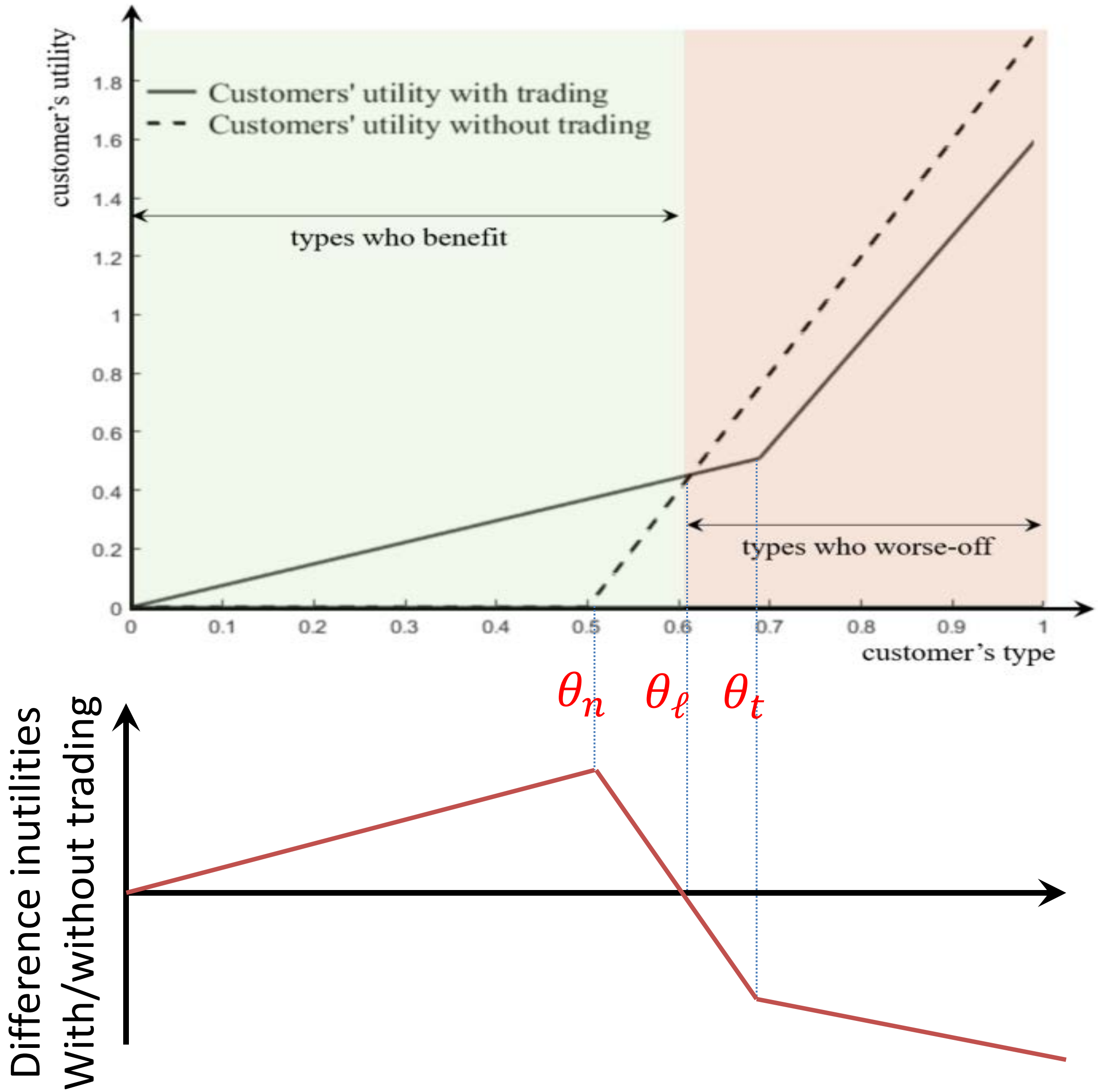
The Service Provider’s profit increases by allowing peer-to-peer trading of usage quota if and only if the trading price $\pi$ is higher than the threshold $\pi_1^t$. Moreover, the threshold $\pi_1^t$ is unique and increases in $c$.



