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Optimal Retail in a Sharing Economy

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Abstract

The emerging sharing economy is fueled by products that some consumers buy new. This paper introduces an overlapping-generations model to analyze consumers' consumption choices and the equilibrium in the sharing market. We derive a retailer's optimal pricing strategy and determine the payoff effects of sharing. The presence of a sharing market increases the price of new products, and therefore a retailer may or may not benefit from the existence of a sharing market, depending on how much more inelastic the demand of the remaining buyers becomes. The retailer's benefits from sharing are largest for high-cost products and in a setting where consumers are relatively patient so that they care about their future consumption options.

1. Introduction

Over the past decade, the sharing economy has experienced a substantial growth, and the widening scope and increasing volume of the items that are being shared has been well documented (Nielsen 2014).[1] When a sharing market is created, the question arises: who benefits and who loses? Weber (2014a,b) has shown that an intermediary (such as AirBnB) may be able to extract a large portion from the gains of trade, and that overall the various parties still benefit from the existence of a sharing market.

Yet there is already at least anecdotal evidence that prices of assets for which active sharing markets exist increase.[2] Since intermediaries have the potential to increase efficiency in sharing markets (Weber 2014b), we assume that sharing markets clear, and therefore allow for the discovery of an efficient market price which does not allow for any arbitrage. We then examine how prices are affected by sharing markets when the sellers of products can endogenously react. As in Weber (2015), we allow for agents of varying current and future need. As a second dimension of heterogeneity we also allow each agent to have a value for the use of the item. The values and need propensities of the agents are continuously distributed.

By means of overlapping generations of consumers, the model allows for the coexistence of individuals in different phases of their consumption lifecycle, so that some consumers (in an early consumption phase) decide about ownership while others (in a late consumption phase) can think about participating in the sharing economy, either as a lender or as a borrower, conditional on the need realization. Without sharing, a consumer at any stage can only decide about ownership, and it turns out that sharing markets allow for a correction of temporary misallocations that come about by initial commitments implied by an early decision to purchase the product or not, which may not be met with the anticipated realization of a need for the product in the future. We show that retailers for products with sharing markets have an incentive to increase prices, which extracts some of the allocational benefits the consumers realize from sharing markets. Depending on the cost of the product we ask if this works to the retailer's advantage or not. A related question we address is how the volume of product sales is affected by sharing markets.

1.1. Literature

Handlon and Gross (1959) noted that sharing behavior is learned and its acceptability as a choice increases with chronological age. Doland and Adelberg (1967) observed that the early learning of sharing behavior of children is increased by social reinforcement; it also goes up with observation of such behavior by models (Harris 1971).[3] More recently, Belk (2007) discusses modern forms of sharing, such as carpooling enabled by the Internet, as "an alternative to private ownership" (p. 127), which may ultimately lead to a purely "access-based consumption" (Bardhi and Eckhardt 2012). Despite the rich sociological motivations and textures of different types of sharing in various contexts, we are

[1] See also "The Rise of the Sharing Economy," *The Economist*, March 9, 2013.

[2] The prices of apartments have increased in areas with increased use sharing intermediaries such as AirBnB, 9Flats, and Wimdu (Roman Rochel, COO of 9Flats, Berlin, Germany; September 2013).

[3] Related to these studies, Furby (1978) examines sharing decisions and moral judgments about sharing across difference age groups and cultures (US vs. Israel).

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concerned here with "rational sharing," in the form of borrowing and lending, which Belk (2014) describes as "borderline cases of sharing that generate an expectation that the object or some equivalent will be returned" (p. 1596).

Rational sharing amounts to realizing gains from trade from the collaborative consumption of durable goods.[4] The matching of sharing partners (i.e., borrowers and lenders) may take place directly or via intermediated marketplaces. Sharing markets are relatively recent. The absence of widespread sharing may be explained by market imperfections, such as the informational asymmetries related to the moral hazard a renter might experience when choosing the effort of being careful with the shared property. Using an analytical model, Weber (2014a,b) shows how intermediaries can eliminate moral hazard in sharing transactions and extract a large fraction of the gains from trade. Based on these findings, we neglect informational problems and focus on the agents' consumption decisions as well as the pricing of ownership with or without sharing markets. Our analysis shares aspects with early work on the decisions of whether to buy or rent a home (Shelton 1968) or land (Reiss 1972).

