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Post-pandemic changes in household food expenditure and affordability: Heterogeneity by income

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Abstract

Food affordability, yet existing evidence on how households across the income distribution have responded relies on aggregate statistics and descriptive reports. This paper uses newly released 2023 Panel Study of Income Dynamics (PSID) data and two-way fixed effects regressions to examine changes in food expenditure and insecurity by income quintile between 2019 and 2023. Bottom-quintile households cut total food spending by about \$510. Food inflation-adjusted results and models conditional on total food expenditure suggest this result may be driven by budget constraints rather than substitution between food categories, whereas Q2 through Q5 households substituted away from non-home toward at-home food. Food insecurity rose sharply for middle-income households: 7.1 and 3.6 percentage points more Q2 and Q3 households reported insufficient food, and 6.2 and 6.9 percentage points more reported an inability to afford balanced meals. These findings suggest that post-pandemic price increases disproportionately affected lower- and middle-income households, and that expansion of food assistance benefits may provide relief.

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Volume 0, Issue 0

Making products last: Sales versus renting

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Abstract

We compare product durability and profitability under sales and renting when product quality is unobservable to consumers. Ownership structure determines who bears the consequences of product failure and thereby shapes incentives to enhance durability. Under sales, consumers invest in maintenance, while firms have no incentive to invest in quality and may benefit from replacement sales following failure. Under renting, consumers exert no maintenance effort, while firms invest in quality because they internalize repair and replacement costs. We show that sales generates greater durability when consumer maintenance is relatively more effective, whereas renting can generate greater durability when firm quality investment is relatively more effective and replacement costs are sufficiently high. Profitability follows a different pattern, so the more profitable business model need not be the more durable one. Extensions with deductibles and complementary durability inputs further highlight the role of failure-risk allocation in shaping durability incentives.

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1 Introduction

At a high level, the Commission’s Executive Vice-President has called for “an economy where products and materials are reused, repaired and recycled ... where circular business models become the norm,” a vision under which renting can align incentives for durability and maintenance. As he put it: “These models are the future. I already see it with my kids: they don’t want to own a car; they want mobility! The same can apply to many other products, from toolkits to home appliances.”¹

Our analysis formalizes when such rental/service models enhance durability and profitability—and when they do not—by comparing renting (service provision) to sales (ownership transfer) and mapping the role of failure-cost internalization and the relative efficiency of consumer effort versus firm quality investment.

Durability entered formal analysis with Martin (1962), Kleiman and Ophir (1966), Levhari and Srinivasan (1969), and Schmalensee (1970), who argued monopolists tend to offer less durability than competitive industries. Swan (1970) challenged this, showing that with initial *and* replacement sales considered, monopolists and competitive markets may select identical durability—though his steady-state assumptions drew criticism.

Coase (1972) reframed the debate via time inconsistency for durable-goods sellers: rational buyers anticipate price cuts, undermining a monopolist’s ability to sustain high prices. Stokey (1981) and Bulow (1982) formalized this logic, and Coase suggested renting, contracts, or reduced durability as remedies. Subsequent work explored commitment and obsolescence: Bond and Samuelson (1984) on capacity as commitment and durability; Bulow (1986) on planned obsolescence; Waldman (1993, 1996) on obsolescence and new products; Fishman et al. (1993) on durability and technological progress; and Hendel and Lizzeri (1999) on incentives to disrupt secondary markets. More recently, the durable-goods literature has also been applied to environmental policy. In particular, Kinokuni et al. (2019) study optimal waste-disposal fees when firms endogenously choose product durability in the presence of planned obsolescence. While their focus is on the design of environmental policy, our paper examines how ownership structure—selling versus renting—affects firms’ incentives to invest in durability under unobservable product quality. Specifically, we compare the profitability and durability of the two business models and identify the conditions under which each ownership structure dominates.

2 The Theoretical Framework

We compare a rental model, in which the firm retains ownership and rents the good, with a sales model, in which the firm transfers ownership through sale,

¹Frans Timmermans, “Speech by Executive Vice-President Timmermans at the World Circular Economy Forum 2023,” European Commission, 23 May 2023.

assessing profitability and durability (subscripts r and s denote renting and selling).

