Peer-to-Peer Rental Markets: Some Simple Economics of the "Sharing Economy"

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Abstract

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1 Introduction

Peer-to-peer (P2P) rental markets have recently sprung up for a variety of durable goods: examples include cars, lodging, clothing, tools, bicycles, cameras, offices, parking spaces and so on. These new marketplaces are invariably computer-mediated, with the facilitating platform taking steps to reduce the transactions costs that presumably made these kinds of exchanges unprofitable to run in the past. There is a large number of "sharing economy" platform businesses that are customized for the P2P rental of houses, cars, boats, bicycles, tools, cameras, parking spaces, offices, clothes and so on. Perhaps the most prominent example of P2P rental markets is Airbnb, which allows individuals to rent out spare bedrooms, apartments or even entire homes.

These so-called "sharing economy" platforms have been heralded by many: they promise to expand access to goods, diversify individual consumption, increase efficiency by increasing asset utiliziation and provide more ways for individuals to earn income. They might also reduce ownership and therefore offer environmental benefits. Aside from the business interest in these platforms—Airbnb alone has attracted nearly $800 million in venture capital investment[1]—these companies have also attracted policy interest—much of it negative. Critics charge that their primary competitive advantage of these platforms is the ability to duck costly regulations—regulations that often are intended to keep costs from being imposed on third-parties.[2]

The somewhat obvious economic rationale for P2P rental markets is that most durable goods are used by their owners far less than 100% of the time: the excess capacity this under-utilization generates can be "shared" (i.e., rented to) non-owners that still value the good but whose planned usage (or income, storage space, credit rating etc.) prevents them from owning the good. These kinds of trades between consumers have always been possible, but they often have substantial transaction costs. It is perhaps for this reason that much of the sharing of consumer goods historically has been between

*Author contact information, datasets and code are currently or will be available at http://www.john-joseph-horton.com/.
[1] http://www.crunchbase.com/organization/airbnb
[2] See Horton (2014) for a discussion of the externalities imposed by Airbnb-style subletting is rented apartments.

family members and neighbors rather than strangers. The emergence of platform-mediated reputation systems and other trust-building socio-economic technologies (plus in many cases, platform-provided insurance) presumably allow the platforms to reduce the otherwise market-preventing transaction costs inherent in P2P rental.

Despite the simple economic story of increased utilization, it raises several questions: what explains the initial distribution of ownership and non-ownership before the P2P rental market emerges? When it does emerge, what determines the rental rate and size of the market? How much consumer surplus is unlocked and how is it distributed? How does the short-run rental rate—where existing owners rent to non-owners—differ from the long-run in which owners and non-owners alike can revise their ownership decision in light of the existence of a P2P rental market? What is effect of total product market demand—both in terms of market-clearing and elasticity? Can non-consuming firm owners compete in the P2P rental market? What goods are particularly amenable to sharing and why?

This paper addresses these questions using a simple consumer theory model augmented with a survey of consumers about their ownership decisions about various goods and their hypothetical (or actual) usage of such goods. In the model, all consumers consider purchasing some durable good before the possibility of rental. The would-be owner's utility depends on how much the good would be "used" if purchased. This assumption that consumers must consider the time required to use a good in making their consumption plan is similar in spirit to Becker (1965); the possibility of sharing a good is similar in spirit to Varian (2000). Varian (2000) in particular discusses—in the context of information goods—how planned usage affects the rent versus own decision. I assume that goods offer declining—and eventually negative—marginal utility from use.[3] If the utility from the optimal level of usage is greater than the purchase price, the consumer buys the good.

With two consumers "types" three possible market configurations are possible: everyone buys the good, no one buys the good and high types but not low types buy the good. While P2P rental markets can cause all market configurations to change, I start with the "only high-types buy" configuration. I assume that a technological shock creates a P2P rental market that owners did not foresee. This creates a "short-run" P2P rental market in which equilibrium is defined by a rental rate that clears the market among existing owners and non-owners. The rental rate is increasing in the valuation of the high-types (which reduces supply) and the valuation of the low-types (which increases demand). Interestingly, with the P2P rental market, both owners and non-owners use the good as if they were renting the good at the market-clearing rental rate. For renters the reason is that they do face that rental rate; for owners, they now face a marginal opportunity cost of usage, which is also the rental rate. The short-run market does not necessarily clear: if pre-P2P rental excess capacity exceeds demand, there is a glut. In practice, the inherent transaction cost of bringing excess capacity to the market would provide a price floor. I consider effect of transaction costs on the rental market by modifying the model as well as explore how the transaction costs of renting various goods differs though my survey of consumers.

In addition to the short-run, I consider a long-run where owners and renters alike can revise their purchase decisions. If the short-run rental rate is below the purchase price plus the costs of renting, then ownership is less attractive, which will reduce *purchase* demand for product, lowering prices. However, if the rental rate is above the purchase price plus the cost of renting, ownership becomes more attractive, increasing demand and raising purchase prices in the product market. In the long-run, the purchase price must equal the rental rate.

[3] Even in the absence of any direct marginal usage cost, individuals will generally not use a good 100% of the time. For example, a hobbyist guitar owner might play 5 hours a week, but few would play 50 voluntarily and 100 hours a week would hellish for nearly everyone.

In the long-run P2P rental market, both high- and low-types receive the same utility from owning or renting, decoupling individual preference from ownership. In practice, consumer risk-aversion would likely still cause higher-value consumers to be the owners, since a fall-off in market demand can be better absorbed by them though own-consumption (Sinai and Souleles, 2005). The revision in the ownership decision in the long-run potentially affects product market demand.

I show that the existence of a P2P rental market allows for a higher maximum price in a market. In other words, the existence of a P2P rental market can generate positive demand for a good at a price at which no consumer would be willing to buy in the absence of the P2P rental market. On the downside for producers, product markets with an "everyone buys" characterization but for which P2P renting is possible, demand could contact.

The survey was designed to assess the basic assumptions and predictions of the model. Consumers were asked a series of questions about a single good (e.g., a BBQ grill) such as whether they own one, whether they have lent it out or borrowed it and, regardless of whether they own it, how much they would use it. If they did not own it, they were asked why. I also asked questions about how the good in question is characteristically used: it is used in long, predictable blocks of time, or in small, granular chunks that arise unpredictably. Finally, the respondent was asked for their household income. Self-reported income affects the purchase decision, but so does planned usage. For only a small number of goods (e.g., vacation homes) does income seem to be the limiting factor. For other goods, planned usage was primary.

To keep the analysis simple, I initially ignore transaction costs. I modify the basic framework to include these costs and consider how it changes the results. One of the main findings is that when transactions costs are sufficiently high, the P2P rental market cannot exist. This finding suggests that the technological changes—namely the maturation and increasing penetration of the Internet and web-based technologies—were the technological shock that made these P2P rental markets feasible.

2 Consumer's decision about how intensively to use a good

Consider a consumer that has to decide how much of their time to allocate to the use of some purchased durable good. Their money-denominated utility function is

$$u(x) = 2\alpha x - x^2 \tag{1}$$

where $x \in [0,1]$ is the fraction of time they spend using the good and $\alpha \in (0,1)$ parameterizes their valuation of the good. Note that in contrast to a conventional utility function from consumer theory, marginal utility can be negative: since the consumer is using time for use a good, usage precludes the usage of other goods whose value from usage is (eventually) higher. Individual intensive margin demand is

$$x^* = \alpha \tag{2}$$

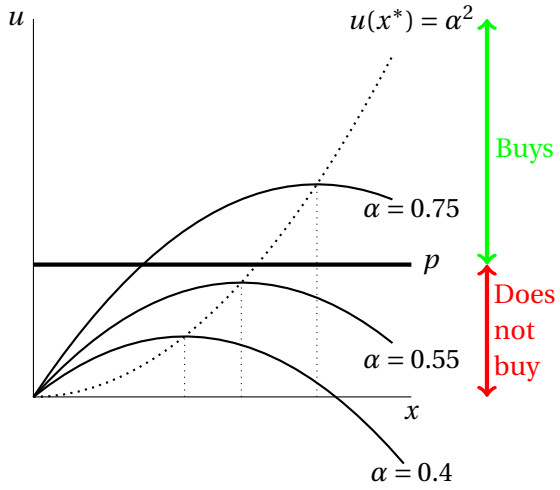
and indirect utility is

$$v(\alpha) = u(x^*) = \alpha^2. \tag{3}$$

The good costs p to own, and so a forward-looking consumer will buy if

$$\alpha^2 > p. \tag{4}$$

Figure 1: Consumer purchase problem



Note that for all $\alpha^2 > p1$, the consumer will have an amount of time $1 - x^*$ when they are not using the good. Figure 1 illustrates the consumer problem by showing the utility from various levels of usage depending on α. The usage solution for each consumer is their α parameter and since indirect utility is just α^2, the optimal usage for each value falls along the curve traced out by x^2. The purchase price p determines who buys the good, with all those having $\alpha^2 > p$ deciding to own and those below choosing not to purchase the good.

