Economics of Information and Communication Technology

Lecture 2: Digital Markets

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What are digital markets?

- ICT technologies allow firms to sell their products online.

- The internet provides customers with better information and firms with an additional distribution channel.

- Digital marketplaces where consumers and suppliers meet virtually (what is a market?).

- In 2011 more than 40% of European citizens use the internet to buy products and services.

- UK and Germany are countries where individuals use internet the most.
On the internet:

1. companies can gain information on competitors’ pricing strategies and products;

2. sellers can react quickly to changes in market conditions (change price instantaneously);

3. no physical boundaries of the market.

- Good approximation of perfect competition? Market is frictionless, transparent and highly competitive.

- According to this view the price should converge to the marginal cost. Is this prediction accurate?
Market Efficiency

- A market is (Pareto) efficient when we cannot improve the utility of any agent without worsening that of at least another agent.

- A perfectly competitive market is efficient.

- In perfect competition the price equals the marginal cost of production.

- No firm can increase price because there are many firms with the same price (which is lower).

- No consumer can purchase the good at a lower price because the firm could not cover the cost of production.

- Key assumption in the model: there is full information.
**Indicators of Efficiency**

1. Prices are cost oriented (i.e. close to marginal cost);

2. Price elasticity of demand is high;

3. Menu costs are low;

4. Price dispersion is low.
Empirical evidence: Price levels and price elasticity of demand

- Does not find clear evidence that prices are lower than in standard markets;

- Software, CDs, Books (Bailey 1998 and Lee 1998). Online prices tend to be higher;

- More recent contributions opposite conclusion.

- Mixed conclusions as well for the price elasticity of demand.
Menu costs and Price Dispersion

- Difficult to measure;

- Proxied by the frequency of price adjustment;

- Online sellers adjust prices more frequently.

- Most studies do not support the evidence of lower price dispersion in online markets.

*Why digital markets are so far from efficiency despite satisfying many of the conditions required for perfect competition to emerge?*
Inefficiency in competitive markets can be due to search costs (limitation of information);

Consumers not fully informed about the distribution of prices ⇒ engage in search activity;

Search is costly so an inefficient price can exist in equilibrium.
A simple model with search costs (1)

- Two stores, A and B, selling the same product and competing on price;

- A just opened;

- B has a pool of loyal customers (buy B regardless of the price);

- Unloyal customers care only about the price but are uninformed. They have to search.
Denote $\eta_B$ the number of consumers loyal to store B;

The number of unloyal consumers is 1. The total number of consumers is then $1 + \eta_B$;

Let $p_A$ and $p_B$ the prices charged by the two stores;

Store B cannot discriminate consumers so charges $p_B$ to everybody.

Store B has lower incentives to cut prices because it loses revenues from loyal consumers so $p_A < p_B$. 

Consumers devote a certain amount of time $s$ to search;

Consumers are heterogeneous in their disutility of time $\alpha$. Total disutility for searching is then $s\alpha$;

$\alpha$ is uniformly distributed in the interval $[0, 1]$. 
We need to determine the demand functions for the two stores;

As in basic microeconomics the demand function of a firm is a mathematical function relating the quantity demanded to the price set;

Consider first unloyal consumers. They know in the market there are the prices $p_A$ and $p_B$ but do not know where.

Unloyal consumers can: 1) search or 2) do not search.
A simple model with search costs (4)

- Assuming that she does not search, she visits a store with probability $1/2$. If she values the product $k$, utility is:

$$U_{ns}(\alpha) = k - \frac{p_A + p_B}{2}$$

- If the consumer chooses to search she finds the smallest price at store A so utility is:

$$U_s(\alpha) = k - p_A - \alpha s.$$  

- We need to find the indifferent consumer for which $U_{ns}(\alpha) = U_s(\alpha)$. This is:

$$\tilde{\alpha} = \frac{p_B - p_A}{2s}$$

- All consumers with low disutility $\alpha < \tilde{\alpha}$ search, the others choose randomly.
Figure 2.3: market segmentation of unloyal consumers
Thus, the number of people who search is \( \tilde{\alpha} \) and the number not searching is \( 1 - \tilde{\alpha} \).

The demand functions for the two stores are then:

- \( D_A(p_A, p_B) = \tilde{\alpha} + \frac{1-\tilde{\alpha}}{2} = \frac{1}{2} + \frac{p_B-p_A}{4s} \);

- \( D_B(p_A, p_B) = \eta_B + \frac{1-\tilde{\alpha}}{2} = \eta_B + \frac{1}{2} - \frac{p_B-p_A}{4s} \).

