Quality, Durability, and Warranties II

Chapter 12.

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Does a monopolist have incentives to produce *high* quality goods?

Kleiman and Ophir (1966) and Levhari and Srinivasan (1969) conclude that monopolists have the incentives to produce goods of lower durability.

Swan (1970, 1971) demonstrated that there is no relationship between monopoly power and durability "Swan’s independence result."

Consider a consumer who lives for two periods.

The consumer desires light services for two periods.

The consumer is willing to pay $V$ per each period, where $V > 0$.
Market Structure, Quality and Durability

- The light bulb-producing firm:
  - **Short-durability** light bulb yielding light services for one period ($S$)
  
  ![Short-durability bulb](image1)
  
  $t=1$

- **Long-durability** light bulb yielding light services for two periods ($L$)

  ![Long-durability bulbs](image2)
  
  $t=1$  $t=2$
The unit cost is $c^S$ and $c^L$, where $c^S < c^L$

In addition, $0 < c^S < V$ and $0 < c^L < 2V$

Let us analyze the market equilibrium under Monopoly and Perfect Competition

MONOPOLY, first assume that the monopoly sells $S$
Market Structure, Quality and Durability

- The monopoly would charge \( p^S = V \) per period, and would sell two units
  \[ \pi^S = 2(V - c^S) \]
- Now assume that the monopoly sells \( L \), then \( p^L = 2V \)
  \[ \pi^L = 2V - c^L \]
- **When will the monopoly produce \( S \)?**
  - \( \pi^S > \pi^L \)
- **Conditions...**
- COMPETITIVE MARKET, the price is \( p^S = c^S \) and \( p^L = c^L \)
- Hence the consumer buys \( S \) when...
- **Proposition:**
  - *The durability of light bulbs is independent of the market structure*
The Innovation-Durability Trade-off

- **When technologies keep changing rapidly consumers desire new-technology products**
- The launch of the iPhone in 2007 transformed the humble mobile phone from a one-trick tool for communication into a catch-all platform whose functionality is constantly evolving.
- The smartphone is now a pocket-size PC. It facilitates instantaneous personal connections that make phone conversations seem like cave paintings.
- Smartphones accounted for four out of every five phones purchased in the U.S. (Nielsen)
- The smartphone paced the TV as the consumer technology with the fastest adoption rate, reaching 40 percent market saturation in just 2 1/2 years. (MIT)
- The majority of Internet traffic (60%) now comes from mobile devices rather than desktops, which long served as the dominant online portal.
"My old computer does not want to break down, so I don’t know what to do with it once I replace it with a newer model"  

whether and under what conditions firms may produce products with excess durability, from a social point of view.

Assume a two-period model, $t = 1, 2$

In period $t = 1$, there is one consumer deciding to buy a computer for the two periods of his life

In $t = 2$, one additional consumer enters the market and seeks to buy one period of the product’s services

$$U_t \equiv \begin{cases} V_t - p_t & \text{if buy the period } t \text{ tech product} \\ 0 & \text{if not buy} \end{cases}$$
The Innovation-Durability Trade-off

- There are two firms
- Firm 1 (operates in $t = 1$ only) is endowed with and old tech providing a (per period) quality $v^0$
- Firm 2 (potential entrant in $t = 2$) can produce the old and new tech, where $v^N > v^0$ for an innovation cost $I > 0$
- The production cost of a nondurable good is $c^{ND}$ and durable is $c^D$, where $0 = c^{ND} < c^D$
2nd period pricing, given that 1st period is nondurable

- The pricing and innovation decision of firm 2 are

\[ p_2 = \begin{cases} 
  v^N & \text{if } 2(v^N - v^O) \geq I \\
  v^O & \text{if } 2(v^N - v^O) < I 
\end{cases} \]

\[ \pi_2 = \begin{cases} 
  2v^N - I & \text{if } 2(v^N - v^O) \geq I \\
  2v^O & \text{if } 2(v^N - v^O) < I \end{cases} \]

(12.12)

- 2nd period pricing, given that 1st period is durable

- Old consumer already possesses the \( v^0 \) tech. Firm 2 has two possibilities:
  - \( p_2^L = v^N - v^0 \) or \( p_2^H = v_N \)
  - \( \pi_2^L = 2(v^N - v^0) - I \) or \( \pi_2^H = v^N - I \)

- when will firm 2 sell its new-tech product to both consumer?
First Period Durability Choice

