ARE 202 - notes
Villas-Boas/Rausser – 2nd half

Topics

1. Product Differentiation, Quality, Advertising, Asymmetric Information
   Problem Set 1
2. Imperfect information and Search models
3. Repeated Games
   Problem Set 2
4. Strategic Non-cooperative Behavior
5. Vertical Relationships, Theory of the Firm
   Problem Set 3
6. Introduction to Auctions

Please see Course Outline at: http://socrates.berkeley.edu/~villas/8mat_are202.html

Main References:

1. 1 . Carlton and Perloff (2000): Modern Industrial Organization, Dennis W. Carlton and Jeffrey Perloff, 3rd Edition, Reading, MA: Addison-Wesley. Book web-page: http://occawlonline.pearsoned.com/bookbind/pubbooks/carlton_awl/

2. Tirole (1989) : The Theory of Industrial Organization, Jean Tirole, 1989, The MIT Press.

What follows are Lecture Notes for your convenience.

1. Notes on Quality, Advertising and Information

References: Tirole (1989) chapter 2.; Carlton and Perloff (2000), chapter 13.

Brief Review of Vertical and horizontal differentiation, goods-characteristics approach

(A)symmetric Information models of product quality

- Search goods: can verify the quality value you purchase the good. – first part of chapter 2 in Tirole.
- Experience goods: have to consume the good to validate quality.- second part of Tirole chapter 2.
- "take their world for it good"

Trademarks/Brand- reputational dynamic repeated purchases

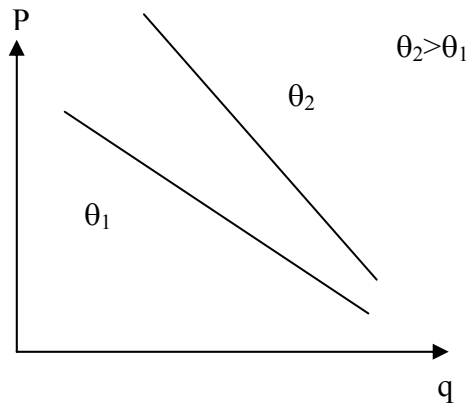
Questions:

- Does the market supply the efficient level of quality

- How can market communicate its quality (reputation, signaling, ostentatious advertising)

1.1. Provision of quality

Search goods:
$q(p,\theta)$ θ= quality level
$P(q, \theta)$



Assumption in this graph:

Welfare:
$W(q, \theta)= S(q, \theta) + \pi(q, \theta)$

$$S(q,\theta)=\int_0^q p(x,\theta)dx - qp(q,\theta)$$

$\pi(q, \theta)= q\, p(x, \theta) - C(q, \theta)$

Looking at the Firm's Decision: choose q and θ s.t. Max Profits

q : $MR(q, \theta)= mc(q, \theta)$

$$p(q,\theta)[1-\frac{1}{\varepsilon(q,\theta)}]=\frac{\partial C(q,\theta)}{\partial q}$$

θ^M : $\underbrace{\frac{\partial p(q,\theta}{\partial \theta})q}=\frac{\partial C(q,\theta)}{\partial \theta}$

Welfare Maximizing: $W= S + \pi$

$$W = \int_0^q p(x, \theta)\, dx - c(q, \theta)$$

q: $$p(q, \theta) = \frac{\partial C(q,\theta)}{\partial q}$$

θ: $$\int_0^q \frac{\partial p(x,\theta)}{\partial \theta} dx = \frac{\partial C(q,\theta)}{\partial \theta}$$

<u>Comparing Firm and Welfare Maximizing Theta:</u>

Lee Baham (1972) Journal of Law & Economics
Question: When θ↑ W↑↓ ?
Welfare Improvements for advertising
Found that states that have lots advertising in eyeglasses <u>have</u> lower quality adjusted prices.