Arrow (1953) introduced a market for contingent claims where agents provide mutual insurance to each other. Sharing markets do provide mutual insurance, which raises the value of ownership. As such, sharing markets allow for the transaction of short-term rental agreements which contain claims to the use of a certain good and insurance provisions in the case of damage or product failure. Our model builds on Weber (2015) who examines the question of ownership in a two-period model of agents who are heterogeneous in their subjective need for the item. In that setting, the sharing market does not necessarily clear, and the resulting supply-demand imbalance is resolved by random allocation and bilateral bargaining. Here we generalize this model to an infinite-horizon setting of overlapping generations, where agents are also heterogeneous with respect to their respective valuations for the use of the shared good. In this setting, there is a unique clearing price for the sharing market, which produces crisp conclusions about the agents' motivations to own and to share, as well as the best pricing of the goods by a retailer.

1.2. Outline

The remainder of this paper is organized as follows: Section 2 introduces the main primitives of the model and establishes the equilibrium choice behavior and market price in an overlapping-generations economy with sharing. Section 3 examines the benchmark scenario when consumers do not have access to a sharing market. It also provides some comparisons. In Section 4, we derive the retailer's optimal pricing strategy with and without sharing market, and characterize products for which sharing can be advantageous from the product seller's perspective. Section 5 concludes.

2. Retail with Sharing Market

Consider a sharing economy with overlapping generations of finitely lived consumers (or "agents"). Each consumer exists for two periods which can be described as "early consumption phase" and "late consumption phase," respectively. The sharing economy operates in steady state at times $t \in \{0, 1, \ldots\}$, and the number of consumers born in any given period t is normalized to 1, without loss of generality. At the end of the following period, $t+1$, these consumers exit the economy. One can interpret the overlapping generations of finitely lived consumers *either* literally, as consumers who enter and exit the economy, *or* in terms of two overlapping consumer preference classes, for each of whom the product becomes obsolete after two periods. Note that at any time t, the total number of consumers in the sharing economy is 2, as the sum of the two extant consumer generations in the two consumption phases, which we refer to as $\mathcal{C}_0$ (early consumption) and $\mathcal{C}_1$ (late consumption), respectively.

Consumers have heterogeneous preferences for the durable consumption good in the economy. This could be any good worth sharing, such as a car, a party costume, or a power tool. Any consumer is characterized by the likelihood of need, $\theta \in [0,1]$, and the value $\nu \in [0,1]$ for the item in case it is needed. Thus any consumer's "type" is characterized by a point (θ, ν) in the unit square $\mathcal{Q} = [0,1] \times [0,1]$. For simplicity, we assume that the type distribution for any generation is uniform on $\mathcal{Q}$.[5] Each consumer's type is persistent over his lifetime. The realizations of his need for the product are uncorrelated, and nothing can be learned from other consumers or his own consumption about this need. If the item is not needed, its consumption utility drops to zero.

2.1. Consumption Choice

In any given consumption phase, a consumer of type $(\theta, \nu) \in \mathcal{Q}$ either needs the item or not at all. If

[4]The idea of "collaborative consumption" was introduced by Felson and Spaeth (1978) as an act of consuming while engaging in joint activities with others. Botsman and Rogers (2010) drop the social context and use the notion equivalently to sharing.

[5]Some of our results hold under the more general assumption that the two attributes are independently distributed where θ follows the cumulative distribution function (cdf) F and ν the cdf G, respectively, where $F, G : [0,1] \to [0,1]$ are continuously differentiable and increasing functions, i.e., their derivatives $f \triangleq F'$ and $g \triangleq G'$ are continuous on $[0,1]$ and positive almost everywhere.

he needs the item (which happens with probability θ), his value is ν, otherwise the consumption value of the item vanishes. At any time t, the product can be bought from a retailer at a price $r > 0$; alternatively, the right for a one-time use of the product can be traded (i.e., acquired or relinquished) on a sharing market at the (non-negative) price $p < r$.[6] Thus, for a given consumer generation, ownership decisions are made in the early consumption phase $\mathcal{C}_0$: any consumer therefore becomes an owner or a non-owner, respectively. Because of the relatively high retail price, borrowing/lending decisions on the sharing market become more important than ownership decisions in the late consumption phase $\mathcal{C}_1$. In any consumption phase $\mathcal{C}_i$, for $i \in \{0, 1\}$, the consumer is in a random need state $\tilde{s}_i \in \{0, 1\}$, where by assumption

$$\text{Prob}(\tilde{s}_i = 1) = \theta.$$

This need state realizes at the beginning of each time period t. Given, p and r (such that $0 < p < r$), we now consider the agents' decisions in their two consumption phases, starting with the last.

