**Vertical Product Differentiation**


Assume

1. A number of firms offer distinct substitute goods which vary in quality.
2. Consumer buy 1 unit or zero.
3. Zero costs.
4. Label goods \( k = 1, \ldots, n \), firm \( k \) sells product \( k \) at \( p_k \).
5. Continuum of consumers of different incomes uniformly distributed, with a density of one, along a line segment \( a \) to \( b \).

\[
\begin{array}{c}
\text{1} \\
\text{a} \quad \text{b} \\
\text{t}
\end{array}
\]

6. Utility \( 0 < u_0 < u_1 < \ldots < u_n \)

\[
U(t, k) = u_k(t - p_k) \\
U(t, 0) = u_0t
\]

7. Define \( C_k = \frac{u_k}{u_k - u_{k-1}} > 1 \)

Equation of the Indifferent Consumer

\[
u_k(t_k - p_k) = u_{k-1}(t_k - p_{k-1})
\]

or

\[
t_k = p_{k-1}(1 - C_k) + p_k C_k
\]

NOTE: \( \frac{\partial t_k}{\partial p_k} = C_k \) and \( \frac{\partial t_k}{\partial p_{k-1}} = 1 - C_k \)
Market Share:

Consider good $n$: if $t_n > a$ so more than one good survives

$\pi_n = p_n(b - t_n)$

F.O.C

$$\frac{\partial \pi_n}{\partial p_n} = b - t_n - p_n \frac{\partial t_n}{\partial p_n} = 0$$

$$b - t_n - p_n C_n = 0$$

Note $p_n . C_n = t_n - p_{n-1} (1 - C_n)$

$$b - t_n - (t_n - p_{n-1} \cdot (1 - C_n)) = 0$$

$$b - 2t_n + p_{n-1} \left(1 - C_n\right) < 0$$

$\therefore \quad b - 2t_n > 0$

$\therefore \quad t_n < b/2$
Now assumes that \( a < b/2 \)

\[
\pi_k = p_k(t_{k+1} - t_k)
\]

F.O.C

\[
\frac{\partial \pi_k}{\partial p_k} = t_{k+1} - t_k - p_k [(C_{k+1} - 1) + C_k] = 0
\]

Note \( p_k.C_k = t_k - p_{k-1}.(1- C_k) \)

\[
t_{k+1} - 2t_k - p_k (\frac{C_{k+1} - 1}{>0}) - p_{k-1} (\frac{C_k - 1}{>0}) = 0
\]

\[
\therefore \quad t_{k+1} - 2t_k > 0
\]

\[
\therefore \quad t_k < \frac{t_{k+1}}{2}
\]

It's follows that,

\[
t_n < \frac{b}{2}, \quad t_{n-1} < \frac{b}{4}, \quad t_{n-2} < \frac{b}{8}, \ldots \quad \text{etc for any } a > 0
\]

There exists a bound independent of product qualities and consumer density to the number of firms which can survive with positive prices at a NE in prices.

Number of firms depends on lower bound to income, \( a \).

a. Can have lots of firms, \( a \rightarrow 0 \) and \( b \rightarrow \infty \), but 2-3 firms will dominate.

b. A firm that sets price equal to zero will NOT win all the market.

c. Pattern of Market shares will be independent of the density of consumers (Market Size).
Entry Games in Endogenous Sunk Costs Industries (Sutton, Chapter 3 & 10)

- Firms pay exogenous sunk cost of entry, $\sigma$
- Advertising competition involves an endogenous sunk cost, $A$, to give a quality level $u$

Three stage game

<table>
<thead>
<tr>
<th>Stage 1 Long Run</th>
<th>Stage 2 Advertising $N$</th>
<th>Stage 3 Short Run Competition $u, N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry $\sigma$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Solve in a process of backward induction…..
Stage 3: Price Competition \( P(N) \)

*given* a quality level \( u \) (decided in stage 2 of the game) and *given* the number of firms \( N \) (decided in stage 1 of the game)

(*Augmented Salop Circular Road Model....*)

- \( N \) Sellers located symmetrically around circle
- Unit Circumference, thus distance between each seller is \( 1/N \)
- Density of consumers at each point is \( S \)
- \( t \) (exogenous) per unit transport cost
- \( d \) distance travelled
- \( u \) is quality of good