Demand for A: unloyal searching + random consumers.

Demand for B: loyal + random consumers.
Assume firms have **zero costs**. Then profits are:

\[
\pi_A(p_A, p_B) = D_A(p_A, p_B)p_A = \left(\frac{1}{2} + \frac{p_B - p_A}{4s}\right)p_A;
\]

\[
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\]

We are now in the position to find the price that each firm sets to maximize profits.
By differentiating profits of A by $p_A$ and of B by $p_B$ we obtain:

- $p_A^* = \frac{2}{3} s(3 + 2\eta_B) > 0$;
- $p_B^* = \frac{2}{3} s(3 + 4\eta_B) > 0$;

1. B’s price is larger
2. Prices exceed marginal cost ($=0$)
3. Price dispersion increases with search costs $s \Rightarrow p_B^* - p_A^* = \frac{4s\eta_B}{3}$.

If consumers are not fully informed and search is costly, a potentially competitive market turns to be inefficient.

Search costs seem to be small in online sales. Need to look for more explanations.
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We present an alternative model of sales based on two empirical observations:

1. Online stores change prices frequently;
2. Offers appear as random, that is, not related to specific market conditions.

If firms set prices randomly there are two main consequences:

4. Since the probability of two firms posting the same price is zero, there is price dispersion.
5. Consumers cannot be informed about prices even if search costs are null.

Such model includes two typical aspects of digital markets: little menu costs and negligible search costs.
A large number of consumers willing to buy one unit of a product available at \( n \geq 2 \) stores.

Consumers have homogeneous preferences and value the product \( k > 0 \).

There are two types of consumers:

1. Informed consumers \( I \) who check all prices and buy at the cheapest one;

2. Uninformed consumers \( D \) who do not check prices and pick a random shop: they buy if the price is smaller than \( k \).

Uninformed consumers are spread evenly across stores, so that \( NI = D/n \) is the fraction of uninformed consumers that visit each shop.
Stores have *high fixed costs* and *small marginal costs*.

Denote the store cost function by \( C(q) \).

Then, the average cost function is \( AC(q) = C(q)/q \), and we assume it is decreasing in \( q \).

Also, the market is characterized by *free entry*. This assumption implies that until there are positive profits, new firms enter the market.

So it must be that in equilibrium expected profits are zero:

\[ E[\pi_i] = 0. \]
In this environment we want to understand the **pricing strategy** of stores.

The upper bound is $p < k$. If the price is larger than the valuation of the good, nobody would buy it.

The lower bound is average cost. Firms must charge a price such that $p > AC(q)$.

The maximum amount a firm can sell is $NI + I$.

The lower bound for the price is then $p^* = AC(NI + I)$.

Thus the price must be in the interval $[p^*, k]$. 

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Economics of Information and Communication Technology
The cost of production

Average cost vs. quantity

$AC(q)$

$p^*$

$k$

$NI + I$
A model of sales (5)

- An *equilibrium in pure strategies* in which all firms set the same price *does not exist*.

- Suppose all firms set the same price \( p \).

- The amount a firm sells is \( NI + (I/n) \) and the average cost is \( AC(NI + (I/n)) \).

- So \( p \) cannot be smaller than \( AC(NI + (I/n)) \).

- Consider all firms setting \( p \geq AC(NI + (I/n)) \).

- This cannot be an equilibrium because firms have the incentive to undercut price a bit and obtain the market:

- \( p \geq AC(NI + (I/n)) > AC(NI + I) \).
Only a **mixed strategy** equilibrium is possible.

Firms play a mixed strategy choosing \( p \in [p^*, k] \) using the density function \( f(p) \).

Even if firms use the same mixed strategy, the probability they choose the same price is zero.

Hence, there is *price dispersion in equilibrium*. 
We now characterize the equilibrium in mixed strategies. We first determine stores’ expected profits. Consider a firm $i$ charging price $p$. Two possible events:

1. the $n - 1$ rival stores charge a price larger than $p$.
2. at least one store charges a price smaller than $p$.

