

## Monopolist Strategies in a Durable Goods Market

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# Monopolist Strategies in a Durable Goods Market

Shikha Basnet, Simpson College

## Abstract:

In his classical model for a durable goods monopoly, Ronald Coase conjectured that a monopoly will never be able to charge a price above the equilibrium competitive price and the monopoly will end up forgoing dominant market power. Under certain circumstances, the ideas in the Coase conjecture break down, which we can see in the high-end fashion industry. In this paper, we will analyze some classical and modern contributions in the field of a durable goods monopolist. Based on the ideas of various contributors, we introduce a new model while less formidable vividly presents the complexity in the topic.

## 1. Introduction

The durable goods market poses numerous issues that contribute to the depth of microeconomic analysis involved in studying the subject. A monopoly firm faces the direct burden of determining optimal pricing and quantity decisions. Therefore, combining the durable goods market with a dominant monopoly power provides an arena of questions to be explored. In 1972 a classical economists, Ronald Coase sparked the study of the durable goods market. He concluded that the behavior of a durable goods monopolist is not optimal and suggested some mechanisms to prevent the adverse results.

Based on his assumptions, many theories evolved studying the durable goods market. As the study in the field advanced, the depth of the problem involved called for the authors to approach the issue from different angles. The model developed by Pessendorfer stands as an example of diversification in the topic, whereas, the model by Bagnoli et al provides further questions to be analyzed.

Combining the ideas of Coase, Pessendorfer, Bagnoli et al, and game theory ideas we present a new model that is much simpler to understand. The model provides insight into the problem and presents an additional strategy that has never been presented before. We also introduce a flexibility option for the monopolist. If the goal of the monopolist is to limit the number of rounds of price decline, we then have an optimal strategy the monopolist can utilize. Similarly, if the goal of the monopolist is to reduce the total decline in the price of the durable good, we then have another optimal strategy the monopolist can utilize.

## 2. Background

The 1970s saw the emergence of a great deal of literature concerning the durable goods monopolist. One of the earliest works was contributed by Peter Swan, who considered the question of optimal durability (Swan 1970, Sieper and Swan 1973). The other major contribution in the field was advanced by Ronald Coase in the year 1972. Due to the nature of the durability of the good, the value of the good that will be sold in the future is directly affected by the behavior of the monopolist in the present. Therefore, with all the

incentives and constraints the monopolist faces, Coase conjectured that the production behavior of the monopolist is not optimal and that the producer will earn zero monopolist power (Coase). Based on his assumptions and arguments, numerous theories emerged.

Most of the theories were focused on deriving a formal proof of the results conjectured by Coase or the theories were based on testing the robustness of Coase's result. Bulow, for example, showed that under similar assumptions as Coase, renting a durable good is always more profitable than selling it (Bulow). Similarly, Stokey showed that precommitting to a time path of prices increases the monopolist's profits (Stokey 1979). Furthermore, Stokey in a later paper formally derived results that confirm the Coase conjecture (Stokey 1981).

Since our model is based on the ideas of Coase, Pessendorfer, and Bagnoli et al, we will take a brief look at these models.

### 3. Coase Conjecture

To understand the conjecture, consider a hypothetical situation where one person owns all the land in the U.S. Assume that the land is of uniform quality, the ownership of the land yields no utility to the owner, and that the owner can not work the land himself. In addition, assume that the marginal cost is zero and that there is no cost involved in disposing of the land. Given this situation, the owner has every incentive to sell the land and derive as much revenue from it as possible (Coase).

Consider the following diagram. OB is the total land available. Assuming that the demand schedule is derived, the owner sells the portion of land where the marginal revenue is zero. This optimal level corresponds to point A in Figure 1. At point A, the seller sells OA portion of land and charges price P1, i.e. he sells a small portion of the land and charges a higher price.

