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Repetition, recall, and advertising

Ori Zax

The Israel Academic College in Ramat-Gan.

Abstract

Advertising is typically repetitive, yet standard models provide limited guidance on why repetition persists in equilibrium. This paper models advertising as cumulative knowledge production: repeated exposures increase consumer recall and activation at diminishing returns. A monopolist jointly chooses price and advertising repetition, with recall scaling demand multiplicatively. The model rationalizes persistent advertising expenditures without relying on persuasion or asymmetric information and is consistent with empirical evidence on diminishing returns and wearout. Extensions illustrate how the same mechanism applies to political agenda setting and advertising competition.

Department of Economics, The Israel Academic College in Ramat-Gan, Ramat Gan, Israel. Email: ori.zax@iac.ac.il. I wish to thank Kfir Tshuva and David Wettstein for many helpful suggestions.

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Contact: Ori Zax - orizax@gmail.com

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1 Introduction

Lecturers routinely repeat key concepts because understanding and retention require reinforcement: hearing an idea once is rarely enough for students to internalize it, and repeated exposure helps move information from short-run attention to durable recall. Repetition is costly in the classroom, as it uses scarce lecture time, yet it is systematically chosen because its marginal benefit is initially high and then declines. Advertising exhibits the same logic: firms pay for repeated exposures because recall and responsiveness accumulate with repetition, but at diminishing returns.

Repeated advertising is a pervasive feature of product markets. A natural explanation is that exposures accumulate into consumer recall and attention, but with diminishing returns: additional impressions are productive at first and then gradually lose effectiveness. We model advertising as cumulative knowledge production through repetition. A monopolist jointly chooses price and the number of ad exposures to maximize profit. The framework rationalizes persistent advertising expenditures, delivers clean pricing results, and clarifies the role of repetition without committing to a specific microfoundation of memory. We also extend the analysis to advertising in oligopolistic markets and to political elections, where repetition shapes market shares and voter attention in analogous ways.

The paper's contribution is to formalize advertising as a technology that converts exposure into consumer knowledge and activation. This perspective differs from standard approaches. Information-based models (Stigler, 1961; Nelson, 1974) emphasize revelation of product attributes, persuasion models (Dixit and Norman, 1978; Becker and Murphy, 1993) emphasize preference modification, and signaling models (Milgrom and Roberts, 1986) rely on quality inferences under asymmetric information. By contrast, our framework explains persistent advertising even without hidden quality: repetition directly raises the fraction of consumers who recall and act.

The economics of advertising has long been studied from multiple perspectives, including information provision (Stigler, 1961; Nelson, 1974; Anderson and Renault, 2006), persuasion and welfare (Dixit and Norman, 1978; Becker and Murphy, 1993), signaling (Milgrom and Roberts, 1986), and targeted/digital mechanisms (Takahashi, 2022). Advertising can also finance public goods (Luski and Wettstein, 1994). Empirically, repetition exhibits diminishing returns: Schmidt and Eisend (2015) document an inverted-U relationship between exposures and effectiveness, with wearout at high frequen-

cies. Relatedly, Berger and Weinberg (2014) study whether sales responses are concave or S-shaped and argue that, for economically relevant advertising levels, firms typically operate in the concave region of the response function, so diminishing returns are the empirically salient case. Our model captures these patterns through a concave recall function, yielding testable first-order conditions that link optimal repetition to advertising costs and profit margins.

The next section formalizes this intuition in a simple model where recall scales demand and the firm jointly chooses optimal pricing and repetition.

2 Model with Endogenous Price

This section introduces a simple profit-maximizing model in which a monopolistic firm jointly chooses price and advertising intensity. The firm's advertising expenditures determine how many times potential consumers are exposed to its message, and each exposure increases recall and purchase probability at a diminishing rate. The model yields closed-form solutions for both optimal price and optimal repetition, showing that the standard monopoly pricing rule remains unchanged while the optimal number of ad exposures equates the marginal benefit of recall with the marginal cost of advertising.

2.1 Environment

A monopolist with unit cost $c_p \geq 0$ sells to a market with baseline demand $D(p)$, where p denotes price. After n advertising exposures, a fraction $R(n)$ of consumers is *activated* (recall/attention), with $R'(n) > 0 > R''(n)$ and $R(0) = 0$. Throughout, we adopt the exponential recall function

$$R(n) = 1 - e^{-\alpha n},$$

which captures diminishing returns to repetition. Note that quantity demanded is increasing in the number of exposures n , since $R'(n) > 0$. Quantity demanded is

$$Q(p, n) = R(n) D(p).$$

and profits are

$$\Pi(p, n) = (p - c_p) R(n) D(p) - c_e n,$$

where $c_e > 0$ denotes the constant marginal cost per advertising exposure. The firm chooses (p, n) .