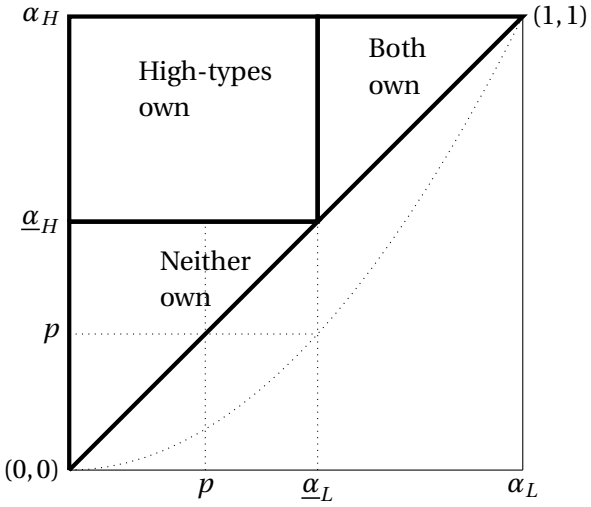
2.1 Three consumption possibilities with two consumer types

Consider a marketplace with two consumer types that are equally common: α_H and α_L with $\alpha_H > \alpha_L$. For a given price p, there are three market possibilities: when $\alpha_L^2 > p$ everyone buys the good; when $\alpha_H^2 > p > \alpha_L^2$, high-types buy the good but low-types do not; when $\alpha_H^2 < p$ no one buys the good. This gives a market demand curve of

$$D(p) = \begin{cases} 0 & : p > \alpha_H^2 \\ 1 & : \alpha_H^2 \geq p > \alpha_L^2 \\ 2 & : p \leq \alpha_L^2 \end{cases} \tag{5}$$

The three market possibilities as they depend upon the values of α_L, α_H and p are shown in Figure 2. The figure shows the space defined by $\alpha_H \in [0,1] \times \alpha_L \in [0,1]$ when $p = \frac{1}{2}$. Since $\alpha_H > \alpha_L$ by definition, we only consider the space about the 45 degree line. The upper-right triangle labeled "Both buy" is the region where both consumer-types buy and the lower-left triangle where neither buy. This area is defined by $\alpha_L^2 > p$ and $\alpha_H^2 > p$. To show the geometry of the problem, the square of the valuation parameter is plotted in a faint dotted line; the associated minimal-but-still-purchasing valuation parameter is shown as $\underline{\alpha}_H$ and $\underline{\alpha}_L$ for the high- and low-types, respectively. The upper left rectangle shows the region where the high-types buy but the low-types do not, while the lower left triangle shows the region where neither buy. We are particularly interested in the rectangle where high-types buy but low-types do not, because in this region, the purchasing high-types have excess capacity ($\alpha_H < 1$) but the low-types still value usage

Figure 2: Three consumer market possibilities in the absence of P2P rental with two consumer types



of the good ($\alpha_L > 0$) despite their non-purchase. In this region, the immediate possibility of mutually beneficial trade exists.

2.2 Short-run P2P rental market equilibrium

We now suppose that through some technological advance, it becomes possible for the high-types to costlessly rent their entire excess capacity to the low-types. As first, we will assume that no one can revise their purchase decisions in light of this advance. Call the resulting equilibrium the "short-run." Before the possibility of rental, the high-types were simply consuming α_H, giving $1-\alpha_H$ to rent out. If they had purchased the good, the low-types would consume α_L. However, with the new possibility of rental, each consumer's decision problem has changed. The new owner optimization problem is

$$\underset{x}{\text{argmax}} \quad 2\alpha_H x - x^2 + \underbrace{(1-x)r}_{\text{Rental income}} - p, \tag{6}$$

whereas the renter optimization problem is

$$\underset{x}{\text{argmax}} \quad 2\alpha_L x - x^2 - \underbrace{xr}_{\text{Rental cost}}. \tag{7}$$

where r is the taken-as-given rental rate. Both decision problems yield the same usage decision,

$$x^*(\alpha_i) = \alpha_i - r/2. \tag{8}$$

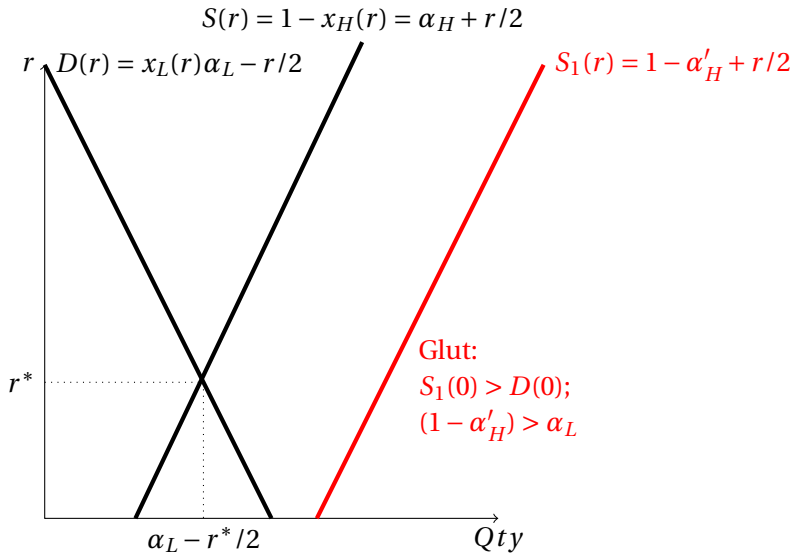
where i indexes consumer type. Let $x_H = x^*(\alpha_H)$ and $x_L = x^*(\alpha_L)$. For the rental market to clear

$$1 - x_H(r) = x_L(r). \tag{9}$$

If the market clears, then the rental rate is

$$r = \alpha_H + \alpha_L - 1. \tag{10}$$

Figure 3: Market clearing with two consumer types in a P2P rental market



Note that if $1-\alpha_H > \alpha_L$, then a negative rental rate would be market clearing. This condition arises when the owner's excess capacity even in the absence of a rental market, $1-\alpha_H$, exceeds the non-owner's demand, $1-\alpha_L$. **In contrast, if all consumers were allocated the good and their cumulative usage, $\alpha_H + \alpha_L$, would exceed the capacity of the actual stock of purchased goods, then a positive rental rate is needed to clear the market.** Figure 3 illustrates market clearing with a positive rental rate and the glut condition. The rental market demand is simply $x_L(r)$, whereas supply is $1 - x_H(r)$. The market-clearing quantity is the optimal consumption of the low-types, $\alpha_L - r/2$. We add a supply curve with a lower α_H value (which moves out the supply curve, in red) such that the offered supply at $r = 0$ exceeds demand, creating a glut. **It is also clear from the figure that if the valuation parameter of either type rises, short-run rental rates increase, as increases in valuation lower supply and increase demand.**

2.3 Social Surplus in the P2P rental market short-run

With the introduction of the P2P rental market there are several welfare-impacting changes: high-type consumption goes down (from $x_H = \alpha_H$ to $x_H = \alpha_H - r/2$) and low-type consumption goes up (from $x_L = 0$ to $x_L = \alpha_L - r/2$). Change in utility for the high-types from reduced consumption is

$$\begin{aligned} \Delta v_H &= \underbrace{\left[2\alpha_H(\alpha_H - r/2) - \alpha_H^2\right]}_{\text{New P2P consumption utility}} - \underbrace{\left[\alpha_H^2\right]}_{\text{Old consumption utility}} \\ &= -\frac{r^2}{4}. \end{aligned} \tag{11}$$

This is obviously negative, but it is compensated by the rental income (which is irrelevant from a social surplus perspective—we will consider the distribution of surplus later). For the low-types, the change in

utility from increased consumption is

$$\Delta v_L = \alpha_L^2 - \frac{r^2}{4}. \tag{12}$$

The total change in consumer surplus from the introduction of the P2P rental market is thus:

$$\begin{aligned}\Delta S &= \Delta v_H + \Delta v_L \\ &= \alpha_L^2 - \frac{r^2}{2} \\ &= \alpha_L^2 - \frac{1}{2}(\alpha_H + \alpha_L - 1)^2.\end{aligned} \tag{13}$$

Figure 4 is a contour plot of change in social surplus from the emergence of the P2P rental market for the space of possible valuation parameters. The figure shows what we might already intuit: higher values of α_L increase the gain in social surplus. Indeed, $\partial \Delta S / \partial \alpha_L = 1 - \alpha_H + \alpha_L > 0$ since $\alpha_H < 1$ and $\alpha_L > 0$. **The more the non-owners value the good, the greater the increase in social surplus from the emergence of P2P rental markets.** The case of α_H is more complex. Recall that a positive rental rate only occurs when $\alpha_H + \alpha_L > 0$. **As such, an increase in the valuation of the high-types reduces social surplus in non-glut P2P rental scenarios:**

$$\frac{\partial \Delta S}{\partial \alpha_H} = 1 - (\alpha_H + \alpha_L) < 0. \tag{14}$$

In Figure 4 the line stretching from $(1,0)$ to $(1/2, 1/2)$ indicates the glut/non-glut boundary. For all points to the right of that line, a higher α_H valuation reduces social surplus. As, such the greatest social surplus is "unlocked" by the emergence of the P2P rental market when both purchasers and non-purchasers have similar and high-valuations. In terms of the figure, the highest obtainable social surplus values for a fixed $\alpha_H + \alpha_L$ run along the 45 degree line that indicates $\alpha_H = \alpha_L$.