- In $t = 1$, firm 1 selects $p_1$ and whether to produce a durable or nondurable
- If firm 1 selects nondurable then $p_{1D}^N = v^0$, where
  $\pi_{1D}^N = v^0 - c_{1D}^N = v^0$
- If firm 1 selects durable then $p_{1D}^D = 2v^0$, where
  $\pi_{1D}^D = 2v^0 - c^D$
- When will firm 1 produce durable goods?
- Social welfare?
The market for lemons

- Consumers cannot determine the quality before the actual use (experience good)
- Can the market work when buyers cannot observe quality?
- Markets with Asymmetric information
- Reputation does not play a role (Market for used cars)
A model of used and new car markets

- Akerlof (1970), let us consider an economy with 4 types of cars

1. Brand-new good cars \((N^G)\)
2. Brand-new lemon cars (bad cars) \((N^L)\)
3. Used good cars \((U^G)\)
4. Used lemon cars \((U^L)\)

All individuals have the same preferences for all the 4 types of cars
A model of used and new car markets

Assumption:

- The value of a new and old lemon car is zero; $N^L = U^L = 0$
- Half of all cars (new and old) are lemons, and half are good cars
- New good cars are preferred over used good cars; $N^G > U^G > 0$

$$EN \equiv 0.5N^G + 0.5N^L = 0.5N^G$$
$$EU \equiv 0.5U^G + 0.5U^L = 0.5U^G$$

Clearly the expected value of a new car exceeds the expected value of a used car.
A model of used and new car markets

There are 4 types of agents in this economy:

1. New car dealers, who sell new cars for $p^N$
2. Buyers
3. Owners of good used cars (Seller), price $p^U$
4. Owners of lemon used cars (Seller), price $p^U$

The utility of a buyer is

$$V^b \equiv \begin{cases} 
EN - p^N & \text{if he buys a new car} \\
EU - p^U & \text{if he buys a used car}
\end{cases}$$
A model of used and new car markets

- The utility of a seller of a good used car who sells his used car and buys a new car is:

\[ V^{s,G} \equiv \begin{cases} \ EN - p^N + p^U & \text{if he buys a new car and sell his used car} \\ U^G & \text{if he maintains his (good) used car} \end{cases} \]

- The utility of a seller of a lemon car who sells his used lemon and buys a new car is:

\[ V^{s,L} \equiv \begin{cases} \ EN - p^N + p^U & \text{if he buys a new car and sell his used car} \\ U^L & \text{if he maintains his lemon used car} \end{cases} \]
A model of used and new car markets

- **The problem of the buyers:** she has the option of either buying a new car or an old car. Hence, she will buy a used car when

  \[ EU - p^U \geq EN - p^N \text{ or } p^U \leq \frac{U^G - N^G}{2} + p^N \]

- **The problem of the lemon used-car seller:** he has the option of keeping his car or selling it and buying a new car. He sells his car if

  \[ 0 \leq EN - p^N + p^U \text{ or } p^U \geq p^N - 0.5N^G \]
A model of used and new car markets

- **The problem of the good used-car seller:** he has the option of keeping his car or selling it and buying a new car. He sells his car if

  \[ U^G \leq EN - p^N + p^U \text{ or } p^U \geq p^N + U^G - 0.5N^G \]

- **Proposition.** Good used cars are never sold. That is, lemon used cars drive good used cars out of the market.
Quality-Signaling Games

- Problem of Asymmetric Information
- A monopolist knows the quality of the brand it sells, but consumers do not.

**Objective:** We want to show that a monopoly firm can signal the quality of its product by price and quantity restriction.

- Suppose there is a continuum of identical consumers
- Each consumer buys one unit and knows that the product can be $H$ or $L$, $H > L$
- Consumer’s utility function is

$$U = \begin{cases} 
H - p & \text{if the brands is } H \\
L - p & \text{if the brands is } L \\
0 & \text{if he does not buy}
\end{cases}$$

- Will consumers purchase the product if they find that $p = H$?
Cost is \( c_H \) if high quality and \( c_L \) if low, \( c_H > c_L \geq 0 \)

Assume

- The monopolist is a high-quality producer
- Production costs are sufficiently low relative to consumers’ valuation of the two quantities. \( L > c_H \)

This assumption ensures that a high-quality charges \( p = L \)

The firm chooses price \((p)\) and quantity \((q)\) [Signals]

How can a high-quality convince the consumers that he or she does not cheat by selling a low-quality brand for a high price?

