Owning, Using and Renting: Some Simple Economics of the "Sharing Economy"*

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Abstract

New Internet-based "sharing economy" markets enable consumer-owners to rent out their durable goods to non-owners. We model such markets, and explore their equilibria both in the short-run, in which ownership decisions are fixed, and in the long-run, in which ownership decisions can be changed. We find that "sharing economy" markets always expand consumption and increase surplus, but may increase or decrease ownership. Regardless, ownership is decoupled from individual preferences in the long-run, as the rental rates and the purchase prices of goods become equal. If there are costs of bringing unused capacity to the market, they are partially passed through, creating a bias towards ownership. To test our theoretical work empirically, we conduct a survey of consumers, finding broad support for our modeling assumptions. The survey also allows us to offer a partial decomposition of the bring-to-market costs, based on attributes that make a good more or less amenable to being shared.

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1 Introduction

In traditional rental markets owners hold assets to rent them out. In recent years, firms have created a new kind of rental market, in which owners sometimes use their assets for personal consumption, and sometimes rent them out. Such markets are commonly referred to as peer-to-peer (P2P) rental or "sharing economy" markets. To be sure, some renting by consumer-owners has long existed, but given the high transaction cost per rental, it was largely confined to expensive, infrequently used goods, such as vacation homes and pleasure boats, usually with rental periods of longer duration. More often, goods were shared among family and friends, often without explicit payment. In contrast, these new P2P rental markets are open markets, and the good is "shared" in exchange for payment.

Airbnb is a prominent example of a P2P rental market, enabling individuals to rent out spare bedrooms, apartments, or entire homes. Airbnb and platforms like it have been heralded by many, as they promise to expand access to goods, diversify individual consumption, bolster efficiency by increasing asset utilization, and provide income to owners (Botsman and Rogers, 2010; Edelman and Geradin, 2015; Sundararajan, 2016). The business interest in these platforms has been intense.[1]

Companies organizing "sharing economy" markets have also attracted substantial policy interest, much of it negative (Malhotra and Van Alstyne, 2014; Avital et al., 2015; Slee, 2015; Filippas and Horton, 2018). Critics charge that the primary competitive advantage of these platforms is their ability to duck costly regulations—regulations that protect third-parties and remedy market failures.[2] However, the counter-argument is often made that existing regulations were designed to solve market problems that these "sharing economy" platforms solve in an innovative fashion, primarily with better information provision and reputation systems, thereby making top-down regulation unnecessary (Koopman et al., 2014).

Progress in designing and operating P2P rental markets, as well as in advancing the corresponding policy debate, requires a better understanding of these markets. More specifically, what are the economic problems that P2P rental markets address, what are the drivers behind their recent emergence, and what are the likely short- and the long-run properties and effects of these markets? The goal of this paper is to provide answers to these questions.

[1] Airbnb alone has attracted nearly \$4.4 billion in venture capital investment, and was valued at \$31 billion during its most recent funding round. Uber, which also has a P2P rental market—albeit with a substantial labor component—was valued at \$62.5 billion in its last funding round (see also `http://www.crunchbase.com/organization/airbnb`, and `http://www.crunchbase.com/organization/uber`).

[2] For example, Dean Baker, in an opinion piece for the Guardian characterizes Airbnb and Uber as being primarily based on "evading regulations and breaking the law" (see also `http://www.theguardian.com/commentisfree/2014/may/27/airbnb-uber-taxes-regulation`). Edelman and Geradin (2015) discuss both the promised efficiencies of "sharing economy" platforms, and the regulatory issues they raise. Cannon and Summers (2014) offer a playbook for "sharing economy" companies to win over regulators.

Our first major question is why P2P rental markets only became a force in the 21st century, despite the fact that the economic problem these markets are able to solve—under-utilization of durable goods—is hardly new. We argue that technological advances, such as the mass adoption of smartphones with high-definition digital cameras, and the falling cost and rising capabilities of the Internet, while clearly important, provide only part of the story. In addition to technological advances, P2P rental markets utilize the hard-won industry and academic experience in the design and management of online marketplaces.

During the early days of electronic commerce, market creators developed three broad categories of mechanisms/features to solve characteristic problems of online markets. These mechanisms are now ubiquitous, and have substantially decreased the costs of making goods available to be rented. We discuss three categories of mechanisms: (i) market-thickening mechanisms, including taxonomies, search algorithms, and recommendation systems, (ii) reputation systems conveying information that allows P2P rental platforms to overcome—or at least substantially ameliorate—traditional market problems, such as moral hazard and adverse selection, and (iii) mechanisms that reduce "practical" transaction costs, such as ways of accepting payments, escrow services, self-marketing features, and other software tools. We develop this argument in depth, point out relevant works from the literature, and identify problems arising in implementing these mechanisms in the context of P2P rental markets.

Our second major question is what economic properties characterize P2P rental markets. For example, what determines the rental rate and the quantity exchanged in a P2P rental market? Do consumption and ownership increase or decrease following the emergence of these markets? How much total surplus do such markets "unlock," and how is it distributed? When there are substantial *bring-to-market* costs (such as labor, asset depreciation, and transaction costs), who bears them, and how do these costs affect market outcomes?

To address these questions, we develop a simple model in which consumers decide whether to purchase a good or not based on their expected personal usage. We initially consider a market where consumers do not have the option to rent out their assets (and, by implication, rent from or to other consumers), reflecting the status quo. In this market, consumers segment themselves to owners and non-owners by weighing their planned usage against the purchase price of the good. Owners use the good less than 100% of the time, leaving some of its capacity unused. Non-owners do not purchase the good, but would use it some of the time if they did own it—but less time than the current owners use it. In short, purchased goods remain unused some of the time even though there is some demand for the excess capacity, as owners lack a way to transfer it to non-owners.

