# Competition Between Networks: A Study in the Market for Yellow Pages

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**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 know, but not the unconditional share of yellow page $s_j$, or outside option $s_0$

Directory usage:

$$U_j = Ms_j$$

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:

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

Optimal advertising:

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

Aggregating $m a_j = A_j$

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

where $\pi_j = \widehat{\pi}_j / m^{\gamma_1 - 1}$

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.

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

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

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

$$MR_j = MC_j$$

Notice that parameters of inverse demand function $P_k()$ 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

| | | |
|---|---|---|
| Advertising $\alpha_2$ | 0.154 | (0.131) |
| $\sigma$ | 0.803 | (0.079) |

Advertising Price Equation

| | | |
|---|---|---|
| Advertising $\gamma$ | -0.729 | (0.193) |
| Usage $\alpha_1$ | 0.564 | (0.131) |

Marginal Cost Equation

| | | |
|---|---|---|
| Population Coverage | 0.437 | (0.116) |
| Earnings Per Worker | 0.003 | (0.014) |
| Bell South | -0.631 | (0.529) |
| GTE | 0.612 | (0.129) |

- Network Effects: $\alpha_1 > 0$, $\alpha_2 > 0$

- $\sigma$ close to 1. Not much product differentiation in yellow pages.

## Model Analysis

| Pages | | |
|---|---|---|
| Equilibrium | 418 | (110) |
| Classical Social Optimum | 1,784 | (506) |
| Social Optimum | 3,039 | (1,511) |
| **Surplus ($000)** | | |
| Equilibrium | 25,525 | (23,054) |
| Classical Social Optimum | 30,515 | (25,439) |
| Social Optimum | 36,788 | (32,535) |
| **Dead Weight Loss ($000)** | | |
| Classical Social Optimum | 4,920 | (2,541) |
| Social Optimum | 6,273 | (7,725) |

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.

TABLE 7

*Equilibrium for different numbers of competitors*

| No. of competitors | Advertising (pages) | | Refs./HH/mth. | | Price ($) (DQC ad) | | Profits ($)* | | Advertiser surplus* (1 directory) | | Total surplus* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 613 | (578) | 4·10 | (0·69) | 2136 | (1207) | 5·16 | (1·60) | 21·45 | (17·07) | 26·61 | (19·67) |
| 2 | 707 | (606) | 2·38 | (0·38) | 1416 | (794) | 2·85 | (1·00) | 16·40 | (13·10) | 38·50 | (29·45) |
| 3 | 624 | (533) | 1·68 | (0·28) | 1273 | (736) | 1·97 | (0·79) | 13·03 | (10·53) | 45·00 | (35·06) |
| 4 | 549 | (470) | 1·30 | (0·22) | 1212 | (712) | 1·53 | (0·68) | 10·91 | (8·94) | 49·74 | (39·39) |
| 5 | 490 | (420) | 1·07 | (0·19) | 1178 | (699) | 1·26 | (0·60) | 9·45 | (7·85) | 53·55 | (43·01) |
| 6 | 443 | (381) | 0·91 | (0·16) | 1156 | (690) | 1·08 | (0·55) | 8·38 | (7·05) | 56·79 | (46·18) |
| 7 | 405 | (349) | 0·79 | (0·15) | 1141 | (684) | 0·95 | (0·50) | 7·57 | (6·43) | 59·62 | (49·02) |

*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*

| No. of competitors | Surplus increase minus profits (%) (no fixed costs) | | Profits (incl. fixed costs) | | Surplus increase (%) (incl. fixed costs) | | Adjusted surplus increase (%) (incl. fixed costs) | |
|---|---|---|---|---|---|---|---|---|
| 2 | 0·76 | (0·17) | 1·80 | (1·15) | 0·42 | (0·11) | 0·26 | (0·11) |
| 3 | 0·70 | (0·22) | 0·92 | (0·98) | 0·15 | (0·06) | 0·07 | (0·08) |
| 4 | 0·68 | (0·25) | 0·48 | (0·90) | 0·09 | (0·04) | 0·03 | (0·07) |
| 5 | 0·67 | (0·26) | 0·21 | (0·85) | 0·06 | (0·03) | 0·01 | (0·06) |
| 6 | 0·67 | (0·27) | 0·03 | (0·82) | 0·05 | (0·03) | 0·00 | (0·06) |
| 7 | 0·66 | (0·27) | −0·10 | (0·80) | 0·04 | (0·03) | −0·01 | (0·06) |

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.