Equation of the Marginal Consumer:
*(note: capital \( U \) denotes utility)*

\[
U_i = \bar{C} - P_i - td + u_i = \bar{C} - P - t \left[ \frac{1}{N} - d \right] + u = U
\]

Market Share for Representative Firm \( i \) *(solving marginal consumer equation for 2d):*

\[
X_i = \left[ \frac{1}{N} + \left( \frac{P - P_i}{t} \right) - \left( \frac{u - u_i}{t} \right) \right] S
\]
Profit Function for Representative Firm $i$:
\[ \pi_i = P_i X_i \]

Optimal Price Setting:
\[ \frac{\partial \pi_i}{\partial P_i} = P_i \left( -\frac{S}{t} \right) + X_i = 0 \]

**Symmetric** Nash Equilibrium ($P = P_i$ & $u = u_i$):
\[ P^* = \frac{t}{N} \quad \text{and} \quad \pi^* = \frac{tS}{N^2} \]

Illustration additional profit for Deviant Firm setting $u_i > \bar{u}$:
Stage 2: Advertising Competition

given the number of firms N (decided in stage 1 of the game), and in anticipation of the expost entry profits determined in stage 3 of the game

Look at the deviant firm....

\[ A_i(u_i) = au_i^2 \]

where \( a \) = effectiveness of advertising A in increasing \( u \)

Diminishing Marginal Returns to Advertising

Note, total sunk costs \( firm_i = F(u_i) = \sigma + A_i(u_i) \)

\[ MC_i = 2au_i \]

The higher \( a \) is, the less effective advertising expenditure is at increasing quality \( u \).
Marginal Benefit of advertising:

\[ MB = \frac{\partial \pi_i}{\partial (u_i - u)} \]

*From Stage 3 FOC:* \( P_i = X_i \frac{t}{S} \)

Thus, \( P_i = \frac{t}{N} - (u - u_i) \) when \( P_i = P \)

So, \( \pi_i = \left[ \frac{t}{N} - (u - u_i) \right] \left[ \frac{1}{N} - \frac{(u - u_i)}{t} \right] S \)

\[ \frac{\partial \pi_i}{\partial (u_i - u)} = \left[ \frac{t}{N} - (u - u_i) \right] \frac{S}{t} + \left[ \frac{1}{N} - \frac{(u - u_i)}{t} \right] S \]

All firms same incentive – so in equilibrium, \( u_i = u \). Thus,

\[ MB = 2 \frac{S}{N} \]
Optimal Level of advertising:

\[ MB = \frac{2S}{N} = 2au = MC \]

\[ u^* = \frac{S}{aN} \Rightarrow A^* = au^2 = \frac{S}{a} \left( \frac{S}{N^2} \right) \]

Two Different Regimes......

1) If for the deviant firm \( MB \) adv < \( MC \) adv, then NO Advertising
   Thus, \( u_i = \bar{u} = 1 \) and \( A(u) = 0 \)
   Total sunk cost = exogenous sunk cost \( \sigma \)
   Elementary model of chapter 2....

2) If for the deviant firm \( MB \) adv > \( MC \) adv, then have Advertising

\[ MB = \frac{\partial \pi}{\partial u} \bigg|_{u_i = \bar{u} > 1} = \frac{\partial F}{\partial u} \bigg|_{u_i = \bar{u} > 1} = MC \]

Thus, \( u_i = \bar{u} > 1 \) and \( A(u) > 0 \)
   “prisoners dilemma”
   Total sunk costs \( f_{\text{firm}_i} = F(u_i) = \sigma + A_i(u_i) \)
Stage 1: Entry
With an exogenous sunk cost $\sigma$, *in anticipation of* the expost entry expenditure on advertising $A(u)$ (*determined in stage 2 of the game*) *and* of the expost entry profits (*determined in stage 3 of the game*)

