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Defects in Disneyland: Quality Control as a Two-Part Tariff

by

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1. Introduction

A guarantee is a risk-sharing insurance contract tailored to the risky of uncertain flow of consumption services from a commodity (see Heal (1976)). Guarantees provide for full or partial replacement, repair or refund for expected and unexpected short-falls in service. Indeed, Appelbaum and Scheffman (1978) have provided an example in which the refund exceeds the purchase price.[1] The guarantee may come into force in a variety of circumstances ranging from specifically named contingencies to general promises of "satisfaction guaranteed or your money back." Guarantees may be offered as a mandatory tie-in with purchase or may be optional; we refer to the latter as <u>service contracts</u>. They may be priced on a per unit basis or offered at a fixed fee invariant of number of units purchased.

Guarantees can also be used as an information-generating, self-selection device. Consumers may utilize the existence of a guarantee as a signal of

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reliability - no seller would warrant junk. In addition, a consumer's selection of an optional service contract may reveal information about that buyer. For example, if product breakdown is caused by misuse or heavy use, competitive firms will price different guarantees accordingly, either explicitly or implicitly, as explored by Rothschild and Stiglitz (1977) in a conventional insurance context.

Since guarantees reveal material information about buyers to firms, they may be utilized by firms with monopoly power as an instrument for price discriminating against less elastic submarkets. For example, risk aversion held constant, if the heavy user submarket has a more elastic demand than the light user submarket, a monopolist can discriminate against the light users as follows: he offers an optional service contract at a discount below the actuarial cost of the heavy users but above the actuarial cost of the light users. Indeed, if breakdown is correlated with use, any optional guarantee is more highly valued by heavy users than light users. Then an optional guarantee is an instrument that simultaneously separates the market and charges a lower price to the more elastic submarket. Such "noisy monopolists" have been explored by Salop (1977) and Stiglitz (1977).

These models have the property that the monopolist finds it profitable to create a deadweight loss in order to reap the additional profit possible from price discrimination. Extending that reasoning to the context of guarantees, it suggests that the monopolist might be willing to produce a product less reliable than dictated by cost minimization, in order to better discriminate. This, of course, is yet another wrinkle in the longstanding controversy surrounding the monopolistic provision of durability. In a similar vein, Heal (1977) has shown that under certain circumstances, even in the absence of guarantees, a monopolist will produce a more defective product than warranted by cost minimization. Such a policy may exploit risk-averse consumers by effectively forcing them to self-insure by purchasing a larger quantity. For example, the consumer purchases extra light bulbs to avoid running out.

This paper analyzes a related price discrimination issue. We show that under very weak conditions a monopolist finds it profitable to offer an optional fixed fee service contract as a surplus-extracting two-part tariff. This result follows Oi (1971) and holds even if all consumers have identical preferences.[2] It suffices for the consumers to have a zero income elasticity. Risk aversion will only make that strategy even more profitable.

In the spirit of the Heal, Salop and Stiglitz papers, this "noisy monopolist" finds it profitable to produce, guarantee, and replace defective units, even if a zero defect rate could be achieved at no additional production cost. The gains from extracting additional consumer surplus outweigh the deadweight cost absorbed. A positive defect rate serves the following role: if a zero defect rate were selected, consumers would be untilling to purchase such an optional service contract, and thus the two-part tariff could not be effected. In addition, with risk averse consumers, the production of defects serves to create risk, so the monopolist can additionally gain by selling insurance against that risk.

Of course, if conventional two-part tariffs were available to the monopolist, this indirect (and costly) defect and service contract strategy would be unnecessary and less profitable. However, antitrust laws and other government regulations often prohibit direct two-part tariffs. For example, tied sales are generally prohibited under the US antitrust statutes. Some other forms of price discrimination are banned under the Robinson-Patman Act. Given these prohibitions, firms have an incentive to discover effective yet defensible forms of price discrimination as an alternative to possibly illegal tie-ins, quantity discounts, and simple two-part tariffs. The defective product-service contract scheme presents one alternative. By providing a commodity valued by the purchaser (the service contract), allegations of price discrimination may be better defended under a cost-justification defense, if not avoided altogether. By making the service contract optional, the prohibition against tied sales can also be evaded.