2.1.1. Late Consumption Phase

In $\mathcal{C}_1$, an agent of type (θ, ν) observes the realization $s_1 \in \{0, 1\}$ of the random need state $\tilde{s}_1$. As a non-owner, he can either not consume the product at all or rent it on the sharing market at the price p. Given his lack of consideration about the future in his late consumption phase, the latter dominates buying the product at the higher retail price $r > p$. The non-owner's resulting state-dependent payoff is

$$U_{s_1} = \max\{0, \nu s_1 - p\},$$

i.e., all $\nu \in [p, 1]$ borrow in state $s_1 = 1$, and non-owners do nothing otherwise. On the other hand, an owner of type (θ, ν) has the option to consume the product or else lend it out at the price p, with the state-dependent payoff

$$V_{s_1} = \max\{\nu s_1, p\},$$

i.e., all $\nu \in [0, p)$ lend in state $s_1 = 1$ and all $\nu \in [0, 1]$ lend in state $s_1 = 0$; otherwise no action is taken. The following result summarizes the state contingent payoffs in $\mathcal{C}_1$.

Lemma 1. *A type-(θ, ν) agent's $\mathcal{C}_1$-payoffs are $U_0 = 0$, $U_1 = \max\{0, \nu - p\}$ as non-owner, and $V_0 = p$, $V_1 = \max\{\nu, p\}$ as owner, respectively.*

As can be observed in Lemma 1, the payoff difference between owner and non-owner in any need state s_i is equal to the price p in the sharing market.

[6] A situation where $p \geq r$ implies that the sharing market is inactive.

2.1.2. Early Consumption Phase

In $\mathcal{C}_0$, an individual of type (θ, ν), who is in need state $s_0 = 0$ or $s_0 = 1$, has the option to purchase the product from a retailer at the price r to become an owner. In that case, the individual can use the item immediately. Alternatively, the agent can rent the item on the sharing market at the price p. Note that at this early stage in his life, the agent is concerned with his future, anticipating the future expected utility ($\bar{V}$ as owner, or $\bar{U}$ as non-owner) depending on his present choice. Any participant in the sharing economy discounts future payoffs at the common per-period discount factor

$$\delta \in (0, 1].$$

Choosing the best of his three alternatives (do nothing / borrow on the sharing market / buy from the retailer) the agent's discounted state-dependent total payoff becomes

$$T_{s_0} = \max\{\delta\bar{U}, \nu s_0 - p + \delta\bar{U}, \nu s_0 - r + \delta\bar{V}\},$$

where $\bar{U} = (1-\theta)U_0 + \theta U_1$ and $\bar{V} = (1-\theta)V_0 + \theta V_1$, where U_i, V_i, for $i \in \{0, 1\}$, are given in Lemma 1. Combining the first two decision options yields the total expected payoff of non-ownership,

$$\max\{0, \nu s_0 - p\} + \delta\theta \max\{0, \nu - p\},$$

which needs to be compared with the total expected payoff of ownership,

$$\nu s_0 - r + \delta\big((1-\theta)p + \theta \max\{\nu, p\}\big).$$

In the low-need state $s_0 = 0$, an individual would purchase the product if and only if the retail price r does not exceed the discounted price of sharing, δp. However, since $r > p$, this cannot happen in equilibrium, so that agents who do not need the product in their early consumption phase become non-owners. In the high-need state $s_0 = 1$, ownership is attractive for an agent if

$$r \leq \min\{p, \nu\} + \delta p = \min\{(1+\delta)p, \nu + \delta p\}.$$

Conversely, if

$$p \leq \min\{\nu, r/(1+\delta)\},$$

then the individual would prefer to borrow the item from the sharing market, even in the early consumption phase. Failing the last two inequalities, the individual is best off not consuming at all. The following result summarizes an individual's early consumption choice as a function of his type.

Lemma 2. *In $\mathcal{C}_0$, a type-(θ, ν) agent in the need state $s_0 = 1$ becomes an owner if $\nu \geq \min\{p, r - \delta p\}$, and he borrows the item if $p \leq \nu < r - \delta p$; otherwise he does nothing.*

Note that in Lemma 2 it was implicitly assumed that in case of a tie between ownership and non-ownership payoff, an individual would opt for ownership, perhaps due to the residual claims that owners obtain from any asset, as opposed to non-owners who usually experience liability and some inconvenience when borrowing an item. As becomes clear below, the probability that a randomly drawn agent type experiences such indifference vanishes in equilibrium, so the tiebreaking rule is in fact immaterial.

