Competition in Service Industries

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Haifa 2003

Overview

- Consumer Choice Model
- Literature Review
- Base Model
- Generalized Model
- Numerical Examples
- Conclusions

Consumer Choice Model - Objective

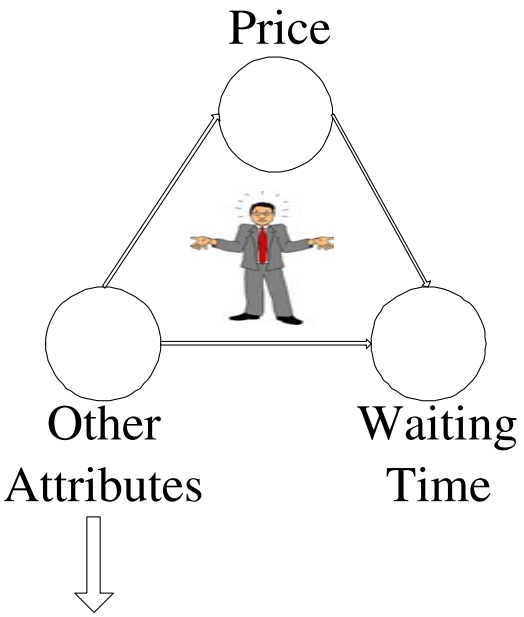
General model in which each firm's market share (size) depends on:

- *All* prices of firms in the industry
- *All* waiting time guarantees of firms in the industry: expected waiting time or a given fractile of waiting time
- *Other* intrinsic attributes

Examples

- Pizza Delivery: Dominos offers a 30-minutes delivery guarantee
- Restaurants: Black Angus chain offers free lunch, if lunch is not served within 10 minutes
- Banks: (Wells Fargo) $5 award if you wait more than 5 minutes in line
- Overnight delivery service: UPS outbid FedEx delivery guarantee 11:00AM $\rightarrow$ 10:00AM $\rightarrow$ 8:30AM
- Supermarket chain: Lucky "3 is a crowd": no checkout line with more than 3 customers

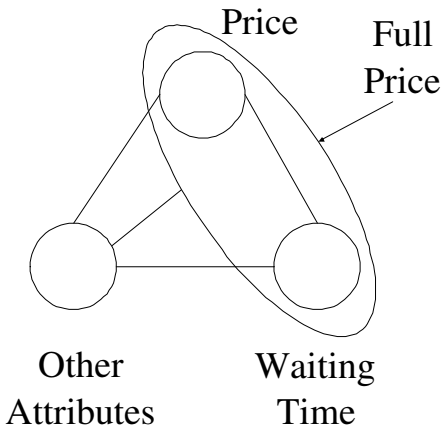
Consumer Choice Model



Examples:

- Mail services: pick-up process, tracking deliveries, likelihood of damage
- Restaurants/Fast Food chains: location, ambiance, quality of food
- Internet Service Providers: service interruptions, technical support

Existing Oligopoly Models With Price and Waiting Time Competition



$$Full\ Price = Price + k \cdot \mathbb{E}\left[Waiting\ Time\right]$$

Restrictive underlying assumptions:

- *All* customers assign a specific cost to their waiting time.
- The cost of waiting is *proportional* with the waiting time.

Literature Review

Firm Instrument / Customr Criteria	**Price**	**Capacity**	**Price+ Capacity**	**Price+ Waiting Time**
Full Price (common waiting cost rate)	Loch (1991) (N=2, M/G/1)	Kamien et al. (1992) (common queue) Gilbert and Weng (1998)	De Vany and Saving (1983)	
Full Price (different waiting cost rate)	Luski (1976) (N=2, M/M/1) Levhari (1978) Chen and Wen(2000) Lee and Li (1992) (Customers observe queue length) Lederer and Li (1997) (multiple customer classes) Armony and Haviv (2 customer classes; collective representation of each class		Reitman (1991)	
Full Price + other attributes			Cachon and Harker (2001) (N=2, M/M/1)	So (2000) (N arbitrary, M/M/1, capacity given)*
Price, Waiting Time and Other attributes				

General Framework

Three potential ways in which choices are made:

- *Waiting Time First*
- *Price First*
- *Simultaneous Competition*

Question:

Does the sequence of choices matter ?

Fudenberg D. and J. Tirole (1984), *American Economic Review*.

Equilibrium Behavior and Game Theory

Equilibrium : Lack of tendency to change

Game Theory

A bag of analytical tools designed to help us understand the phenomena that we observe when decision makers interact.

Solution

A systematic description of the outcomes that may emerge.