Finally, a number of other properties of the fixed fee service contract strategy are interesting, and contrast to Oi's (1971) results. In that paper Oi developed the analysis of two part tariffs. He showed that the optimal policy for a monopolist, when feasible, is to charge an entrance fee into the market and then impose a price per unit equal to the marginal cost. This policy extracts all consumer surplus, since the entrance fee is set to equal the consumer surplus obtained when price equals marginal cost. In contrast to those results, the monopolist here sets the price per unit above the "effective" marginal cost (taking the expected cost of replacement into account). Indeed, he may charge a unit price in excess of even the <u>zero-defect</u> pure monopoly price. Thus, consumers may bear two losses relative to a conventional zero defect monopolist: higher prices plus the cost of the service contract. However, unlike the Oi "Disneyland Dilemma" result, the monopolist here is unable to capture the entire consumer surplus; some surplus does accrue to the otherwise hapless consumer.

The analysis is organized as follows. Section 2 sets out the assumptions and the structure of the model, and describes the monopolist's profit-maximizing strategy. Section 3 discusses the properties of this optimal strategy. Section 4 analyzes the robustness of the model with respect to the main assumptions made. Concluding remarks are presented in Section 5. Finally, the Appendix exhibits some examples of the relationship between the monopoly price and the price per unit charged under the service contract option strategy.

2. The Model

Consider a partial equilibrium model of one market served by a monopolist, taking the prices of all other commodities as given. Assume the monopolist faces a set of consumers with identical incomes and preferences; hence, we carry out th analysis in terms of a representative consumer.

Denote by $U(x, y)$ the representative consumer's direct utility function, where x is the quantity of the commodity consumed by the individual in the monopolistic market under study, and y is the quantity consumed of a composite aggregate of all the other commodities. We assume a zero income elasticity of demand (no income effects). Denote by p the unit price of the commodity supplied by the monopolist. We assume the prices of all other commodities to be fixed; thus, we normalize the price of y as 1. Letting

I denote the consumer's income, then $V(p, 1, I) \equiv V(p, I)$ denotes the indirect utility function.

A technology characterized by a constant proportion $\alpha \in [0, 1]$ of nondefective units generates a distribution function $F(z, x; \alpha)$ that gives the probability that the number of non-defective units is less or equal to z, given that x units have been produced (or purchased by the consumer). Without loss of generality, we will assume that F follows a binomial distribution, with parameter α. For the defect-free technology, $\alpha = 1$, $F(z, x; 1) = 0$ for $z < x$ and $F(x, x; 1) = 1$. We assume that $F(\cdot, \cdot; \alpha)$ is known to consumers. For simplicity, we assumed consumers do not obtain any utility from defective units. Therefore if the consumer purchases x units, of which exactly z are good, his total utility equals $U(z, y)$.

A. Consumers' Options

Given a technology that generates a proportion $(1 - \alpha)$ of defects, suppose the monopolist charges a price p per unit and also offers consumers the option of purchasing a fixed fee service contract at a cost G. This service contract entitles consumers to free replacement of any defective units received. Hence the representative consumer faces the following three options:

Option I. Purchase the product but forego the optional service contract

Let us denote by $V(p, I; \alpha)$ the utility the consumer obtains if this option is exercised. The utility for this option is computed below.

Option II. Purchase the optional service contract

This alternative enables the consumer to replace any defective units with good ones at no additional cost. Under this option, the consumer chooses the quantities that maximize,

$$\text{(1)} \qquad \max \ U(x, y) \quad \text{s.t.} \ px + y = I - G .$$

The solution to this problem, in turn, generates the indirect utility $V(p, I - G)$.

Option III. Stay out of the market

Under this option, the consumer chooses $x = 0$, $y = I$, an action which yields a utility level $U(0, I) \equiv V_o$.

The consumer chooses the alternative yielding the largest expected utility, given (p, α, G). As a convention we assume that if the consumer is indifferent between buying the service contract and not, he will purchase it.[3] If the consumer is risk neutral in income, i.e. if $V(p, I) = \phi(p) + I$, and transactions are costless, then it is optimal for consumers who do not buy the service contract to behave in the following way: choose the number of good units x to ultimately consume, then buy x units the first time. If $(x-z)$ are defectives, the consumer buys $(x-z)$ more units, and so on until he has purchased x non-defective units. Assuming the units are perfectly divisible, all ex post risk is ignored. Instead, the consumer acts as if he faces an effective price βp, where $\beta = 1/\alpha$. His expenditures on other goods are thus random, but his consumption of the goods in our market is not. In this case his utility from option I (foregoing the service contract option) is $V(\beta p, I) = \phi(\beta p) + I$. If the consumer is not risk neutral in income, this strategy does not produce the same result as facing a price βp and the consumer is worse off.