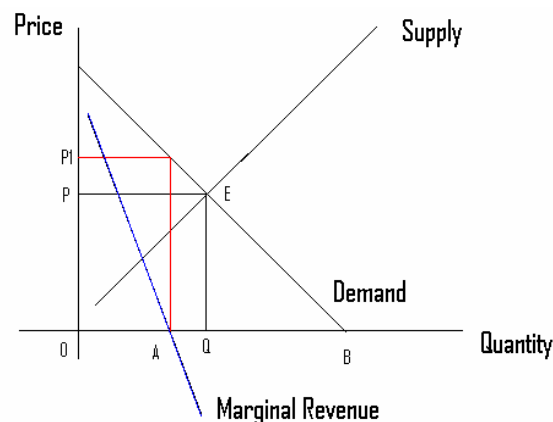


Figure 1

Note that the owner still has AB portion of land left that yields no utility and he can not use the land himself. In this case, he can sell more land and increase his revenue. Due to the downward sloping demand curve, to increase the supply the land owner has to charge a lower price. If he decreases the price of the additional land not sold, then the

value of the OA portion of land will also fall. The buyers who bought the land at price  $P_1$  will suffer from a loss of valuation of their land. At the same time, if the owner keeps increasing supply and reducing price, he builds the reputation of price decline. With this reputation built, no buyer will be willing to pay above the equilibrium price for the land as they will expect the price to fall in the future (Coase).

### **3a. Conclusion**

Based on this kind of situation Coase conjectured that if there is no cost involved in the disposing of the land, all the land will be sold and the entire process will take place very fast. No buyer will pay above the equilibrium price, the price becomes independent of the number of suppliers, and the price is equal to the equilibrium price (Coase). The model implies that the seller will eventually have no monopoly power and derive no monopoly profit. In many real life cases, it is in the interest of the producer to maintain or create significant market power. Therefore, the results conjectured by Coase are certainly undesired.

## **4. Pessendorfer's Model (P-Model)**

In the paper entitled "*Design Innovation and Fashion Cycles*", Pessendorfer explains the reasoning behind periodic design innovation introduced by a monopolist. Using a fashion good as a signaling device, he describes a dynamic game between the consumers. In explaining the dynamic game and the monopolist behavior, he considers the willingness of consumers to react with the "right" consumers. The consumers use the fashionable good as a signaling device and want to date consumers that are equal to or better off than themselves. Therefore, this willingness of consumers to pay certain prices to be able to meet other consumers determines the demand for the design (Pessendorfer).

Assume there is only one designer, who faces a fixed cost of innovation. Assume the buyers can be of two types, high-type or low-type. Buyers like the product not for their own sake, but because the product allows them to signal their quality. The buyers want to signal their quality because they are involved in a matching game in which each person desires to match up with a high-type person rather than a low-type person. The product sold is a durable good of which the consumer can use exactly one unit at a time (Pessendorfer).

### **4a. Conclusion**

For large fixed costs, fashion cycles are long because the designer has to sell at a higher price, which requires the design to stay fashionable longer. Similarly, short periods imply the designer's profit is close to zero as he is unable to commit to a fixed time interval between price changes. According to the model, it is this variation in demand that creates fashion cycles. After a certain portion of buyers have purchased the design, it is profitable to introduce a new design and make the old design obsolete. The producers invest in introducing periodic updates because consumers are willing to pay higher prices for the design and the producer can derive higher profits from periodic changes in the design. Furthermore, the model explains that the sale of a new design occurs because the design goes out of fashion, and buyers anticipate it (Pessendorfer).

In the paper titled “*Durable Goods Theory for Real World Markets*”, Waldman argued that style changes might be common not only because of the demand side effect, but because style changes make used units less suitable for new units and hence allow the producer to increase the price of new units (Waldman 2003).

## **5. The Discrete Demand Model (D-Model)**

As the title suggests, the model developed by Bagnoli et al, considers a finite collection of buyers rather than a continuum one. All the theories that we have analyzed so far and most of the other authors consider a continuum set of buyers and an infinite time horizon. By changing the distribution of buyers, which is considered an innocuous simplification, the authors negate most of the conclusions found in the durable goods monopoly theory.

The authors divide the model into two parts. The first part deals with the seller side of the market and the later part with the consumer side. The seller analyzes the maximum reservation price that a buyer is willing to pay and offers the product to the buyer with highest reservation price. This strategy is called a myopic strategy because the seller observes the highest reservation price and offers the good for that price. The second part deals with the consumer’s side. The only factor that the consumers consider while purchasing the product is whether the price falls within their reservation price. This type of strategy of consumers is called the “get-it-while-you-can” strategy (Bagnoli et al).