<u>Dorfman-Steiner (AER, 1954):</u>
Let $q=D(p,a)$, where a is the advertising level and p is the price and q is quantity demanded. The cost function is assumed to be additive in output and advertising, so the profit of the firm is given by

$$\pi(p,a)=p\, D(p,a)-C(D(p,a))-a$$

The first order conditions for the maximization with respect to price and advertising are

$$D(p,a)+p\, D_p(p,a)-C'(D(p,a))D_p(p,a)=0 \qquad (1)$$

and

$$p\, D_a(p,a)-C'(D(p,a))D_a(p,a)-1=0. \qquad (2)$$

Let the elasticities be defined as

$$\varepsilon_p \equiv -\frac{\partial D}{\partial p}\frac{p}{q} \text{ and } \varepsilon_a \equiv -\frac{\partial D}{\partial a}\frac{a}{q}$$

then rearranging (1) and (2) we obtain the Dorfman-Steiner condition $\frac{a}{pq} = \frac{\varepsilon_a}{\varepsilon_p}$

2. Notes on Asymmetric Information

How do markets get quality right for experience goods?

1. if unverifiable quality and nothing else to correct it → adverse selection.

(Classic Reference: The Market for lemons, George Akerlof)

Typically sellers know more about the quality of their product than consumers do. This asymmetry of information may prevent firms with high quality products from profiting from it. Firms also have less incentives to invest in, increasing the quality of the product because it is hard for consumers to verify which products have high quality.

Note: In the discussion of Leslie and Jin's paper, we will see how increasing information about product quality available to consumers may affect how firms choose the quality of their products.

Ways to correct this:

- Informed consumers
- Quality Certification Agencies
- Warranties
- Reputation and Signaling

We'll introduce the idea of how "information" (or really the lack of information) can play a critical role in the functioning of a market.

We focus on some theoretical issues. Search costs/ adverse selection. And in the empirical paper we'll discuss later, we'll look at how the introduction of hygiene cards, which increase the amount of information consumers have, has affected the functioning of the restaurant industry in Los Angeles.

Throughout we'll focus on the importance of the amount of information that is available to consumers.

More specifically, we'll look at two specific examples of what can go wrong when there are informational problems of particular kinds:

- Search Costs- there are several firms selling a particular good but consumers don't know the price that each firm is selling it at, so consumers undertake a costly search to find out.

- Adverse selection- the firm knows the true quality of the product they are selling, but the consumer does not and will only find out the quality after she has bought the product (think used-cars).

Starting with the second one:

1.3. ADVERSE SELECTION

Adverse selection is a general term in economics used to describe settings in which one party to a transaction has private information that the other party does not know at the time of the transaction.

The text-book example of the adverse selection is so-called the "Lemons Problem":

Commonly used practical solutions to this problem include

- warranties
- reputation (repeated interaction), quality varies, and <u>signaling</u> (next lectures), where low price signals quality
- expert advice
- standard and certification
- there are informed consumers, then high price signals quality.

Ways to correct adverse selection:

I. Informed Consumers

Consumers $U(s,p,\theta)$ $\quad$ s = quality, $\quad$ p= price
θ = value, type of consumer

$U(s, p, \theta) = \theta s - p$

This is a standard vertical model of quality. Suppose there are N consumers and a fraction α of those are informed.

$$S = \begin{cases} 1 & c_1 > c_0 \\ 0 & c_0 \end{cases}$$

Note that here the willingness to pay for the low quality good is zero.

<u>Beliefs:</u>
<u>Suppose:</u> high price signals high quality to uninformed consumers.

Lets find equilibrium given these beliefs.