2.2. Equilibrium in the Sharing Market

Let $r > 0$ be a given retail price. Assuming that the sharing market clears, the price p in the sharing market must be such that demand for the shared product equals the supply.[7] Using Lemma 2, we can identify as potential suppliers in the sharing market all agents in their late consumption phase $\mathcal{C}_1$ who opted for ownership in their early consumption phase $\mathcal{C}_0$. The number of owners is therefore

$$\Omega = (1 - G(\min\{p, r - \delta p\})\,\bar{\theta},$$

where $\bar{\theta} \triangleq \int_0^1 \theta\, dF(\theta)$ is the expected probability of need, and F, G are the distribution functions for θ and ν, respectively (see footnote 5). As pointed out in Section 2.1.1., owners lend in the low-need state ($s_1 = 0$) always, and they lend in the high-need state ($s_1 = 1$) if $\nu < p$. Thus, the actual sharing supply becomes

$$\begin{aligned} S &= (1 - G(\min\{p, r - \delta p\}))\int_0^1 (1-\theta)\theta\, dF(\theta) \\ &\quad + \max\{0, G(p) - G(r - \delta p)\}\int_0^1 \theta^2 dF(\theta). \end{aligned}$$

On the other hand, we also found earlier that non-owners in their late consumption phase $\mathcal{C}_1$ borrow an item on the sharing market if they are in a high-need state and $\nu \geq p$. In the early consumption phase, agents in the high-need state with $p \leq \nu < r - \delta p$ also like to borrow on the sharing market. The resulting demand in the sharing market is

$$\begin{aligned} D &= (1 - G(p))\int_0^1 (1-\theta)\theta\, dF(\theta) \\ &\quad + \max\{0, G(r - \delta p) - G(p)\}\int_0^1 \theta^2 dF(\theta). \end{aligned}$$

Market clearing in the sharing market requires that the excess demand, $\Delta \triangleq D - S$ vanishes. Thus,

$$\Delta = G(r - \delta p) - G(p) = 0,$$

which implies the following result.

Proposition 1. *Given a retail price $r \in (0, 1 + \delta)$, the unique clearing price in the sharing market is $p = r/(1 + \delta)$.*

The clearing price in the sharing market satisfies a no-arbitrage condition in the sense that the present value of the cost of renting the product in successive consumption periods equals the retail price, i.e., $r = p + \delta p$. Proposition 1 determines the liquidity in the sharing market.

Corollary 1. *The transaction volume in the sharing market is*

$$S = D = (1 - G(r/(1+\delta)))\int_0^1 (1-\theta)\theta\, dF(\theta),$$

for any given retail price $r \in (0, 1 + \delta)$.

Example 1. For the initially assumed uniform type distribution it is $F(\theta) = \theta$ and $G(\nu) = \nu$ for all $(\theta, \nu) \in \mathcal{Q}$. In this setting, Corollary 1 implies that

$$S = D = \frac{1}{6}\left(1 - \frac{r}{1+\delta}\right) \in (0, 1/6),$$

for $r \in (0, 1 + \delta)$. □

2.3. Demand for Shared Ownership

The clearing price in Proposition 1 determines the equilibrium demand for ownership in the current early-consumption generation,

$$\Omega = (1 - G(r/(1+\delta)))\ \bar{\theta},$$

given the retail price $r \in (0, 1 + \delta)$. The corresponding retail demand elasticity is

$$\varepsilon = -\frac{r}{\Omega}\frac{\partial \Omega}{\partial r} = rh\big(\frac{r}{1+\delta}\big),$$

where $h(\nu) \triangleq g(\nu)/(1 - G(\nu))$, for all $\nu \in [0, 1]$, denotes the hazard rate of the value distribution G.

Example 2. In the setting of Ex. 1, the hazard rate is $h(\nu) \equiv 1/(1 - \nu)$, and the retail demand elasticity becomes

$$\varepsilon = \frac{(1+\delta)r}{1 + \delta - r} \in (0, \infty),$$

for $r \in (0, 1 + \delta)$. □

[7] In practice, there may be supply-demand imbalances (Weber 2014a,b; Razeghian and Weber 2015).