### **5a. Conclusion**

Analyzing a dynamic game between the buyers and the seller, the author concludes that “get-it-while-you-can” strategy is a sequential best reply for any buyer who can obtain zero utility in all future periods when the other players use their equilibrium strategies. Myopic monopoly strategy and the get-it-while-you-can strategy for each buyer form a subgame perfect equilibrium. The authors also conclude that for a sufficiently high discount factor, there is a subgame-perfect equilibrium in which the monopolist extracts the entire consumer surplus (Bagnoli et al).

The other conclusions are of utmost importance. The idea that renting or precommitting to price path is profitable does not hold true. That is, Bulow’s proposition that asserts renting a durable good is always more profitable than selling it is false. Similarly, Stokey’s theory that precommitting to a time path of prices is always optimal is also false under the assumption of a discrete distribution of buyers. Moreover, Coase’s proposition that in the continuous time limit of the infinite-horizon game, the price would quickly drop to the competitive level still holds true but, his conjecture that avers that no sales would take place before the competitive level was reached is delusive (Bagnoli et al).

## **6. The New Model**

Assume a high-end fashion industry with a sole designer, who faces a constant marginal cost of innovation. There are a finite set of buyers having different elite status based on their disposable income. The buyers are involved in a dating game in which each buyer would like to be matched with another buyer of elite status equal to or higher than themselves. Each buyer has a certain tolerance level that indicates how tolerant the

person is. Based on the tolerance level and elite status, a range of reservation price for each buyer is calculated. The range of reservation price can be interpreted as the maximum and minimum price each buyer is willing to pay for a single unit of the design. If the price exceeds the maximum reservation price, then the buyers do not prefer the design. Similarly, if the price falls beyond the minimum price limit, then the buyers perceive the product as being of inferior quality. The maximum and minimum reservation price form an upper and lower bound on the possible reservation price of a buyer.

It is assumed that the producer is able to observe the range of reservation prices, gather information about the total number of buyer, and different tolerance levels of each buyer. On the demand side, once elite status buyers purchase the design, all buyers have incentive to buy the design. The buyers are willing to cooperate with other buyers whose elite status falls within their tolerance level. Based on this information, the designer offers different prices and decides the optimal point of new innovation. It is important for the designer to maintain his/her reputation among the upper-elite consumers. Therefore, it is not in his best interest to lower the price just to have additional consumers purchase the good or to have extremely frequent price declines.

## 7. Definition of Variables

“In-Group”: It refers to the group of buyers who have purchased a current design and are involved in the dating game.

Tag Value ( $t$ ): The tag value is a number assigned to each buyer based on their elite status. It is a number from 0 to 1. A tag value closer to 0 implies higher elite status.

Tolerance level ( $l$ ): The tolerance level is defined as the willingness of each buyer with a certain tag value to cooperate with buyers with a lower tag value. In other words, it measures the willingness of a buyer to date other consumers with lower elite status.

Maximum Reservation Price ( $P_{max}$ ): It denotes the maximum price a buyer is willing to pay to acquire a single unit of the design. It is an upper bound on the price a buyer is willing to pay

Minimum Reservation Price ( $P_i$ ): It is the minimum price a buyer is willing to pay to acquire a single unit of the design. If the price is below the minimum reservation price, then the buyer perceives the design as being inferior in quality. It can also be interpreted as the lowest price the buyer is willing to pay such that other buyers with lower elite status will be tolerated when joining the “in-group”. The minimum reservation price serves as a lower bound on the price a buyer is willing to pay.

Total Number of Buyers ( $N$ ): It represents the total number of buyers in the market and  $B = \{b_1, b_2, \dots, b_N\}$  is the finite set of buyers.

## 8. Calculation of Variables

### Tag Value ( $t$ )

As mentioned earlier, the tag value is a number between 0-1 assigned to each buyer based on their elite status. The interval, 0-1 will be divided into any number of equal parts. Assume that we divide the interval into  $n+1$  equal parts, i.e.  $0, 1/n, 2/n, \dots, n-1/n, n/n = 1$ . In this model, after determining the number of equal parts, the denominator remains fixed. Ignoring the denominator, we are now concerned with assigning a numerator value to each buyer that will ultimately determine their tag value. This numerator value will be assigned to buyers according to a binomial distribution.