For the firm the strategies are to choose p and s

$$\text{If } \begin{cases} s=1 & \pi_1 = p - c_1 \\ s=0 & \pi_0 = (1-\alpha)(p - c_0) \end{cases}$$

→ High quality (s=1) will be profit maximizing if $\quad p - c_1 > (1-\alpha)\, p - c_0$

$$\leftrightarrow p > \frac{c_1 - (1-\alpha)c_0}{\alpha}$$

For the Consumers:
- for the informed:
  consume if s = 1 and $p \leq \theta$
  don't consume if s = 0
- for the uninformed:
  given p, <u>beliefs</u> on s, and beliefs are such that high price means high quality

So, the monopolist can set a high price, because there are informed consumers.
- The informed consumers→ an externality on the uninformed
  As α increases, it is easier to satisfy profit maximizing s=1.

We just did an example of price signaling to uninformed consumers, where high price signals high quality. We'll next see how a firm can signal high quality in the context of repeated interactions to solve the adverse selection problem.

II. Signaling and Reputation in a repeated purchase environment.

- wasteful advertising
- promotions
- low prices

- the commitment to waste money (←→ /equivalent to a low price) signals quality
- before we had a one-shot game, now we have a repeated game!
- We'll assume that quality s is fixed during the repeated interactions here!
- Extension: s can vary…

II. 1. Signaling/ Reputation Model 1:s fixed

A. No price signal:

Assume:

(i) consumers $U= \theta s-p$, N=1

(ii) No informed consumers

(iii) 2 periods

t= 1,2

Monopolist chooses quality in first period:

s = 1 or s = 0, and quality lasts for both periods.

(iv) $c_1 > c_0$

(v) Consumers buy in period 2 iff s =1 in period 1 and $p \leq \theta$ "Beliefs"

(vi) δ= discount factor for the 2nd period

Profits

High quality period 1:

$\pi_1= (p-c_1) + \delta(\theta-c_1)$

Low quality period 1:

$\pi_0= (p-c_0) + \delta * 0$ →Low quality in period 1 does not sell in period 2

Now, $\pi_1 > \pi_0$ is equivalent to

$$\cancel{p} - c_1 + \delta(\theta-c_1) > \cancel{p} - c_0$$

$$\Leftrightarrow \delta(\theta-c_1) > c_1 - c_0$$

If Reputation effect, i.e., > benefit of cheating
"Happy consumers
come back"

In this case, we don't necessarily have a price signal. The condition to offer s = 1 given the benefits that "buy second period if s = 1" does not depend on price.

What if T periods?

B. <u>Low price- high quality</u>
2 periods again

"<u>Beliefs</u> such that only a low price would be consistent with high quality":

$E[s=1/p>c_0]=0 \rightarrow$ don't buy
$E[s=0/p>c_0]=1 \rightarrow$ don't buy
$E[s=1/p=c_0]=1 \rightarrow$ buy
$E[s=0/p= c_0]=0 \rightarrow$ buy

<u>Profits</u> and possible strategies:
$S=1$ and $p=c_0 \rightarrow \pi_{1,0}$
$S=1$ and $p>c_0 \rightarrow \pi_{1,p}^{T}$
$S=0$ and $p=c_0 \rightarrow \pi_{0,0}$
$S=0$ and $p>c_0 \rightarrow \pi_{0,p}^{T}$

Where

$\pi_{1,0} = (c_0-c_1) + (\theta- c_1)\delta$
$\pi_{1,p}^{+}= 0\ (p^{+}-c1) + \delta * 0=0$
$\pi_{0,0} = (c_0- c_0)+ \delta 0 = 0$
$\pi_{0,p}^{+}= 0\ (p^{+}-c1) + \delta * 0=0$

$(c_0-c_1) + (\theta- c_1)\delta> 0$
or $c_0 > c_1 - (\theta- c_1)\delta$
So these beliefs sustain s=1 and low price in first period.
Low price is a signal for high quality.
→ Price works to a firm's advantage if s=1 because firms <u>can</u> signal through a low price.

II.2. <u>Pure reputation case</u> (s variable)
Price is not a signal, past quality is a signal.

Suppose T periods ($T \rightarrow \infty$)
Quality is a choice variable each period,

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S_t= 0 or 1, quality determined at date t.