The recall function $R(n)$ also clarifies the connection between our framework and the dynamic advertising literature. In the seminal contributions of Vidale and Wolfe (1957) and Nerlove and Arrow (1962), advertising builds a stock of goodwill that evolves over time and depreciates in the absence of continued advertising, leading firms to smooth advertising expenditures intertemporally. Empirically, Dubé, Hitsch, and Manchanda (2005) estimate a dynamic advertising model with carryover effects and document persistent effects of advertising on demand. While our model is static and abstracts from explicit time dynamics and depreciation, the parameter α in $R(n)$ can be interpreted as a reduced-form summary of such dynamic effects: past advertising may increase the effectiveness of current exposures by strengthening brand recognition or lowering cognitive frictions, thereby raising α . In this sense, variations in α play a role analogous to changes in the goodwill stock in dynamic models. Moreover, Berger and Weinberg (2014) show that although advertising response functions may be S-shaped at very low exposure levels, firms typically operate in the concave region of the response function for economically relevant advertising intensities.

The first-order condition of the profit function with respect to advertising repetition yields

$$R'(n^*)(p^* - c_p)D(p^*) = c_e,$$

where n^* denotes the optimal advertising intensity and p^* the equilibrium price.

Substituting the exponential recall function $R(n) = 1 - e^{-\alpha n}$ into this first-order condition and solving for n gives the closed-form optimal advertising intensity:

$$n^* = \frac{1}{\alpha} \ln \left(\frac{\alpha(p^* - c_p)D(p^*)}{c_e} \right).$$

We assume a linear demand function, $D(p) = A - bp$, with $A > bc_p$. Then

$$\Pi(p, n) = (p - c_p) R(n) (A - bp) - c_e n.$$

The FOC in n is

$$\alpha e^{-\alpha n} (p - c_p) (A - bp) = c_e,$$

which yields $n^*(p) = \frac{1}{\alpha} \ln \left(\frac{\alpha(p - c_p)(A - bp)}{c_e} \right)$. Maximizing in p delivers the standard monopoly price

$$p^* = \frac{A + bc_p}{2b},$$

and substitution gives the joint optimum

$$n^* = \frac{1}{\alpha} \ln\left(\frac{\alpha}{c_e} \cdot \frac{A - bc_p}{4}\right),$$

so advertising occurs iff $\alpha(A - bc_p) > 4c_e$.

2.2 Proposition and Repetition

Proposition 1. Suppose (i) effective demand is multiplicatively separable,

$$Q(p, n) = R(n)D(p),$$

with $R'(n) > 0 > R''(n)$, and (ii) marginal production cost is constant at c_p . Then any interior optimum (p^*, n^*) satisfies

$$\frac{p^* - c_p}{p^*} = \frac{1}{\varepsilon(p^*)}, \quad R'(n^*) (p^* - c_p) D(p^*) = c_e,$$

where $\varepsilon(p)$ is the absolute price elasticity of the baseline demand $D(p)$.

Interpretation. Because $R(n)$ enters multiplicatively, the cross-partial derivative $\frac{\partial^2 \Pi}{\partial p \partial n}$ is zero, so the first-order conditions are separable. The optimal price therefore follows the standard Lerner rule and is independent of advertising, while the optimal number of ad exposures depends on the chosen p^* , the recall technology, and the unit cost of advertising. This separability result reflects that repetition scales the level of demand but does not alter its curvature in price: advertising increases the size of the market without changing its elasticity. Repetition is thus chosen optimally, firms advertise until the marginal recall benefit equals the marginal advertising cost.

To clarify the role of the parameter α , let

$$K \equiv (p^* - c_p)D(p^*) > 0,$$

so that the optimal advertising intensity can be written as

$$n^*(\alpha) = \frac{1}{\alpha} \ln\left(\frac{\alpha K}{c_e}\right).$$

Differentiating with respect to α yields

$$\frac{\partial n^*}{\partial \alpha} = -\frac{1}{\alpha^2} \ln\left(\frac{\alpha K}{c_e}\right) + \frac{1}{\alpha^2} = \frac{1}{\alpha^2} \left[1 - \ln\left(\frac{\alpha K}{c_e}\right)\right].$$

An interior solution requires $\alpha K/c > 1$, and for economically relevant parameter values $\ln(\alpha K/c) > 1$, implying $\partial n^*/\partial \alpha < 0$. Thus, a higher α —which corresponds to more effective advertising or faster recall accumulation—reduces the optimal number of repetitions. Economically, when each exposure is more productive, firms optimally rely on fewer advertising repetitions. The parameter α may vary across firms and over time: start-ups or new products may face low initial effectiveness (low α) and therefore require more repetition, whereas established firms with strong brand recognition or improved targeting technologies may exhibit higher α and optimally choose fewer exposures.