There are several reasons why a binomial distribution works very well in the model. First of all, we are concerned with a discrete distribution of buyers. Secondly, the distribution of buyers needs to be realistic. In the real world, there are relatively few people in the high-elite side with many buyers in the mid-elite status. With this in mind, the shape of an approximate binomial distribution simulates the distribution of buyers in the real world. The third reason is that we can easily extend the binomial distribution to approximate a continuum distribution of buyers. If we have  $n$  sufficiently large, then a normal distribution will approximate a binomial distribution very well.

Let,  $p$  denote the probability of success,  $0 < p < 1$ , where the distribution of buyers is  $b(n+1, p)$ . We can use the probability mass function of a binomial distribution to calculate the probability that a buyer will be assigned certain numerator value of a tag number.  $T = \left\{0, \frac{1}{n}, \frac{2}{n}, \dots, \frac{n-1}{n}, \frac{n}{n} = 1\right\}$  is the range of tag values with the possibility that more than one buyer can be assigned the same tag value.

### Minimum Reservation Price ( $P_i$ )

$P_i$  corresponds to the minimum reservation price of buyer  $i$ .

$$P_i = P_{i-\max} * (1 - t_i). \quad (i)$$

Where,  $P_{i-\max}$  is the maximum reservation price and  $t_i$  is the tag value of buyer  $i$ . Note that, the more elite the buyer is the lower is his/her tag value. The lower the tag value, the higher is the minimum reservation price. This means that the consumers at the upper-elite status are willing to pay a higher price for the design than those at a lower-elite status.

### Tolerance Level ( $l$ )

$L = \{l_1, l_2, \dots, l_\alpha\}$  is the set of tolerance levels corresponding to each buyer.

Note that,  $\alpha \leq N$ , allowing for more than one buyer to have the same tolerance level.

$$l_i = \frac{P_E}{P_i}. \quad (ii)$$

Where,  $P_E$  is the equilibrium price of the design if the design was sold in a competitive market and  $P_i$  is the minimum reservation price as calculated in Equation (i). The more elite the consumers are the higher is their minimum reservation price which will yield a corresponding lower tolerance level. Therefore, the more elite the consumers are the more intolerant they are towards other consumers.

## 9. Part I

Part I deals with the supply side of the model. Assuming that the producer has access to calculate the given variables, there are two possible strategies. One strategy is the myopic strategy similar to the one in Bagnoli et al's model and the other is to consider tolerance level when offering the product at a certain price. We will analyze each strategy in detail.

### 9a. Myopic Strategy

The producer observes the maximum reservation price of the buyer and offers the product to those buyers at the maximum reservation price. This strategy is called the myopic strategy.

Let,  $\gamma$  be the price of the good at the time of innovation,  $(r_1, r_2)$  be the range of reservation price of buyer  $r$ , and  $(s_1, s_2)$  be the range of reservation price of buyer  $s$  where  $r_1 > r_2 > s_1 > s_2$ . Assume that  $r_1$  is the highest reservation price among all the buyers. The producer observes the maximum reservation price of all the buyers and offers the good at price,  $\gamma = r_1$ . In the second period, if  $s_1$  is greater than any other reservation prices, then the producer offers the good at price,  $\gamma = s_1$ .

### 9b. Strategy Using Tolerance Level

In this case, the producer first observes the range of reservation prices of each buyer. If the ranges of reservation prices of buyers with different tag values overlap, the producer checks to see if the buyers are tolerant of one another. When both these conditions are satisfied, the producer will offer the design to the buyers at different tag values that are tolerant of one another and whose range of reservation prices overlap.

Assume there are only two buyers in the market, buyer  $r$  and buyer  $s$ . Let,  $\gamma$  be the price of the good at the time of innovation,  $(r_1, r_2)$  be the range of reservation price of buyer  $r$ , and  $(s_1, s_2)$  be the range of reservation price of buyer  $s$ , where  $r_1 > s_1 > r_2 > s_2$ , i.e. the range  $(r_1, r_2)$  and  $(s_1, s_2)$  overlap. Let,  $t_r$  be the tag value of buyer  $r$  and  $t_s$  be the tag value of buyer  $s$  with  $t_r < t_s$ . Let,  $l_r$  and  $l_s$  be the tolerance level of buyer  $r$  and  $s$ , respectively, with  $t_s + l_s < t_r + l_r$ . Given this situation, we know that buyer  $r$  is higher in elite status than buyer  $s$ , and is willing to tolerate buyer  $s$ . The producer observes this and offers the product at price,  $\gamma$  such that  $r_2 \leq \gamma \leq s_1$ . The price will not be below  $r_2$ , because the price will be below the minimum reservation price of buyer  $r$ . Note that it is possible for  $r_1 = r_2$  and/or  $s_1 = s_2$ .