<u>Strategies:</u>
Firms set P_t, S_t
Consumers: buy if $S_{t-1} = 1$
Don't if $S_{t-1} = 0$
Buy at t= 0, to start process

<u>Monopolist</u>

If St= 1→ $\pi_1 = \sum_{t=0}^{\infty}(p-c_1)\delta^t = (p-c_1)/(1-\delta)$

If St = 0 → $\pi_0 = (p- c_0) + \delta\ 0$

If at any date chooses St = 0, he gets sales for that period but from then on he will not sell anymore.

High quality is an equilibrium if

$$(p-c_1)/(1-\delta) > p-c_0 \Leftrightarrow \delta(p-c_0) > c_1 - c_0$$

Let $\delta = 1/(1+r)$, then we have

$$p- c_1 > r\ (c_1-c_0)$$

3. Notes on Imperfect Information and Search Models

(Empirical papers on price dispersion: Sorenson, Alan; Perloff, Jeffrey; Zao, Ying.)

For many consumer goods, consumers do not know how much each firm is exactly selling their product for.

For example, in the Hoteling model, imagine consumers in the linear city are not sure what the price of a product will have until they get to the store.

Or suppose you decide you want to buy a new product. Then you will probably go to some effort shopping around looking for the best deal you can get.

In both these cases, we say that consumers incur search costs.

Question:

What is the economic significance of search costs? What is the difference between markets with search costs and markets without?

Diamond (1971). Tourist Trap Model

Consider the following model (Which is again not entirely realistic, but it helpful to clarify our thinking about search costs):

- *N* firms selling homogeneous goods with constant and identical marginal cost of *c*. Let there be a fixed number of firms.
- Consumers know the distribution of prices, but not the prices at specific stores.

Eg. Consumers know 2 firms sell the good for $10 and three firms sell the good for $12, but do not know which exact stores have which prices.

- Consumers can learn the price at a particular store, but this costs the consumer a search cost of *s* for each store they learn the price of. For example. If they visit two stores they incur in a search cost of 2s.
- Assume firms set prices for homogeneous product (ie. Bertrand equilibrium).
- With no search costs, recall the equilibrium outcome would be for marginal cost pricing.

Question:
Is marginal cost pricing still a Nash equilibrium with this search cost?

In order to buy the good, consumer must go to at least one store to learn of the price. If the consumer went immediately to store *i* and then the prices *pi*, the total price paid by the consumer is given by

$$p = p_i + s$$

- This means if firms charge p = c, then an individual firm would be able to deviate and charge

$$P_i = c + \varepsilon < c + s$$

And this firm would not lose any sales.

- In this case *e* is just some number that is less than *s*.
- Hence, if an individual firm raises its price by an amount less than the search cost, then consumers who arrive at that store will stay and pay the slightly higher price, since it is not worth to leave and go to a cheaper store and incur an additional search cost.

The argument reveals that there exists a profitable unilateral deviation from the marginal cost pricing equilibrium. So that this is no longer a Nash equilibrium in the face of search costs for consumers.

Question:
What is the new equilibrium? Firms keep raising prices until…
Well the maximum price they will ever set is the monopoly price. Is the equilibrium one in which all firms set the monopoly price? Perhaps.

Let's again ask, if all firms are setting a price equal to the monopoly price does there exist a profitable unilateral deviation for a firm?

First note it would not be profitable to raise price any higher.

But what about lowering the price?

Lowering price by $e < s$ would have no effect on quantity sold and simply reduce revenue.
But it may be sensible to lower price by $e > s$. This idea is as follows

For small N, number firms:
Suppose there are two firms, and both are initially setting price at the monopoly level. Then if one firm were to lower price by an amount greater than the search cost, then all consumers will end up buying from the firm with the low price (and this price may still be greater than marginal cost). Any consumer who first arrives at the expensive store will be willing to incur the cost of going to the other store. Multi-price equilibrium.