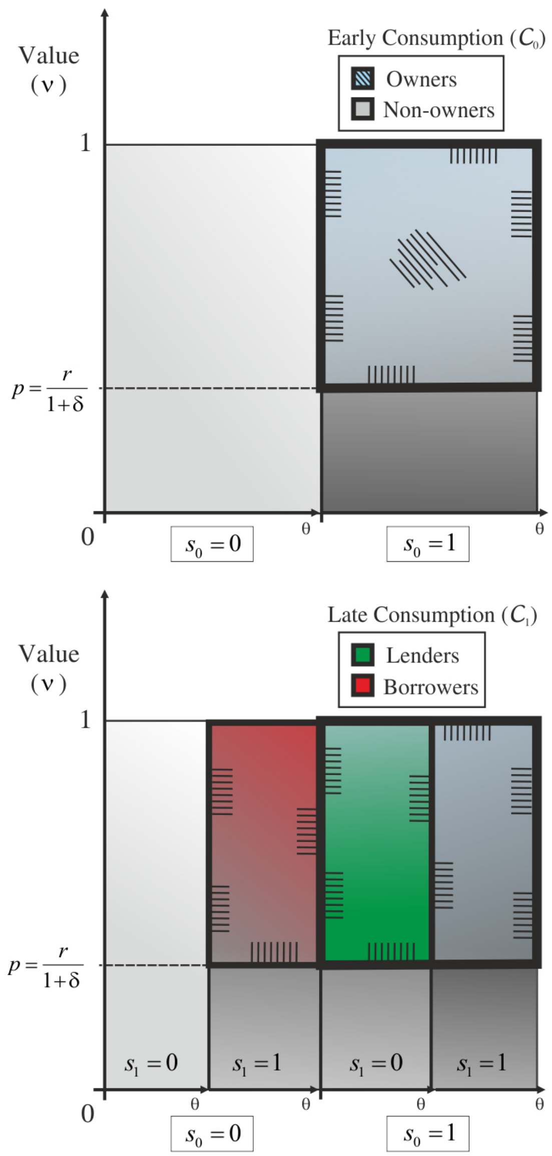

Figure 1: Equilibrium purchasing and sharing behavior in the presence of a sharing market, for both generations.

3. Retail without Sharing Market

In contrast to Section 2., we now assume that the same overlapping generations of consumers do not have access to transactions on a sharing market, and therefore have to make "isolated" consumption decisions, without the possibility of sharing.

3.1. Isolated Retail Consumption

In any given consumption phase, a consumer of type $(\theta, \nu) \in \mathcal{Q}$ can respond to a high-need state in either of his two consumption phases $\mathcal{C}_0$ and $\mathcal{C}_1$ by doing nothing or else by purchasing the product at the price r from the retailer. As before, we backward-induct ownership decisions at the beginning of the agent's lifecycle from the decisions in his late consumption phase.

3.1.1. Purchase in Late Consumption Phase

In $\mathcal{C}_1$, an agent of type (θ, ν) first observes his need state $s_1 \in \{0, 1\}$. As a non-owner, he decides to purchase the product from the retailer if and only if $\nu s_1 \geq r$, resulting in the state-dependent payoff

$$\hat{U}_{s_1} = \max\{0, \nu s_1 - r\}.$$

As an owner, the agent has no choice available as there is no market for sharing, leading to the state-dependent payoff

$$\hat{V}_{s_1} = \nu s_1.$$

The following result summarizes the corresponding payoffs.

Lemma 3. *A type-(θ, ν) agent's isolated $\mathcal{C}_1$-payoffs are $\hat{U}_0 = 0$, $\hat{U}_1 = \max\{0, \nu - r\}$ as non-owner, and $\hat{V}_0 = 0$, $\hat{V}_1 = \nu$ as owner, respectively.*

A payoff difference between owner and non-owner is present only in the high need state. Yet, comparing the agents' payoffs for a fixed retail price r suggests that the presence of a sharing market cannot decrease an agent's payoff, independent of his ownership status and need state.

Lemma 4. *For a fixed retail price, the difference between a type-(θ, ν) agent's $\mathcal{C}_1$-payoffs with and without sharing market is nonnegative. More specifically: $V_0 - \hat{V}_0 = r/(1+\delta)$, $V_1 - \hat{V}_1 = \max\{0, r/(1+\delta) - \nu\}$, $U_0 - \hat{U}_0 = 0$, and*

$$U_1 - \hat{U}_1 = \begin{cases} \max\{0, \nu - (r/(1+\delta))\}, & \text{if } \nu \leq r, \\ (\delta r)/(1+\delta), & \text{otherwise}, \end{cases}$$

for any $r \in (0, 1+\delta)$.

Note that Lemma 4 does not imply that sharing markets are beneficial whenever the retail price is subject to optimization. In Section 4., we show that the presence of a sharing market tends to increase the retail price

3.1.2. Purchase in Early Consumption Phase

In $\mathcal{C}_0$, when taking decisions a type-(θ, ν) agent anticipates his expected payoffs, either as an owner or a non-owner, in his future consumption phase. In the high-need state ($s_0 = 1$), the agent would make an isolated purchase if $v - r + \delta\theta\hat{V}_1 \geq \delta\theta\hat{U}_1$. In the low-need state ($s_0 = 0$), it is clear that the agent would never buy the product because no immediate payoff is available and he will always have the option to purchase in the late consumption phase, should a need for the product arise then. Using Lemma 3, the types seeking ownership in the early consumption phase can be characterized.