## 10. Part II

When the producer offers the design at a certain price, the buyers purchase the design as long as the price is within the range of their reservation price. For example, if  $(r_1, r_2)$  is the range of reservation price for buyer  $r$  and  $\gamma$  is the price of the design such that  $r_2 \leq \gamma \leq r_1$ , then buyer  $r$  will purchase the design.

### Time of Innovation

Innovation of a new design occurs when the producer has derived profits and the maximum potential additional revenue is less than the current profit. Assume  $R$  is the profit from selling the design to  $x$  number of buyers, so there will be  $N-x$  buyers left to



purchase the good. Let,  $\lambda$  be maximum possible revenue from  $N-x$  buyers. If  $R > F$ , then it is more profitable to innovate than to continue decreasing the price. The following example will make this idea apparent.

**Example 1**

Total number of buyers,  $N = 10,000$

Cost of Innovation,  $C = 1,000,000$

Probability of success,  $p = 0.3$

Equilibrium Price,  $P_E = 200$

$$\text{Tag value, } T = \left\{ \frac{0}{19}, \frac{1}{19}, \dots, \frac{18}{19}, \frac{19}{19} = 1 \right\}.$$

i.e.  $n = 19$  and  $n+1 = 20$

The Maximum Reservation Price of each buyer =  $P_{\max}$

The Minimum Reservation Price of each buyer =  $P_i$

$$\text{Probability of assigning a tag value } \frac{j}{19}, P(X = j) = {}_{n+1}C_j * p^j * (1-p)^{n+1-j}.$$

The Expected number of buyers with a particular tag value, say  $\frac{j}{19} =$

$$N * {}_{n+1}C_j * p^j * (1-p)^{n+1-j}.$$

The model results yields the following information to the producer.

tag value	Max. reservation price	1-t	Min. reservation price	probability of a tag value	Tolerance level	Expected number of buyers	Rounded expected no. of buyers
0	1700	1	1700	0.0008	0.118	8	8
1	1600	0.947	1515.789	0.0068	0.132	68	68
2	1550	0.894	1386.842	0.0279	0.144	279	279
3	1300	0.842	1094.737	0.0716	0.183	716	716
4	1200	0.789	947.3684	0.22679	0.211	2267.9	2267
5	1100	0.736	810.5263	0.1789	0.247	1789	1789
6	900	0.684	615.7895	0.1916	0.325	1916	1916
7	800	0.631	505.2632	0.1643	0.396	1643	1643
8	700	0.578	405.2632	0.11443	0.494	1144.3	1144
9	600	0.526	315.7895	0.0653	0.633	653	653
10	550	0.473	260.5263	0.0309	0.768	309	309
11	500	0.421	210.5263	0.012	0.95	120	120
12	450	0.368	165.7895	0.0038	1.208	38	38
13	400	0.315	126.3158	0.001	1.583	10	10
14	350	0.263	92.10526	0	2.171	0	
15	300	0.210	63.15789	0	3.167	0	
16	290	0.157	45.78947	0	4.368	0	
17	280	0.105	29.47368	0	6.786	0	
18	250	0.052	13.15789	0	15.2	0	
19	200	0.05	10	0	20	0	

Table 1

(Note: we assume that the producer has mechanism to calculate  $P_{\max}$  ).

The value of "probability of  $i$ " in the fifth column is calculated using the binomial distribution or  $b(20,0.3)$ . The values are an excerpt from the book "*Probability and Statistical Inference*" by Hogg and Tannis (Hogg and Tanis).

In Table 1, the first column represents the numerator of different tag values. The values in the second column are assumed to be derived using some marketing tool or other study, the tolerance level is calculated using the formula in Equation (ii). The expected number of buyers gives us the expected number of buyers with a certain tag value. This value will have great importance to the seller because he can calculate how many buyers he expects with a certain tag value. Since the number of buyers can not be a decimal number, we estimate by rounding the value to the lowest number.