Starting from a market configuration of owners and non-owners, there is a shock: some technological/entrepreneurial innovation creates a P2P rental market that allows owners to rent their unused capacity to non-owners. For clarity, we initially assume that owners can make their unused capacity available on the P2P rental market on a costless basis. After the P2P rental market emerges, the consumption problem of both owners and non-owners changes. Non-owners now have the option to rent the good for some time, facing the market-clearing rental rate. For owners, the possibility of rentals creates a new opportunity cost for their own usage: owners can not only rent out their excess capacity, but also have an incentive to reduce their own consumption, in order to make more of the good available for rental.

We first examine how a P2P rental market clears in the short-run, where we assume that ownership decisions are fixed, having been made before renting was an option. The short-run rental market does not necessarily clear: if the pre-rental unused capacity exceeds demand, a glut results. In the case of a glut, owners do not need to reduce their consumption of the good; instead, rental rates are pushed to zero. If the pre-rental unused capacity cannot meet the demand, the market clears at some positive rental rate, and owners reduce their consumption. The market-clearing rental rate is increasing in the average valuation of owners, which reduces supply, and the average valuation of renters, which increases demand. As such, the market-clearing rental rate is also increasing in the purchase price of the good.

Although goods are durable, they are eventually used up and have to be replaced. In the presence of the P2P rental option, owners can make a different choice and become renters, and non-owners may decide to buy. We consider the equilibrium in which consumers can revise their ownership decisions, which we call the long-run equilibrium. We find that if the short-run rental rate is below the purchase price, then ownership becomes less attractive and decreases in the long-run relative to the short-run, and vice versa. This result also offers an intuitive test for whether total ownership will decrease in the long-run. Ownership adjusts so that the long-run rental rate equals the purchase price. As a result, owners and renters receive the same utility at the margin, thereby decoupling individual preferences from ownership.

While ownership may increase or decrease in the long-run, the option of renting out an owned good makes ownership more valuable. As such, a P2P rental market can have a market-expanding effect, in the sense that it allows a previously infeasible product market to emerge. The reason is that the rental option can generate positive purchase demand at a price that exceeds all consumers' pre-"sharing" valuations.

Total surplus increases relative to the pre-sharing status quo both in the short- and the long-run P2P rental market equilibria. Although owners consume less in both equilibria, they are more than compensated with rental income. From a distributional perspective, owners with lower valuations are the biggest beneficiaries, as they consume the good less of the time, and hence they have more excess capacity to rent. Similarly, non-owners with higher valuations see the largest increase in surplus. As such, the greatest gains in surplus are obtained when original non-owners value the good nearly as highly as owners, suggesting that goods where income (rather than taste or planned usage) primarily explains ownership could offer the greatest increase in surplus.

Although we began by assuming that owners can rent out their unused capacity costlessly, in practice, making a good available for rentals is at least somewhat costly—as we argued, one could conceptualize the rise of the "sharing economy" as caused by a significant decrease in these costs. Some of these bring-to-market (BTM) costs are straightforward, such as labor, depreciation, and complementary consumables. For example, driving with Uber requires labor, increases the car's mileage, and consumes gas.

In our model, when we assume that owners do face BTM costs, the predictions change in several important ways. We find that if BTM costs are sufficiently high relative to the purchase price of the good, a P2P rental market cannot be supported at all. If the market can exist, BTM costs lower the quantity of the good transacted in the market and raise the rental rate, both in the short- and the long-run. In particular, we show that BTM costs do get incorporated into rental rates, being the equivalent of a per-unit sales tax. As with a sales tax, they are not fully incorporated in the rental rate—the magnitude of the pass-through depends on the elasticity of the supply (owners) and the elasticity of the demand (renters). An implication of the incomplete pass-through is that both owning and renting become less compelling as BTM costs increase. Furthermore, total ownership may either increase or decrease in the long-run as BTM costs change, depending on the incidence of the BTM costs.

When making a good available to be rented is costless, the rentals option decouples individual preferences from ownership. However, when BTM costs are introduced, the incomplete pass-through of BTM costs couples preferences and ownership again, tilting consumers with higher valuations towards ownership. The reason consumers with higher valuations—and hence more planned usage—find ownership relatively more attractive than owners with low valuations, is that consumers bear no BTM costs for own-usage. This is similar to the inefficient bias towards home production that a labor market wedge creates.

The incomplete pass-through finding implies that, when BTM costs are positive, it becomes loss-making to buy the good solely to rent it out—if BTM costs are zero, it is merely zero-profit. This result has important managerial implications for would-be rental firms. However, in the presence of large setup costs, or significant economies of scale in offering rental services, for-profit firms can compete.

In addition to the straightforward BTM costs, such as labor and depreciation, another source of costs is simply the coordination costs of renting. We argue that these coordination costs depend on the patterns of how goods are characteristically used. Goods whose consumption is easily planned for are easier to rent out, with little loss in utility to the owner. Similarly, goods that are used in large chunks of time—with no use in between—are more amenable to rental than goods whose usage is broken up into many small "chunks" of time. We show how these attributes can affect BTM costs, with goods with low chunkiness requiring owners to incur higher transaction costs to rent out some "amount" of the good, and goods with low predictability requiring owners to engage in more intensive search to find a counterparty.