Timeline. The analysis is formulated as a two-period, two-stage game. In the contracting stage (period 1), the firm first chooses the product quality, which remains fixed throughout the product's lifetime but is not observable to consumers. It then offers either a sales or a rental contract, and consumers decide whether to accept it.

In the maintenance stage (also period 1), consumers choose their maintenance effort. The product does not fail during period 1; rather, the maintenance effort, together with the firm's quality choice, determines the probability that the product does not fail in period 2.

At the beginning of period 2, the uncertainty regarding product failure is resolved. If the product does not fail, consumption continues uninterrupted. If it fails, under the sales model the consumer purchases a replacement from the firm, whereas under the rental model the firm repairs or replaces the product.

Durability. Although the product cannot fail during period 1, the maintenance effort exerted during that period, together with the firm's quality choice, determines the probability that the product does not fail in period 2.

$$\delta(a, q) = \gamma_a a + \gamma_q q. \quad (1)$$

where a denotes the consumer's maintenance effort and q denotes product quality. Parameters $(\gamma_a, \gamma_q > 0)$ capture the marginal contributions of effort and quality to durability; higher values indicate greater effectiveness of the corresponding input in preventing failure. This specification treats effort and quality as perfect substitutes; the complementary case is considered in the discussion. Since $\delta(a, q)$ is a probability, it is bounded between zero and one. We focus on parameter values for which the unconstrained solution satisfies $\gamma_a a + \gamma_q q \leq 1$. When the unconstrained solution would imply $\delta(a, q) > 1$, durability reaches its upper bound of one, generating a corner solution. These corner cases are characterized in the Appendix but are not discussed in the main text, as they do not yield additional economic insights and would unnecessarily complicate the graphical analysis presented below.

Consumer utility. The utility differs across regimes. In the sales model, $U_s = 2u - \frac{\alpha}{2}a^2 - [1 - \delta(a, q)]p_2 - p_1$, where u is per-period consumption utility, p_1 is the period-1 purchase price, and with probability $1 - \delta(a, q)$ the good fails in period 2 and the consumer buys a replacement at price p_2 . Effort costs are quadratic ($\alpha > 0$), capturing increasing marginal disutility of effort.

In the rental model, $U_r = 2u - \frac{\alpha}{2}a^2 - 2r$, where r is the per-period rental fee. The firm bears failure risk, so the consumer's per-period utility u is unaffected by breakdowns.

Profit functions. The firm's profits differ across regimes because durability risk is allocated differently. In the sales model, $\pi_s = p_1 - k - \frac{\beta}{2}q^2 + [1 - \delta(a, q)](p_2 - k)$. In the rental model, $\pi_r = 2r - k - \frac{\beta}{2}q^2 - [1 - \delta(a, q)]k$. Here, k is the cost of producing/repairing a baseline-quality unit ($q = 0$), and quality cost is $(\beta/2)q^2$ with $\beta > 0$.

Information structure. The firm chooses product quality before consumers make their decisions. Since product quality is neither directly observable nor contractible, consumers choose their maintenance effort based on their equilibrium expectations about product quality.

2.1 The Sales Model

The consumer does not observe the firm's quality choice. Let $\hat{q}$ denote the consumer's belief about product quality. Taking $\hat{q}$, p_1 , and p_2 as given, the consumer chooses maintenance effort to solve

$$\max_{a \geq 0} 2u - \frac{\alpha}{2}a^2 - [1 - \delta(a, \hat{q})]p_2 - p_1.$$

The first-order condition yields the consumer's best response

$$a_s = \frac{\gamma_a}{\alpha} p_2. \quad (2)$$

Because durability is additive in effort and quality, the consumer's optimal maintenance effort is independent of the belief $\hat{q}$.