# Individual Customer's Surplus

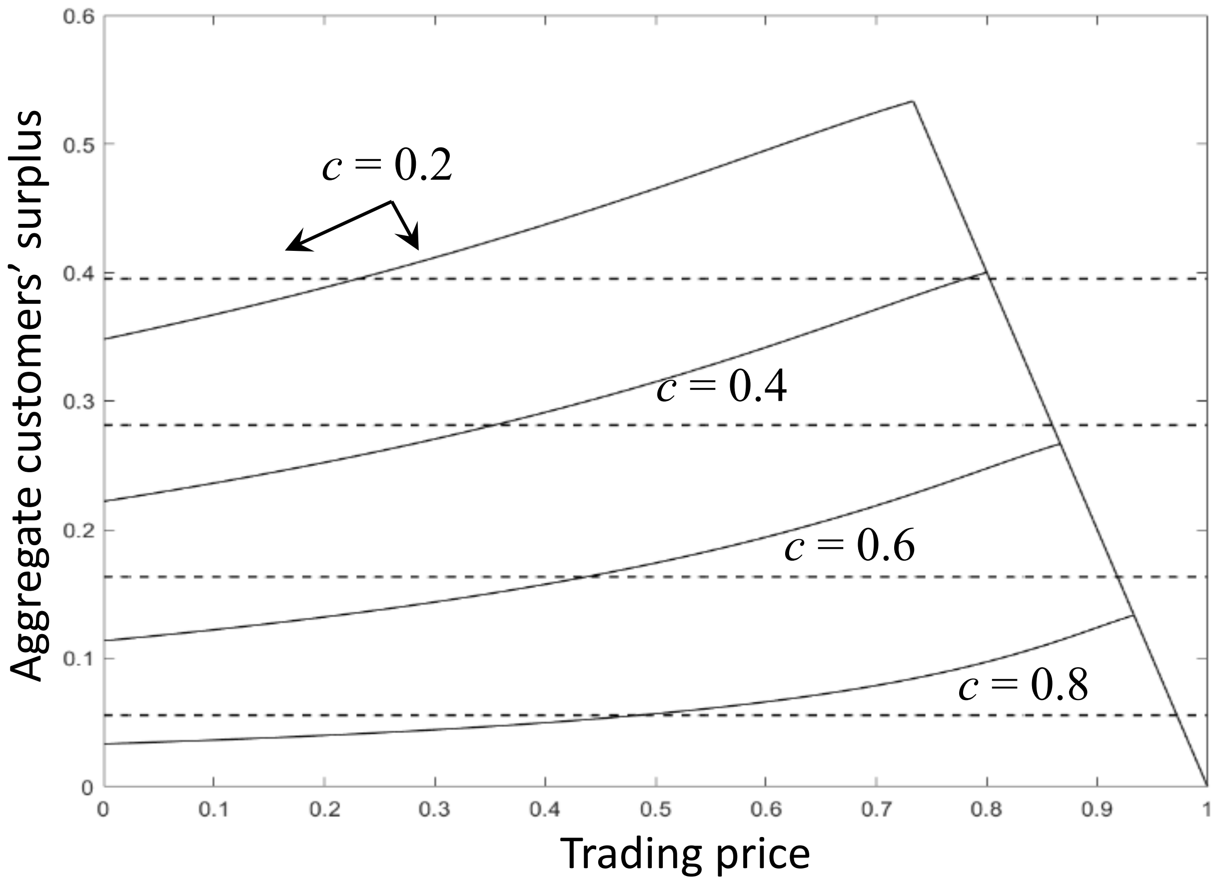
1. There is $\theta_\ell \in [0,1]$ such that all customers of types $\theta \geq \theta_\ell$ are better off and all customers of type $\theta < \theta_\ell$ are worse off.