We will establish our results for the risk neutrality in income case, i.e. $V(p, I) = \phi(p) + I$. We are choosing this case for expositional simplicity and to illustrate that the results do not depend on risk aversion. Finally, this is the weakest case for our theory. For this case the consumer obtains the highest relative utility from foregoing the service contract. Therefore if it is optimal in this case for the monopolist to produce defectives and offer a service contract-option, it also will be optimal in the other cases (risk aversion), because there the service contract fee will also include a risk premium. In Section 4 we show how our results easily extend to the case of risk aversion and/or costly transactions. Until the, we assume that $V(p, I) = \phi(p) + I$, with $\phi' < 0$, $\phi'' > 0$. Then the utility of option I, or purchasing but foregoing the optional service contract, is $\phi(\beta p) + I$. Also by Roy's Identity, then, the demand function for the product can be expressed as $x(p) = -\phi'(p)$; thus x is a normal good with a downward sloping demand function.

B. <u>The Monopolist's Problem</u>

The monopolist's strategy space is $A = \{\alpha, p, G\}$, $0 \leq \alpha \leq 1$; namely an action in A describes a technology characterized by a proportion α of non-defective units produced, a price p per unit purchased, and a price G

for the optional fixed fee service contract. As mentioned above we assume that the distribution $F(z, x; \alpha)$ of defective units is binomial with parameter α.

We assume a constant marginal production cost c that is independent of the defect rate. We will relax this assumption in Section 4.

Our aim is to show that the monopolist's profits are maximized by selecting a positive defect technology, $\alpha < 1$ and offering consumers an optional service contract, $0 < G < \infty$, as opposed to a defect-free technology, $\alpha = 1$.

We first obtain an expression for the optimal price G of the optional service contract. Since we are undertaking our analysis in terms of the representative consumer, the optional contract is necessarily purchased at the profit-maximizing price G. Therefore if $V(p, I-G)$ is the consumer's utility of purchasing the service contract and $V(\beta p, I)$ is the utility of entering the market but not purchasing the service contract, then $V(p, I-G) \geq V(\beta p, I)$. Moreover, in the absence of income effects at the optimum, the service contract constraint must be binding. Otherwise, if the monopolist were to slightly increase the service contract fee G, no consumers would leave the market and the monopolist would make higher profits. Note that G does not affect the demand of the product or $V(\beta p, I)$. Thus we can rewrite that constraint as follows.

$$V(p, I-G) = \phi(p) + I - G = \phi(\beta p) + I = V(\beta p, I)$$

Rewriting, we have the following expression for G,

$$G = \phi(p) - \phi(\beta p) \; .$$

Next, we show that given that the monopolist produces a certain percentage of defectives, he is better off offering a service contract option than not. To see this, note that if the consumer buys the service contract at price G and purchases x(p) units, the monopolist needs to manufacture $\frac{1}{\alpha}x(p)$ units, on average, to replace defectives. Recalling that $\beta = \frac{1}{\alpha} \geq 1$, then the monopolist's profit from offering the service contract option is $(p - \beta c)x(p) + G$. On the other hand, if he does not offer the service contract option, the monopolist's profits are given by $x(\beta p)\beta(p - c)$. It is easy to show that

(2) $$x(\beta p)\beta(p - c) < x(p)(p - \beta c) + G .$$

Since $x(\beta p) < x(p)$, it suffices to show that

(3) $$x(\beta p)\beta(p - c) \leq x(\beta p)(p - \beta c) + G .$$

Since $G = \phi(p) - \phi(\beta p)$ and $x(p) = -\phi'(p)$, equation (3) can be rewritten as

(4) $$-\phi'(\beta p)\, p(\beta - 1) \leq \phi(p) - \phi(\beta p) .$$

By the mean value theorem, rewriting equation (4), we have

(5) $$-\phi'(\beta p)\, p(\beta - 1) \leq -\phi'(\zeta)(\beta p - p) , \quad \zeta \in (p, \beta p) .$$

Since $-\phi'(\zeta) > \phi'(\beta p)$ equations (5) and (2) follow. Therefore for any β and p, the strategy of offering a service contract option dominates the alternative of not offering that option. Notice that even if $p < \beta c$ this result holds since if there is no service contract then the profit maximizing β equals 1.[4] But at $\beta = 1$ there is no difference between the no service and service contract. Therefore if the optimal service contract has $\beta > 1$, then profits under the optimal service contract must be higher than under the optimal non-service contract.

We now solve for the (p, β, G) that maximizes the monopolist's profits.