## 11. Myopic Strategy

It is assumed that the buyers will use the "get-it-while-you-can-strategy". Following the myopic strategy, the producer will offer the product to the buyer with maximum reservation price. In Table 1, there are 8 consumers with tag value 0 who are willing to pay \$1,700.00 for the design. Since this is the highest price any consumer is willing to pay, the producer will offer the design at a price of \$1,700.00. Therefore, at time period  $T_1$  the price of the design is \$1,700.00 and the revenue is \$13,600.00 ( $8 * \$1,700.00$ ). This revenue is not enough to offset the cost of \$1,000,000.00.

This insufficient revenue induces the producer to reduce the price so that more consumers buy the design. In time period  $T_2$ , the good will be offered at a price of \$1,600.00 and 68 additional buyers will purchase the good. This process will continue until the producer is able to obtain a positive profit. At this point, the designer will consider the potential revenue generated by the consumers who have not purchased the design.

In the above example, at time period  $T_4$  the producer has positive profit equal to \$485,650.00. Since the producer has positive profit now, he will consider his potential revenue from the buyers who have not yet purchased the design. The procedure for calculating maximum possible revenue is the same as the one that we have considered for calculating profit till  $T_4$ . In other words, the producer will follow myopic strategy and calculate revenue from consumers with tag value 4 till 19, i.e. if he were to continue until all the remaining consumers have purchased the design. Hence we calculate the maximum potential revenue from the consumers who have not yet purchased the design to be \$9,170,750.00. The maximum potential revenue is greater than his current profit. Therefore, the producer will further decline the price and increase his profit. At time period  $T_6$  the producer will stop dropping the price further, sell the good at zero price, and at the same time introduce a new design because it is more profitable to innovate at this point than to continue dropping the price. Hence, we have 6 rounds of price decline, the total decline in price is \$600.00, and the total profit is \$517,3950.00.

When he introduces a new design, the identical sequence of events takes place and the producer's profit and number of price declines will be the same in each

innovation unless the producer charges different prices. The following figure explains Example 1.

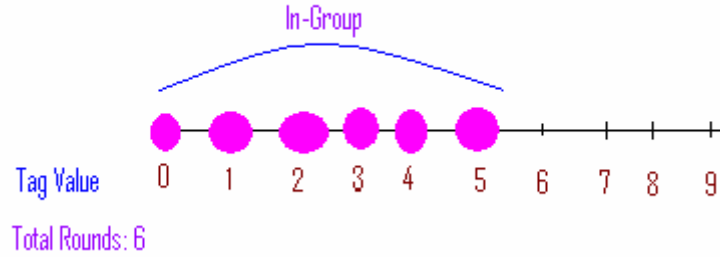


Figure 2

## 12. Strategy Using Tolerance Level

Recall that under this strategy two conditions need to be satisfied. First of all, the buyers must be willing to cooperate with each other and secondly, their range of reservation prices must overlap. In Table 1, the buyers at tag value 0 have a tolerance level of 0.1. This means that those buyers are willing to cooperate with other buyers with tag value less than or equal to 0.1 ( $0+0.1$ , i.e. their tag value+ tolerance level). However, the buyers at tag value 0 are willing to pay only \$1700 for the product and nothing less. Therefore, the range of reservation price of buyers with tag value 0 and with tag value  $\frac{1}{19}$  does not overlap. In this case, in time period  $T_1$ , the producer offers the product at price of \$1700 to the buyers with tag value 0.

In the time period  $T_2$ , the producer again considers whether the two conditions for applying the strategy is met. Buyers with tag value  $\frac{1}{19}$  are willing to cooperate with buyers with tag value  $\frac{3}{19}$  and their range of reservation prices do not overlap, but buyers with tag value  $\frac{1}{19}$  are willing to cooperate with buyers with tag value  $\frac{2}{19}$  and their range of reservation prices also overlap. Hence, the producer will offer the design at price \$1550 so that the buyers with tag value  $\frac{1}{19}$  and  $\frac{2}{19}$  will purchase the design at the same time. The process continues until the seller is able to obtain positive profit. He analyses maximum potential revenue as in the case of the myopic strategy. The decision of optimal time for innovation is the same for both strategies. Following the same sequence of events, the series of price decline ceases at time period  $T_3$  with 3 rounds of price decline, a total decline in price of \$600, and a total profit of \$4800650. The following diagram gives a pictorial view of the two strategies and the results.