For large N:
If there are 100 firms and all are initially setting price at the monopoly level, then it is no longer clear that a single firm would profit by lowering price by more than the search cost. This is because consumers still don't know which firm has the low price, they just know there I one firm out there somewhere. So consumers will tend not to want to change from the first store they arrive at and find the monopoly price is offered.

Conclusion:
In summary, as long as the number of firms is large enough, relative to magnitude of the search costs. Then even a relatively small search cost will cause equilibrium prices to be higher.

Comparative statics:
If s tends to zero, then full information, then p=c, price equals to marginal costs.
Free-entry, increase in N may decrease competition! Surprising Result! As N increases, it does not pay to lower price because the probability of inducing consumers to seach and find lower price is low. (Some of these results change with repeated interactions.)

Empirical Evidence?

Limited Information about Price: Tourist Trap Model- Diamond (1971)

Survey of literature (Salop 76, Stiglitz (79))

As a review of one of last lectures, in the Diamond model:
Cost of searching
Price if visits one store: p + c at least
Search cost if visits two stores: 2c
We had firms with equal costs, homogenous product, consumers have identical demand functions they know general distribution of prices but not which stores has which price.
-fixed number of firms:
Competitive equilibrium? $p=p^c$? No
Incentive to charge $p^*= p^c +\varepsilon$ as long as $p^*< p^c +c$
Is all stands $p=p^*$ an equilibrium? No…
Similar reasoning…

Is $p=p^m$? When n too large, where n is the number of firm, yes.

If n small it pays to set $p=p^m -c$ lowers the price more than the search cost and the consumers will switch because the chances of finding the lower price store are higher if n is small → multi-price equilibrium.

- lowering c does not lower equilibrium price as long as there is a single price equilibrium.
  If $c\rightarrow 0$, then full information implies $p=p^c$.
- free entry- ↑N may ↓ competition (and not decrease p) because it will not pay to lower p because probability of inducing customers to search and find lower price is low. (Stigliz 1979). Some of these "surprising" results change with repeated interactions.

Lets introduce some informed consumers now:

The Tourists- and Natives Model

Salop Stiglitz (1977)

- Tourists and Natives Model: Not all consumers are un-informed.

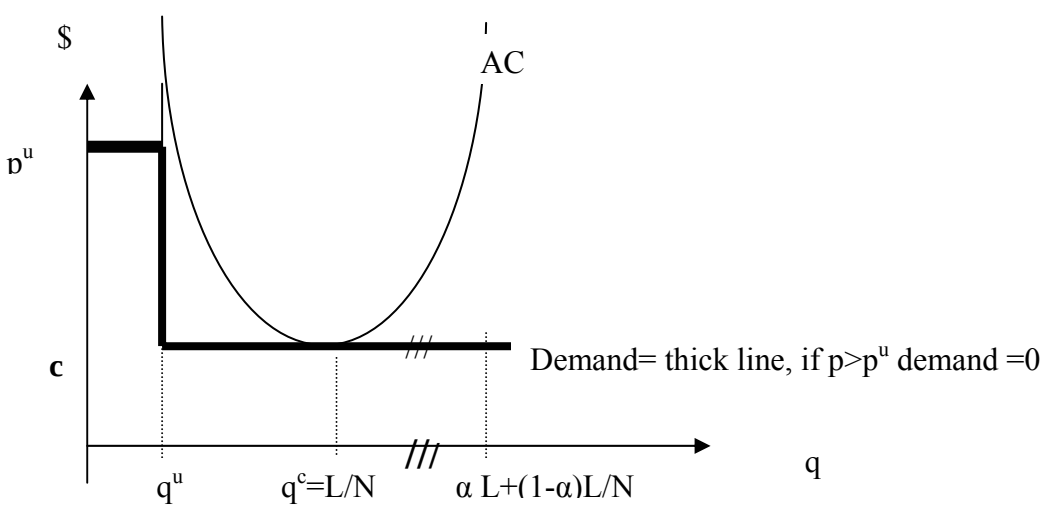
Questions: 1) Is there a model in which multi-price equilibrium is possible? Is there price dispersion?
2) If some consumers are fully informed, even though others have limited information, can there be p=mc? We will see that Yes.