2. The customer of type $\theta_n$ benefits the most



# Aggregate Customers' Surplus

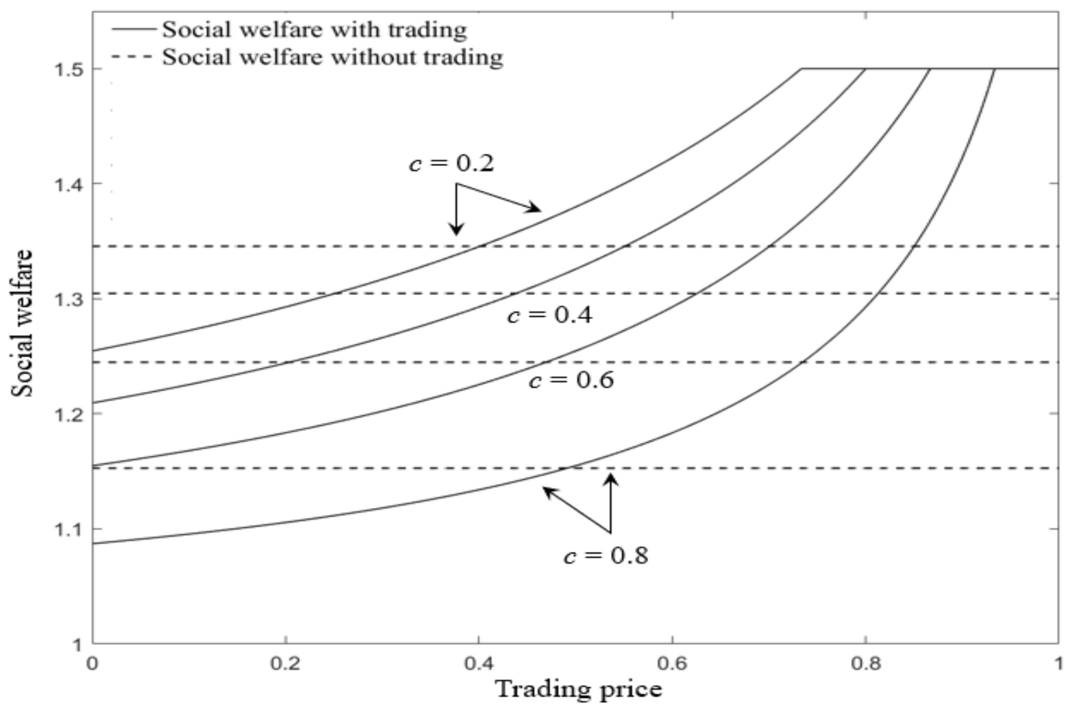
The aggregate customers' surplus increases, by peer-to-peer trading, if and only if $\pi_3^t \leq \pi \leq \pi_4^t$. Moreover, both thresholds increase in $c$.



# Social Welfare

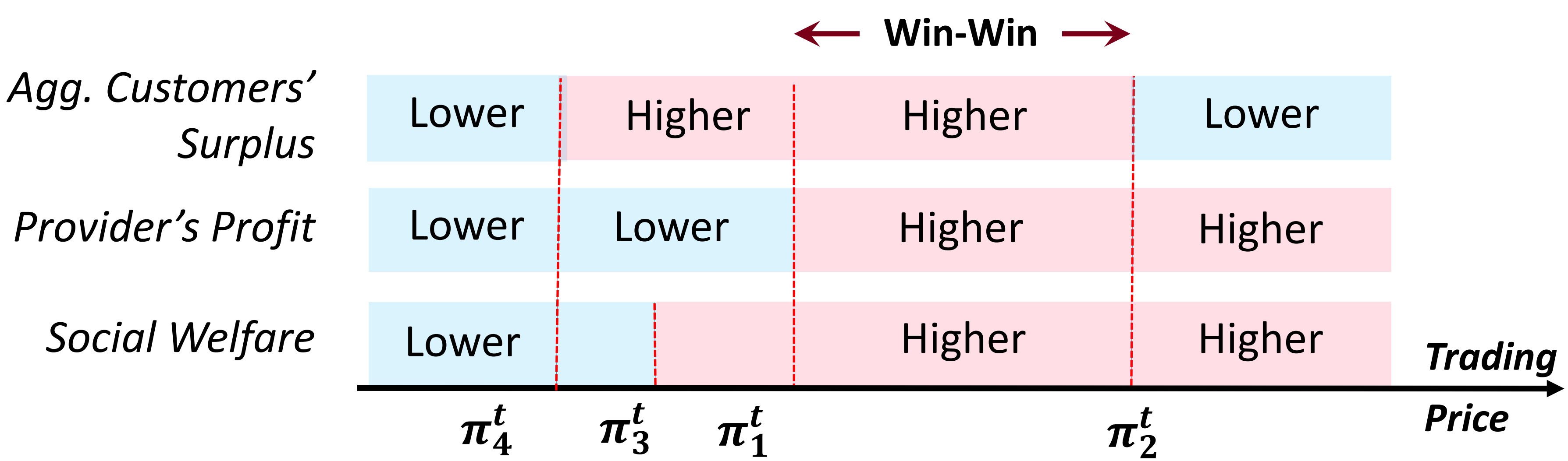
Peer-to-peer trading leads to higher social welfare if and only if the trading price is higher than the unique threshold $\pi_2^S$. Moreover, $\pi_2^S < \pi_1^S$ and $\pi_2^S$ increases in $c$.