Given that all firms use the same probability distribution, event 1 occurs with probability $(1 - F(p))^{(n-1)}$. With this probability the firm sells to all informed consumers, obtaining profits:

$$\pi^a(p) = p(I + NI) - C(I + NI)$$

With the complement probability $1 - (1 - F(p))^{(n-1)}$ at least one firms sets a price larger than $p$ and profits are

$$\pi^b(p) = p(NI) - C(NI)$$
Following the definition of mixed strategies any store must be indifferent across $p$’s.

Together with the condition $E[\pi_i] = 0$ (free entry), it must be that, for any $p \in [p^*, k]$

$$\pi^a(p)(1 - F(p))^{(n-1)} + \pi^b(p) \left[ 1 - (1 - F(p))^{(n-1)} \right] = 0$$

We can then solve for the equilibrium strategy distribution function:

$$F(p) = 1 - \left( \frac{\pi^b(p)}{\pi^b(p) - \pi^a(p)} \right)^{\frac{1}{n-1}}.$$

The result proves that it is optimal for firms to choose prices randomly.

It follows that in this model there is price dispersion despite the absence of search costs, and it is a permanent phenomenon.
The internet allows firms to segment the market and price discriminate.

This implies firms retain a large amount of market power.

In particular retailers can use information they acquire about consumers to tailor consumers’ preferences: mass customization.

Example: Dell computers.

Versioning and bundling two common online discrimination strategies.
This is a *second type discrimination strategy*.

Several versions of the product, each targeted to a different market segment.

Example: hardcover vs paperback book editions.

Why price discrimination is profitable?

With respect to the standard monopolist, price discrimination can increase profits.
The cost of production

With respect to the standard monopolist (price $p^m$), price discrimination may increase profits because:

1. The monopolist might charge a price larger than $p^m$ to those willing to pay it;
2. The monopolist can increase sales by selling at lower prices to consumers with a willingness to pay smaller than $p^m$. 

Figure 2.7: the aims of price discrimination
How to induce consumers to buy the product targeted to them?

Example: an editor who is about to launch a new novel.

Following market investigation, there are two types of consumers: loyal (eager to buy the book as soon as possible) and indifferent (interested in the book but willing to wait).

The editor wants to segment the market to charge a higher price to the loyal consumers.

The editor knows the percentage of each type in the population but cannot identify the type of each consumer.

One possibility to segment the market is versioning, that is produce two different versions of the book.
Versioning

Two differences:

1. Cover (hardcover vs paperback);

2. Time (paperback comes later than hardcover);

3. Price (hardcover more expensive).
### Readers’ willingness to pay

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- If the editor decides to sell only one version of the book should produce the hardcover and sell it at 60 (check). Profits are 6000.
- If the editor could distinguish each type of consumer she would sell the hardcover at 110 to loyal and at 60 to normal making profits of 8000 (perfect discrimination).
- The editor can still improve adopting versioning. A crucial aspect of versioning is *self selection*.
- The optimal versioning strategy is:
  1. sell paperback at 40, the willingness to pay of normal consumers;  
  2. sell hardcover at 100 (loyal consumers indifferent between hardcover and paperback).

- Editor’s profits are 6400. Versioning less profitable than perfect discrimination.
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Two-step procedure of versioning

- identify the characteristics and price of the low-end version;

- determine the features and price of the high-end version so that loyal consumers are indifferent.
The second reason versioning might be profitable is to *increase sales*;

- The firm knows the distribution of heterogeneous consumers, but cannot recognize each type;
- The firm produces a product of quality $m$;
- Consumer preferences towards $m$ are represented by the parameter $\theta$, uniformly distributed in $[0, 1]$ (*so also number of consumers*).
- Thus the utility of the consumer is given by $k$ (basic willingness to pay) and $\theta m$, the personal valuation of the good.
- The firm can produce two versions, $m_1$ and $m_2$, with $m_2 > m_1$.
- Utility is then given by $U(\theta, m_i, p_i) = k + \theta m_i - p_i$.
- Cost of production is zero for the firm.
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Cost of production is zero for the firm.
With only one version the firm chooses to produce the *high quality good*: same cost, higher value for the consumer;

- If $p_N$ is the price charged, the indifferent consumer has $U(\theta, m_2, p_N) = 0$.

- The taste parameter of the indifferent consumer is then $\tilde{\theta}(p_N) = \frac{p_N - k}{m_2}$

- Only consumers with $\theta > \tilde{\theta}(p_N)$ buy the product.

- So $1 - \tilde{\theta}(p_N)$ consumers buy the product.