The monopolist's problem is given by

$$(6) \qquad \max_{p, \beta, G} \; (p - \beta c)\, x(p) + G$$

$$\text{s.t.} \quad V(p, I - G) = V(\beta p, I) \qquad \text{Service Contract Constraint}$$

$$V(p, I - G) \geq V_0 \qquad \text{Market Entry Constraint}$$

$$\beta \geq 1 \; .$$

Recall that V_0 is the utility of staying out of the market, while $V(\beta p, I)$ is the utility of entering the market but not purchasing the service contract option. The opportunity set of a consumer under option I (entering the market) contains the choice element $x = 0$; hence, it follows that $V(\beta p, I) \geq V_0$; therefore, we can disregard the Market Entry Constraint. To prove that the introduction of a positive-defect technology dominates pure monopoly pricing, we show that (6) has an optimum where $\beta > 1$ and $G > 0$.[5]

Since $V(p, I) = \phi(p) + I$, noting that $\phi'(p) < 0$, $\phi''(p) > 0$, and $x(p) = -\phi'(p)$, we can rewrite the service contract constraint as follows,

$$\phi(p) + I - G = \phi(\beta p) + I$$

or

$$G = \phi(p) - \phi(\beta p) \; .$$

Substituting G into the objective function in (6), we obtain

$$\text{(7)} \qquad \max_{p,\beta} \ (p-\beta c)(-\phi'(p)) + \phi(p) - \phi(\beta p)$$

$$\text{s.t.} \quad \beta \geq 1.$$

The first order conditions are given as follows:

$$\text{(8)} \qquad \beta \geq 1, \ \pi_\beta = c\phi'(p) - \phi'(\beta p)p \leq 0, \text{ with equality for } \beta > 1.$$

$$\text{(9)} \qquad \pi_p = -\phi''(p)(p-\beta c) - \phi'(\beta p)\beta = 0 \quad .$$

We now show that the solution to (7) must be an interior solution. First, we exclude $p \leq c$. If the optimal p is less than c, i.e. $p < c$, then $\pi_\beta\big|_{p<c} < 0$, implying that $\beta = 1$. If $p=c$, then $\pi_\beta\big|_{p=c} < 0$ for $\beta > 1$, implying that $\beta = 1$. Hence for $p \leq c$, it must follow that $\beta = 1$; thus $G = 0$ and the profits of the monopolist are $(p-c)\,x(p) \leq 0$, a contradiction, since the pure monopoly pricing must generate strictly positive profits. Therefore $p > c$. Second, we show that $\beta > 1$. For any $p > c$, $\pi_\beta\big|_{\beta=1} = (c-p)\,\phi'(p) > 0$. Therefore, $\beta > 1$. To show that β is bounded, it suffices to show that $\lim_{\beta \to \infty} \pi_\beta < 0$. But $\pi_\beta = p\,x(\beta p) - c\,x(p)$, and $\lim_{\beta \to \infty} x(\beta p) = 0$. Therefore the solution to (7) is an interior solution with $\beta > 1$. These results are summarized in the following proposition:

Proposition 1. In the absence of income effects, the monopolist maximizes profits by manufacturing a positive proportion of defective units, and offering a fixed fee service contract, even though a zero defect rate could be achieved at no additional cost.

With the aid of Figure 1, we illustrate the profitability of the service contract strategy relative to conventional monopoly pricing. As diagrammed below, the conventional monopoly price and quality are (p_m, x_m) respectively.

Insert Figure 1

Suppose the monopolist holds the unit price p_m constant, but produces defective units at the rate of $1-\alpha$. Denoting $\beta \equiv 1/\alpha$, the "effective" price to a risk neutral consumer rises to βp_m. In the absence of a service contract the consumer would purchase the quantity x corresponding to that effective price. Since the expected consumer surplus falls by more than the area $G(\beta)$ relative to the defect-free units at price p_m, the monopolist may charge at least up to $G(\beta)$ for the service contract. His costs rise by the area $\Delta C(\beta)$, since all defective units must be replaced by the firm. Hence, the service contract strategy is profitable if $G(\beta) > \Delta C(\beta)$.