Anticipating this best response, the firm chooses (q, p_1, p_2) to maximize expected profit

$$\max_{q, p_1, p_2} p_1 - k - \frac{\beta}{2}q^2 + [1 - \delta(a_s, q)](p_2 - k), \quad (3)$$

subject to the first-period participation constraint

$$2u - \frac{\alpha}{2}a_s^2 - [1 - \delta(a_s, \hat{q})]p_2 - p_1 \geq 0,$$

and the second-period purchase constraint

$$u \geq p_2.$$

Using backward induction, the firm sets $p_2 = u$ in period 2. Substituting $p_2 = u$ into (2) yields

$$a_s^* = \frac{\gamma_a}{\alpha} u. \quad (4)$$

The first-period participation constraint binds, implying

$$p_1 = 2u - \frac{\alpha}{2}(a_s^*)^2 - [1 - \delta(a_s^*, \hat{q})]u. \quad (5)$$

Substituting (5) into the firm's profit function and differentiating with respect to q yields

$$q_s = \frac{\gamma_q}{\beta}(k - u).$$

We restrict attention to the economically relevant case $u \geq k$, in which the consumer's second-period willingness to pay is at least as large as the firm's

replacement cost. When $u < k$, replacing a failed product becomes loss-making in the sales model. Under the maintained condition $u \geq k$, the firm's optimal quality choice in the sales model is the corner solution

$$q_s^* = 0. \quad (6)$$

In a Perfect Bayesian Equilibrium, consumers' beliefs must be consistent with the firm's optimal quality choice. Hence, $\hat{q} = q_s^* = 0$.

Using (1), (6), and (4), equilibrium durability under sales is

$$\delta_s^* = \frac{\gamma_a^2}{\alpha} u. \quad (7)$$

Finally, substituting the equilibrium values into (3), with the first-period participation constraint binding, yields

$$\pi_s^* = \left[\left(1 + \frac{\delta_s^*}{2} \right) u - k \right] + [(1 - \delta_s^*) (u - k)]. \quad (8)$$

The firm's profit has two components: first-period profit and expected second-period replacement profit. Differentiating profit with respect to durability shows that greater durability does not always increase profit under sales. In particular, when $2k < u$, the loss in expected replacement-sale revenue associated with greater durability outweighs its cost-saving effect, so higher durability reduces profit. Intuitively, when the replacement cost k is sufficiently low relative to the consumer's willingness to pay u , product failures generate highly profitable replacement sales, giving the firm an incentive to prefer lower durability.

2.2 The Rental Model

The consumer's utility maximization program is given by:

$$\max_a 2u - \frac{\alpha}{2} a^2 - 2r.$$

Since the consumer does not have to pay any deductibles, it has no incentive to exert effort. Consequently, the optimal effort level is zero:

$$a_r^* = 0. \quad (9)$$

Next, the firm's maximization problem is given by:

$$\max_{q,r} 2r - k - \frac{\beta}{2} q^2 - [1 - \delta(0, q)] k \quad (10)$$

subject to the binding participation constraint $2u \geq 2r$. The first-order condition in q yields:

$$q_r^* = \frac{\gamma_q}{\beta} k. \quad (11)$$

Using (1), (9) and (11), durability is given by

$$\delta_r^* = \frac{\gamma_q^2}{\beta} k. \quad (12)$$

Finally, using (9), (10) and (11), the firm's profit is

$$\pi_r^* = 2(u - k) + \frac{\delta_r^*}{2} k. \quad (13)$$

As discussed in the sales model, we maintain the assumption $u \geq k$. In the rental model, this condition ensures that the cost of repairing or replacing a failed unit does not exceed the value u of providing second-period service and, in particular, guarantees non-negative equilibrium profit.

Differentiating profit with respect to durability shows that greater durability always increases profit under renting. Unlike under sales, the firm does not benefit from product failure through additional replacement sales. Instead, it bears the cost of repairing or replacing failed products. Higher durability therefore reduces the firm's expected failure costs without reducing its revenue, giving the firm an unambiguous incentive to increase durability.