Lemma 5. *In $\mathcal{C}_0$, a type-(θ, ν) agent in the need state $s_0 = 1$ becomes an owner in the absence of a sharing market if $\nu \geq r/(1 + \delta\theta)$.*

An equivalent representation for the ownership condition in Lemma 5 is that the probability of need θ exceeds a threshold that is decreasing in an agent's valuation ν:

$$\theta \geq \frac{r - \nu}{\delta\nu}.$$

This condition is automatically (i.e., for all $\theta \in [0, 1]$) satisfied if $\nu \geq r$. However, it cannot be satisfied at all if $v < r/(1 + \delta)$.

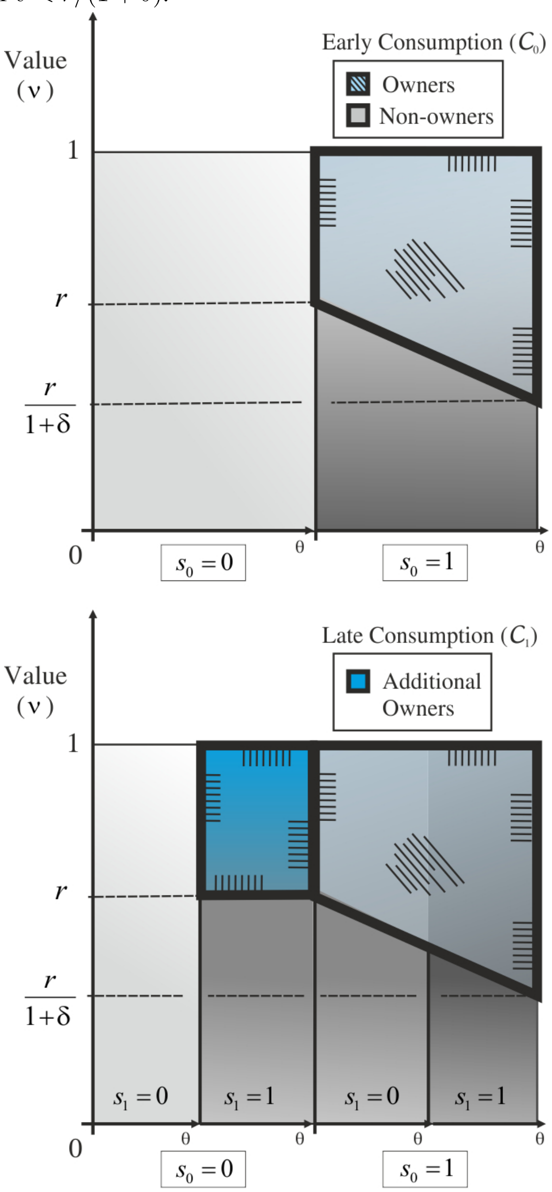

Figure 2: Purchasing behavior without sharing, for both generations.

3.2. Demand for Isolated Ownership

As noted in Section 3.1., without sharing markets ownership can be acquired in the early or late consumption phase. In $\mathcal{C}_0$, the demand for ownership,

$$\begin{aligned}\hat{\Omega}_0 \quad &= \quad \max\{0, 1 - G(r)\}\,\bar{\theta} \\ &\quad + \int_{r/(1+\delta)}^{\min\{1,r\}} \left(\int_{(r-\nu)/(\delta\nu)}^{1} \theta\, dF(\theta) \right) dG(\nu).\end{aligned}$$

depends on the perceived likelihood of future need, at least for intermediate valuations. In $\mathcal{C}_1$, the demand for ownership is

$$\hat{\Omega}_1 = \max\{0, 1 - G(r)\} \int_0^1 (1 - \theta)\theta\, dF(\theta).$$

Thus, the total demand for ownership in the absence of a sharing market becomes

$$\hat{\Omega} = \hat{\Omega}_0 + \hat{\Omega}_1,$$

for any given retail price $r \in (0, 1 + \delta)$.