For simplicity, I have ignored income effects as a cause of the pattern of ownership. However, for goods where income effects are important in the consumer's ownership decision problem, the $\alpha_H > \alpha_L$ requirement would no longer hold and potentially larger gains in social surplus would be unlocked by the P2P rental market emergence.

2.4 Long-run P2P rental equilibrium

In the long-run equilibrium, all parties can revise their ownership decisions. The utility from owning is

$$v_i^{OWN} = 2\alpha_i x_i - x_i^2 + (1 - x_i) r_{LR} - p \tag{15}$$

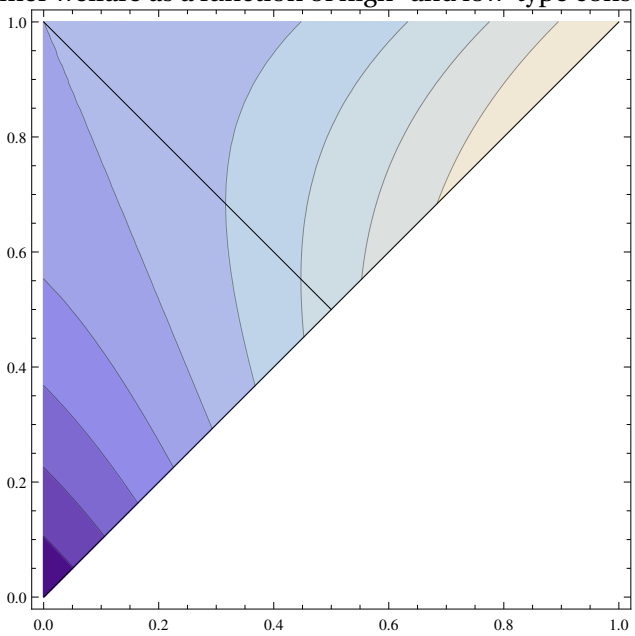
whereas the utility from renting is

$$v_i^{RENT} = 2\alpha_i x_i - x_i^2 - x_i r_{LR} \tag{16}$$

where r_{LR} is the market-clearing long-run rental rate. The first order condition in both choices is $2\alpha_i - 2x_i - r_{LR} = 0$ and so $x^* = \alpha_i - r_{LR}/2$. Computing the indirect utility for both decisions, we have

$$v^{OWN} = \alpha_i^2 - p + \frac{r_{LR}^2}{4} + (1 - \alpha_i) r_{LR} \quad \text{and} \quad v^{RENT} = \frac{1}{4}(r_{LR} - 2\alpha)^2. \tag{17}$$

Figure 4: Consumer welfare as a function of high- and low-type consumer valuations



Setting $v^{OWN} = v^{RENT}$ to find the conditions under which a user would be indifferent between renting and owning, the α_i term drops out and we are left with

$$p = r_{LR}. \tag{18}$$

In the long-run P2P rental equilibrium, the rental rate equals the product market purchase price and ownership does not depend on usage patterns or valuation.

For this new market to clear, we have to determine what fraction of consumers choose to own. Let f be the fraction of consumers that purchase the good in equilibrium. As ownership does not depend on valuation, we assume that both consumer types are equally likely to own. For the market to clear,

$$\left[(1 - x_H(p)) + (1 - x_L(p))\right] f = \left(x_H(p) + x_L(p)\right)(1 - f) \tag{19}$$

which simplifies to

$$f = \frac{x_H(p) + x_L(p)}{2}. \tag{20}$$

The fraction of consumers owning in the long-run is the average usage rate in the population. In this long-run P2P rental equilibrium, even though both types own, we might expect in practice for higher-valuation types to be the ones to own, as they can better bear the risk in the rental rate, ala Sinai and Souleles (2005).

In the long-run P2P rental market equilibrium, there are no profits from owning to simply rent-out. However, owners and non-owners alike get a surplus. **This suggests that firms that derive no consumption value from the good can not compete in a competitive market: because the consumer has excess capacity after satisfying their own consumption, they can "profitably" sell their excess capacity at any price and still have positive utility.** A firm owning simply to rent would make zero profit. There is already perhaps some evidence that P2P rental markets are adversely affecting traditional firms: Byers

et al. (2013) find that Airbnb is already winning customers from hotels catering to the lower-end of the market.

2.5 Product market demand in the long-run P2P rental market equilibrium

Most commentators considering the sharing economy have often implicitly assumed that ownership would be reduced under full sharing, the intuition being that there is some fixed amount of demand for some good and that when idle goods are pulled into the market, demand can be met with a smaller total number of goods. **This is not the case: ownership would increase if the product market price was below the rental rate.** Intuitively, when the short-run rental rate is creater than the purchase price, a consumer could buy the good at p and rent out the entire capacity for r and since $r > p$, earn a profit.

To see this algebraically, first consider that in the long-run P2P equilibrium, the new product market demand curve, D_1, is

$$\begin{aligned} D_1(p) &= 2f \\ &= x_H(p) + x_L(p) \\ &= \alpha_H + \alpha_L - p. \end{aligned} \tag{21}$$

In the pre-sharing product market, $D_0(p) = 1$ since all of the high-types purchased the good. Let r_{SR} be the short-run rental rate, which we recall from Equation 10 is just $\alpha_H + \alpha_L - 1$. If demand is higher after the long-run P2P equilibrium emerges, then

$$\begin{aligned} D_1(p) &> D_0(p) \\ \alpha_H + \alpha_L - p &> 1 \\ \alpha_H + \alpha_L - 1 &> p \\ r_{SR} &> p. \end{aligned} \tag{22}$$

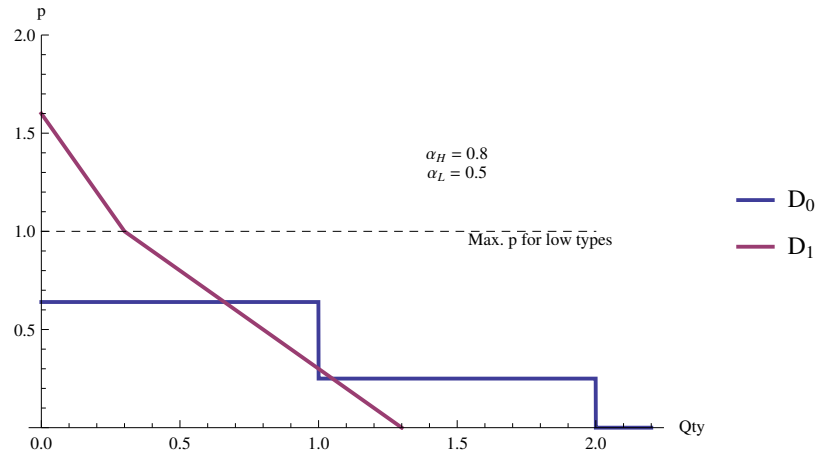
If the market-clearing short-run rental rate is above the purchase price, ownership will increase, otherwise decrease. Practically speaking, this is likely to occur in situations where there are high valuations from both consumer types (making demand high and supply tight) as well as relatively low purchase prices, which make ownership more attractive.

2.6 Long-run P2P equilibrium product market demand versus the original "no sharing" demand

Previously, there were "kinks" in the product market demand curve at α_H^2 and α_L^2. In the long-run P2P rental equilibrium, product demand now varies continuously, with $D(p) = x_H(p) + x_L(p) = \alpha_H + \alpha_L - p$ when both consumer-types participate. Figure 5 illustrates the new product market demand curve, with the pre-P2P rental market curve indicated as D_0 and the post-P2P rental market by D_1. One thing to note is that a higher product market price is supportable: the demand curve D_1 is non-zero for a range of prices for which D_0 is zero.

Recall that in the pre-P2P rental market with two consumer types, if $p > \alpha_H^2$, then no one bought the good. **A P2P rental market in long-run equilibrium can support a higher product market price than pre-rental.** Intuitively, if a would-be owner can earn rental income from their unused portion, it seems likely that a higher product market price is supportable. The highest possible price that can support a market pre-P2P rental is $\bar{p}_0 = \alpha_H^2$. In the long-run P2P market, $D(p) = \alpha_H + \alpha_L - p$, and so $\bar{p}_1 = \alpha_H + \alpha_L$.

Figure 5: Product market demand pre-P2P rental market and post-P2P rental market (long-run)



Since $\alpha_H > \alpha_H^2$ and $\alpha_L > 0$, $\bar{p}_1 > \bar{p}_0$: the existence of a P2P rental market can support a higher product market price.