- Profits are $\pi_N(p_N) = p_N \left[ 1 - \tilde{\theta}(p_N) \right] = p_N \left[ 1 - \frac{p_N - k}{m_2} \right]$

- Optimal price is then $p_N^* = \frac{k + m_2}{2}$, profits are $\pi_N^* = \frac{(k + m_2)^2}{4m_2}$ and $\tilde{\theta}(p_N^*) = \frac{1}{2} - \frac{k}{2m_2}$. 
One version of the product

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- The taste parameter of the indifferent consumer is then $\tilde{\theta}(p_N) = \frac{p_N - k}{m_2}$

- Only consumers with $\theta > \tilde{\theta}(p_N)$ buy the product.

- So $1 - \tilde{\theta}(p_N)$ consumers buy the product.

- Profits are $\pi_N(p_N) = p_N \left[ 1 - \tilde{\theta}(p_N) \right] = p_N \left[ 1 - \frac{p_N - k}{m_2} \right]$

- Optimal price is then $p^*_N = \frac{k + m_2}{2}$, profits are $\pi^*_N = \frac{(k + m_2)^2}{4m_2}$ and $\tilde{\theta}(p^*_N) = \frac{1}{2} - \frac{k}{2m_2}$. 

Lecture 2: Digital Markets
With only one version the firm chooses to produce the **high quality good**: same cost, higher value for the consumer;

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Two versions of the product

- The monopolist *sells two versions*;

- Need to set prices $p_1$ and $p_2$ such that *consumers self-select*;

- First, we determine demand functions. We do this by finding *indifferent consumers*.

- One consumer is indifferent between buying the low quality and not buying, $\tilde{\theta}_{0,1}$;

- Another consumer is indifferent between buying the high and the low quality $\tilde{\theta}_{1,2}$. 
Two versions of the product (2)

1. \( U(\theta, m_1, p_1) = U(\theta, m_2, p_2) \Rightarrow \tilde{\theta}_{1,2}(p_1, p_2) = \frac{p_2 - p_1}{m_2 - m_1} \).

2. \( U(\theta, m_1, p_1) = 0 \Rightarrow \tilde{\theta}_{0,1}(p_1) = \frac{p_1 - k}{m_1} \).

- Three types of consumers.
  - \( 1 - \tilde{\theta}_{1,2}(p_1, p_2) \) buy \( m_2 \)
  - \( \tilde{\theta}_{1,2}(p_1, p_2) - \tilde{\theta}_{0,1}(p_1) \) buy \( m_1 \).
  - \( \tilde{\theta}_{0,1}(p_1) \) buy nothing.
Market segmentation with versioning

Figure 2.8: market segmentation with versioning
The firm maximizes profits by choosing the two prices

$$\max_{p_1, p_2} \pi_V (p_1, p_2) = p_2 \left[ 1 - \tilde{\theta}_{1,2} (p_1, p_2) \right] + p_1 \left[ \tilde{\theta}_{1,2} (p_1, p_2) - \tilde{\theta}_{0,1} (p_1) \right] = p_2 \left[ 1 - \frac{p_2 - p_1}{m_2 - m_1} \right] + p_1 \left[ \frac{p_2 - p_1}{m_2 - m_1} - \frac{p_1 - k}{m_1} \right]$$

The optimal prices are $p_1^* = \frac{k + m_1}{2}$, $p_2^* = \frac{k + m_2}{2}$ and

$$\pi^*_V (p_1^*, p_2^*) = \frac{2km_1 + m_2 m_1 + k^2}{4m_1}.$$  

Using $p_1^*$ in $\tilde{\theta}_{0,1} (p_1)$, the number of consumers not buying is $\frac{1}{2} - \frac{k}{2m_1}$.

With no versioning, $\tilde{\theta} (p^*_N) = \frac{1}{2} - \frac{k}{2m_2} > \frac{1}{2} - \frac{k}{2m_1} = \tilde{\theta}_{0,1} (p_1)$.

Finally, profits are $\pi^*_V = \pi^*_N + \frac{k^2 (m_2 - m_1)}{4m_1 m_2} > \pi^*_N$.

Thus with versioning market size and profits increase.
In versioning the low quality product cannibalizes somehow the high quality one.

However, in the previous result, market enlargement dominates cannibalization.

All benefits for the firm come from the market effect, as $p_2^* = p_N^*$.