Example 3. Given a uniform type distribution as in the earlier examples, one obtains

$$\hat{\Omega}_1 = \max\{0, \frac{1 - r}{6}\}.$$

To determine $\hat{\Omega}_0$, note first that for $r \in [0, 1]$:

$$\int_{\frac{r}{1+\delta}}^{r} \left(\int_{\frac{r-v}{\delta v}}^{1} \theta d\theta \right) dv = \frac{r}{2\delta} \int_0^1 \frac{1 - x^2}{((1/\delta) + x)^2} dx$$

is linear in r. The right-hand side of the preceding equation is equal to

$$\left(\frac{1}{2} - \frac{1}{\delta} \left(1 - \frac{\ln(1 + \delta)}{\delta} \right) \right) r,$$

and it is increasing in $\delta \in (0, 1]$. Thus, for $r \in [0, 1]$:

$$\hat{\Omega}_0 = \frac{1}{2} - \left(1 - \frac{\ln(1 + \delta)}{\delta} \right) \frac{r}{\delta}.$$

Similar computations yield

$$\hat{\Omega}_0 = \frac{(r - \delta)^2 - 1}{2\delta^2} - \left(\frac{\ln(r) - \ln(1 + \delta)}{\delta} \right) \frac{r}{\delta},$$

for $r \in (1, 1 + \delta)$. Finally, the demand for the product in the absence of a sharing market becomes

$$\hat{\Omega} = \begin{cases} \frac{2}{3} - \rho r, & \text{if } r \in [0, 1], \\ \hat{\Omega}_0 & \text{if } r \in (1, 1 + \delta), \end{cases}$$

where $\rho \triangleq \frac{1}{6} + \frac{1}{\delta}\left(1 - \frac{\ln(1+\delta)}{\delta}\right) \in [\frac{7}{6} - \ln(2), \frac{2}{3})$ is decreasing in $\delta \in (0, 1]$. $\square$

Example 4. Analogous to Example 2, one can determine the price elasticity of the product demand determined in Example 3:

$$\hat{\varepsilon} = \frac{\rho r}{(2/3) - \rho r}$$

for $r \in [0, 1]$ and $\delta \in (0, 1]$.[8] □

4. Retail Price Optimization

Consider now a monopolist retailer who is able to set the retail price so as to maximize (per-period) profits in the steady state of the overlapping-generations economy. Assuming that the retailer's cost of procurement is linear in the number of products, the corresponding marginal cost c is constant and nonnegative. By the monopoly pricing rule (Tirole 1988), at the optimal rate r the relative markup equals the inverse elasticity (Lerner index):[9]

$$\frac{r - c}{r} = \frac{1}{\varepsilon}.$$

Because the left-hand side of the preceding relation is less than 1, the monopolist retailer sets the optimal retail price in the elastic portion of the demand curve where $\varepsilon \geq 1$. If we denote by r^* and $\hat{r}^*$ the optimal retail price with and without sharing market, respectively, then the last observation implies a lower bound on either one, based on the results in the earlier examples.

Lemma 6. *For any $c > 0$, the optimal retail prices are such that $r^* \geq (1 + \delta)/(2 + \delta)$ and $\hat{r}^* \geq 1/(3\rho)$.*

Interestingly, the lower bound for the retail price in the economy without sharing market exceeds the corresponding lower bound in the economy with sharing market. Provided that $\hat{r}^* \in [0, 1]$, the optimal retail prices can be obtained explicitly.

Proposition 2. *(i) The optimal retail price with sharing market is $r^* = (1 + \delta + c)/2$ for $c \geq 0$. (ii) The optimal retail price without sharing market is $\hat{r}^* = \frac{1}{3\rho} + \frac{c}{2}$, for $c \in [0, 1/2]$.*[10]

We can therefore conclude that the presence of sharing has a unidirectional impact on retail prices.

Corollary 2. *For $c \in [0, 1/2]$ and all $\delta \in (0, 1]$, it is $r^* - \hat{r}^* = \frac{1+\delta}{2} - \frac{1}{3\rho} > 0$, independent of c.*

The difference in the retail prices is increasing in the discount factor; it ranges up to $(6 \ln(2) - 5)/(6 \ln(2) - 7) \approx 0.2961$ (for $\delta = 1$), which corresponds to a price increase of over 42% for a zero-marginal cost good and to a price increase of over 31% when $c = 1/2$. The effects of sharing markets on retail prices can therefore be considered significant.

4.1. Profit Comparison

Let $c \in [0, 1/2]$. Using the results in Proposition 2, the retailer's optimal profit with sharing market is

$$\Pi^* \triangleq (r^* - c)\, \Omega\Big|_{r=r^*} = \frac{(1 + \delta - c)^2}{8(1 + \delta)}.$$

Without sharing market it becomes

$$\hat{\Pi}^* \triangleq (\hat{r}^* - c)\, \hat{\Omega}\Big|_{r=\hat{r}^*} = \frac{(2 - 3\rho c)^2}{36\rho}.$$

The ratio of the profits,

$$\eta \triangleq \frac{\Pi^*}{\hat{\Pi}^*} = \frac{9\rho}{2(1 + \delta)} \left(\frac{1 + \delta - c}{2 - 3\rho c} \right)^2,$$

is increasing (and convex) in c and increasing in δ.