Although our paper is mainly theoretical, we also test our model's assumptions with data. To do this, we surveyed a convenience sample of consumers, asking questions about a series of goods (e.g., a BBQ grill, or a tuxedo). These questions included whether consumers own the good, whether they have lent it out or borrowed it, and how much they do or would use it. We also asked questions about how the good in question is characteristically used, focusing on the typical size of usage "chunks," as well as how predictable that usage is. If the respondents did not own the good, they were asked to select the reason why, such as because of not high enough income, or no need for the good. We selected a number of goods and encouraged respondents to answer our questions about multiple goods, as in some cases this allows us to control for the identity of the respondent or the good. The respondents were also asked for their household incomes.

Our main finding is that income is only important in determining ownership for a small number of the goods we asked about (e.g., vacation homes); for most goods, planned usage was the primary driver, thus supporting our basic modeling framework. In addition, looking across the population, those goods that are owned more frequently are rented less frequently. We also find that goods that have unpredictable usage, and goods that are being used in small chunks of time are more likely to be owned, supporting our claim that chunkiness and predictability matter.

As the "sharing economy" is a relatively recent phenomenon, we conclude our paper with some thoughts on how P2P rental markets might evolve. Our model considers a single homogeneous good, and while we show surplus increases, a key welfare implication of P2P rental markets could be to facilitate greater diversity in goods offered and consumed. Beyond the direct utility this diversification provides, it might also increase the stock of people with direct experience with a particular good, which combined with the continued proliferation of consumer-generated reviews and ratings might stimulate quality improvements. In that same vein, producers of goods might do more than simply improve quality—they might also explicitly modify their goods to make them more amenable to rental.

The rest of the paper is organized as follows. Section 2 explores the reasons behind the recent emergence of P2P rental markets, and reviews extant work on their economic effects. Section 3 develops the model and presents the main results about equilibria. Section 4 examines the implications of rentals for consumers' consumption, ownership, and surplus. Section 5 extends the base model by adding BTM costs. Section 6 examines extensions, and discusses the managerial implications of our findings. Section 7 offers a test of the main modeling assumptions, and empirically examines the temporal division aspect of BTM costs. Section 8 concludes with thoughts on directions for future research.

2 The rise of P2P rental markets

2.1 Explanatory factors

The economic rationale for P2P rental markets is that owners of most durable goods use them substantially less than 100% of the time. This under-utilization generates excess capacity that can then be rented out to non-owners who would like to use the good, but not enough to purchase it.[3] Given the obvious rationale for these kinds of transactions, "sharing" is not a recent phenomenon.[4] But if "sharing" makes economic sense, then why have P2P rental markets begun to flourish only in recent years? We argue that the emergence of P2P markets could only happen at the confluence of two significant innovations that substantially decreased transaction costs.

The first reason is a number of technological advances that entrepreneurs have taken advantage of in building these platforms. Chief amongst these technological leaps are the maturation and increasing penetration of the Internet, and the proliferation of smartphones with high-resolution digital cameras. These new capabilities enable would-be trading partners to find and assess each other and the goods being traded more efficiently. For example, Uber is only possible because both sides of the market can find each other, and also carry with them taximeters (when running the appropriate software) at all times: a smartphone enabled with GPS technology allows for the precise measurement of distance traveled. In fact, this computer-mediated approach works better than the traditional taximeter in that both parties can verify that the best route was taken (Liu et al., 2018). Similarly, Airbnb benefits greatly from the proliferation of high-resolution digital cameras that make it easy for parties to inspect goods ex ante, and leave credible reviews ex post.

[3]A non-owner might mean a non-owner in a particular place and time. For example, many Airbnb guests are homeowners, but they do not own homes everywhere.

[4]One third of nineteenth century American households took in boarders (Jefferson-Jones, 2014).

The second, often understated, reason behind the decrease in transaction costs and the subsequent proliferation of P2P rental markets, is that these markets have stood on the shoulders of their electronic commerce predecessors, such as eBay and Amazon. There are now more than 20 years of accumulated industrial experience in building online marketplaces and solving their fundamental problems. The creator of a potential P2P rental market can easily draw upon this experience. At the same time, several aspects of these fundamental problems are different in the P2P context, requiring innovative solutions.

Online markets generally lack the market-thickening mechanisms available in physical markets, such as coordinating on time and geography.[5] Online marketplaces compensate by creating taxonomies, and extensively classifying goods. A complementary approach is to use search algorithms and recommendation systems (Resnick and Varian, 1997; Adomavicius and Tuzhilin, 2005). These approaches are particularly important in P2P rental markets, because both the goods being rented and consumers' preferences for these goods are often highly differentiated, making the matching aspect more important.[6] P2P rental market platforms continue to invest heavily in research designed to improve matching, some of it in collaboration with economists (Athey and Luca, 2019). For example, Horton (2017) shows that recommending workers to employers in an online labor market increases the job fill rate by 20%. Fradkin (2017) estimates that personalized recommendations could improve match rates by 10% on Airbnb.

Even if they find a potential trading partner, online market participants must decide whether to trust the counterparty. As such, a key challenge in all markets is facilitating trust among strangers. This problem is acute in P2P rental markets, given the "opportunity" renters have to misuse or destroy the owners' capital; in most markets the buyer's "type" matters little to the seller, but in rental markets the buyer's "type" can be critical. One practical solution is bilateral reputation systems, which convey information on seller and buyer "types" by essentially digitizing word-of-mouth information to reduce moral hazard (Dellarocas, 2003). A substantial empirical literature characterizes the importance of reputation systems to the functioning of online markets (Cabral and Hortaçsu, 2010; Resnick et al., 2000; Resnick and Zeckhauser, 2002; Moreno and Terwiesch, 2014).