Linearizing the demand curve in the neighborhood of $\beta = 1$, to correspond to the introduction of a small defect rate, the trapezoid $G(\beta)$ is given by $G(\beta) = (\beta-1)\, p_x x_m - (1/2)(\beta-1)\, p_m(x_m - x)$. From the definition of elasticity $\epsilon = \frac{p}{x}\frac{\Delta x}{\Delta p} = \frac{x_m - x}{(\beta-1)\, x_m}$, and substituting for $x_m - x$, we have $G(\beta) = (\beta-1)\, p_m x_m - (1/2)(\beta-1)^2 \epsilon\, p_m x_m$. Now, $\Delta C(\beta) = (\beta-1) c\, x_m$, then assuming $x_m > 0$, $\frac{G(\beta)}{\Delta C(\beta)} = \frac{p_m - \frac{1}{2}(\beta-1)\epsilon\, p_m}{c} = \frac{p_m}{c}\left(1 - \frac{1}{2}(\beta-1)\epsilon\right) > 1$

if $p_m > c$ and β is near 1. This also can be seen by noting that $G'(1) > \Delta C'(1)$.[6] Hence for β near 1, $G(\beta) > \Delta C(\beta)$. Thus, the service contract strategy is more profitable than pure monopoly pricing. Note that the argument presented above shows that our result does not depend on any risk aversion characteristics of the consumer. It only depends on the monopoly price exceeding the marginal cost and the price elasticity of demand being finite, both of which are inherent characteristics of a monopolist market structure.

3. Properties of the Solution

Since the monopolist produces defects at a cost solely to effectuate the two-part tariff, it is apparent that total surplus is not maximized under this strategy. This result is in contrast to Oi (1971) in which a simple (defect-free) two-part tariff strategy does maximize total surplus, though the entire surplus accrues to the monopolist.

In this section, we explore several more properties of the profit-maximizing positive-defect strategy. These properties may be contrasted to both the conventional (defect-free) pure monopoly strategy and to Oi's (defect-free) two-part tariff strategy.

Proposition 2. *Unlike a perfect (defect-free) two-part tariff strategy, consumer surplus is strictly positive.*

Proof. By contradiction. Assume consumer surplus, (CS) is zero under the optimal positive-defect strategy. Then,

$$CS = V(\beta p, I) - V_0 = \phi(\beta p) + I - I = \phi(\beta p) = 0,$$

implying that at the effective price βp, the consumer leaves the market, i.e., $x(\beta p) = \phi'(\beta p) = 0$. Hence, for the first order condition (8) to equal zero, it must also be that $x(p) = -\phi'(p) = 0$. This means, therefore, that the consumer does not purchase under the monopolist's optimal strategy, a contradiction. Q.E.D.

Proposition 3. Defining the effective marginal cost to include the replacement cost of defective units, the monopolist's unit price exceeds the effective marginal cost, i.e., $p > \beta c$.

Proof. From the first order condition (9)

$$\pi_p = -\phi''(p)(p - \beta c) - \phi'(\beta p)\beta = 0$$

Since $\phi' < 0$ and $\phi'' > 0$, it follows that $p > \beta c$. Q.E.D.

As mentioned earlier, this result contrasts with the corresponding simplest model in Oi's (1971) "Disneyland Dilemma" in which defect-free units were priced at marginal cost.[7]

It would be of interest to compare the unit price charged by the monopolist under the service contract strategy with the pure monopoly price. The comparison is ambiguous. There are situations where the monopolist not only charges a fixed service contract fee, but also charges a higher unit price than the monopoly price. The analysis is shown in the Appendix, where we present examples of each phenomenon.

In summary it is optimal for the monopolist to produce defectives and offer a service contract, even though a zero defect rate could be achieved at no extra cost. Since the consumers have the option to enter the market without purchasing the service contract, the amount of consumer surplus the monopolist can extract is bounded by the utility of that option. Thus the consumer retains a positive surplus. Finally, the price charged by the monopolist is greater than the effective marginal cost and can even be greater than the pure monopoly price.

4. Extensions

In this section we explore the sensitivity of our results to the assumptions made in the model.

Up to now, we assumed consumers are risk neutral in income. As hinted previously, our results do not depend on that assumption. They extend easily to the risk aversion case. The argument is the following. Let $U(x,y)$ and $V(p,I)$ be the direct and indirect utility functions respectively and $V(p,I,\alpha)$ the utility the consumer obtains when entering the market with a percentage of non-defective units α, and not purchasing the service contract option. That utility will not be greater than the utility the consumer would obtain if he were to face a price βp for good units with certainty, i.e. $V(\beta p, I)$. If we were to solve the problem using $V(\beta p, I)$ instead of $V(p,I,\alpha)$ in the service contract constraint, our results still hold, because the problem is the same. But the fact that $V(p,I,\alpha) \leq V(\beta p, I)$ implies that the optional service contract strategy, $\beta > 1$, $G > 0$, will be even more profitable.

