Competition Between Networks: A Study in the Market for Yellow Pages
Mark Rysman
Network effects between consumers and advertisers.

- Consumers: Choose how much to use the yellow page directory $j$, given the advertisements contained.

- Advertisers: Choose how much ads to place in directory $j$ given the usage.

- Publishers try to internalize the network externality by choosing the optimal price.
Nested Logit
utility function of consumer \(i\) for product \(j\) in category \(g\).

\[ u_{ij} = \delta_j + \zeta_{ig} + (1 - \sigma)\epsilon_{ij} \]

- \(\delta_j\): deterministic component of utility.

- \(\zeta_{ig}\): group \(g\) specific preference shock. Common shock of all products within group \(g\).

- \(\epsilon_{ij}\): individual idiosyncratic taste shock for product \(j\), i.i.d. extreme value distributed.

- \(\zeta_{ig} + (1 - \sigma)\epsilon_{ij}\): i.i.d. extreme value distributed as well.
Nested Logit formula:
Within group conditional share of product $j$:

$$s_{j|g} = \frac{e^{(\delta_j/(1-\sigma))}}{D_g}$$

$$D_g \equiv \sum_{j \in G} e^{(\delta_j/(1-\sigma))}$$

Group share among all products:

$$s_g = \frac{D_g^{1-\sigma}}{\sum_{h \in G} D_h^{1-\sigma}}$$

Together:

$$s_j = s_{j|g}s_g = \frac{e^{(\delta_j/(1-\sigma))}}{D_g^{\sigma}[\sum_{h \in G} D_h^{1-\sigma}]}$$
and outside option of not buying anything is:

\[ s_0 = \frac{1}{\sum_{h \in G} D_h^{1-\sigma}} \]

Hence,

\[ \log(s_j) - \log(s_0) = \delta_j/(1 - \sigma) - \sigma \log(D_g) \]

Then, use

\[ \log(s_{j|g}) = \delta_j/(1 - \sigma) - \log D_g \]

to get

\[ \log(s_j) - \log(s_0) = \delta_j + \sigma \log(s_{j|g}) \]
The Model

Consumer Choice Problem: Utility Function of consumer \( i \) for yellow page directory \( j \).

\[ U_{ij} = \alpha_2 \ln(A_j) + X_j^U \beta^U + \xi_j + \zeta_{i,YP}(\sigma) + (1 - \sigma)\epsilon_{ij} \]

- \( A_j \): advertisement
- \( x_j \): demographic characteristics.
- \( \xi_j \): unobserved directory characteristics.
- \( \zeta_{i,YP} \): individual preference shock for yellow pages.
• $\epsilon_{ij}$: individual idiosyncratic taste shock for yellow page directory $j$.

• $\epsilon_{ij}$: i.i.d. extreme value distributed.

• $\zeta_{i,YP}(\sigma) + (1 - \sigma)\epsilon_{ij}$: i.i.d. extreme value distributed. $\zeta_{i,YP}$ is the common shock among all the yellow page directories.

Then, the shares of yellow page $j$ is

$$\ln(s_j) - \ln(s_0) = \alpha_2 \ln(A_j) + X_j^U \beta^U + \sigma \ln(s_j|_{YP}) + \zeta_j$$
Share of directory $j$ among yellow pages $s_{j|YP}$ is known, but not the unconditional share of yellow page $s_j$, or outside option $s_0$.

Directory usage:

$$U_j = M s_j$$

where $M$ is constant.
Demand for Advertising
Advertiser places $a_j$ ads in $j = 1, ..., J$ yellow page directories given the total ads being $A_j$, $j = 1, ..., J$. Its profit:

$$\Pi = \sum_{j=1}^{J} \left[ \hat{\pi}_j a_j^{\gamma_1} A_j^{\gamma_2} U_j^{\alpha_1} - P_j a_j \right]$$

Optimal advertising:

$$a_j = \left( \frac{P_j}{\gamma_1 \hat{\pi}_j A_j^{\gamma_2} U_j^{\alpha_1}} \right)^{\frac{1}{\gamma_1-1}}$$

Aggregating $ma_j = A_j$

$$A_j = \left( \frac{P_j}{\gamma_1 \hat{\pi}_j A_j^{\gamma_2} U_j^{\alpha_1}} \right)^{\frac{1}{\gamma_1-1}}$$

where $\pi_j = \hat{\pi}_j / m^{\gamma_1-1}$
Inverse demand curve:

\[ P_j = \gamma_1 A_j^{\gamma_1 + \gamma_2 - 1} U_j^{\alpha_1} \pi_j \]

with the error term \( \nu_j \) added for estimation

\[ \ln(P_j) = \gamma \ln(A_j) + \alpha_1 \ln(U_j) + X_j^P \beta^P + \nu_j \]
Publisher of the Phone Directory