Honest reputational information can be hard to elicit, and a substantial literature docu-

[5]Buyers and sellers of stocks benefit from agreeing that the New York Stock Exchange is open from 9:30-4:00. Geography also matters; buyers and sellers of vegetables benefit from agreeing that the Union Square green market in Manhattan is located in the northwest side of Union Square Park.

[6]Dinerstein et al. (2018) use data from eBay to highlight the difficulty in creating search and ranking algorithms for differentiated products where price is only one dimension of interest; they show examples where limiting choice might be pro-competitive. There is an increasing understanding of how individuals do search online: De los Santos et al. (2012) use detailed web browsing data to show that customers rely more on a fixed sample size search strategy rather than sequential search.

ments ongoing efforts by platforms to fix common problems with reputation systems. Topics include: reducing the role of reciprocity (Bolton et al., 2013); incentivizing the provision of feedback (Fradkin et al., 2018); introducing new signals of quality, such as badges or other constructed measures (Nosko and Tadelis, 2015; Hui et al., 2016; Barach et al., 2018); addressing the incentives for review fraud (Mayzlin et al., 2014; Luca and Zervas, 2016); and dealing with the tendency towards inflated reputations (Filippas et al., 2018). The rise of social networks, such as Facebook, has also given platforms new opportunities to inject information into the platform that parties can use to decide whether to contract (Holtz et al., 2017).

Sellers in online platforms are often individuals, and lack the resources of firms organized around selling goods. This creates a number of "practical" transaction costs—individuals typically lack marketing budgets and expertise, ways of accepting payments that are convenient for customers, standard contracts and procedures to draw upon, well-adapted insurance products, procedures and facilities for re-setting goods after use, and so on. Individual participants would find too costly—or even impossible—to build and maintain these functionalities themselves.[7]

To reduce transaction costs, and close these gaps, P2P rental markets give individual owners resources that are available to traditional firms. Platforms can do this because they enjoy scale economies for many costly tasks compared to individual owners. For example, platforms handle credit card payments, create tools for "self-serve" marketing (such as through attractive profile pages), and engage in general platform marketing to bring renters to the platform. Furthermore, platforms also create software tools that let owners manage their availability, learn about the attributes of potential renters, and so on.[8]

2.2 Previous work on economic effects of P2P rental markets

Several papers try to understand various facets of online markets. Einav et al. (2016) develop a model where rental platforms reduce entry costs for individual providers, for whom it would be previously unprofitable to enter the market. Einav et al. also stress that much of the increase in surplus is due to fact that the added supply is highly elastic, especially in markets where demand is highly variable. Farronato and Fradkin (2018) verify this claim empirically

[7]As it is, even ostensibly "peer" platforms do seem to tilt towards quasi-firms that can reap economies of scale or enjoy other firm benefits. For example, there are Uber "drivers" who manage fleets of vehicles and Airbnb "hosts" with multiple properties.

[8]Both Horton (forthcoming) and Fradkin (2017) consider the platform's role in overcoming search frictions related to buyers trying to match with unavailable sellers—Fradkin in the case of Airbnb, and Horton in the case of an online labor market. In the context of online dating sites, Hitsch et al. (2010) present evidence that the realized matches are *close* to what the Gale-Shapley algorithm would deliver, based on their estimates of underlying preferences.

in the case of home-sharing.

Benjaafar et al. (2018) consider the ownership choice with and without the possibility of P2P rentals, with participants differing in their expected usage. This paper differs from ours in at least two important ways. First, Benjaafar et al. explicitly consider the matching aspect of these markets, modeling how a participant's utility from being an owner or renter can depend on the possibility of finding the appropriate counter-party. For some questions, these considerations is likely to be important, but for others—say in markets where platform pricing choices clear the market—the matching aspect is likely less important. Second, in our model, owners and renters decide how intensively to use a good in light of the rental rate (or in the case of owners, the opportunity cost created by the rental market).

Another related paper is Fraiberger and Sundararajan (2015), who offer a calibrated model of the P2P rental market, focusing on short-term rentals of cars. They model consumers choosing among ownership, rental and non-participation, and find that the introduction of "sharing" would decrease ownership but increase utilization. As in our model, the biggest gains in surplus come to previous non-owners who gain access to the good.

Previous work has examined the effects of entry of online platforms on offline competitors (Seamans and Zhu, 2013; Kroft and Pope, 2014). As "sharing economy" markets affected several industries, much of the early literature has focused on identifying economic effects on incumbents. For example, Zervas et al. (2017) exploit the natural experiment created by the introduction of Airbnb in Texas and show that a 10% increase in Airbnb supply resulted in a 0.35% drop in monthly hotel revenues, with lower-priced accommodation options bearing a larger percentage of this decrease.

While the effects of new "sharing economy" entrants can be sizable, the waxing and waning of various industries does not constitute market failure. In contrast, as "sharing economy" platforms blur the lines between the personal and the professional, they create new social costs and benefits. Edelman and Geradin (2015) discuss the regulatory policy implications of "sharing economy" companies using the traditional "market failure" framework that motivates much of public economics. An example is found in the case of home-sharing, where residential houses now become mixed-use real estate, creating negative externalities that can lead to market failure, and which previous public policy responses are not fit to address (Filippas and Horton, 2018).