This is true because to the value of G obtained when solving the problem with $V(\beta p, I)$ can be added the risk premium $V(\beta p, I) - V(\beta, I, \alpha)$.[8] Similar arguments can be used to extend the results when transactions are costly to the consumer (i.e., the time spent in going back to the store to purchase additional units).[9]

We next relax the assumed independence of marginal costs c and the defective rate β. We assumed in the model that the cost per unit produced c is invariant to the defect rate. Our results generalize easily to the case where the cost per unit produced decreases as the defect rate increases, or $c'(\beta) < 0$. This situation would only increase the dominance to the service contract strategy over pure monopoly pricing. The cost of the former strategy would now be even cheaper. Briefly, the analysis is the following. Given a functional relationship, $c(\beta)$, the cost of producing x units with defect rate β is $c(\beta)x$. Thus, on average, the cost of producing x non-defective units equals $\beta c(\beta) \equiv g(\beta)$. There are three cases according to $g'(\beta) \gtreqless 0$. Consider first a simple (single price, non-discriminating) monopolist. He chooses the defect rate β that minimizes cost, according to the first-order condition $\beta \geq 1$, $g'(\beta) \leq 0$, with equality for $\beta > 1$. If $c'(\beta) \geq 0$ he chooses $\beta = 1$. If $c'(\beta) < 0$, leading to a U-shaped $g(\beta)$, then $\beta > 1$. In the fortuitous case in which $c'(\beta) \leq 0$ such that $g(\beta) = k$, a constant, the simple monopolist is indifferent among all $\beta \geq 1$.

Our analysis generalizes easily in all the cases except $g(\beta) = k$. Introduction of an optimal fixed fee service contract implies a choice of β

in excess of that chosen by the simple monopolist, or $\bar{\beta} > 1$. This result can be obtained by showing that at the profit-maximizing optimum $g'(\beta) = c(\beta) + \beta c'(\beta) > 0$. Thus, costs are not minimized.[10]

Up to now, we have assumed a zero income elasticity of demand. This assumption is critical to the analysis. A high income elasticity of demand implies that the quantity demanded of the product is significantly affected when the consumer were to purchase the service contract. The effect of this demand shift may alter the optimality of the service contract strategy with respect to its alternatives. On the other hand, by continuity, our results should hold at least for fairly low income elasticities of demand. Thus the zero elasticity assumption is sufficient but may not be necessary.

5. Conclusion

We have shown that firms endowed with monopoly power can utilize a service contract form of guarantee as an instrument for effecting a two-part tariff. The monopolist finds it profitable to produce, guarantee, and replace defective units, even if a zero defect rate could be achieved at no additional production cost. The gains from extracting additional consumer surplus outweigh the deadweight cost absorbed in replacing defectives. In contrast to Oi's (1971) corresponding results, we demonstrate that the price per unit charged by the monopolist is greater than the "effective" marginal cost; it may even be higher than the pure monopoly price. Moreover, the monopolist is unable to extract all of the consumer surplus.

These results are obtained under the assumption that there are no income effects; thus, we can conjecture that as long as these effects are not "too large" the same qualitative results should hold. Furthermore, the analysis here has proceeded under the assumption that all consumers are identical. As a result, only a single price and service contract pair must be offered by the monopolist. In a more general model in which consumers' preferences and incomes vary, the monopolist faces a more difficult problem, for he must then extract differential surplus from different consumers. This might then entail multiple self-selecting contracts that jointly create self-selection as they extract surplus. This phenomenon is discussed by Bowman (1957) and Burstein (1960) in a tie-in context as well as Oi (1971).

Appendix

We show here that beyond the statement that price is greater than the effective marginal cost, not much else can be said with respect to which price the monopolist will charge. Specifically, we show that there are situations where the price charged along with the service contract fee exceeds the pure monopoly price (zero-defect rate).

First we show that a direct comparison cannot be made. Substituting equation (8) into equation (9) we obtain

$$\text{(A1)} \qquad \pi_p = (p - \beta c)\, x'(p) + \frac{c}{p}\, x(p)\beta = 0 \ .$$

Defining the demand elasticity as $\varepsilon = -\dfrac{x'(p)p}{x(p)}$, rewriting (A1), we have

$$\text{(A2)} \qquad p = \beta c(1 + 1/\varepsilon) \ .$$

In contrast, the usual Lerner mark-up equation for a zero-defect, pure monopolist is given as follows:

(A3) $$p = c\left(\frac{1}{1-\frac{1}{\varepsilon}}\right) .$$

Notice that in general the elasticities in (A2) and (A3) will differ, because they are evaluated at different prices. Therefore a direct comparison cannot be made. But, given a constant elasticity demand function, the unit price charged by the monopolist under the defective technology exceeds the pure monopoly price if

(A4) $$\beta > \frac{\varepsilon^2}{\varepsilon^2 - 1} .$$

We give two examples below. The first fulfills condition (A4), thereby generating a unit price greater than the pure monopoly price. The second generates the opposite, a unit price below the monopoly price.