Proposition 3. *For $c \in [0, 1/2]$, there exists $\bar{\delta}(c)$ in $(0, 1)$ such that the retailer's optimal profit is larger with sharing market than without sharing market, for all $\delta \geq \bar{\delta}(c)$. The threshold $\bar{\delta}(c)$ is decreasing in c.*

For $c = 0$, one finds that $\eta > 1$ if and only if δ exceeds $\bar{\delta}(0) \approx 0.7902$, while for $c = 1/2$ it is $\eta > 1$ if and only if δ exceeds $\bar{\delta}(1/2) \approx 0.2646$. The threshold logic also applies in the cost dimension.

Corollary 3. *For $\delta \in (\bar{\delta}(1/2), \bar{\delta}(0))$, there exists $\bar{c}(\delta)$ in $[0, 1/2]$ such that the retailer's optimal profit is larger with sharing market than without sharing market, for all $c \geq \bar{\delta}(c)$. The threshold $\bar{c}(\delta)$ is decreasing in δ.*

As a benchmark, when there is no discounting, i.e., for $\delta = 1$, a sharing market increases the retailer's profit by about 6.5% for zero-marginal-cost products ($c = 0$) and by about 44.1% for high-cost products ($c = 1/2$). Conversely, when there is substantial discounting ($\delta = 1/2$), then the sharing market *reduces* the retailer's profit by about 8% for zero-marginal-cost products and increases the retailer's profit by about 16.8% for high-cost products.

4.2. Ownership Incentives

To compare the retailer's sales with and without sharing market, consider again the case where $c \in [0, 1/2]$. By Proposition 2, the difference in sales volume due to sharing is

$$\Omega\Big|_{r=r^*} - \hat{\Omega}\Big|_{r=\hat{r}^*} = -\frac{1}{12} + \frac{c}{2} \left(\rho - \frac{1}{2(1 + \rho)} \right).$$

Thus, for relatively low-cost products sales, the presence of a sharing market has a negative effect on sales. The effect is amplified as the discount factor increases.

[8] The case where $r \in (1, 1 + \delta)$ is more complicated and has been omitted.

[9] The inverse-elasticity rule generalizes to nonconstant marginal costs, but this complication is omitted here.

[10] The precise interval of validity for c is $[0, (12 \ln(2) - 10)/(6 \ln(2) - 7)] \approx [0, 0.5921]$.

Lemma 7. *For $c \leq 5/11$ (≈ 0.4545), the introduction of a sharing market decreases the retailer's sales, for any discount rate $\delta \in (0, 1]$.*

The bound in Lemma 7 is tight. Indeed, for $c = 1/2$ the introduction of a sharing market increases sales, for discount factors less than about 9%.[11] Overall, the negative effect of sharing on sales for sufficiently low-cost products is somewhat unsurprising, since by Corollary 2 sharing increases prices significantly, independent of the product cost. In parallel to this, Corollary 3 indicates that sharing may improve profitability for sufficiently high-cost products. Yet, for large discount factors, when consumers are sufficiently patient, it is possible that for some costs, sharing decreases sales but at the same time increases retail profits. This reflects the fact that sharing may decrease the demand elasticity, thus outweighing the negative profit impact of the decrease in sales volume by the concomitant increase in price. Because of the possibility to *ex post* transact in the sharing market, the consumers who want to become product owners are more determined to do so than without this possibility of exchange.

5. Conclusion

In the absence of sharing, consumers buy the product when they need it; they become less enthusiastic about purchasing in their late consumption phase when the relatively high retail price has to be justified by the current use. Sharing markets separate the consumers' ownership decisions from their choices about collaborative consumption: the former are taken in the early consumption phase, whereas the latter only arise to correct allocations in the economy. Sharing markets allow owners to earn a rent from an unneeded product, and non-owners in need can benefit from the use value. The clearing price p in the sharing market closely tracks the retail price, so that the retail price r equals the capitalized present value of a lifetime worth of renting the product: $r = (1 + \delta)p$. This prevents arbitrage.

The comparison of the optimal retail prices and profits with and without sharing indicates that sharing markets are attractive for retailers especially for high-cost products and in situations where the future consumption of the product matters in the present. Despite the significant increase of retail prices, the retailer's profit with sharing may increase due to the less elastic consumption behavior of the agents who need the item in the early consumption phase and who are sufficiently likely to need it in the late consumption phase.

[11] The generically ambivalent effect of sharing on sales echoes earlier findings by Weber (2015).

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