3 A model of the introduction of a P2P rental market

3.1 Consumption and ownership decisions

Someone has to own before anyone can "share." And to have someone with whom to "share," someone has to not own but still want to use the good, at least some of the time. To explain consumers' ownership decisions, we assume that goods can be thought of as having an intensive margin of usage, i.e., how much a good is used, which drives the extensive margin decision, i.e., ownership. Individuals differ in their intensive margin of usage, and hence in the utility they derive from the good. The assumption that consumers consider the time required to use a good in making their consumption plan follows Becker (1965) in spirit.[9]

Every consumer has a unit of time to allocate to various activities. Some of these activities involve using the good, and consumers have to decide on the time $x \in [0, 1]$ for such use. By using the good, a consumer receives a benefit of $2\alpha x$, where $\alpha \in (0, 1)$ also differs amongst individuals. The consumer also incurs a cost of x^2, which can be thought of as the opportunity cost of time, increasing in the time spent with the good rather than with the best alternatives. The consumer's utility from using the good is then $b(x; \alpha) = 2\alpha x - x^2$. Therefore, the optimal usage and utility for a consumer of "type" α is

$$x^*(\alpha) = \alpha, \quad u^*(\alpha) = \alpha^2. \tag{1}$$

Note that α admits the convenient interpretation of the fraction of time an owner would use the good.

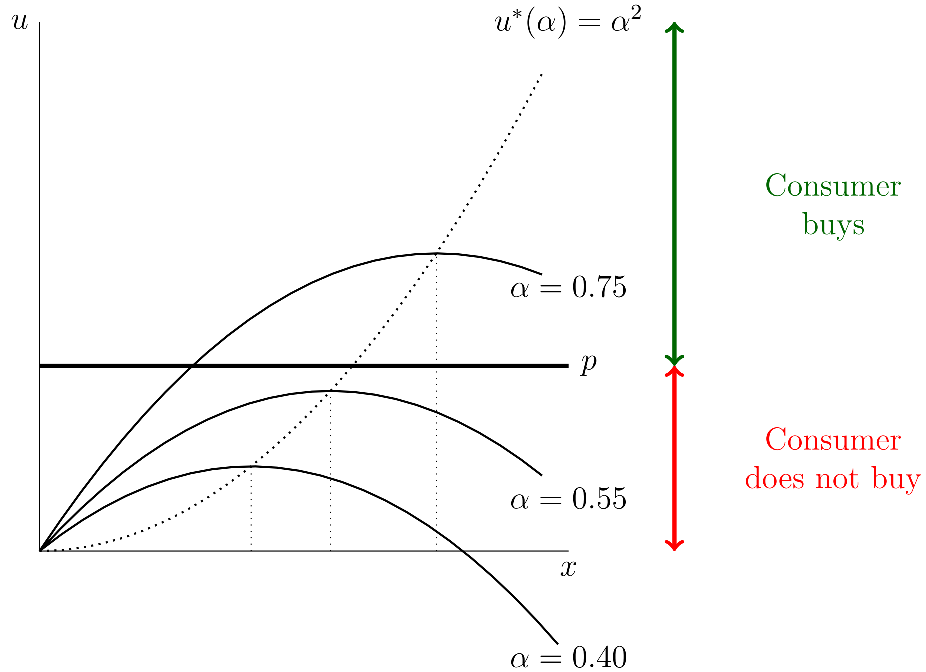
Assume for now that the price of the good is exogenously set to $p > 0$. Consumers with valuation α such that $\alpha^2 > p$ will buy the good and become owners, and all other consumers will choose to live without the good. In the absence of a rental market, the determinants of ownership are the purchase price p and the individual's valuation α. Figure 1 illustrates the consumer's decision problem, showing the utility from various levels of usage depending on a consumer's valuation α. An owners' utility falls along the curve traced out by x^2.

In what follows, we assume without loss of generality that the market consists of a unit mass of consumers, whose valuations follow some distribution $F : [0, 1] \to [0, 1]$. The ownership of the good at price $p \in [0, 1]$ is then $Pr(\alpha^2 \geq p) = 1 - F(\sqrt{p})$, which yields a convex, downward-sloping demand curve.

In Figure 2, we illustrate the market configuration prior to the emergence of the P2P rental market, as well as how the market subsequently adjusts, for the case of uniformly

[9] We offer an empirical test for this assumption in Section 7.1.

Figure 1: Consumer's optimal usage of a good and resulting purchase decision



Notes: This figure illustrates the utility derived from different levels of usage of a good, with individuals differing in their values from usage based on their α parameters.

distributed valuations on the unit interval, i.e., $\alpha \sim U[0,1]$.[10] In the top left panel, we plot the usage of consumers against their valuation for the good. The marginal non-owner has valuation $\sqrt{p}$, with all higher-valuation users owning the good but not using it all the time, thereby having unused capacity. All lower valuation-users do not purchase the good, despite having a positive valuation. The top right panel plots the utility of consumers against their valuation for the good. The utility of owners is increasing in their valuation, and non-owners obtain zero utility. Before rentals are possible, only owners with sufficiently high valuations consume, and hence only these owners obtain some benefit from the focal product.