The portion of D_1 that is non-zero where D_0 is not straight—it is actually kinked at $p = 2\alpha_L$. **The reason for this kink is that if $2\alpha_L < p$, the low-types do not use the good in the long-run P2P equilibrium.** The reason is simple: if $p > 2\alpha_L$, usage of the good offers negative utility from any amount of usage and so the low-types use none. If $p > 2\alpha_L$, then the long-run P2P equilibrium is one in which the high-types simply trade with themselves, creating a market demand of just $D(p) = \alpha_H - p/2$. **The model suggests the possibility of a transitory short-run phase in which low-types get access that disappears once former-owners become renters and bid up rental rates until low-types would get no usage utility at the market rental rate.**

2.7 Long-run P2P rental market consumer surplus when both consumer types use the good

If both high- and low-types participate in the long-run P2P equilibrium, social surplus is

$$\begin{aligned} S_1 &= \frac{1}{4}(p - 2\alpha_H)^2 + \frac{1}{4}(p - 2\alpha_L)^2 \\ &= \alpha_H^2 + \alpha_L^2 - p(\alpha_H + \alpha_L) + \frac{p^2}{2} \end{aligned} \tag{23}$$

whereas in the pre-P2P rental market it was

$$S_0 = \alpha_H^2 - p. \tag{24}$$

The long-run social surplus from the introduction of the P2P rental market is

$$\Delta S = S_1 - S_0 = \alpha_L^2 + (1 - \alpha_L - \alpha_H)p + p^2/2. \tag{25}$$

From the requirement that $\alpha_L^2 < p < \alpha_H^2$ and the assumption that the low-type still consumes some of the good in equilibrium ($2\alpha_L > p$), we can show that $\Delta S > 0$. **We can also show that social surplus from the long-run P2P rental market is increasing the low-type valuation, or $\Delta S'(\alpha_L) > 0$, again because $2\alpha_L > p$. For the high-types, $\Delta S'(\alpha_H) = -p < 0$, and so the social surplus from sharing is reduced when the high-types have a higher valuation.**

2.8 Transaction costs

In practice, the utilization of a good—even with an efficient P2P rental market—will be far less than 100%. Setting up trades, making repairs, transporting goods and so on all take time. Furthermore, even durable goods are consumed more quickly when used more intensively.

There are several ways one could model these kinds of costs. For utilization, one approach is to simply re-define what is the unit of time available and the corresponding α. For example, we might think of a the unit of time for a vacation home on a ski slope to be 4 months, with high-types wanting to take three week vacations and low-types one week vacations and one week in total lost to cleaning and maintenance. For transaction costs, we could think of owners in the P2P rental market has facing a cost of c that captures both the transaction costs of listing on a market, finding trading partners and so on, as well as the cost from increased usage that leads to either more extensive or more frequent repairs or faster replacement. In the short-run P2P equilibrium, c provides a price-floor in the rental market. In the long-run P2P equilibrium, the rental rate "includes" these costs, with $r_{LR} = p + c$.

If c is sufficiently high, then no P2P rental market will exist in either the short- or long-run: many goods have "missing" rental markets despite generating usage far below 100% because the rental rate r required to cover the added transaction costs of renting would be too high to create a viable market. Goods that have unpredictable usage patterns would be particularly poor rental candidates. It is only with the emergence of computer-mediate platforms that seem to dramatically reduce transaction costs that a P2P rental market has emerged for some of these goods. Before these markets sprung up, simply finding an appropriate trading partner would be difficult, to say nothing of coming to terms, writing a contract, monitoring compliance, handling disputes, making payment and so on.

3 The attributes of goods and the feasibility of renting

The model abstracts away from the nature of the good, but it is described by several parameters that characterize the nature of the good: the purchase price, p, the usage valuation, α, and the transaction cost of renting, c. If we look to what goods are currently commonly rented now, we get a sense of what makes something amenable to renting: relatively low α, high p and low c, or expensive goods that are used infrequently but predictably and are not wholly consumed by usage. Examples include cars and hotels in distant cities, tuxedos, certain kinds of specialty tools (e.g., rototillers, carpet shampoers) and so on. The conditions necessary for the P2P rental market are similar, except that we also need some stock of owners and non-owners.

The usage of some goods cannot be cleanly divided into large chunks of time. Some goods, even if used rarely in total, are used intermittently. For example, a fly-swatter generally is not used very often (giving lots of $1 - x$), but when it will be used is highly unpredictable. For a high-priced example, a gas-powered back-up generator is used infrequently but would be difficult to rent in a P2P market, as demand is likely to be correlated in space and time. Other goods can be nicely divided: it is easy for one family to use a vacation home one week while another family uses it another week. Goods with predictable or easily adjustable usage patterns are more amenable to be P2P rental.

When product market prices are so low that nearly everyone buys the product, no P2P rental market can exist even when usage is low. For example, there is no rental market in kitchen timers—although they are used infrequently and quite durable, there is neither supply (no one owning finds it worth the trouble to rent them out) nor demand (if one wants one, they go to the product market and buy one). Other goods are expensive but there is no excess capacity, as they are used more or less continuously.

This is why there is no P2P rental market in dentures.

To move beyond the casual empiricism of considering what rental markets might be like for various goods, I conducted a consumer survey on Amazon Mechanical Turk. The survey focused on questions about consumer decision-making and usage patterns for a variety of goods. While far from being nationally representative, this MTurk population is useful for two reasons. First, because it is easy to pay for small amounts of work, it easy to keep incentives high for even a very long survey. Second, because the MTurk population is willing—and has incentives to—carefully answer a tedious set of questions, they are less likely to "pencil whip" the survey. Workers on MTurk who have their work "rejected" by dissatisfied employers become ineligible for the best, highest-paying kinds of work on the marketplace and as such show a high level of diligence. This respondent diligence makes it useful for certain kinds of questions (c.f., Kuziemko et al. (2013)). Finally, although MTurk is a convenience sample, there is no strong reason to think they would have highly idiosyncratic consumption patterns.

3.1 Design and administration of the survey

I hired US-based "Master" workers to answer a questions about a consumer good, e.g., BBQ grill, pick-up truck, men's suit, toothbrush etc. I asked them: whether they owned the good; whether they had ever rented or lent out the good; how much they would use the good *regardless* of whether they actually owned the good; their reasons for not owning the good; whether they would use the good in one large chunk or many small chunks; whether usage was predictable; why they did not own the good; and finally, what was their household income. See Appendix A for the full list of goods as well as the actual survey questions and answers. Each "human intelligence task" or HIT was about one particular good. Workers were allowed to answer for each of the 20 goods.

3.2 Ownership and renting patterns

For each good, the respondent was asked whether their household owns such a good. Figure 6 shows the fraction of respondents reporting owning various goods. There are few surprises: nearly everyone owns a toothbrush, a hammer and a blender; no one reported owning a jet ski and only one reported owning a vacation home. Figure 7 shows the fraction of respondents reporting having rented the various goods. **Generally, ownership and renting appear to be gross substitutes, with the notable exception of cars (presumably because people rent cars when traveling).**

Figure 8 plots the fraction of respondents reporting having rented a good versus the fraction owning, on a square-root scale. There is generally a negative relationship between owning and renting. Goods that are used during special occasions like weddings, celebrations and vacations show the highest rates of rental and lowest rates of ownership, e.g., tuxedos, vacation homes, jet ski, tuxedos, canoe's, bouncy castles. There may also be some evidence of expensive tools useful for one-off jobs being rented, such as an electric generator and a pick-up truck. Unsurprisingly, goods with nearly universal ownership show little renting with the notable exception of cars, which are both owned and rented at high rates, presumably because people rent cars when traveling. **There are a number of goods (not all labeled) that show medium ownership levels (e.g., around 50%) and yet zero recorded instances of renting.**

To confirm the visual pattern of renting declining in ownership, I report the results of two OLS regressions of the form