2.3 Sales versus Renting

Comparing (7) with (12) and (8) with (13) permits a joint assessment of durability and profitability in the (u, k) -space. All formal conditions and thresholds are provided in the Appendix. We distinguish two cases: (i) $\gamma_a^2/\alpha > \gamma_q^2/\beta$ (Figure 1) and (ii) $\gamma_a^2/\alpha \leq \gamma_q^2/\beta$ (Figure 2). Figures 1 and 2 are drawn under the maintained assumption $u \geq k$, which ensures that second-period replacement or repair is economically viable.

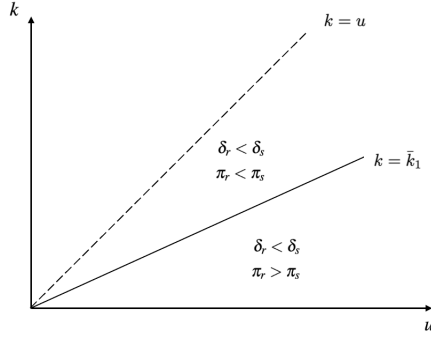


Figure 1: The case where $\frac{\gamma_a^2}{\alpha} > \frac{\gamma_q^2}{\beta}$.

In Figure 1, where the effort efficiency ratio exceeds the quality efficiency ratio ($\gamma_a^2/\alpha > \gamma_q^2/\beta$), the sales model delivers higher durability through consumer maintenance (e.g., goods whose lifespan depends strongly on user care,

such as musical instruments). Profitability follows a different logic: as shown in the Appendix, there exists a threshold $\bar{k}_1$ such that renting is more profitable when $k < \bar{k}_1$, whereas sales is more profitable when $k > \bar{k}_1$.

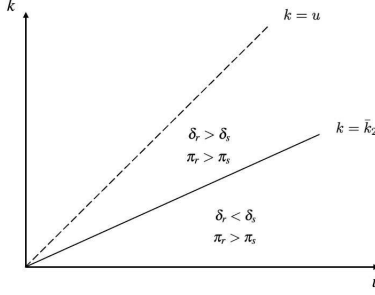


Figure 2: The case where $\frac{\gamma_a^2}{\alpha} \leq \frac{\gamma_q^2}{\beta}$.

In Figure 2, where the effort efficiency ratio is weakly below the quality efficiency ratio ($\gamma_a^2/\alpha \leq \gamma_q^2/\beta$), the *rental* model is always more profitable. Durability follows a different logic: there exists a threshold $\bar{k}_2$ such that renting is more durable when $k > \bar{k}_2$ and less durable than sales when $k < \bar{k}_2$. Two examples clarify the intuition. For goods like dishwashers, user maintenance has limited impact on longevity relative to design quality; when replacement is sufficiently costly, the provider under renting invests in quality, so renting both dominates in profitability and (for $k > \bar{k}_2$) in durability. However, renting does not universally imply high quality: for items such as light bulbs—where user effort is ineffectual and replacement is cheap—the rental firm optimally supplies lower quality and replaces units upon failure.

Key result: When $\gamma_a^2/\alpha > \gamma_q^2/\beta$ (Figure 1), sales is always more durable, while renting is more profitable if and only if $k < \bar{k}_1$. When $\gamma_a^2/\alpha \leq \gamma_q^2/\beta$ (Figure 2), renting is always more profitable and is more durable if and only if $k > \bar{k}_2$.

The results reflect the different incentives created by the two business models. Under sales, consumers maintain the product because they bear the consequences of failure, whereas under renting firms invest in quality because they internalize the cost of repair or replacement. Durability therefore depends on whether consumer maintenance or firm quality investment is the more effective source of reliability. Profitability follows a different logic: sales can benefit from replacement sales following product failure, whereas renting benefits from preventing failures by reducing expected repair and replacement costs.

3 Discussion

Our model highlights when each economic model is both more profitable and durables for the sales and renting model which could shed light on policy mat-

ters. However, it is also important to consider some extensions to our model.