Model:
1. firms have identical costs c, AC
2. two types of consumers: (number of consumers=L). Let maximum price consumers are willing to pay be p^u.

Let there be αL- informed (natives) zero search costs; know entire distribution of prices in the market.
Let there be (1-α)L- uninformed (tourists) that have costs s of search.
Natives buy only at low price stores.

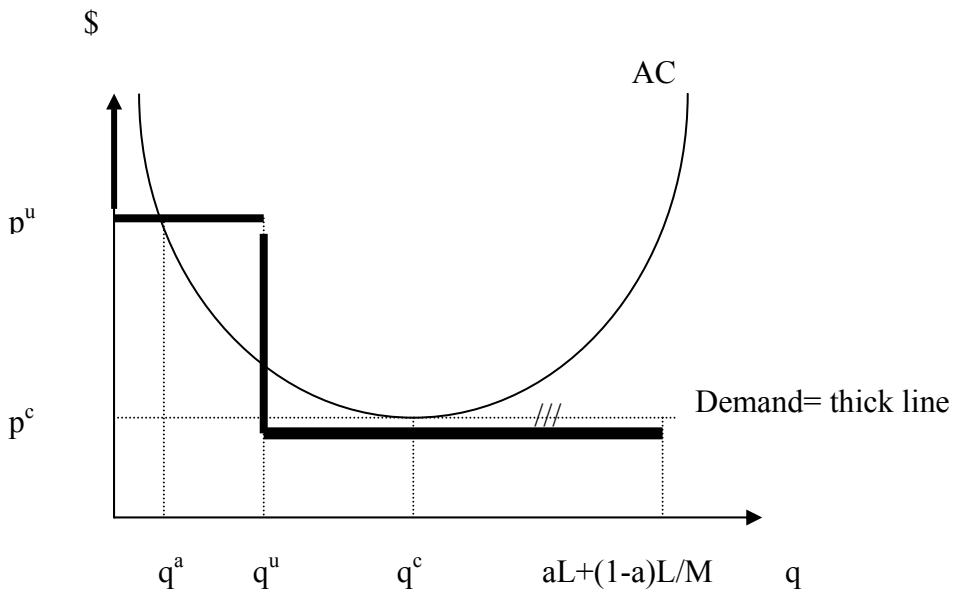
***A**- If substantial number of informed, then $p \rightarrow p^c = c$. No profitable deviations.*

--If $p = p^c$, each firm gets the same market share $q^c = L/N$.
Intuition, please see graph below:
–If there are many informed consumers it does not pay to p> c, because $p \in [c, p^u]$ and selling to the un-informed group q^u would get price below $AC(q^u)$. So selling to uninformed consumers firms lose money, and no informed consumers buy.
Note that the higher alpha, the more to the left is $q^u = (1-\alpha) L/N$.
--p< c also not profitable



Tourists-Natives Model, Salop Stiglitz (1979)

B *Few informed consumers: It pays to deviate from p=c.*



Question: Is $p=p^c$ an equilibrium? No.
Let q^a such that $AC(q^a)=p^u$.
A deviant firm can raise p without losing many consumers. It pays to deviate if $\underline{q}^u > \underline{q}^a$
OR

$\underline{q}^u = (1-\alpha)\, \underline{q}^c > \underline{q}^a$ at $\underline{q}^u$, $\pi(\underline{q}^u)>0$

$\alpha < 1 - \underline{q}^a / \underline{q}^c$ $\underline{q}^c$, $\pi(\underline{q}^c) = 0$

so wants to raise p.
The lower alpha the more condition above is satisfied, and it pays to deviate form p=c.