Enter where expost entry profits = total sunk cost outlays

**If No Advertising:**

$$\frac{tS}{N^2} = \sigma \quad so \quad N^* = \sqrt{\frac{tS}{\sigma}}$$

$$C^* = \frac{1}{N^*} = f\left(\frac{S}{\sigma}, t\right)$$

*(simple exogenous sunk cost model of chapter 2)*
If Advertising:

\[
\frac{tS}{N^2} = \sigma + \frac{S}{a} \left( \frac{S}{N^2} \right) \quad \text{so} \quad N^* = \sqrt{\left( \frac{t}{a} - \frac{S}{a} \right) \frac{S}{\sigma}}
\]

\[C^* = \frac{1}{N^*} = f\left( \frac{S}{\sigma}, \frac{S}{a}, t \right)\]

Way in which \(N\) varies with \(S\) depends on values of \(S/a\) relative to \(t/2\)…. 

\[
\frac{\partial N^*}{\partial S} > 0 \quad \text{if} \quad \frac{S}{a} < \frac{t}{2} \quad (\uparrow S \Rightarrow \uparrow N \ & \downarrow \text{conc}.
\]

\[
\frac{\partial N^*}{\partial S} = 0 \quad \text{if} \quad \frac{S}{a} = \frac{t}{2} \quad (\uparrow S \Rightarrow \text{no change in } N \ or \ \text{conc}.
\]

\[
\frac{\partial N^*}{\partial S} < 0 \quad \text{if} \quad \frac{S}{a} > \frac{t}{2} \quad (\uparrow S \Rightarrow \downarrow N \ & \ \uparrow \text{conc}.
\]

\(S/a < t/2\): need small \(S\) and/or big \(a\) (advertising ineffective)

\(S/a > t/2\): need big \(S\) and/or small \(a\) (advertising effective)
1/N* = equilibrium level of concentration whereby further increases in S do not induce entry/exit to the market – additional profits are simply absorbed by higher levels of advertising
As \( S \rightarrow \infty \), concentration \( \rightarrow 1 \) in the limit.

Note, higher that \( a \) is, the less effective advertising is. This will shift down the lower bound to concentration.
Main Findings:
1. Failure of Convergence property…..i.e. the Limit Theorem breaks down.
As $S \to \infty$, then $1/N$ does not $\to 0$

“If it is possible to enhance consumers’ willingness to pay for a given product to some minimal degree by way of a proportionate increase in fixed cost (with either no increase or only a small increase in unit variable costs), then the industry will not converge to a fragmented structure, however large the market becomes”

Why? high degree of fragmentation at large $S \Rightarrow$ profitable for a deviant firm to advertise $\Rightarrow$ sparks off an escalation in advertising competition $\Rightarrow$ increase concentration

2. Market Size, $S$, and Concentration, $1/N$, are not necessarily monotonic

3. Advertising only becomes profitable at a minimal market size $S$, given $N$. Thus, as increase $S$ you get an increase in $N$ only before “switch” level at which advertising becomes profitable is reached

4. As $S \to \infty$, concentration $1/N$ becomes independent of set up costs $\sigma$

5. May get the emergence of a dual structure beyond minimal market size
Differences in consumer tastes can result in dual structure e.g. retail versus non-retail segments

Above critical value of $S$, where advertising triggered, get split in market

1. Within Retail – market structure evolves as in endogenous sunk cost model

2. Within Non-Retail – market structure evolves as in exogenous sunk cost model
Empirical Evidence: Frozen Foods (Sutton Chapter 8)

Theory predictions:

increase in $S$ can not lead to emergence of fragmented structure

1. some small set of firms must emerge at some point as high advertisers

2. fringe of small firms may co-exist - viability depends on size of market in which consumers not responsive to advertising and exogenous sunk costs $\sigma$.

Theory says nothing about dynamics.....

Note: Frozen food consumers very responsive to advertising – expect escalation in adv competition to be triggered early on in market
The Case:

**US and UK:**

Small set high adv firms emerge (adv. is BTE).

Dual structure emerges – fringe firms with low/no adv compete for rest of the market.