3.1 Deductibles in the Rental Model

All computations are in the Appendix. Introducing a deductible f in renting gives consumers a direct maintenance incentive (stronger when γ_a/α is higher). The firm then chooses (q, f) . Two cases arise: if $\gamma_a^2/\alpha > \gamma_q^2/\beta$, the optimum is $f = k$ and $q = 0$ (the firm relies on consumer effort); if $\gamma_a^2/\alpha \leq \gamma_q^2/\beta$, the consistent equilibrium is $f = 0$ with positive q , as in renting without deductibles.

Relative to sales, when $\gamma_a^2/\alpha > \gamma_q^2/\beta$ and $k \leq u$, renting with a deductible is *more profitable but less durable*. Profit is higher because the rental contract commits to $f = k$, shifting failure costs and allowing higher rents, whereas the seller cannot credibly commit to $p_2 = k$ (time inconsistency pushes $p_2 = u$), depressing p_1 . Durability is lower because consumer effort under renting depends on $f = k$, while under sales it depends on $p_2 = u \geq k$, yielding higher effort—and thus durability—in the sales model.

3.2 Effort and Quality as Perfect Complements

Our baseline assumes $\delta(a, q) = \gamma_a a + \gamma_q q$. If instead effort and quality are perfect complements, $\delta(a, q) = \min\{\gamma_a a, \gamma_q q\}$, durability is constrained by the weaker input. Under sales, consumers choose effort based on their belief $\hat{q}$ about quality. Since the firm optimally chooses $q = 0$, equilibrium consistency implies $\hat{q} = 0$, and consumers therefore choose $a = 0$. Under renting, consumers have no incentive to exert effort and choose $a = 0$, making quality investment ineffective and leading the firm to choose $q = 0$. Hence both regimes converge to zero durability and identical profitability, making the complements case trivial in this framework. A formal derivation is provided in Appendix E.

4 Conclusion

This paper compares durability and profitability under sales and rental regimes when quality is unobserved at contracting. Ownership structure shapes incentives in systematic ways: renting internalizes failure costs and thus rewards durability, whereas sales can profit from failures when $2k < u$. Durability is higher under sales when consumer effort is the efficient lever ($\gamma_a^2/\alpha > \gamma_q^2/\beta$), and higher under renting when firm quality investment is more efficient ($\gamma_q^2/\beta \geq \gamma_a^2/\alpha$). Thresholds in the (u, k) -space delineate these regions and clarify how utility and replacement cost jointly determine the dominant regime.

Extensions reinforce these mechanisms. With deductibles in renting, the provider can commit to failure charges, shifting risk and inducing effort; when effort is relatively efficient, this renders renting more profitable yet less durable than sales. Time inconsistency further strengthens this result: the seller cannot credibly commit to a low second-period price, which depresses the first-period price and profits, whereas the rental contract can commit ex ante to failure

charges (or service levels), making renting strictly more profitable in our framework. That said, our model may overstate rental profitability by abstracting from administrative and operational costs of managing rental fleets (billing, monitoring, logistics), which could erode or reverse the profit advantage in practice. Under perfect complements between effort and quality, asymmetric information collapses both regimes to identical (low) durability, highlighting the importance of substitutability in durability production.

Policy implications follow directly: interventions that make the producer more responsible for product performance or longevity. (e.g., standards, warranties tied to provider responsibility) tend to favor rental models, while measures that enhance the effectiveness or lower the cost of user maintenance tilt toward sales. By making the trade-offs transparent, the framework offers a map for aligning business models with durability targets.

Appendix

A. Corner solutions

The Corner solutions do not change the qualitative comparisons. In each regime, the relevant maximization problem is strictly concave (quadratic cost functions and linear durability), and the only additional restriction is the feasibility cap $\delta(a, q) \leq 1$. By standard constrained-concave optimization logic, the constrained optimum coincides with the unconstrained (interior) optimum whenever it satisfies the cap; if the interior solution violates $\delta \leq 1$, the constrained optimum is obtained by setting $\delta = 1$ (with minimal effort under sales and minimal quality under renting).

It follows that the optimal durability and profit functions are continuous at the parameter values where the cap begins to bind. Therefore, the profitability and durability rankings derived under the interior analysis extend unchanged into the corner regions: the cap merely truncates durability at $\delta = 1$ and does not generate additional dominance regions.

