Designing Pricing Contracts for Homo Sapiens: A Behavioral Theory

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Outline

- Research Question
- Standard Model’s Predictions
- Experimental Tests
- A Behavioral Theory of Pricing
Examples of Pricing Contract

- Linear
- Two-part Tariff
- Three-part Tariff
- Two-Block Tariff

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A Simple Framework

Number of Block

Single  Multiple

No

Linear  Block-tariff

Two-part Tariff  Three-part Tariff

Yes

Fixed Fee
Research Question

Does Format of Pricing Contract Matter Empirically?

- Total surplus generated from trading
- Division of surplus (e.g., which format favors the seller)
Outline

- Research Question
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- Experimental Tests
- A Behavioral Theory of Pricing
A B2B Market Setting

Independent Manufacturer (seller) → Retailer (Buyer) → Price (Single)

Demand = 10 - price

C = 2

Which Type of Pricing Contract to Use?

Example

Office DEPOT USA

Price

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Integrated Manufacturer and Retailer

Manufacturer

Retailer

C = 2

Price* = 6

Demand = 10 - price

* Assume equal division

Manufacturer Profits

Retailer Profits

0 8 16

0 8 16

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Linear Price

Independent

Manufacturer

Retailer

$C = 2$

$W^* = 6$

$\text{Demand} = 10 - \text{price}$

$\text{Price}^* = 8$

Manufacturer Profits

Retailer Profits

$\text{Total Surplus (Integrated)} > \text{Total Surplus (Independent)}$
A Simple Framework

<table>
<thead>
<tr>
<th></th>
<th>Single</th>
<th>Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Fixed Fee</td>
<td>Linear</td>
<td>Block-tariff</td>
</tr>
<tr>
<td>Yes Fixed Fee</td>
<td>Two-part Tariff</td>
<td>Three-part Tariff</td>
</tr>
</tbody>
</table>
Two-Part Tariff (TPT-S)

Manufacturer

Retailer

C = 2

F, W = 2

Demand = 10 - Price

Price* = 6

Total Cost to Retailer

Two-part Tariff

Quantity

F

W

Manufacturer Profits

Retailer Profits

Price* = 6

16

0

F

16-F

16
TPT-O:
Quantity Discount (QD) Scheme

- Average cost = $W + \frac{F}{q}$

- It is equivalent to two-part tariff with total cost = $W \cdot q + F$

- The equilibrium choices of $W$ and $F$ are the same as under two-part tariff.
Two-Block Tariff

Manufacturer

Retailer

C = 2

W1, X1 < Q*, W2 = 2

Price* = 6

Demand = 10 - Price

Total Cost to Retailer

Multi-Block Tariff

Quantity

Demand = 10 - Price

Retailer Profits

Manufacturer Profits

M = (W1 - C)X1

M = (W1 - C)X1

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Number of Block: 2B vs. 3B

\[
W_2 = 2 \quad \text{(2B & 3B)}
\]
\[
M = (W_1 - C)X_1 \quad \text{(2B)}
\]
\[
= (W_0 - C)X_0 + (W_1 - C)(X_1 - X_0) \quad \text{(3B)}
\]
1. Revenue Equivalence

Manufacturer Profits $(\pi_M)$

Retailer Profits $(\pi_R)$

$X = \text{TPT-S, 2B}$ ; $Y = \text{TPT-O, 3B}$
2. Division Equivalence

Manufacturer Profits ($\pi_M$) vs. Retailer Profits ($\pi_R$)

$X = \text{TPT-S, 2B}$ ; $Y = \text{TPT-O, 3B}$
3. Empirical Equivalence

Manufacturer Profits ($\pi_M$)

Retailer Profits ($\pi_R$)

$X = TPT-S, 2B$ ; $Y = TPT-O, 3B$
Standard Model’s Predictions

- The wholesales price (the last block) = marginal cost

- Fixed fee:
  1. Efficiency hypothesis: TPT-X > LP
  2. Frame invariance hypothesis: TPT-S = TPT-O (e.g., QD)