— If the market is such that the trading price is kept sufficiently high, then sharing is **socially optimal**.



# Summary of Results

- Peer-to-peer trading creates a win-win situation if the trading price is moderate
- Interestingly, if the trading price is low enough the aggregate customers' surplus decreases by the peer-to-peer trading
- If the trading price is sufficiently high, both the service provider's profit and the social welfare are improved by peer-to-peer trading

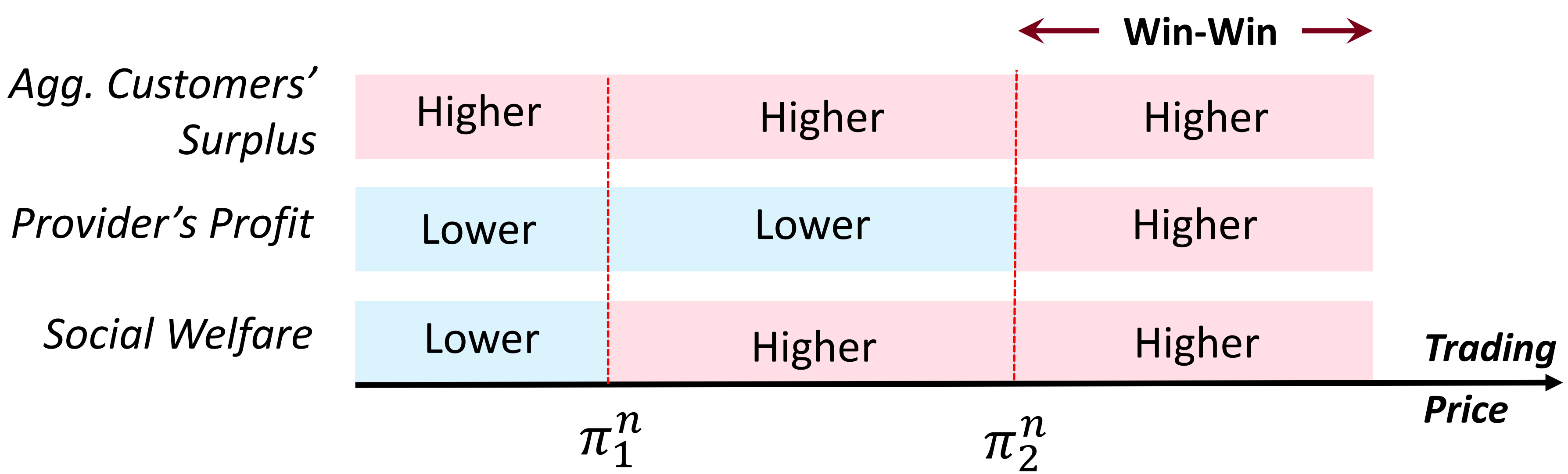


# Fixed Contracts

— All customers are better off and the aggregate customers' surplus is always higher

— If the trading price is sufficiently high, both the service provider's profit and the social welfare are improved by peer-to-peer trading

— The win-win condition is characterized by **only** a lower bound on the trading price



# Main Contributions and Takeaways

- A model of trading unused capacity among customers
- Insights into the impact of trading on **consumer surplus**, **provider's profit**, and **social welfare**
- Characterize the condition under which trading unused capacity is **win-win** with respect to performance metrics we introduced
- Our results provide a framework for firms and social planers to evaluate the profitability of peer-to-peer trading