That is, with versioning the firm is not able to charge a larger price to high taste individual with respect to the one product case.
Versioning is not always profitable as in the previous case.

Consumers’ preferences need to meet certain conditions.

Let’s consider a modified version of the table we previously saw.
Limits of versioning

<table>
<thead>
<tr>
<th></th>
<th>Loyal Readers N=40</th>
<th>Normal Readers N=60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardcover</td>
<td>110</td>
<td>60</td>
</tr>
<tr>
<td>Paperback</td>
<td>80</td>
<td>40</td>
</tr>
</tbody>
</table>

Following the argument above, versioning requires:

- A price of 40 for the paperback (willingness to pay for the normal readers)
- A price of 70 for the hardcover (makes loyal consumers indifferent)
- Profits are 5200. Larger profits if selling hardcover at 60 ⇒ 6000.
Limits of versioning

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1. A price of 40 for the paperback (willingness to pay for the normal readers)
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Profits are 5200. Larger profits if selling hardcover at 60 ⇒ 6000.
With respect to the previous case, hardcover and paperback are closer substitutes.

To induce loyal consumers to self select, the editor must substantially reduce the price of the hardcover (70 vs 100).

The cannibalization effect dominates on the market effect.
LIMITS OF VERSIONING

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<td>40</td>
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- With respect to the previous case, hardcover and paperback are closer substitutes.

- To induce loyal consumers to self select, the editor must substantially reduce the price of the hardcover (70 vs 100).

- The cannibalization effect dominates on the market effect.
Under more general conditions, we can say that versioning is always profitable when the number of consumers served when the firm sells only the high quality version is lower than the number of consumers served when the firm sells only the low quality one.

- Let’s go back to the model of versioning to increase the market. When selling only the high quality, sales amount to \( \frac{1}{2} + \frac{k}{2m_2} \).

- This is smaller than if selling only the low quality \( \frac{1}{2} + \frac{k}{2m_1} \), as \( m_2 > m_1 \).

- Thus in this case versioning is profitable.
Bundling: sale of more than one product together (i.e. in a bundle).

Example: television networks offering a wide range of channels;

When is bundling profitable?

The aim is to reduce heterogeneity in consumers’ preferences.

Consider a software company selling a text editor (Wordy) and a spreadsheet (Calc).

There are only two consumers, an accountant and a writer.
Without bundling, the optimal strategy is to sell Wordy at 11 and Calc at 7. Profits=$18.

With bundling, it can sell the bundle at 10 and make profits=$20.
Strategies can be more articulated.

Consider a TV network: entertainment channel (E), a sports channel (S) and a news channel (N).

Four categories of consumers of equal size: A, B, C, D.
### Bundling strategies

<table>
<thead>
<tr>
<th></th>
<th>Channel S</th>
<th>Channel E</th>
<th>Channel N</th>
<th>Bundle</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>12</td>
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<td>B</td>
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<td>10</td>
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<td>1</td>
<td>9</td>
<td>5</td>
<td>15</td>
</tr>
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- Without bundling, \( P_S = 9, \ P_E = 9, \ P_N = 5 \), profits = 46 and six subscriptions.

- With bundling, sell at 12 the bundle and obtain profits = 48.
### Mixed Bundling strategies

<table>
<thead>
<tr>
<th></th>
<th>Channel S</th>
<th>Channel E</th>
<th>Channel N</th>
<th>Bundle</th>
<th>Bundle E+S</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>1</td>
<td>1</td>
<td>12</td>
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</tr>
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- The firm can improve by selling:
  1. the bundle E+S at price 10;
  2. channel N at price 5.

- Profits = 50.
## Mixed Bundling strategies

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- Valuations for the bundle E+S are less dispersed than those for the bundle S+E+N.

- The objective of the bundle is to make consumers’ preferences similar.
Online firms can use information to price discriminate.

One way to do it is to condition price on purchase history.

Amazon in 2001 was caught charging customers different prices: regular customers were charged more than occasional one!

Most common way to obtain information is through cookies.

Servers read cookies stored on the customer’s pc and personalize ads.

To sum up, firms can easily segment the market.