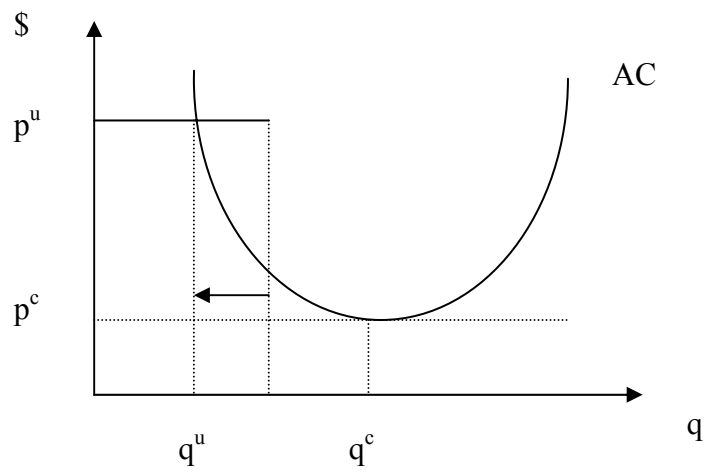
There cannot be an equilibrium where all firms charge , p^u however.
This is because there are profitable deviations to charge slightly below that price and get all informed consumers.

There will be two-price equilibrium: High price stores selling at p and low price stores selling at p=c. Why not a three price equilibrium? (practice: see p.440 answer C&P book)

Two-price equilibrium in Tourists and Natives Model

A two-price equilibrium is possible: p^u and p^c=c. It does not pay to set $p \in [\, p^c, p^u \,]$.
→ All informed consumers shop at low price stores, all uninformed consumers shop randomly. Low price stores have larger market share than the proportion of informed consumers. See next page.

→ All Firms make zero profits (otherwise would want to change price):
Low price stores π=0 because p^c .
High price stores enter the market until π= 0.



<u>What are the Market Shares in the Two-price equilibrium?</u>

Let there be n stores.
βn low price stores sell at p^c, $q^A = q^c$
$(1-\beta)n$ high price stores sell at p^u, $q^a = q^u$
they only sell to share $(1-\beta)$ of uninformed consumers

<u>Each individual HIGH</u> price firm sells the quantity

$$q^u = \frac{(1-\beta)(1-\alpha)L}{\text{\# low price stores}} = \frac{(1-\alpha)L(1-\beta)}{(1-\beta)\ n}$$

share of total sales

$$(1-\beta) = \frac{q^u}{L} = \frac{(1-\alpha)}{n}$$

<u>Each individual LOW price firm sells to:</u>
Its share of L informed consumers and to its share of uninformed consumers who were luck enough to find a low price store

$$q^c = \frac{\alpha L + (1-\alpha)L\,\beta}{n\beta}$$

Share of total sales

$$\beta = \frac{q^c}{L} = \frac{\alpha}{n\beta} + (1-\alpha)/n > \frac{(1-\alpha)}{n} = (1-\beta)$$

The share of the market of low price is greater than high price so $\beta > \alpha$.

n is determined s.t. $\pi_{High} = 0$

$$\rightarrow q^A = q^u = \frac{(1-\alpha)L}{n}$$

$$\rightarrow n^* = \frac{(1-\alpha)L}{q^A}$$

$$\text{So } \beta^* = \frac{\alpha\, q^A}{(1-\alpha)\, L\beta} + \frac{\cancel{(1-\alpha)}\, q^A}{\cancel{(1-\alpha)} L}$$

So, low price stores have larger market share than the proportion of informed consumers, since beta is larger than alpha.

The noisy Monopolist Salop (1977)

Since limited consumers information can lead to higher prices, it may be that a firm create noise in the market by changing different prices for nearly identical products or for the same product at different stores. By creating price dispersion → (↑ search costs) but ↓ consumer information.

It is the fact that consumers have different abilities of gathering information that makes firm want to create price dispersion → in order to price discriminate!