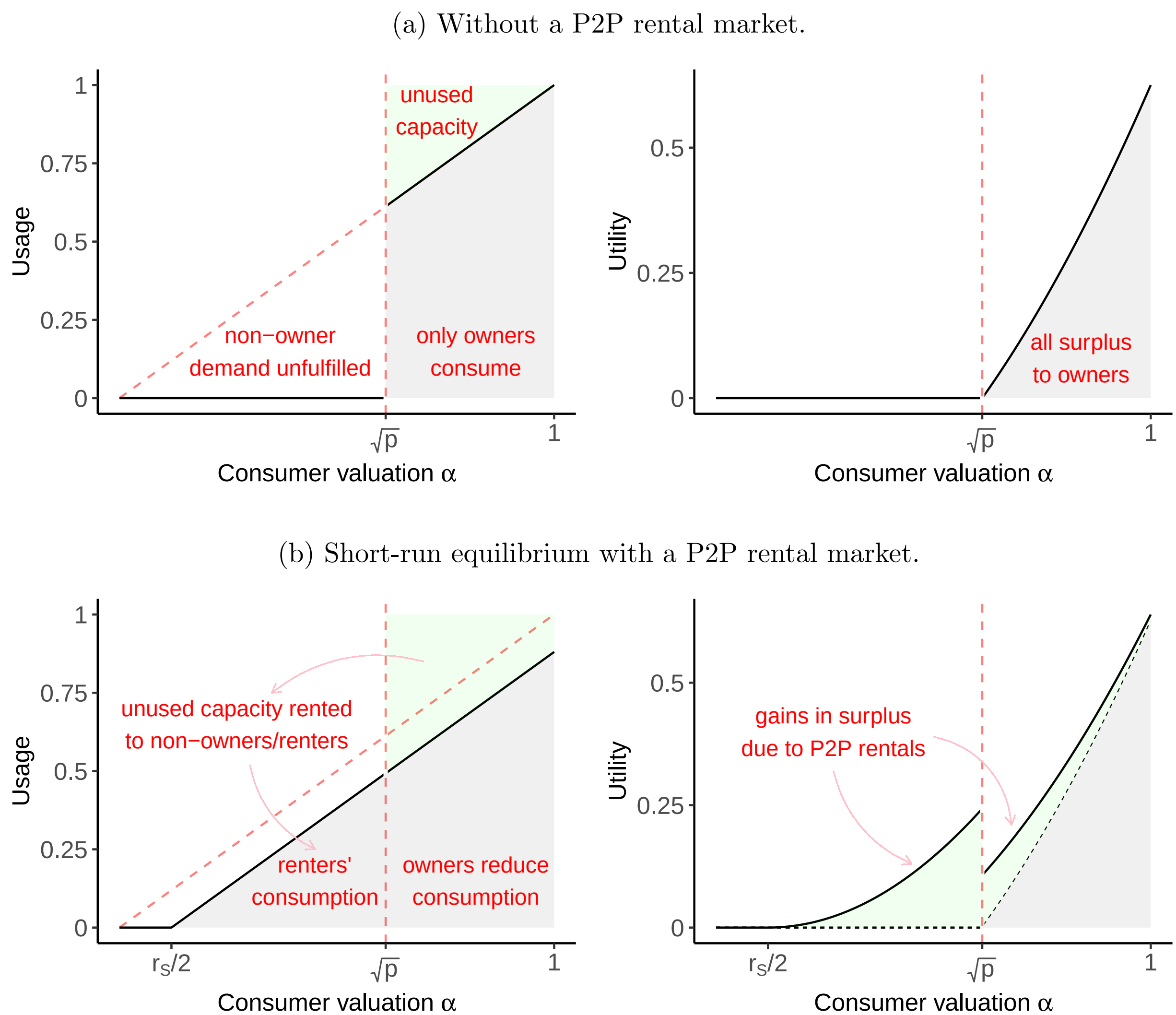
3.2 Consumption and ownership decisions with P2P rentals

Now posit that through some technological advance it becomes possible for owners to rent their excess capacity to non-owners.[11] With rentals being possible, owners with valuation α are able to immediately rent out their $1-\alpha$ unused capacity, plus whatever additional amount

[10] We maintain the uniformly distributed valuations assumption throughout all figures, as it allows for convenient graphical depictions of ownership and rental activity.

[11] The possibility of "sharing" a good bears some similarity to Varian (2000), who discusses how planned usage affects the rent-versus-own decision, but focuses on information goods.

Figure 2: Consumer usage, renting, and utilities without rentals, and in the short-run equilibrium of the P2P rental market, for the case of uniformly distributed consumer valuations



Notes: This figure plots consumers' usage, renting, and utilities, before and after the introduction of the P2P rental market. It illustrates the case of uniformly distributed valuations on the unit interval, and $p = \frac{3}{8}$. Panel 2a plots the consumers' usage (left) and utilities (right) before the introduction of the P2P rental market. In its left panel, the gray shaded area depicts the consumption of the good, and the green shaded area depicts the unused capacity. In its right panel, the gray shaded area depicts the corresponding utility. Panel 2b plots the consumers usage and renting (left) and utilities (right) in the short-run equilibrium of the P2P rental market. In its left panel, the gray shaded area depicts the consumption of the good. Note that non-owners' consumption is equal to the unused capacity (green shaded area), as a glut does not occur. In its right panel, the green shaded area depicts the surplus gains to consumers in the short-run equilibrium.

that they choose to make available. The existence of the rental option may incentivize owners to economize on their usage in order to earn rental income.

Assume that owners of the good can provide their unused quantities to the market at a rental rate r, where the rental period is the lifetime of the asset.[12] An owner's problem becomes to select the optimal personal usage

$$x_O(r;\alpha) = \underset{x\in[0,1]}{\text{argmax}} \quad \underbrace{2\alpha x - x^2}_{\text{consumption util.}} + \underbrace{r(1-x)}_{\text{rental income}} = \max\left\{0, \alpha - \frac{r}{2}\right\}, \tag{2}$$

which yields utility

$$u_O(r;\alpha) = \alpha^2 - \alpha r + \frac{r^2}{4} + r - p. \tag{3}$$

In the presence of the rental market, owners of the good reduce their usage to gain the benefits of "sharing." Owners are never worse off than they were before the rental option, as they can choose not to participate in the P2P rental market.