- Number of blocks:
  1. Efficiency hypothesis: N-block > LP (N>1)
  2. N invariance hypothesis: 2-block = 3-block
Framing of Fixed Fee

Fixed Fee and its Framing

Total Pie

1600
1200

Linear TPT-S TPT-O

M’s Share of Pie

100%
67%

Linear TPT-S TPT-O

Fixed Fee and its Framing
Number of Blocks

Number of Blocks

Total Pie

1600
1200

1 2 3

Number of Block

M’s Share of Pie

100%
67%

1 2 3

Number of Block

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Outline

- Research Question
- Revenue and Division Equivalence Hypotheses
- Experimental Tests
- A Behavioral Theory of Pricing
Experimental Design

- Standard experimental economics methodology
- **Series F experiments** (Ho and Zhang, Management Science, 2008)
  - Linear price (LP)
  - Two-part tariff (TPT-S) (2-stage decision)
  - Two-part tariff (TPT-O) (Quantity discount)
- **Series B experiments** (Lim and Ho, Marketing Science 2007)
  - Linear price (LP)
  - Two-block tariff (2B)
  - Three-block tariff (3B)
- Random matching protocol
Fixed Fee: Empirical Regularities

1. $W$ in both TPT-S and TPT-O are above marginal costs. $W$ is higher in TPT-S than in TPT-O

2. Total surplus is lower in TPT-S than in TPT-O

3. Manufacturer’s share of channel profits is lower in TPT-S than in TPT-O
Fixed Fee: Empirical Regularities

Fixed Fee and its Framing

- Total Pie
  - Linear: 1200
  - TPT-S: 1600
  - TPT-O: 1600

- M’s Share of Pie
  - Linear: 67%
  - TPT-S: 100%
  - TPT-O: 100%
4. \( W_2 \) in both 2B and 3B are above marginal costs. \( W_2 \) is higher in 2B than in 3B.

5. Total surplus is lower in 2B than in 3B.

6. Manufacturer’s share of channel profits is lower in 2B than in 3B.
Number of Block: Empirical Regularities

![Graph showing Total Pie and M's Share of Pie across different blocks. The graph compares the number of blocks (1, 2, 3) with Total Pie on the y-axis and M's Share of Pie on the x-axis.](image-url)

- H1: 1200, 100%
- H2: 1600, 100%
- H3: 1200, 67%
- H4: 1600, 100%
Outline

- Research Question
- Revenue and Division Equivalence Hypotheses
- Experimental Tests
- A Behavioral Theory of Pricing
Three modeling premises

1. A generalization of the standard model

2. The retailer has a reference-dependent preference
   a. Loss looms larger than gain (TPT-X)
   b. Counterfactual payoff matters (2B and 3B)

3. Quantal response equilibrium: The retailer’s prob. of mistake is inversely proportional to the cost of mistake
Reference-Dependent Preference in TPT-S and TPT-O

Manufacturer utility

\[(w - 2)(10 - p) + F\]

Retailer utility

\[(p - w)(10 - p) - \lambda \cdot F\]
Reference-Dependent Preference in 2B and 3B

- Let $\lambda$ be the weight on counterfactual payoff

- For the 2-Block tariff, the Retailer’s Utility is:

$$\max_{0 \leq p \leq 10} U_R = (p - w_2)(10 - p) - \lambda (w_1 - w_2)x_1$$

- The retailer imagines the scenario where the manufacturer charges the same lower price $w_2$ for all units

- Manufacturer knows this and revises her contract offer
Quantal Response Equilibrium (QRE)

- **QRE Model**: Allow Retailer to be less than perfectly sensitive to payoffs across blocks (i.e., noisily best respond)
QRE Model (Cont’d)

- Assume that the retailer follows a multinomial logit choice rule so that the probability of the retailer choosing ‘Right’ is

\[
e^{\gamma U_R^r} \quad \frac{1}{1 + e^{\gamma U_L^l} + e^{\gamma U_R^r}}
\]

- Parameter \( \gamma \) captures the sensitivity to differences in monetary payoffs.