What is the effect of dynamic pricing on market’s equilibrium, profits and social welfare?
There is an online monopolist operating in two periods.
Each consumer visits the website twice, one in each period.
Four possible event: 1) buy/buy, 2) buy/not-buy, 3) not-buy/buy, 4) not-buy/not-buy.
The benefit depends on $k$, valuation of the good, and on $m_i$, where $i$ denotes the first or the second visit and $m$ is the benefits of purchasing online.
We assume that consumers:

1. have heterogeneous preferences with respect to $m_i$,
2. the benefit increases when the product is purchased on the second visit, $m_2 > m_1$.

We justify assumption 2 with the consumer being more informed, wasting less time, or with firms providing additional services in a second visit.
Net utility during visit $i$ is then $U(\theta, m_i, p_i) = k + \theta m_i - p_i$, with $\theta$ uniformly distributed in $[0, 1]$. 
Aim is to determine the optimal pricing strategy, that is the prices charged in the two periods.

With no price discrimination the price is the same in the two periods.

The indifferent consumer in period \( i \) is identified by \( U(\theta, m_i, p) = 0 \) and \( \tilde{\theta}(m_i, p) = \frac{p-k}{m_i} \).

All consumers with \( \theta > \tilde{\theta}(m_1, p) \) purchase in period 1.

All consumers with \( \theta > \tilde{\theta}(m_2, p) \) purchase in period 2.

Some consumers can buy in both periods.
With zero production costs, profits are

$$\pi_N(p) = p \left[ 1 - \tilde{\theta}(m_1, p) \right] + p \left[ 1 - \tilde{\theta}(m_2, p) \right] = \frac{p}{m_1 m_2} \left[ 2m_1 m_2 - (p - k)(m_1 + m_2) \right]$$

From the FOC with respect to $p$ we obtain

$$p_N^* = \frac{k}{2} + \frac{m_1 m_2}{m_1 + m_2}. \text{ Plugging the price in profits}$$

$$\pi_N^* = \frac{(2m_1 m_2 + k(m_1 + m_2))^2}{4m_1 m_2(m_1 + m_2)}.$$
Cookies: price discrimination

- In period 1 cookies does not exist and the firm cannot discriminate;
- In the second period cookies contain information;
- If the consumer purchased in the first period it must be she has a high $\theta$;
- We need to determine 3 prices: one for period 1 ($p_o$) and two for period 2 ($p_b$ and $p_{nb}$).
- In period 2 the firm can discriminate between those who purchased ($p_b$) in period 1 and those who did not ($p_{nb}$).
- Those who purchased in period 1 have a high $\theta$ so the firm charges a high $p_b$. 
• Choice of $p_{nb}$ more articulated.

• Consumers who didn’t buy in period 1 have a small $\theta$. So $p_{nb}$ should be sufficiently small.

• However, setting a small $p_{nb}$ induces some consumers buying in period 1, not to buy and wait period 2.

• Thus $p_{nb}$ should be sufficiently high to induce some consumers to buy in period 1.

• Indeed, the optimal price for $p_{nb}$ is infinite.

• We then need to determine $p_o$ and $p_b$. 
Figure 2.10: market segmentation with dynamic pricing
Let’s determine the indifferent consumer at time 1 for price $p_o$.

$U(\theta, m_1, p_o) = 0$ and $\tilde{\theta}_L(p_o) = \frac{p_o-k}{m_1}$.

Let’s determine the indifferent consumer between buying at time 1 or at both times.

$U(\theta, m_1, p_o) + U(\theta, m_2, p_b) = U(\theta, m_1, p_o)$ or, $U(\theta, m_2, p_b) = 0$.

So $\tilde{\theta}_H(p_b) = \frac{p_b-k}{m_2}$. The profit function is:

$\pi_D(p_o, p_b) = p_o \left[ \tilde{\theta}_H(p_b) - \tilde{\theta}_L(p_o) \right] + (p_o + p_b) \left[ 1 - \tilde{\theta}_H(p_b) \right] = p_o \left[ 1 - \frac{p_o-k}{m_1} \right] + p_b \left[ 1 - \frac{p_b-k}{m_2} \right]$. Optimal prices are then

$p_o^* = \frac{k}{2} + \frac{m_1}{2}$, $p_a^* = \frac{k}{2} + \frac{m_2}{2}$, and profits

$\pi_D^* = \frac{(k^2+m_1m_2)(m_1+m_2)+4km_1m_2}{m_1m_2}$.

Thus the firm profitably discriminate by conditioning prices on purchase history. $\pi_D^* > \pi_N^*$. 

Cookies: price discrimination (3)