Non-owners can choose to become renters. At rental rate r, a renter's problem is

$$x_R(r;\alpha) = \underset{x\in[0,1]}{\text{argmax}} \quad 2\alpha x - x^2 - \underbrace{rx}_{\text{rental cost}} = \max\left\{0, \alpha - \frac{r}{2}\right\}, \tag{4}$$

through which a renter obtains utility

$$u_R(r;\alpha) = \alpha^2 - \alpha r + \frac{r^2}{4}. \tag{5}$$

With P2P rentals, non-owners can consume the good some of the time, and hence reap higher utility. However, not all non-owners benefit, as those with valuations $\alpha < \frac{r}{2}$ remain excluded from consumption, and their utility remains unchanged.

3.3 Short-run equilibrium (fixed ownership)

To examine the short-run effects of the emergence of a P2P rental market, we assume that original purchase decisions are fixed: owners cannot become renters, and non-owners cannot buy the good to become owners.

With ownership being fixed, the short-run equilibrium is characterized by the equilibrium market rental rate r_S. The highest-valuation potential renter is the one who was previously indifferent between owning and not owning the good, and hence for any quantity to be rented, $r_S \leq 2\sqrt{p}$. As owners can make their capacity available on the market without costs, owners have an incentive to rent out their good if $r_S \geq 0$. The short-run rental market is

[12] We examine the case where making the excess capacity available in the market is costly in Section 5.

hence supported so long as $p > 0$.

The supply offered by owners in the rental market at rental rate r is

$$S(r; \sqrt{p}) = \int_{\sqrt{p}}^{1} \left(1 - \alpha + \frac{r}{2}\right) dF(\alpha). \tag{6}$$

As one would expect, supply increases in r, as owners further reduce thereby making more capacity available in the rental market.

Similarly, renter demand for the good is

$$D(r; \sqrt{p}) = \begin{cases} 0, & \text{for } r > 2\sqrt{p} \\ \int_{r/2}^{\sqrt{p}} \left(\alpha - \frac{r}{2}\right) dF(\alpha), & \text{for } r \leq 2\sqrt{p} \end{cases}. \tag{7}$$

Demand decreases in r, as the renting activity narrows both in size and in intensity: fewer non-owners become renters, as the marginal renter's valuation α is equal to $r/2$, and non-owners who become renters rent less.

The short-run market-clearing process depends on the distribution of users' valuations for the good, and the purchase price of the good. The market can clear in the short-run in two distinct ways: (i) a glut, with $r_S = 0$, and (ii) an "economizing" solution, with $r_S > 0$. The glut case arises when the unused capacity exceeds the maximum demand for rentals. Let $S_0 = S(0; \sqrt{p})$ denote the minimum available supply, that is, the total amount of unused capacity before renting was an option. This is the amount of capacity that could be made available on the rental market, even if owners had no incentive to reduce their usage of the good ($r = 0$). Similarly, let $D_0 = D(0; \sqrt{p})$ denote the maximum demand, that is, the demand under $r = 0$. Unused capacity exceeds the maximum demand for rentals when $S_0 \geq D_0$, which can be usefully rewritten as

$$\underbrace{\int_{\sqrt{p}}^{1} dF(\alpha)}_{\text{total available capacity}} \geq \underbrace{\mathbb{E}[\alpha]}_{\text{total latent demand}}. \tag{8}$$

In words, a glut occurs when the total capacity of the good under the current ownership level exceeds the total population demand for consuming the good. Because the unused capacity of the good from owners is enough to fulfill the demand of all would-be renters—and making the unused capacity available on the market is costless—owners compete on rental prices, and the market-clearing rental rate is $r_S = 0$.

The "economizing" case occurs when the unused capacity is less than the maximum rental demand, and a positive market-clearing rental rate r_S is needed to clear the market.

Owners then have the incentive not only to rent out their $1 - \alpha$ excess capacity, but also to reduce their usage to supply more of their good to the rental market. As such, owners now essentially choose "production" quantities, and the market clears at the rental rate $r_S \in (0, 2\sqrt{p})$ for which demand equals supply, i.e., $S(r_S; \sqrt{p}) = D(r_S; \sqrt{p})$.

Given the monotonicity and continuity of the supply and demand curves (see Equations 6 and 7), it immediately follows that the equilibrium is unique. The short-run equilibrium rental rate r_S is increasing in p, as more high-valuation would-be renters enter the demand pool, while the owners with the highest capacities opt out of the supplier pool.

Returning to Figure 2, the bottom panel shows how consumers adjust to the emergence of the P2P rental market in the short-run. In the bottom left panel, we see that owners can now rent their unused capacity to non-owners. For the parameter configuration of Figure 2, owners rent out all of their previous excess capacity, and further economize on their consumption to take advantage of the rental market. Non-owners with valuations higher than $r_S/2$ now consume the good.

The bottom right panel of Figure 2 plots the surplus changes in the short-run equilibrium of the P2P rental market. Non-owners closer to the extensive margin see the largest increases in utility, as they value the good more, and hence consume more of it. Owners closer to the extensive margin also see the greatest increases in utility, because they have more idle capacity to rent out (see Equation 1). For the parameter configuration chosen, owners near the extensive margin, while made better off by the P2P rental market, are not as well off as non-owners near the extensive margin. This reflects the fact that, for the parameter values used, the short-run rental rate is lower than the purchase price of the good: even though consumption is now "smooth" in valuation, non-owners near the extensive margin consume for a lower price than owners near the extensive margin. This gap will be important when considering the long-run changes in the market, as it will incentivize some owners to revise their ownership decisions.