Critical phase observed (“prisoners dilemma”)

**Germany and Italy:** markets develop later – avoid escalation in advertising - cooperation between market leaders and rapid convergence to dual structure
US:

1929: Birds Eye (GFC) first mover. Initially high $\sigma$ (so little entry)

1940s: Snowcrop/Minute Maid enter – low prices & high advertising strategy – marks beginning of emergence of dual structure

1959:

top 1/3 (101 firms) ~ 53% market (early)
next 75 firms ~ 31% market (middle – 1945-49)
next 67 firms ~ 8% market (late – 1950-58)
Top 2 – spend 6% sales on adv (versus 2-3%)
46% total advertising in ind by GFC and Minute Maid

$\downarrow \sigma$ (entry at lower tier easier), and $\uparrow$ expost adv competition, thus endog sunk costs (entry at top difficult)

within retail: highly segmented – advertising specific -
1950s critical phase – entry easy, competing across board with leaders not…. Many middle tier firms attempt to compete – some make it, others fall out……

Late entrants only succeed by innovating ‘new niche’ eg Green Giant

price competition and mergers/acquisitions became prevalent

Today: overall modest concentration

High concentration within retail food segments – different leadership across segments

Dual structure
UK

Like US initially – but own-label brands big phenomenon

Late 1930s: Birds Eye (Unilever) first mover – 80% market by end 1950s

1960s – Findus & Ross (due to ↑ S) - small firms – low price – Birds eye respond – Findus & Ross forced to focus on non retail dual structure – without escalation advertising….

1970s – own labels – initiated escalation adv in industry as whole

Continental Europe:

Frozen food market develops later – 1960s – Unilever and Nestle

Players pre-empted escalation advertising which would result as market developed – cooperation between market leaders and rapid convergence to dual structure
Ready to Eat Breakfast Cereals Industry
(Sutton 1991, Chapter 10 and Schmalensee 1978)

Background:

• Highly Concentrated Market
  C4 ~ 85% Sales in US
  C6 ~ 95% Sales in US

• Kellogs (market leader) enjoys first mover advantage

• High degree of Brand Proliferation – constant flow of new brands (many short lived)

• High proportion advertising devoted to supporting new products in introductory years

• These features induced FTC investigation (1976 – 1978)
Agenda:

• Outline two alternative mechanisms for explaining the market structure of RTE cereals

  1. Schmalensee (1978): brand proliferation (associated with exogenous advertising outlays) creates barrier to entry

  2. Sutton (1991): a role for endogenous advertising competition in driving a concentrated market structure, independent of brand proliferation

• Examine the evolution of RTE cereals in the US and UK to distinguish between the two mechanisms

• Consider the implications of the alternative mechanisms for Antitrust
Schmalensee (1978) “Entry Deterrence in the ready-to-eat cereal industry”

- A theory of endogenous brand proliferation
- Although $\uparrow S$, which $\Rightarrow \uparrow \pi$, there is no corresponding $\uparrow$ entry. He argues that this is due to Barriers to Entry created by endogenous brand proliferation

**The Model**

Models RTE cereals in Salop Circular Road model – brands located around circle, where different segments relate to different characteristics of the product

Assume

- No Scale Economies
- No ownership of raw materials
- Exogenous Advertising Expenditure
- Increasing returns at the brand level
- Localised rivalry among brands, due to Horizontal product differentiation

“Variations in consumer taste give rise to product differentiation” (pg. 308)

“..brands differ in such potentially relevant dimensions as sweetness, protein content, shape, grain base, vitamin content, fibre content, and crunchiness, for instance” (pg. 309)

Compete only with brands located nearest to you (in terms of the “relevant dimensions”)

- Brand immobility in product space
  Better to introduce a new brand, than revamp an old brand
Mechanism:

Recall, firm sells to marginal consumer each side

In Salop circular road model, with N firms symmetrically located about unit circumference circle, cost = 0, then \( p^* = \frac{t}{N} \) and \( \pi = \frac{t}{N^2} \) (see overheads on horizontal product differentiation)

If the N firms offer a set of goods ‘interleaved’ symmetrically between those offered in the original economy (see handout)

New prices correspond to 2N. Thus, equilibrium price will be lower, \( p^* = \frac{t}{2N} \)

Firm profits will fall. Prices are lower, but each firm will have the same number of consumers as before \( \pi^* = \frac{tS}{2N^2} \) (since goods not introduced by new firm entrants)
Now consider the Schmalensee argument:

Market share determined by marginal consumer either side of the firm

Enter a brand on circle → take share of market from neighbouring rivals, but incur entry cost (exogenous advertising)
Firm with first mover advantage may be free to enter many products/brands

Brand proliferation: ‘optimal entry deterrence’

Incumbent firms enter many brands with different horizontal product characteristics

⇒ ‘crowd out’ product space - lots of similar brands offered

⇒ deter new entry since “gap” between brands too small to justify entry \( i.e. \) share of market from neighbours ‘too small’, thus ex post entry profits too small to justify entry

First mover advantage is important in explaining entry deterrence by this mechanism

Schmalensee (1978): High concentration in the RTE cereal market is due to Kellogs First mover advantage ⇒ brand proliferation ⇒ fills up all available niches so entry is deterred

What about new firm entrants in ‘Natural Cereals’?