B. Profit Comparison

Using the interior solutions,

$$\pi_r^* = 2(u - k) + \frac{\gamma_q^2}{2\beta} k^2, \quad \pi_s^* = 2u - 2k - \frac{\gamma_a^2}{2\alpha} u^2 + \frac{\gamma_a^2}{\alpha} uk.$$

Hence, for fixed k , the profit difference can be written as

$$\Delta\pi(u) \equiv \pi_r^* - \pi_s^* = \frac{\gamma_a^2}{2\alpha} u^2 - \frac{\gamma_a^2}{\alpha} ku + \frac{\gamma_q^2}{2\beta} k^2.$$

Step 1: derivatives in u .

$$\frac{\partial \Delta\pi}{\partial u} = \frac{\gamma_a^2}{\alpha} (u - k), \quad \frac{\partial^2 \Delta\pi}{\partial u^2} = \frac{\gamma_a^2}{\alpha} > 0.$$

Thus $\Delta\pi(u)$ is strictly convex in u , with a unique minimizer at $u = k$. Since the economically relevant region is $u \geq k$, it follows that $\Delta\pi(u)$ is increasing in u over the admissible set.

Step 2: sign at $u = k$. Evaluating at $u = k$ gives

$$\Delta\pi(k) = \frac{k^2}{2} \left(\frac{\gamma_q^2}{\beta} - \frac{\gamma_a^2}{\alpha} \right).$$

If $\frac{\gamma_a^2}{\alpha} \leq \frac{\gamma_q^2}{\beta}$, then $\Delta\pi(k) \geq 0$, and since $\Delta\pi(u)$ is increasing for $u \geq k$, we have $\Delta\pi(u) \geq 0$ for all $u \geq k$. Hence renting is (weakly) more profitable throughout the admissible region.

If $\frac{\gamma_a^2}{\alpha} > \frac{\gamma_q^2}{\beta}$, then $\Delta\pi(k) < 0$ while $\Delta\pi(u) \rightarrow +\infty$ as $u \rightarrow \infty$. By strict convexity and monotonicity on $u \geq k$, there exists a unique threshold $\bar{u}_1(k) > k$ such that $\Delta\pi(\bar{u}_1) = 0$. Solving $\Delta\pi(u) = 0$ yields

$$\bar{u}_1(k) = k \left[1 + \sqrt{1 - \frac{\alpha\gamma_q^2}{\beta\gamma_a^2}} \right].$$

Equivalently, the profitability frontier in the (u, k) -plane can be written as

$$\bar{k}_1 = \frac{u}{1 + \sqrt{1 - \frac{\alpha\gamma_q^2}{\beta\gamma_a^2}}}.$$

Therefore, when $\frac{\gamma_a^2}{\alpha} > \frac{\gamma_q^2}{\beta}$, renting is more profitable if $k < \bar{k}_1$, whereas sales is more profitable if $k > \bar{k}_1$.

C. Durability Comparison

Using the interior solutions,

$$\delta_s^* = \frac{\gamma_a^2}{\alpha} u, \quad \delta_r^* = \frac{\gamma_q^2}{\beta} k.$$

Hence

$$\delta_r^* > \delta_s^* \iff \frac{\gamma_q^2}{\beta} k > \frac{\gamma_a^2}{\alpha} u.$$

Define the durability threshold

$$\bar{k}_2 = \frac{\gamma_a^2/\alpha}{\gamma_q^2/\beta} u.$$

Then renting is more durable if $k > \bar{k}_2$, while sales is more durable if $k < \bar{k}_2$.

D. Rental Model with Deductible

Let f be the deductible paid by the consumer in case of failure. Consumer effort solves

$$a = \frac{\gamma_a}{\alpha} f.$$

Durability becomes

$$\delta = \gamma_a a + \gamma_q q.$$

Firm profit is

$$\pi_r = 2r - k - \frac{\beta}{2} q^2 - (1 - \delta)(k - f).$$

Maximization yields two regimes:

Case 1:

$$\frac{\gamma_a^2}{\alpha} > \frac{\gamma_q^2}{\beta}.$$

The firm sets

$$f = k, \quad q = 0.$$

The rental contract shifts all failure risk to the consumer.