Example 1: Constant Elasticity. Let the indirect utility function be $V(p,I) = kp^{-a} + I$, $a > 0$. Then $V_p(p,I) = -kap^{-(a+1)}$, $V_{pp} = ka(a+1)p^{-(a+2)}$. Since $x(p, I-G) = kap^{-(a+1)}$, the price elasticity of demand is a constant, $\varepsilon = -(a+1)$. Utilizing (7), the monopolist profit function can be written as $\pi = (p - \beta c)kap^{-(a+1)} + k(p^{-a} - (\beta p)^{-a})$. For the optimal β, we have $\beta^* = ((a+2)/(a+1))^{1/a} > 1$. The optimal price per unit is $p^* = c((a+2)/(a+1))^{(a+1)/a}$. It is easy to confirm that $\beta^* > \varepsilon^2/(\varepsilon^2 - 1)$. Since the pure monopoly price is $\hat{p} = c((a+1)/a)$, it follows that $p^* > \hat{p}$; the monopolist not only charges a fixed service contract fee, but also charges a price per unit higher than the monopoly price.

Example 2. The following quadratic utility function gives rise to the opposite result, i.e., $p^* < \hat{p}$. Let $U(x, y) = y - (1/2)(x-k)^2$ for $x \le k$, where x is the commodity produced by the monopolist. Then the indirect utility function is $V(p, I-G) = I-G-p(k-p) - \frac{1}{2} p^2$. The demand function is given by $x(p, I-G) = k-p$ for $p \le k$, 0 for $p \ge k$, and the service contract fee $G = (1/2)(1-\beta^2)p^2 + (\beta-1)kp$. The profit function is $\pi = (p-\beta c)(k-p) + (1/2)(1-\beta^2)p^2 + (\beta-1)kp$. The optimal β^* is given by the solution of $\beta/(1+\beta^2)^2 = ck/(k+c)^2$. It is easy to confirm that $\beta^* > 1$. The pure monopoly price is $\hat{p} = \beta(k+c)/(1+\beta^2)$. Then $\hat{p} > p^* > \beta^* c$.

Notes

[1] This does not rely on consumer losses in excess of the purchase price. Instead, the driving force of the example is that consumers underestimate the reliability of the commodity; the guarantee penalty is so large that consumers hope the commodity does break down.

[2] That is, the "metering" rationale for a tie-in is not reached in our analysis, cf., Bowman (1957).

[3] This convention is inessential.

[4] We are grateful to the referee for pointing this case to us.

[5] Of course to ensure the existence of positive profits, we are assuming that the marginal utility at zero is greater than the marginal cost of production.

[6] $G'(\beta) = p_m x_m - (\beta - 1)\, \varepsilon\, p_m x_m$ and $G'(1) = p_m x_m$. Since $\Delta C'(\beta) = cx_m$ and $p_m > c$, $G'(1) > \Delta C'(1)$.

[7] Oi's later analysis of consumer heterogeneity does lead to price above marginal cost for some cases.

[8] As mentioned, with risk averse consumers, the monopolist has additional incentives to produce defects for the purpose of selling insurance against the risk of defects. The more risk averse consumers are, the more profitable is the service contract fee strategy. This also leads to additional results. For any risk averse consumer, the riskier is the distribution that he faces (holding the mean constant) the greater is the profitability of the service contract fee strategy for the monopolist. This can be easily seen by noting that the service contract fee G is constrained to satisfy

$V(p, I-G) \geq V(p, I, \alpha)$ for any particular defect rate selected. Thus, the monopolist has an incentive to produce that risk as efficiently as possible, namely, for any p and α he should try to make $V(p, I, \alpha)$ as small as possible. For any particular defect rate $(1 - \alpha)$, the effective risk consumer faces is affected by the manner in which the monopolist "packages" defective and non-defective units. An analysis of optimal packaging technologies is presented in Braverman, Guasch and Salop (1982).

[9] Whatever the consumer strategy is, his utility of entering the market but not purchasing the service contract option would be less than $V(\beta p, I)$. Therefore via analogous reasoning, our results would hold in that case too.