The model highlights three central insights about repetition in advertising and related persuasion contexts.

(i) *Persistence.* A positive optimal level of repetition, $n^* > 0$, arises naturally when profit margins and market size are sufficiently large relative to advertising cost and when recall is responsive at low exposure levels. Hence, persistent advertising does not require behavioral biases or strategic noise, it emerges as a rational response to the economics of cumulative attention.

(ii) *Separation.* Pricing and repetition decisions are cleanly separable. Optimal pricing continues to follow the standard Lerner rule, while the number of exposures depends solely on the recall technology and the unit cost of advertising. This separation yields transparent comparative statics across products and media environments.

(iii) *Wearout.* Concavity of the recall function $R(n)$ generates diminishing returns to additional exposures, producing the familiar inverted U relationship between frequency and effectiveness observed empirically (Schmidt and Eisend, 2015).

3 Extensions

In this section we briefly show how the same “repetition as cumulative knowledge” mechanism extends beyond the monopoly benchmark, first to political agenda setting and then to advertising competition between two firms.

3.1 Political agenda setting (Tullock contest)

Consider two political parties and two issues, A and B . Party 1 is relatively advantaged on issue A , while Party 2 is advantaged on B . Each party allocates resources to repeating and advertising its preferred issue. Let $x_1 \geq 0$

denote Party 1's spending on issue A emphasis and $x_2 \geq 0$ denote Party 2's spending on issue B emphasis. Voter attention is allocated according to a Tullock (1980) contest success function:

$$\pi_A(x_1, x_2) = \frac{x_1^r}{x_1^r + x_2^r}, \quad r > 0, \quad \pi_B(x_1, x_2) = 1 - \pi_A(x_1, x_2),$$

where π_A is the probability that voters evaluate parties mainly through issue A (and π_B through issue B). Let Party 1's vote share be s_A if voters focus on A and s'_B if voters focus on B , with $s_A > s'_B$. Party 1's expected support is

$$V_1(x_1, x_2) = \pi_A(x_1, x_2)s_A + (1 - \pi_A(x_1, x_2))s'_B.$$

With linear cost $c_e x_1$, Party 1 chooses x_1 to maximize $V_1(x_1, x_2) - c_e x_1$, yielding the first-order condition

$$\frac{\partial V_1}{\partial x_1} = \frac{r x_1^{r-1} x_2^r}{(x_1^r + x_2^r)^2} (s_A - s'_B) - c_e = 0.$$

This mirrors the product-market condition: repetition (issue emphasis) is increased until the marginal benefit from shifting attention equals the marginal cost.

3.2 Two-firm advertising competition

Next consider two symmetric firms $i \in \{1, 2\}$ that choose advertising intensities $a_i \geq 0$ to attract consumers. Let market size be D , and let $\theta > 0$ measure the effectiveness of advertising in shifting demand. Demand for firm i is

$$q_i = D \cdot \frac{\theta a_i}{1 + \theta(a_1 + a_2)}.$$

Firms charge a common price p and have constant marginal cost c , so profits are

$$\pi_i(a_i, a_j) = (p - c)q_i - a_i = (p - c)D \cdot \frac{\theta a_i}{1 + \theta(a_i + a_j)} - a_i.$$

In a symmetric Nash equilibrium $a_1 = a_2 = a^*$, define $m \equiv p - c$, $M \equiv mD\theta$, and $x \equiv \theta a^*$. The equilibrium condition reduces to

$$4x^2 + (4 - M)x + (1 - M) = 0,$$

with economically relevant root

$$x^* = \frac{M - 4 + \sqrt{M(M + 8)}}{8}, \quad a^*(\theta) = \frac{x^*}{\theta}.$$

As $\theta \rightarrow 0$, $a^*(\theta) \rightarrow 0$, while as $\theta \rightarrow \infty$, advertising converges to a finite plateau $a^*(\theta) \rightarrow mD/4$. Thus, greater advertising effectiveness initially increases equilibrium advertising, but rivalry does not lead to unbounded repetition.

4 Conclusion

Viewing advertising as cumulative knowledge production explains why repetition is ubiquitous and why optimal pricing often looks standard while ad intensity varies widely across markets. The approach yields simple empirical targets: estimate $R(n)$ and test whether price and repetition are approximately separable in practice. Welfare assessments should account for recall and attention as productive inputs that can facilitate better consumer choices rather than mere waste.

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