$$\text{FracRent} = \beta_0 + \beta_1 \text{FracOwn} + \epsilon, \tag{26}$$

Figure 6: Fraction of respondents owning various goods

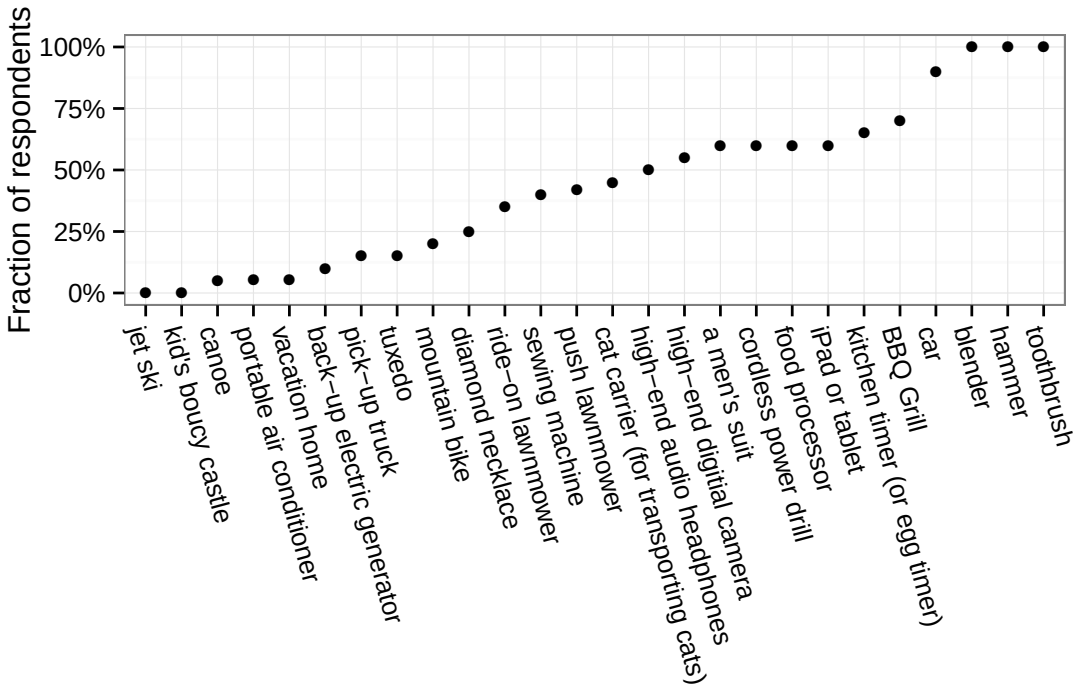


Figure 7: Fraction of respondents reporting having rented various goods

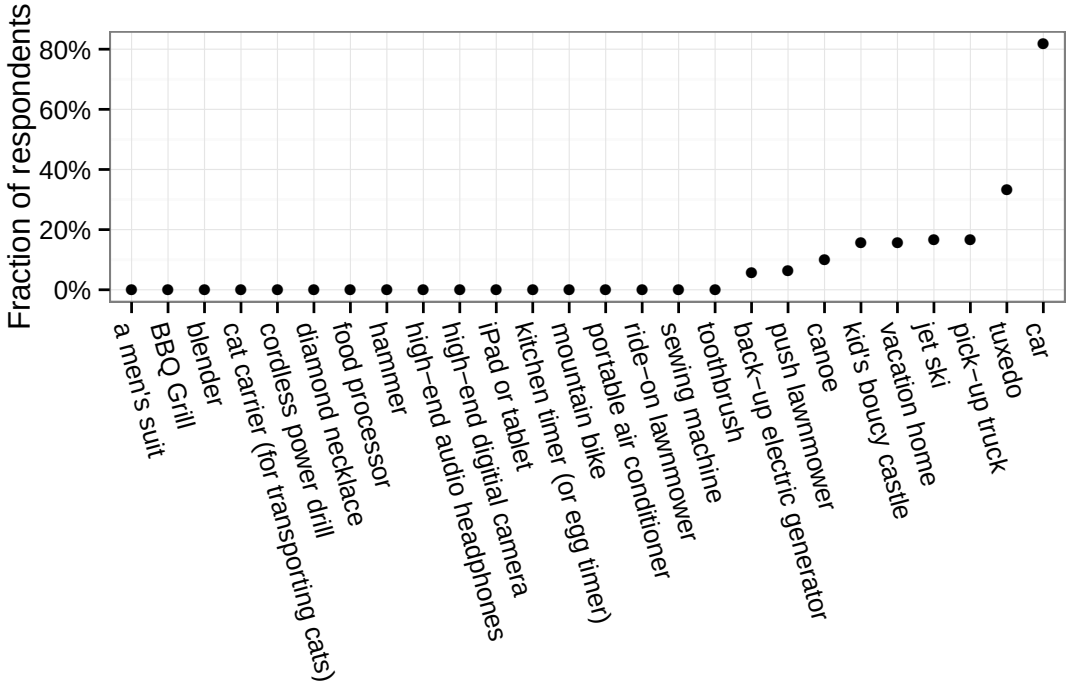
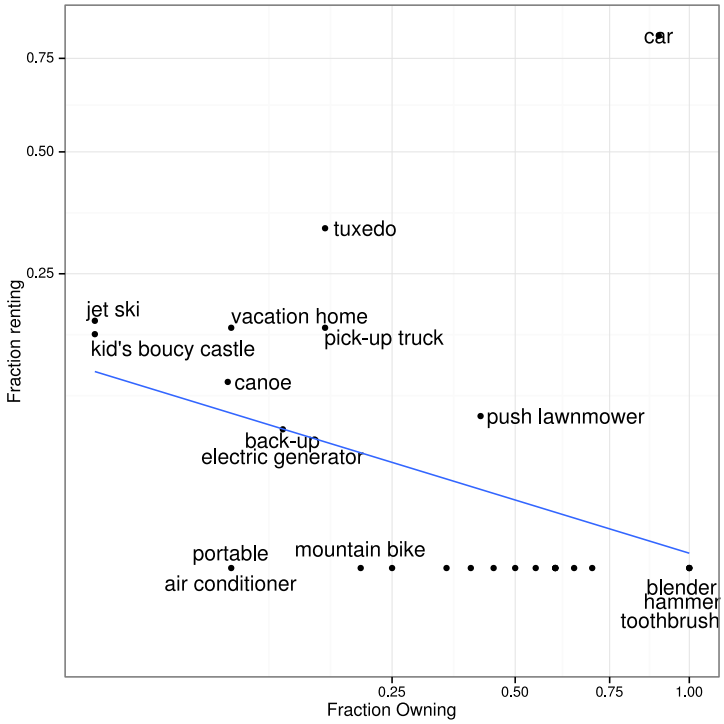


Figure 8: Fraction renting versus fraction owning



where FracOwn is the fraction of respondents claiming to own the good and FracRent as the faction claiming to have rented the good. Table 1 reports the estimated regression of this equation, with cars included in Column (1) and cars excluded in Column (2). **We can clearly see the importance of cars in the overall pattern: while both regression estimates have a negative slope, the effects are much stronger when cars are excluded.**

3.3 Ownership and usage

In the model, consumers considered how much they would use some good and compared the utility this level of usage would bring them against the purchase price. The model predicts increasing ownership in estimated usage. To elicit usage, I asked respondents to select how often they would use a good in time units, using familiar measures of time e.g., 1 hour a week, 1 hour a day and so on. I framed the time units as being approximately on a logarithmic scale, with each increase in usage being about a doubling of the fraction of time.

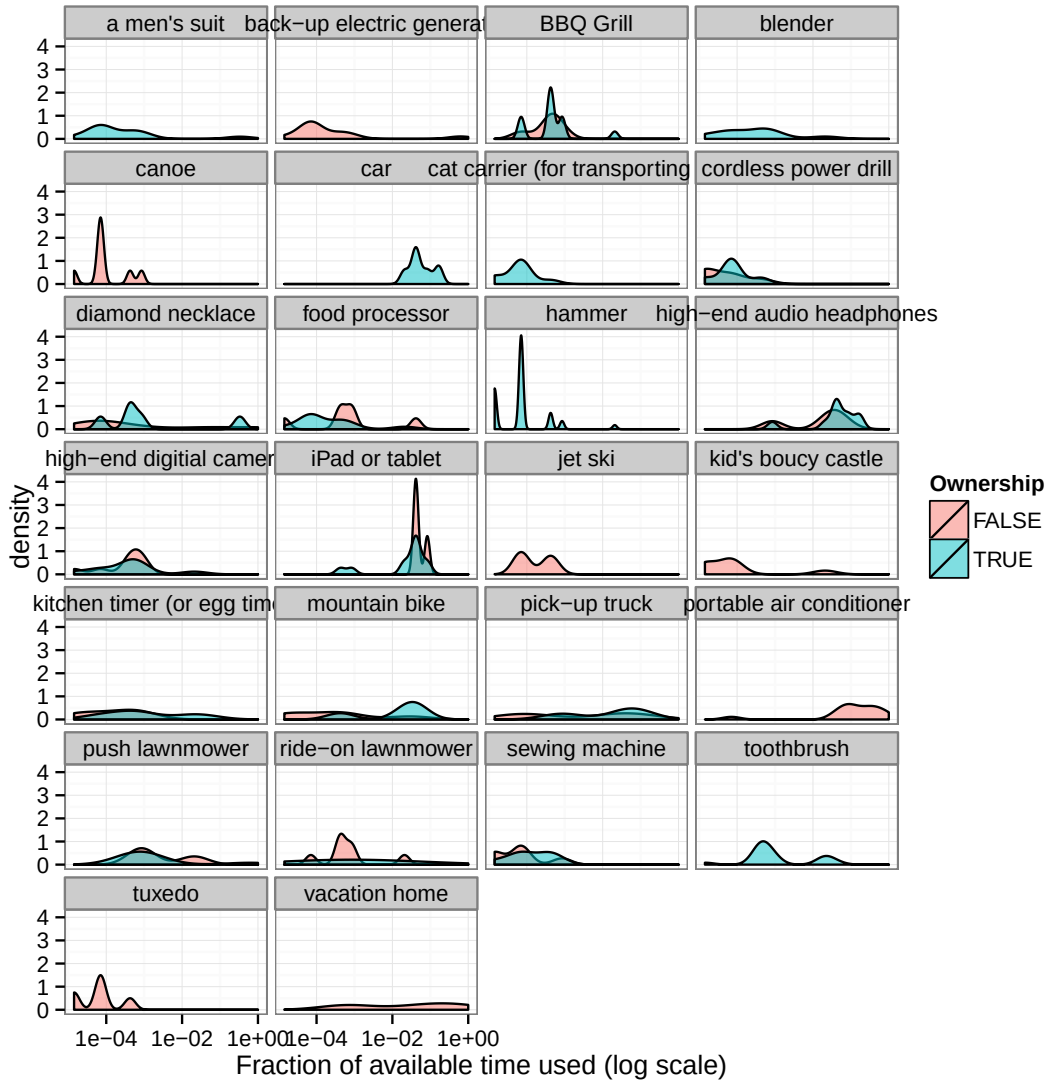
In Figure 9, I plot the kernel density estimates of log usage (as fractions of time) for owners and non-owners, with those saying no usage at all excluded. Because ownership fractions differ substantially across goods, a density estimate is not always possible for both owners and non-owners. Even when it is, one is often far less precise than the other. For some goods with both, there does seem to be a right-shifted usage distribution among owners: the power drill, the diamond necklace, the high-end headphones, the mountain bike, the pick-up truck and perhaps the sewing machine. However, the food processor and perhaps the tablet and the push lawn-mowers show an alternate pattern. A limitation of this graphical approach is that it fails to account for any income effects.