Profit maximization: $K(j)$: set of yellow page directories owned by the publisher.

$$\max_{A_j} \sum_{k \in K(j)} P_k(A_k, U_k(A_1, \ldots, A_J))A_k - MC_j A_j$$

$$MC_j = X_j^C \beta^C + \omega_j$$

Derive $MC$ by using the F.O.C.

$$MR_j = MC_j$$

Notice that parameters of inverse demand function $P_k(\cdot)$ is recovered from the advertiser’s equation, and parameters of usage function $U_k$ is recovered from the consumers’ problem.
Estimation:

Consumer Choice:

\[ \ln(s_j) - \ln(s_0) = \alpha_2 \ln(A_j) + X_j^U \beta^U + \sigma \ln(s_j|YP) + \zeta_j \]

- Data: Usage rate for each yellow page directory: get \( s_j|YP \), and usage \( U_j = M s_j \). Get \( s_j \) by setting \( M \). Demographic controls

- Endogeneity of \( A_j \): IV: number of people covered by a directory. Does not enter in \( X_j^U \).
  Endogeneity of \( \ln(s_j|YP) \): square mileage of the distribution area of a directory. Larger area means less competition from neighboring directory
Inverse Demand for Advertising

\[ \ln(P_j) = \gamma \ln(A_j) + \alpha_1 \ln(U_j) + X_j^P \beta^P + \nu_j \]

- Endogeneity of \( U_j \): Instrument: number of people who recently moved. % Switched county, % switched state, % in same house.

- Endogeneity of \( A_j \): Instrument: local wages, dummy for printing facilities used.

Publisher First Order Condition:

\[ MR_j = MC_j = X_j^C \beta^C + \omega_j \]
### Estimation Results:
#### Usage Equation

<table>
<thead>
<tr>
<th>Advertising $\alpha_2$</th>
<th>0.154 (0.131)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>0.803 (0.079)</td>
</tr>
</tbody>
</table>

#### Advertising Price Equation

<table>
<thead>
<tr>
<th>Advertising $\gamma$</th>
<th>-0.729 (0.193)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usage $\alpha_1$</td>
<td>0.564 (0.131)</td>
</tr>
</tbody>
</table>

#### Marginal Cost Equation

<table>
<thead>
<tr>
<th>Population Coverage</th>
<th>0.437 (0.116)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earnings Per Worker</td>
<td>0.003 (0.014)</td>
</tr>
<tr>
<td>Bell South</td>
<td>-0.631 (0.529)</td>
</tr>
<tr>
<td>GTE</td>
<td>0.612 (0.129)</td>
</tr>
</tbody>
</table>
• Network Effects: \( \alpha_1 > 0, \alpha_2 > 0 \)

• \( \sigma \) close to 1. Not much product differentiation in yellow pages.

**Model Analysis**

<table>
<thead>
<tr>
<th></th>
<th>Pages</th>
<th>Surplus ($000)</th>
<th>Dead Weight Loss ($000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equilibrium</td>
<td>418 (110)</td>
<td>25,525 (23,054)</td>
<td>4,920 (2,541)</td>
</tr>
<tr>
<td>Classical Social Optimum</td>
<td>1,784 (506)</td>
<td>30,515 (25,439)</td>
<td>6,273 (7,725)</td>
</tr>
<tr>
<td>Social Optimum</td>
<td>3,039 (1,511)</td>
<td>36,788 (32,535)</td>
<td></td>
</tr>
</tbody>
</table>
Classical Social Optimum: Social planner chooses optimal advertisement but takes usage as given.

Deadweight Loss:
\[ \int_{A_e}^{A_o} P_j(A_j, U(A_e))dA_j - (A_o - A_e)MC \]

Network Social Optimum: Includes change in usage rate.

\[ \int_0^{A^*} P_j(A_j, U(A^*))dA_j \]

Network Deadweight Loss:
\[ \int_0^{A^*} P_j(A_j, U(A^*))dA_j - \int_0^{A_o} P_j(A_j, U(A_e))dA_j - (A^* - A_e)MC \]
Entry:

- Duopoly higher advertising per firm than monopoly: competitive phone book market ($\sigma$ high) drives down price of advertising, and increases advertising.

- Negative network effects: usage per phone book decreases. With further entry, advertising per phone book decreases.

- Welfare increase due to competition outweighs the network effect.
• Not much utility increase due to increase in numbers of phone books.