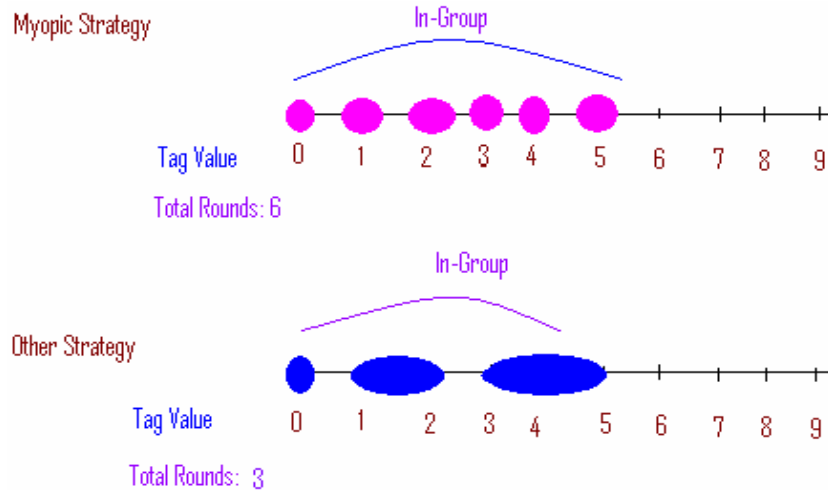


Figure 3

### 13. Conclusion

A simulation with different number of buyers, different probabilities, and different reservation prices was conducted. The range of variation in the number of buyers was from 10,000, 30,000, and 50,000. The probability was tested for  $p = 0.25$  to  $p = 0.5$ . Different probability values alter the tag value distribution of the buyers. If the probability of success is higher then there are few buyers with upper-elite status.

#### 13a. Myopic Strategy

For a fixed probability, as the total number of buyers increases the total profit increases, the total rounds of price decline is likely to increase, and the total decline in price is either the same or decreases. If the probability  $p$  of success is low, the myopic strategy and the strategy using tolerance levels yield equal reductions in price. However, the total rounds of price decline and the total profit is greater using the myopic strategy. If the goal is sole profit maximization without consideration towards reducing the total rounds of price decline, the myopic strategy is the optimal strategy.

#### 13b. Strategy using Tolerance level

Under the condition of low probability of success, if the goal of the monopolist is to reduce the total rounds of price decline, the tolerance level strategy is optimal. In simulations where the total number of buyers remains fixed, as probability of success increases, the total rounds of price decline increases. With increasing probability of success, the total decline in price also increases and the total profit decreases. We can not compare the total profit using the myopic strategy and the tolerance level strategy, because it does not follow a recognizable pattern. The strategy using tolerance levels almost always out-performs the myopic strategy in terms of reducing the total rounds of price decline. The total decline in price is also generally higher when using the tolerance level strategy. The following tables give a synopsis of the result.

$p = 0.25$

**Myopic Strategy**

Total number of buyers, N	Total Rounds of Price Decline	Total Decline in Price	Total Profit
10000	6	600	6672800
30000	6	600	22018400
50000	6	600	37364000

**Tolerance Level Strategy**

Total number of buyers, N	Total Rounds of Price Decline	Total Decline in Price	Total Profit
10000	3	600	6151378
30000	3	600	20746700
50000	3	600	35024250

Table 2

**N = 10000**

**Myopic Strategy**

$p$	Total Rounds of Price Decline	Total Decline in Price	Total Profit
0.25	6	600	6672800
0.3	6	600	5173950
0.35	8	900	4909500
0.4	8	900	4162550
0.45	9	1000	3481300
0.5	9	1000	2930600

**Tolerance Level Strategy**

$p$	Total Rounds of Price Decline	Total Decline in Price	Total Profit
0.25	3	600	6151378
0.3	3	600	4800650
0.35	4	1000	5218150
0.4	3	900	3687800
0.45	4	1250	4152900
0.5	4	1250	3392200

Table 3

If the monopolist wants to always reduce the total rounds of price decline and is not concerned about the total decline in price, then strategy using the tolerance levels is optimal. In an extreme case where the two conditions for using the strategy with tolerance can not be met, the myopic strategy is the only possible strategy. From simulations, it is also clear that the higher the cost of innovation, the longer is the period for which the good remains fashionable. At the same time, having fewer buyers with high elite status produces the same result as having a high cost of innovation. In both cases, the rounds of price decline are greater.