Table 1: Fraction of respondents owning a good versus fraction having rented a good

	Dependent variable:	
	Rental Fraction	
	All goods	Cars Excluded
	(1)	(2)
Ownership Fraction	−0.009	−0.160***
	(0.109)	(0.046)
Constant	0.081	0.115***
	(0.059)	(0.024)
Observations	26	25
R^2	0.0003	0.345
Adjusted R^2	−0.041	0.317
Residual Std. Error	0.176 (df = 24)	0.071 (df = 23)
F Statistic	0.006 (df = 1; 24)	12.127*** (df = 1; 23)

Notes: The unit of observation for the regressions in this table is the individual good. The dependent variable is the graction of respondents reporting having rented that good, while the indendent variable is the fraction reporting owning that good. Column (1) includes all goods surveyed, while Column (2) excludes cars. For the full list of goods and the survey langugage, see Appendix A. Significance indicators: $p \leq 0.05 : *$, $.p \leq 0.01 : **$ and $p \leq .001 : ***$.

Figure 9: Usage by ownership, by good



I examine the graphical relationship shown in Figure 9 by regressing the ownership indicator on usage. In Column (1) of Table 2, I report a regression where an ownership indicator is simply regressed upon log fraction of usage,

$$\text{own}_{ig} = \beta_0 + \beta_1 \log x_{ig} + \beta_2 1 \cdot \{x_{ig} = 0\} + \mu_g + \epsilon_{ig}. \tag{27}$$

where and indicator is included for the cases when x_{ig} is exactly zero (a dummy value replaces $\log x_{ig}$ in the design matrix) and μ_g is a good-specific effect (random in Column (1) and fixed in Column (2)). Aside from the difficulty in transforming a highly-skewed x distribution that contains zero, treating the $x = 0$ case separately with its own indicator seems sensible in our context, as this response is qualitatively different from the other answers, which have some positive amount of usage.

We can potentially get a more precise estimate of the effects of usage differences on ownership by controlling for some other sources of variation in ownership. First, the nature of the good being affects the probability of ownership independent of the respondent's estimated usage. Second, different goods presumably have different income effects. To capture these sources of variation, in Column (3) I estimate

$$\text{own}_{ig} = \beta_0 + \beta_1 \log x_{ig} + \beta_2 1 \cdot \{x_{ig} = 0\} + \mu_g + \beta_g \text{IncomeIndex}_i + \epsilon_{ij} \tag{28}$$

where μ_g is a good-specific random effect and β_g is a good-specific slope on the respondent's income index (the standardized mean of their income response—see Appendix A for the bins). Column (3) of Table 2 reports the estimate of Equation 28.

importantAs the model predicts, higher estimate usage predicts ownership, even when we exclude individuals who said they would have no usage the good at all. The coefficient on log usage is approximately the same across specifications, with somewhat more precise estimates offered when controlling for income effects. As we would expect, individuals claiming they would not use the good at all are far less likely to own the good. While it increases precision, accounting for income effects as in Column (3) seems to have little effect on the estimates. The absence of strong income effects is puzzling, as some of the goods in question are clearly normal goods (e.g., high-end audio headphones). We can partially investigate this finding by examining by-good the reasons give for non-ownership.

In the survey, non-owners were asked for there reasons for not owning the good: "If you do not own a **good**, what is the primary reason?"

- NA - we own one.
- We wouldn't use it enough to justify the purchase price
- We would use it, but we simply do not have the money.
- I don't have the space for this item

Figure 10 shows the fraction of respondents selecting among the reasons given for non-ownership of a good. For each point estimate, a 95% confidence interval is shown (when possible) using the Wilson method. Given that some items are nearly universally owned, presenting uncertainty using standard confidence intervals would regularly exceed 1 or go below 0 otherwise. The only goods where income-effects are the primary explanation (and non-ownership is not trivial) are the car, the audio headphones, and the vacation home (strongly so). In nearly all the other goods, the response about too little usage to justify the purchase was paramount. Interestingly, the goods that to date have seen the most successful P2P rental markets merge are those for cars (e.g., RelayRides, UberX) and housing (Airbnb).

Table 2: Estimated product usage and ownership

	Dependent variable:		
	Item is owned		
	linear mixed-effects Good and Consumer REs	*felm* Good FEs	*linear mixed-effects* (1) + Good-specific income slope
	(1)	(2)	(3)
Log frac. usage, $\log x$	0.019^{**}	0.022^{**}	0.020^{**}
	(0.009)	(0.011)	(0.008)
No Use indicator, $1 \cdot \{x = 0\}$	-0.582^{***}	-0.592^{***}	-0.605^{***}
	(0.096)	(0.128)	(0.095)
Constant	0.663^{***}		0.663^{***}
	(0.084)		(0.086)
Observations	524	524	519
R^2		0.510	
Adjusted R^2		0.482	
Log Likelihood	-245.829		-233.007
Akaike Inf. Crit.	501.657		482.014
Bayesian Inf. Crit.	522.964		516.029
Residual Std. Error		0.359 (df = 496)	

Notes: This table reports regressions of an indicator for whether a respondent reported owning a good on that same respondent's estimate of how much they would use that good. In Column (1), I estimate a multi-level model with good-specific random effects. In Column (2), I instead use good-specific fixed effects and cluster at the good level. Equation 27 shows the estimated equation for Columns (1) and (2). In Column (3), I re-run the estimate from Column (1) but also allow for random slope on the respondendent's income index, as per Equation 28 shows the estimated equation for Column (3). Significance indicators: $p \leq 0.05 : *$, $.p \leq 0.01 : **$ and $p \leq .001 : ***$.