• Large increase in social surplus with more number of firms.
RYSMAN  
COMPETITION BETWEEN NETWORKS  

TABLE 7  
Equilibrium for different numbers of competitors  

<table>
<thead>
<tr>
<th>No. of competitors</th>
<th>Advertising (pages)</th>
<th>Refs./HH/mth. (DQC ad)</th>
<th>Price ($)</th>
<th>Profits ($)</th>
<th>Advertiser surplus* (1 directory)</th>
<th>Total surplus*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>613</td>
<td>(578)</td>
<td>4.10 (0.69)</td>
<td>2136 (1207)</td>
<td>5.16 (1.60) 21.45 (17.07)</td>
<td>26.61 (19.67)</td>
</tr>
<tr>
<td>2</td>
<td>707</td>
<td>(606)</td>
<td>2.38 (0.38)</td>
<td>1416 (794)</td>
<td>2.85 (1.00) 16.40 (13.10)</td>
<td>38.50 (29.45)</td>
</tr>
<tr>
<td>3</td>
<td>624</td>
<td>(533)</td>
<td>1.68 (0.28)</td>
<td>1273 (736)</td>
<td>1.97 (0.79) 13.03 (10.53)</td>
<td>45.00 (35.06)</td>
</tr>
<tr>
<td>4</td>
<td>549</td>
<td>(470)</td>
<td>1.30 (0.22)</td>
<td>1212 (712)</td>
<td>1.53 (0.68) 10.91 (8.94)</td>
<td>49.74 (39.39)</td>
</tr>
<tr>
<td>5</td>
<td>490</td>
<td>(420)</td>
<td>1.07 (0.19)</td>
<td>1178 (699)</td>
<td>1.26 (0.60) 9.45 (7.85)</td>
<td>53.55 (43.01)</td>
</tr>
<tr>
<td>6</td>
<td>443</td>
<td>(381)</td>
<td>0.91 (0.16)</td>
<td>1156 (690)</td>
<td>1.08 (0.55) 8.38 (7.05)</td>
<td>56.79 (46.18)</td>
</tr>
<tr>
<td>7</td>
<td>405</td>
<td>(349)</td>
<td>0.79 (0.15)</td>
<td>1141 (684)</td>
<td>0.95 (0.50) 7.57 (6.43)</td>
<td>59.62 (49.02)</td>
</tr>
</tbody>
</table>

*Profits and surplus are in millions. Profits and surplus are computed assuming there are no fixed costs of production. Standard errors are in parenthesis.

TABLE 8  
Private returns vs. social returns  

<table>
<thead>
<tr>
<th>No. of competitors</th>
<th>Surplus increase minus profits (%) (no fixed costs)</th>
<th>Profits (incl. fixed costs)</th>
<th>Surplus increase (%) (incl. fixed costs)</th>
<th>Adjusted surplus increase (%) (incl. fixed costs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.76 (0.17)</td>
<td>1.80 (1.15)</td>
<td>0.42 (0.11)</td>
<td>0.26 (0.11)</td>
</tr>
<tr>
<td>3</td>
<td>0.70 (0.22)</td>
<td>0.92 (0.98)</td>
<td>0.15 (0.06)</td>
<td>0.07 (0.08)</td>
</tr>
<tr>
<td>4</td>
<td>0.68 (0.25)</td>
<td>0.48 (0.90)</td>
<td>0.09 (0.04)</td>
<td>0.03 (0.07)</td>
</tr>
<tr>
<td>5</td>
<td>0.67 (0.26)</td>
<td>0.21 (0.85)</td>
<td>0.06 (0.03)</td>
<td>0.01 (0.06)</td>
</tr>
<tr>
<td>6</td>
<td>0.67 (0.27)</td>
<td>0.03 (0.82)</td>
<td>0.05 (0.03)</td>
<td>0.00 (0.06)</td>
</tr>
<tr>
<td>7</td>
<td>0.66 (0.27)</td>
<td>−0.10 (0.80)</td>
<td>0.04 (0.03)</td>
<td>−0.01 (0.06)</td>
</tr>
</tbody>
</table>

Surplus increase minus profits (%) is \((incsurp(k, k - 1) - prof(k))/incsurp(k, k - 1)\). 
Surplus increase (%) is \(incsurp(k, k - 1)/surp(k - 1)\) where \(surp(k)\) equals surplus generated by \(k\) competitors. \(incsurp(k, k - 1) = surp(k) - surp(k - 1)\). \(prof(k)\) is profit when there are \(k\) competitors. Adjusted surplus is computed ignoring the upper tip of the demand curve. Standard errors are in parenthesis.