Policy Recommendation: break up big firms!

1. Kellogs has first mover advantage

2. Advertising is endogenous (may be either brand specific, or firm specific)

3. Products/Brands differ in both
   - Vertical attributes [advertising image/quality $u$]
   - Horizontal attributes [physical characteristics - sweetness, protein fibre etc.]

Note, if consumers have very strong preference for a given physical characteristic $\Rightarrow$ greater market segmentation $\Rightarrow$ high $t$ (steeper slope to umbrella)

Note, an $\uparrow u$ (via advertising) or $\downarrow p$ (so $\downarrow p/u$) is represented by a vertical shift in umbrella – this is less effective in drawing consumers away from other segments with different characteristics where $t$ is higher
Case 1: Firm specific advertising – a given fixed cost outlay on advertising establishes a common level of quality $u$ for all the firms brands. Sutton theory on endogenous sunk costs predicts that escalation in endogenous advertising competition will prevent a fragmented structure from emerging as the market grows.

Case 2: Brand specific advertising - a given fixed cost outlay on advertising is required to reach quality $u$ for any one brand. Analysis of Sutton chapter 3 is the same, except the lower bound to concentration is now lower than in the case of firm specific advertising - advertising in this case is more expensive / less effective
Impact of horizontal product differentiation and market segmentation? Gives rise to presence of many different equilibrium configurations above the predicted lower bound to equilibrium concentration. e.g. first mover advantage can allow for product proliferation and result in just a few firms offering many products – even within the endogenous advertising framework
Discrimination Between the Models

- Brand proliferation salient feature of US RTE cereals market over past 30 years. But very high concentration in all countries, and from early days (even when number of brands offered relatively few)

- Early history of industry similar to that of other advertising intensive industries – process of advertising escalation observed in US and UK

- Sutton (1991) posits that advertising outlays by incumbents creates the BTE. Schmalensee (1978) posits that brand proliferation creates the BTE.
Evidence

US and UK evolution of RTE illustrate escalation of advertising competition over time, and the emergence of a dual structure, even while brand proliferation was a feature.

The fact that the advertising/sales ratio of Kellogs was far less than that of main rivals - pattern which emerges in advertising intensive industries and suggests that advertising is endogenous.

UK RTE cereals industry is very concentrated, as for the US, but has far less brand proliferation than the US.

Details of US and UK suggest that main cause of high concentration in RTE cereals lies in mechanism common to many advertising intensive industries and special features of RTE cereals (brand proliferation) modify rather than replace this.
Implications for Antitrust?

FTC Kellogs case – took approach that advertising is exogenous and brand proliferation drives concentration ⇒ feasible to break up the industry leader(s) into a larger number of smaller firms of “viable” size

as from Sutton chapter 2 theory on exogenous sunk costs: as $S \rightarrow \infty$, then $1/N \rightarrow 0$. Above the predicted lower bound to concentration, any equilibrium configuration may exist

$$C = \frac{1}{N}$$

⇒ FTC can choose what configuration/concentration to “freeze” the industry at ⇒ fragmented industry can be feasibly forced on the industry
Suttons framework for endogenous sunk costs in advertising – the range of choice of feasible equilibrium concentration levels is lower than the case where advertising is exogenous

\[ C = \frac{1}{N} \]

⇒ If FTC imposes a fragmented structure on the industry, then higher N will increase the profits of firms, and increase the MB advertising ⇒ incentive of firms to deviate and spark off escalation in advertising which will once again increase concentration

Thus, ‘freezing’ at fragmented structure is not viable
Instead, FTC needs to focus on advertising as a policy tool to change structure…… A ban or ceiling on advertising would increase the degree of fragmentation in the industry