Case 2:

$$\frac{\gamma_a^2}{\alpha} \leq \frac{\gamma_q^2}{\beta}.$$

The firm sets

$$f = 0, \quad q = \frac{\gamma_q}{\beta} k,$$

replicating the no-deductible rental solution.

E. Complements Case

Suppose that

$$\delta(a, q) = \min\{\gamma_a a, \gamma_q q\}.$$

Under sales, consumers choose effort based on their belief $\hat{q}$ about quality. Their optimal effort is

$$a_s(\hat{q}) = \min\left\{\frac{\gamma_a}{\alpha} u, \frac{\gamma_q}{\gamma_a} \hat{q}\right\}.$$

Taking consumer effort as given, the firm's profit is decreasing in q when $u \geq k$. Hence,

$$q_s^* = 0.$$

Belief consistency then requires

$$\hat{q} = q_s^* = 0,$$

which implies

$$a_s^* = 0 \quad \text{and} \quad \delta_s^* = 0.$$

Under renting, the consumer bears no failure cost and therefore chooses

$$a_r^* = 0.$$

Since effort and quality are perfect complements, any positive quality investment is then ineffective. Thus,

$$q_r^* = 0 \quad \text{and} \quad \delta_r^* = 0.$$

Therefore, both regimes yield zero durability and identical profits:

$$\delta_s^* = \delta_r^* = 0, \quad \pi_s^* = \pi_r^* = 2(u - k).$$

References

- [1] Bond E. and Samuelson L. (1984), “Durable Good Monopolies with Rational Expectations and Replacement Sales”, *RAND Journal of Economics*, 15(3), 336-345.
- [2] Bulow, J.I. (1982), “Durable-goods monopolists”, *Journal of Political Economy*, 90, 314-32.
- [3] Bulow, J.I. (1986), “An economic theory of planned obsolescence”, *Quarterly Journal of Economics*, 101, 729-749.
- [4] Coase, R.H. (1972), “Durability and Monopoly”, *Journal of Law and Economics*, 15, 143–150.
- [5] Fishman A., Gandal N. and Shy O.(1993), “Planned Obsolescence as an Engine of Technological Progress”, *The Journal of Industrial Economics*, 41(4), 361-370.
- [6] Hendel I. and Lizzeri A. (1984), “Interfering with Secondary Markets”, *RAND Journal of Economics*, 30(1), 1-21.
- [7] Kinokuni, H., Ohori, S. and Tomoda, Y. (2019), “Optimal waste disposal fees when product durability is endogenous: Accounting for planned obsolescence”, *Environmental and Resource Economics*, 73, 33-50.
- [8] Kleiman E. and Ophir T. (1966), “The Durability of Durable Good”, *Review of Economic Studies*, 33, 165-178.
- [9] Levhari D. and Srinivasan T.N. (1969), “Durability of Consumption Goods: Competition Versus Monopoly ”, *American Economic Review*, 59, 102-09.
- [10] Martin D.D. (1962), “Monopoly Power and the Durability of Durable Goods”, *Southern Economic Journal*, 28, 271-277.
- [11] Schmalensee, R.L. (1970), “Regulation and the Durability of Goods ”, *Bell Journal of Economics and Management Science*, 1, 54–64.
- [12] Stokey, N.L. (1981), “Rational expectations and durable goods pricing”, *Bell Journal of Economics*, 12, 112-28.
- [13] Swan P.L. (1970), “Durability of Consumption Goods ”, *American Economic Review*, 60(5), 884-894.
- [14] Waldman, M. (1993), “A new perspective on planned obsolescence “, *Quarterly Journal of Economics* 108, 273-83.
- [15] Waldman M. (1996), “Durable Goods Pricing When Quality Matters ”, *Journal of Business*, 69(4), 489-510.