[10] The case where $g'(\beta) = 0$ leads to an unbounded solution for the sophisticated monopolist, or $\beta \to \infty$. We may interpret this in a number of ways. First note that if $g(\beta) = k$, then the cost of producing each good unit is invariant to the defect rate, on average. Thus the firm may create unbounded risk (an infinite expected defect rate for packages placed on the market and purchased by uninsured consumers) at no effective cost to himself. Thus, he may extract the entire consumer surplus by choosing $\beta \to \infty$. A second interpretation is that if the firm can identify at no cost and withhold non-defective units from the market, he can achieve a defect rate purchased of $\beta \to \infty$ and hence extract all the consumer surplus without creating any additional cost.

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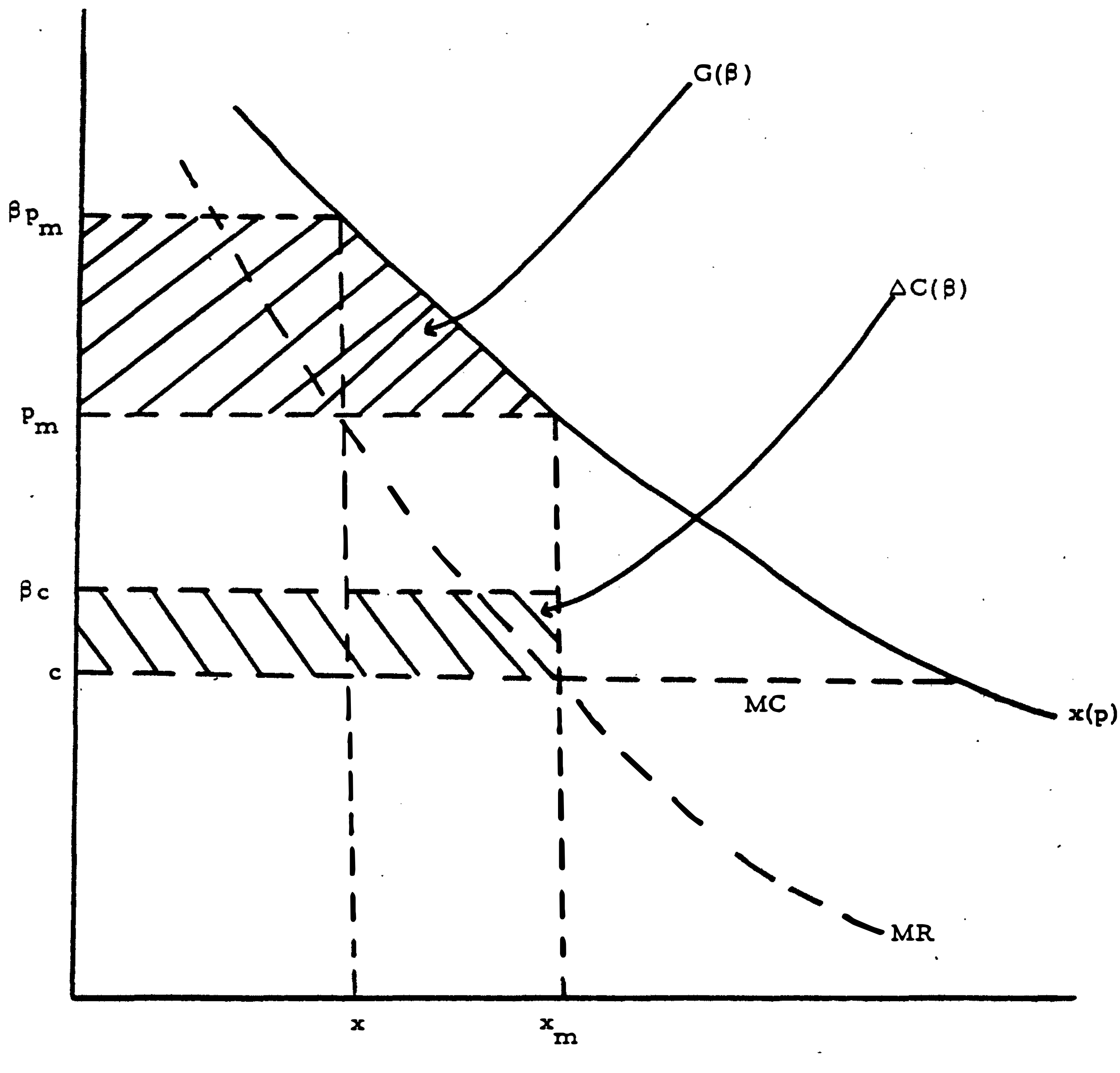

Figure 1