These results are obtained from numerous simulations and lack a theoretical proof. Given the model and the strategies, a theoretical proof of the conclusions remains a less daunting task. It is also to be noted that the efficiency of the strategies need to be tested. We have conclusions from the strategies but not enough tools to determine the best strategy.

## 14. Strengths and Weaknesses

The simplicity is one of the biggest advantages of the model. The model is a rich combination of ideas from several theories and the functioning of the model is most apparent with the examples. Introduction of ideas like tolerance level and the binomial distribution makes the model interesting and flexible. Unlike Bagnoli et al's model, the new model presents two possible strategies and we obtain different results from each strategy.

We still need to develop theoretical proofs of the conclusions. Though we have many simulations, we have yet to determine patterns that can predict certain behavior of the monopoly. Furthermore, the efficiency of the strategies needs to be theoretically tested. One other aspect of the model that can be a potential drawback is the lack of incorporating a discount factor into the model.

The model can be easily extended to a continuum case and then the difference between the discrete and continuum case can be analyzed. So far, all theories in the durable goods market consider constant cost of innovation. Having an increasing cost of innovation can significantly increase the complexity involved in analyzing the model. This is one more area that needs to be explored. Also, we can use some real life data to determine the parameters so that the model becomes representative of the real world.

## Work Cited

- Akerlof, George. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." Quarterly Journal of Economics. 84:3 (August 1970): pp 488-500.
- Axelrod, Robert, Michael Cohen, and Rick Riolo. "Evolution of Cooperation without Reciprocity." Nature. 414 (22 November 2001).
- Bagnoli, Mark, Stephen Salant and Joseph Swierzbinski. "Durable-Goods Monopoly with Discrete Demand." Journal of Political Economy. 97:6 (December 1989): pp 1459-478.
- Bulow, Jeremy. "Durable Goods Monopolist." Journal of Political Economy. 90:2 (April 1982): pp 314-32.
- Coase, Ronald. "Durability and Monopoly." Journal of Law and Economics. 15:1 (April 1972): pp 143-49.
- Hendel, Igal and Alessandro Lizzeri. "Interfering with Secondary Markets." Rand Journal of Economics. 30:1 (Spring 1996): pp 1-21.
- Hendel, Igal and Alessandro Lizzeri. "Adverse Selection in Durable Goods Markets." American Economic Review. 89:5 (December 1999): pp 1097-1115.
- Hogg, Robert and Elliot Tanis. Probability and Statistical Inference. New Jersey: 2006.
- Kleiman, Ephraim and T. Ophir. "The Durability of Durable Goods." Review of Economic Studies. 33:2 (August, 1966): pp 165-78.
- Levhari, David and T. Srinivasan. "Durability of Consumption Goods: Competition versus Monopoly." American Economic Review. 59:1 (March 1969): pp 102-07.
- Pessendorfer, Wolfgang. "Design Innovation and Fashion Cycles." American Economic Review. 85:4 (September 1995): pp 771-92.
- Schmalensee, Richard. "Regulation and the Durability of Goods." Bell Journal of Economics. 1:1 (Spring 1970): pp 54-64.
- Sieper, E. and Peter Swan. "Monopoly and Competition in the Market for Durable Goods." Review of Economic Studies. 40:3 (July, 1973): pp 333-51.
- Stokey, Nancy. "Intertemporal Price Discrimination." Quarterly Journal of Economics. 93 (August 1979): pp 355-71.
- Stokey, Nancy. "Rational Expectations and Durable Goods Pricing." Bell Journal of Economics. 12:1 (Spring 1981): pp 112-28.

Swan, Peter. "Durability of Consumption Goods." American Economic Review. 60:5 (December, 1970): pp 884-94.

Waldman, Michael. "Durable Goods Pricing When Quality Matters." Journal of Business. 69:4 (October 1996): pp 489-510.

Waldman, Michael. "Durable Goods Theory for Real World Markets." Journal of Economic Perspectives. 17:1 (2003): pp 131-154.