Types of Equilibria

- Nash Equilibrium
- Dominant Solution

The Model

$\lambda_i = a_i(\theta_i) - b_i p_i + \sum_{i \neq j} \beta_{ij} p_j$

$\theta_i = \overline{w} - w_i$ (Service Level)

$$w_i = \begin{cases} \alpha - \text{fractile of waiting time distribution} \\ \text{Expected waiting time} \end{cases}$$

$a_i(\cdot)$ concave increasing

Operational and Cost Structure:

- N M/M/1 models: capacity μ_i to meet guarantee w_i
- γ_i – cost per unit of capacity per unit of time
- c_i – cost per customer served

Price Competition

- *Unique* equilibrium *globally stable* vector p^*
- $p_i^* \uparrow$ in *any* of the service levels and cost parameter
- $\lambda_i^* \uparrow$ in *any* of the service levels and competitors' cost parameters
- $\lambda_i^* \downarrow$ in firm's *own* cost parameters
- $\pi_i^* \uparrow$ in *any* of the competitors' service levels.

However, in general not monotone in firm's own service level.

Waiting Time First Competition

The two stage game has a Nash equilibrium θ^* and $p^*(\theta^*)$

- θ^* not necessarily unique
- If multiple equilibria: there exists a component-wise largest equilibrium $\overline{\theta}$, preferred by all firms
- $\overline{\theta}$ easily computed by iterative method

Price First and Simultaneous Competition

Price First and Simultaneous Competition are Equivalent

$\theta^*(p) =$ *equilibrium* response to a given price vector.

$\Rightarrow \theta^*(p)$ is dominant solution.

- If $\widehat{p}$ equilibrium of Price First Model
  $\Rightarrow (\widehat{p}, \theta^*(\widehat{p}))$ equilibrium of Simultaneous Competition model
- If $(\widehat{p}, \widehat{\theta})$ equilibrium of Simultaneous Competition model
  $\Rightarrow \widehat{\theta} = \theta^*(\widehat{p})$ and $\widehat{p}$ equilibrium in Price First model

Main Takeaway Message: Comparison Between Equilibria

Waiting Time First results in *higher* service levels and *higher* prices compared to Price First or Simultaneous Competition

Model exhibits "Fat Cat" Phenomenon

Generalized Demand Model

Each firm's demand volume depend on *all* service levels in industry:
$\lambda_i = a_i(\theta_i) - \sum_{i \neq j} \alpha_{ij}(\theta_j) - b_i p_i + \sum_{i \neq j} \beta_{ij} p_j$

$a_i(\cdot)$ increasing concave.

$\alpha_{ij}(\cdot)$ increasing.

Main Results:

- Equilibrium exists but only if service level is bounded.
- Price First and Simultaneous Competition: each firm's service level is determined as a function of the firm's characteristics only and is a *dominant* solution
- Price First and Simultaneous Competition are equivalent
- Ranking of equilibria: equilibrium service level in the Waiting Time First may be *lower* than in the Simultaneous Competition

Numerical Results

Non linear intercept functions (a)

h	profits- WTF	profits- SC
0.0001	1071.27	1071.14
0.0002	1054.70	1054.69
0.0003	1038.51	1038.63
0.0004	1022.77	1023.05
0.0005	1007.58	1008.05
0.0006	993.11	993.78
0.0007	979.59	980.50
0.0008	967.46	968.60
0.0009	957.31	958.61
0.0010	949.77	951.07

Numerical Results

Evolution of a Market

p_1	w_1	π_1	p_2	w_2	π_3	p_3	w_3	π_3
68.01	21.10	5318.12	62.42	24.26	3048.07	64.40	27.90	1240.96
51.64	39.28	445.50	49.76	46.41	228.92	57.66	52.48	99.02
47.57	63.15	66.80	47.19	68.47	48.27	56.11	81.26	16.85
46.69	77.85	28.55	46.60	79.93	25.63	55.77	97.79	7.80
46.49	82.82	22.03	46.47	83.36	21.44	55.69	100.00	6.23
46.45	84.06	20.70	46.45	84.19	20.57	55.67	100.00	5.90
46.44	84.34	20.42	46.44	84.37	20.39	55.67	100.00	5.83

Summary and Future Work

Summary:

- Price First and Simultaneous Competition are Equivalent
- Waiting Time First results in *higher* service levels and *higher* prices compared to Price First or Simultaneous Competition
- Model exhibits "Fat Cat" Phenomenon.

Future work:

- Non-linear demand rate functions: (Attraction model, Cobb-Douglass)
- More general queueing systems: M/G/1, G/G/1.
- Multiple customer classes with differentiated prices and waiting time guarantees
- Outsourcing/ Coordination Mechanisms