Figure 10: Reasons given for non-ownership

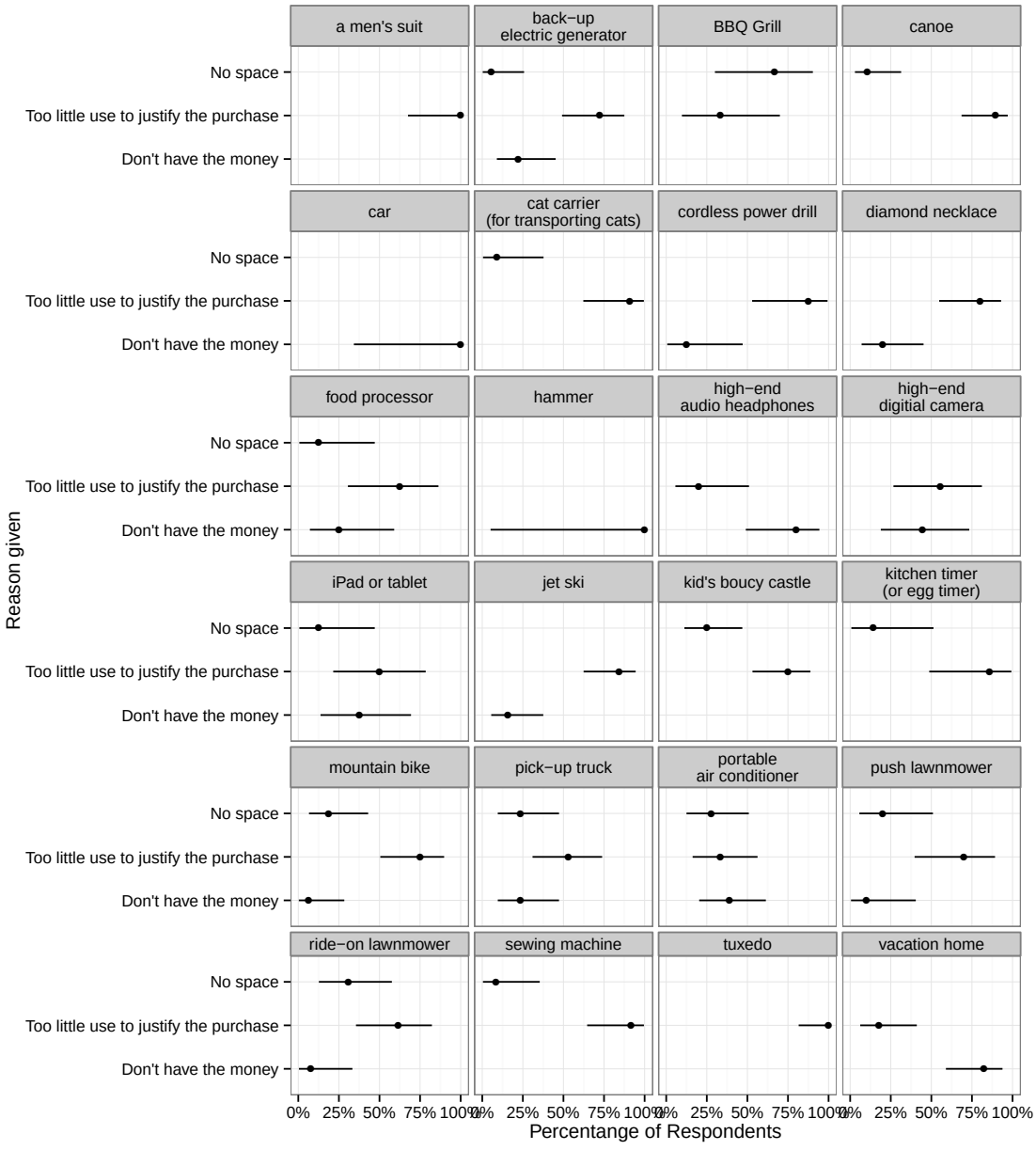
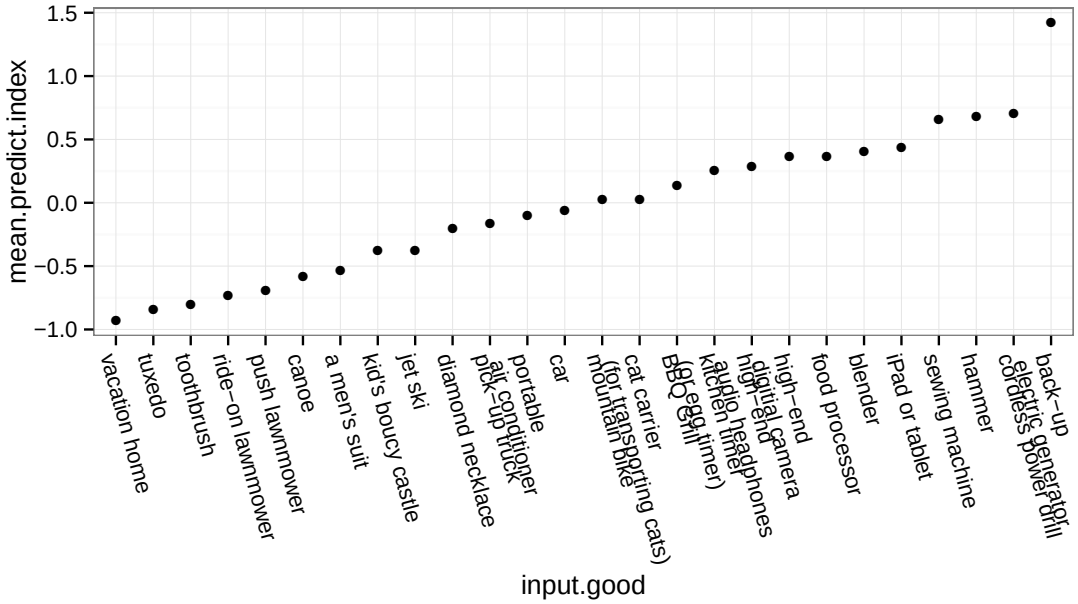


Figure 11: Mean unpredictability index by good



3.4 Good attributes and usage patterns

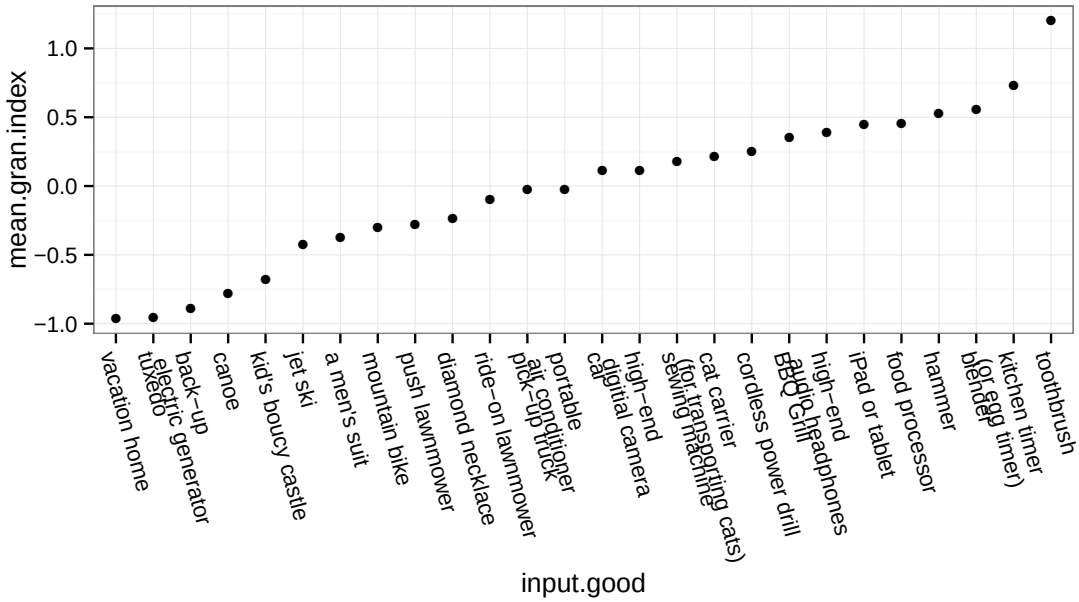
In addition to price and planned usage, goods differ in the predictability and granularity of that usage. Goods with highly predictable usage patterns might be easier to rent (or lend out), whereas goods that have unpredictable usage patterns would be difficult to lent without substantial utility loss to the owner. Similarly, for goods that are used in numerous small sessions, renting or lending out the good to others would create high transaction costs. Respondents were asked to rate the unpredictability of usage on a 1-5 scale (1 was highly predictable and 5 was highly unpredictable) as well as granularity (1 was low granularity—one big chunk— and 5 was high granularity—lots of little chunks).

The mean scores by good seem reasonable and intuitive: Figure 11 shows the mean unpredictability index per good. The most predictable goods are either those associated with planned recreation (e.g., vacation home, canoe, jet ski, tuxedo) or predictable chores (e.g., toothbrush, the two kinds of lawnmowers). The most unpredictable goods are associated with either food preparation (e.g., blender, food processor) or repairs (e.g., hammer, sewing machine, cordless power drill). Back-up electric generator is a clear (and unsurprising) outlier—you are in a sense always surprised when you need to use it.

Figure 12 shows the mean granularity index per good. There appears to be some similarity in high predictable usage, but some goods with very granular usage also appear to have highly predictable usage—namely the toothbrush. To make this relationship explicit, in Figure 13 the granularity and unpredictability indices are plotted against each other. **With the exception of two goods—the toothbrush and back-up generator—unpredictability and granularity are strongly positively correlated.**

To test whether these unpredictability/granularity measures are related to ownership, in Table 3, I report regressions of the ownership decision on the respondent's granularity and unpredictability scores. I include worker-specific random-effects in each regression. **Goods with unpredictable and highly granular usage are substantially more likely to be owned.** In Column (1), we see that the less predictable perceived usage, the more likely the good is to be owned. In Column (2), the more granular usage is, the

Figure 12: Mean granularity index by good



more likely the good it to be owned. Column (3) shows that both measures still have a positive relationship with ownership but that there is no strong interaction effect between the two measures.

4 Discussion and conclusions

The model and the survey complement are designed to complement each other in two ways. First, the survey provides justification for some of the modeling conventions, such as making planned usage the primary explanation for the pattern of ownership rather than "taste" or income. This is not to say that income effects do not matter when explaining purchases, but rather that they give an incomplete picture—particularly for relatively inexpensive goods. Second, the survey offers a partial decomposition of the non-specific "transaction costs" that would make a good difficult or easy to share. P2P rental markets are now possible in part because technology has reduced transaction costs, but such markets have not emerged for all goods. The survey results suggest that those goods with unpredictable and highly granular usage might not support a P2P rental market even if too total usage is small. However, it also suggests that innovations that make usage more predictable might change this calculus. As with all models, much was left out. However, there are "predictions" that follow from the logic of the model, if not the formal set-up.