**Proposition:** There exists a pair of a price and a quantity level that convinces consumers that the brand they buy is \( H \).

\[
p^m = H \text{ and } q^m = \frac{L - c_L}{H - c_L}
\]

Consumers infer that the brand is \( H \) and \( q^m \) consumers will buy the product and \((1 - q^m)\) will not (due to lack of supply).
Quality-Signaling Games

- In order to signal its type, the firm selects both a price and a quantity produced that a low quality firm would not find profitable to set!

- **Proof:**
  - **The monopolist has to show that a low-quality producer would not choose** \( p^m \) **and** \( q^m \)
  - **If the firm is low quality producer then** \( p = L \) **and** \( \pi^L(L, 1) = 1(L - c_L) \)
  - **The question is whether a low-quality monopoly could profitable choose** \( p^m \) **and** \( q^m \) **as the profit-maximizing price and quantity?**
    
    \[
    \pi^L(p^m, q^m) = (p^m - c_L) q^m = (H - c_L) \frac{L - c_L}{H - c_L} = (L - c_L)
    \]

- Hence the low quality producer will obtain the same profit by setting \( p = L \)
Quality-Signaling Games

1. What is the cost paid by the monopoly to resolve consumers’ uncertainty?

2. Would this monopolist find it profitable to signal its (high) quality to consumers?

First, the cost of revealing information is

\[ \pi^H(p^m, q^m) = (p^m - c_H) q^m = (H - c_H) \frac{L - c_L}{H - c_L} < (H - c_H) \]

Second, the monopolist finds it profitable if

\[ \pi^H(p^m, q^m) = (H - c_H) \frac{L - c_L}{H - c_L} > (L - c_H) \times 1 \]
Warranties

- Some warranties restrict the manufacturer’s liability only to parts, others to labor and parts.
- They are limited to a certain time period after the purchase.

*Moral Hazard* phenomenon

**Assumptions**

- *The product can be either fully operative or fully defective*
- *At the time of purchase neither sellers nor buyers know whether the product is defective*
- *The manufacturer has to options:*
  - *sell the product without a warranty*
  - *(2) sell the product with a full replacement warranty (no loss of value to the buyer)*
Warranties under symmetric information

- Consider a product whose value to the consumer is $V$ if the product is operative and 0 if it is defective, $V > 0$
- $\rho$ is the probability that this product is functional, $0 < \rho < 1$
- $(1 - \rho)$ is the probability that the product is defective
- The seller and buyer have symmetric information about the product’s reliability
- $p$ is the monopoly price and $c > 0$ the unit production cost
- The consumer’s utility function is

$$U \equiv \begin{cases} 
V - p & \text{if he buys with warranty} \\
\rho V - p & \text{if he buys without warranty} \\
0 & \text{if he does not buy}
\end{cases}$$

- Assume that $\rho V > c$
Warranties under symmetric information

- **NO WARRANTY**: then the maximum price the monopoly can charge is $p^{NW} = \rho V$ and $\pi^{NW} = \rho V - c$
- **WARRANTY**: The expected unit production cost for a firm providing a full replacement warranty is $\frac{c}{\rho}$. Hence, $p^{W} = V$ and $\pi^{W} = V - \frac{c}{\rho}$

$\frac{c}{\rho}$, assume $c = 10$
Warranties under symmetric information

- **Will the monopoly sell with a warranty?** \[ \pi^W > \pi^{NW} \]
- **Proposition:** *Under symmetric information where the reliability parameter \( \rho \) is common knowledge, a monopoly will always sell the product with a warranty.*
Warranties under asymmetric information

- Sellers are better informed about the product’s quality than the buyers
- **Duopoly**: one firm produces a reliable product and one firm produces an unreliable product
- Consumers cannot distinguish between the two products
- **Signaling principle**: if a high-quality firm wants to prove that it is High, it has to carry an act that is unprofitable for a Low-quality.
- \( \rho_H \) and \( \rho_L \) are the probabilities that the High- and Low-quality good are reliable, respectively, where \( 0 < \rho_L < \rho_H < 1 \)
- **No warranties**: \( p_{NW} = c \) and \( \pi_{iNW} = 0, \ i = H, L \)

- **Warranties**: If \( V > c \). The High-quality producer can push the low quality out of the market by setting \( p_{W} = \frac{c}{\rho_L} \) and providing warranty. The consumer will buy only the more reliable product and the high-quality firm will make positive profits.