- Manufacturer takes retailer’s decision rule into account. Sets the contract by maximizing the following expected profit function:

\[
E(\pi_M) = \frac{e^{\gamma U_L^l}}{1 + e^{\gamma U_L^l} + e^{\gamma U_R^r}} \cdot \pi_M^l + \frac{e^{\gamma U_R^r}}{1 + e^{\gamma U_L^l} + e^{\gamma U_R^r}} \cdot \pi_M^r + \frac{1}{1 + e^{\gamma U_L^l} + e^{\gamma U_R^r}} \cdot 0
\]

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Actual versus Predicted: Series F Experiments

**TABLE 6: DATA VERSUS BEST FITTED VALUES OF THE REFERENCE-DEPENDENCE MODEL**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Treatment Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TPT</td>
</tr>
<tr>
<td></td>
<td>Data</td>
</tr>
<tr>
<td>w</td>
<td>4.05</td>
</tr>
<tr>
<td>F</td>
<td>4.61</td>
</tr>
<tr>
<td>quit (%)</td>
<td>28.79</td>
</tr>
<tr>
<td>p (conditional on participation)</td>
<td>6.82</td>
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</table>
## Actual versus Predicted: Series B Experiments - 2 Block

<table>
<thead>
<tr>
<th>Variable</th>
<th>Actual Data</th>
<th>Predictions</th>
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<tbody>
<tr>
<td>w1</td>
<td>63.7</td>
<td>63.51</td>
</tr>
<tr>
<td>w2</td>
<td>34.0</td>
<td>32.20</td>
</tr>
<tr>
<td>Left</td>
<td>0.36</td>
<td>0.39</td>
</tr>
<tr>
<td>Right</td>
<td>0.53</td>
<td>0.50</td>
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<tr>
<td>Reject</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Conditional Efficiency</td>
<td>80.8%</td>
<td>85.7%</td>
</tr>
<tr>
<td>m</td>
<td>65.3%</td>
<td>67.9%</td>
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</table>
# Actual versus Predicted: Series B Experiments - 3 Block

<table>
<thead>
<tr>
<th>Variable</th>
<th>Actual Data</th>
<th>Predictions</th>
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</thead>
<tbody>
<tr>
<td>W1</td>
<td>57.3</td>
<td>56.1</td>
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<tr>
<td>w2</td>
<td>29.9</td>
<td>28.4</td>
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<tr>
<td>Left</td>
<td>0.11</td>
<td>0.11</td>
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<tr>
<td>Right</td>
<td>0.74</td>
<td>0.82</td>
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<tr>
<td>Reject</td>
<td>0.15</td>
<td>0.06</td>
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<tr>
<td>Conditional Efficiency</td>
<td>95.1%</td>
<td>96.0%</td>
</tr>
<tr>
<td>$m$</td>
<td>72.7%</td>
<td>77.4%</td>
</tr>
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</table>
Summary

- The standard model failed to predict subject behaviors well

- Both framing of fixed fee and number of blocks (when N > 1) matter

- By allowing reference-dependent preferences and mistakes, the behavioral theory can account for all 6 regularities well
Future Research

- A mini field application project at HP

- Field data (B2B pricing contract data from HP)

- B2C settings (mobile phone plans, 3-block tariffs)
**Business Objective**
- Optimize incentives for IPG new product business

**Policy Issues**
- Fixed vs. % target before discount kicks in
- 2-block versus 3-block tariffs

**Research Results**
- Fixed threshold better quantity discount policy
- 3-block is better for several retailers

**Business Results**
- HP adopted all recommendations

**Experimental Design**
- Stanford students as subjects held at HP Labs
- One new and one old product in IPG Commercial Value-added Reseller Program
- Demand model calibrated with business inputs
  - Reseller competence / sales activity modeling
  - Demand drivers
Thank You
Equilibrium Channel Efficiency
Equilibrium Channel Efficiency

Total Channel Profits

3-Block  2-Block

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