One area where P2P rental markets could have a long-term effect is on the diversity of goods consumed. For example, they might "convexify" consumption, with consumers renting a variety of goods that are horizontally differentiated. Consider that in some formulations of the consumer problem, consumers consume some positive amount of every good offered. This is obviously a large departure from empirical reality if we draw find-grained distinctions between "goods." For example, Amazon.com currently lists 6,238 results for "blender" in the Home & Kitchen category: presumably most households own far fewer than this, with most owning one or none. The reason for this pattern in the language of

Figure 13: Usage predictability versus granularity

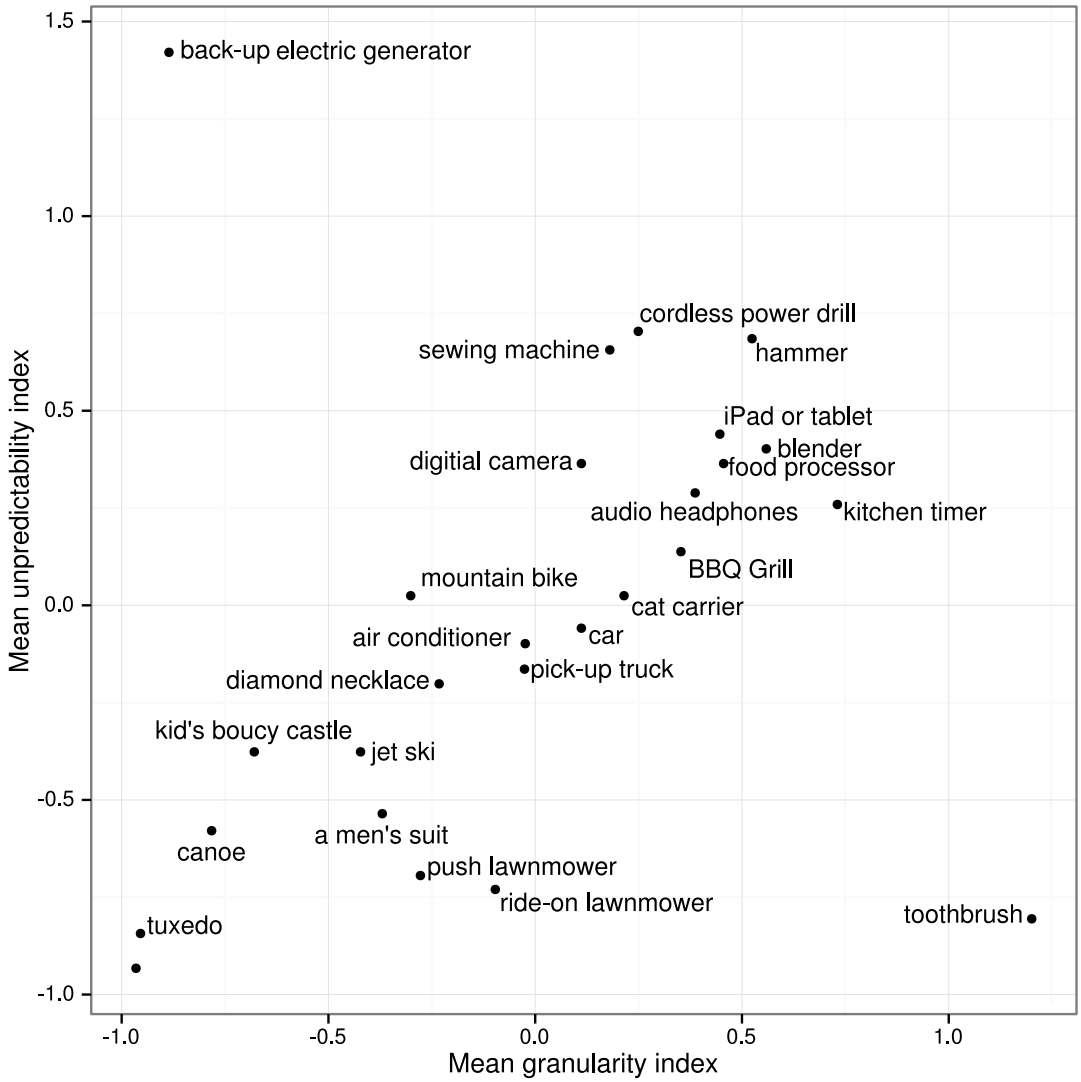


Table 3: Good attributes and ownership—usage predictibility and granularity (toothbrush and electric generator excluded)

	Dependent variable:		
	Item is owned		
	(1)	(2)	(3)
Unpredictability index (UI)	0.123^{***}		0.090^{***}
	(0.023)		(0.026)
UI x GI			-0.008
			(0.021)
Granularity index (GI)		0.121^{***}	0.080^{***}
		(0.023)	(0.025)
Constant	0.453^{***}	0.450^{***}	0.454^{***}
	(0.031)	(0.032)	(0.033)
Observations	491	494	489
Log Likelihood	-343.392	-346.230	-342.063
Akaike Inf. Crit.	694.785	700.460	696.126
Bayesian Inf. Crit.	711.570	717.270	721.280

Notes: This table reports regressions of an indicator for whether the respondent owns a good on that same respondent's estimates of the unpredictability and granularity of usage for that good. The two indices are just standardized (mean 0, standard deviation 1) of the 1-5 scale on granularity and predictability. See Appendix A for the actual survey language and responses. In each regression, worker-specific random effect is included.

this model is clear: a consumer's α for Blender 2 *conditional* upon owning Blender 1 is quite low and so another blender is not purchased. However, if a rental market existed for both blender types, consumers could act upon their taste for diversity without owning a dozen blenders. Even if the blender example seems implausible, we should consider that very few consumers try to rent the car they normally drive or vacation in their hometown. Presumably they diversify consumption in these cases precisely because they can.

As P2P rental markets become commonplace, presumably manufacturers will begin designing products more attractive for this additional purpose. For example, locks on cars and houses that allow remote entry will be more appealing. The Internet-of-Things revolution will make it easier to identify goods that are not being used at a moment in time and perhaps facilitate trade automatically. Similarly, technologies that make it easier to monitor usage (GPS, embedded sensors, streaming video of how they are being used and so on) should make contracting easier and reduce some of the informational asymmetries that contribute to sharing costs. As more of economic and social life are computer-mediated, platforms will use this information to verify the identify and reputation of buyers and sellers, further mitigating moral hazard and adverse selection. Even without these changes, individuals will purchase more durable goods to reduce the frequency of replacement. Advertisers will trumpet the rental stream income from a purchase and highlight the advantages of residual control rights.

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A Survey Questions

The actual goods were:

- BBQ Grill
- toothbrush
- a men's suit
- blender
- canoe
- car
- cordless power drill
- hammer
- diamond necklace
- food processor
- hammer
- cat carrier (for transporting cats)
- high-end audio headphones
- high-end digitial [sic] camera
- iPad or tablet
- jet ski
- kid's boucy [sic] castle
- kitchen timer (or egg timer)
- mountain bike
- pick-up truck
- push lawnmower
- ride-on lawnmower
- tuxedo
- vacation home
- back-up electric generator
- portable air conditioner

- sewing machine
- Does your household own a **good**?
  - Yes
  - No
- Have you ever lent your **good** to someone else?
  - Yes
  - No
  - NA - we do not own one.
- Have you ever borrowed a **good** from someone else?
  - Yes
  - No
  - NA - we own one.
- Have you ever rented a **good**?
  - Yes
  - No
  - NA - we own one.
- Regardless of whether your household owns a **good**, if you did own one, how much do you estimate it would be used by members of your household on average?
  - We would not use this at all
  - 1 minute a week (about 1 hour a year)
  - 5 minutes a week (about 4 hours a year)
  - 1/2 an hour a week
  - 1 hour a week
  - 1/2 an hour a day
  - 1 hour a day
  - 2 hours a day
  - 4 hours a day
  - 8 hours a day
  - 16 hours a day
  - 24 hours a day (I would continuously be using this good)
- Regardless of whether you actually own a **good**, how do you imagine it would be used if it was owned by your household (on a scale of 1 to 5):

  - 1 - Used in one big block of time
  - 2
  - 3 - Used in a mixture of large and small blocks of time
  - 4
  - 5 - Used in many small blocks of time

- Regardless of whether you actually own a **good**, how predictable would your usage of it be if you did own it:
  - 1 - Very predictable—I can plan usage many weeks in advance
  - 2
  - 3 - Somewhat predictable
  - 4
  - 5 - Very unpredictable—I would never know exactly when I would need to use it until right beforehand.

- If you do not own a **good**, what is the primary reason?
  - NA - we own one.
  - We wouldn't use it enough to justify the purchase price
  - We would use it, but we simply do not have the money.
  - I don't have the space for this item

- What is your total household income?
  - Less than $10,000
  - $10,000-$19,999
  - $20,000-$29,999
  - $30,000-$39,999
  - $40,000-$49,999
  - $50,000-$59,999
  - $60,000-$69,999
  - $70,000-$79,999
  - $80,000-$89,999
  - $90,000-$99,999
  - $100,000-$149,000
  - More than $150,000