3.4 Long-run equilibrium (revised ownership)

We now consider what happens in the long-run, when both owners and non-owners can revise their ownership decisions. In real-life markets, the long-run equilibrium will emerge through good depreciation and replacement, as well as through consumers aging in and out of the product market.

Let r_L be the long-run equilibrium rental rate, and assume that changes in ownership do not change p. Whether consumers will choose to become owners or opt for renting the good will depend on the comparison of their corresponding utilities. From Equations 3 and 5, which hold generally, we get:

$$u_O(r;\alpha) - u_R(r;\alpha) = r - p. \tag{9}$$

From Equation 9, we see that if $r_L > p$ every consumer wants to own the good, whereas if $r_L < p$ every consumer wants to rent the good. Consequently, the long-run equilibrium rental rate equals the purchase price, that is,

$$r_L = p. \tag{10}$$

In the long-run P2P rental equilibrium, the rental rate equals the product market purchase price, and ownership does not depend on either usage patterns or valuation. Owners and renters must receive the same utility at the margin, and so the P2P rental market decouples individual preferences from ownership in the long-run.

Although ownership is decoupled from valuation in the long-run equilibrium, to derive the equilibrium ownership we will assume that there is some α_L such that consumers with $\alpha \geq \alpha_L$ will become owners in equilibrium.[13] Let $\theta = 1 - F(\alpha_L)$ be the equilibrium ownership level, which is also the total available product capacity. For the market to clear in equilibrium, $S(p;\alpha_L) = D(p;\alpha_L)$, from which we get

$$\underbrace{\theta}_{\text{number of owners}} = \underbrace{\int_{p/2}^{1} \left(\alpha - \frac{p}{2}\right) dF(\alpha)}_{\text{total consumption}}. \tag{11}$$

From Equations 10 and 11 we can see that as the purchase price of the good increases, then, all other factors equal, the long-run equilibrium rental rate increases and ownership decreases.

We illustrate some of the key market-level differences between the short- and long-run equilibria in Figure 3, for the case of uniformly distributed valuations and for different purchase prices. In each panel, we plot a market outcome—the rental rate, the fraction of consumers owning the good, and the change in aggregate consumer surplus—versus the purchase price. The dashed line depicts short-run equilibrium quantities, and the solid line depicts long-run equilibrium quantities.

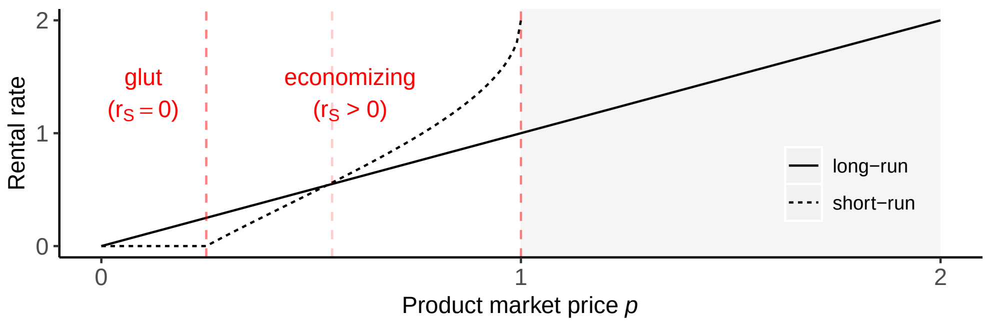
In the top panel, we plot the rental rate versus the good's purchase price. Both the short- and the long-run rental rates are non-decreasing in the purchase price. The long-run rental rate is equal to the purchase price, but the short-run rental rate can be either higher or

[13] We show in Appendix A that this threshold property holds for any positive BTM cost. Our assumption is thus equivalent to assuming that the same property holds in the limit.

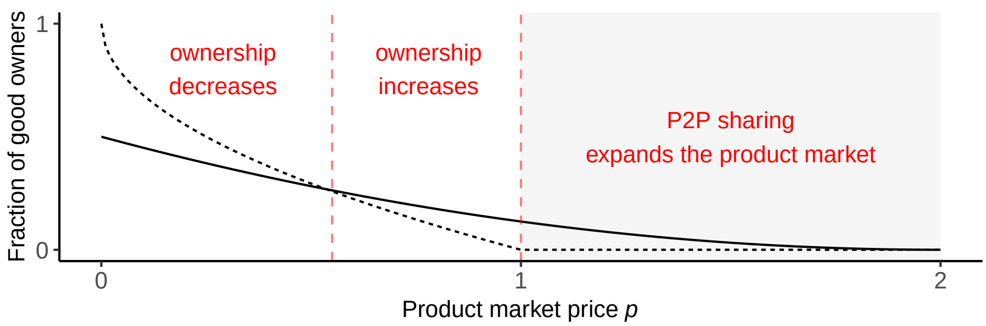
lower—and is at zero in the “glut” region. The middle panel depicts fraction of consumers owning in the short- and the long-run. Although ownership is decreasing in price, the price where the short-run and long-run rental rates are the same divides the market into regions where ownership increases or decreases relative to the pre-“sharing” status quo.

Figure 3: Short- and long-run rental rate, ownership, and surplus with a P2P rental market, for the case of uniformly distributed consumer valuations

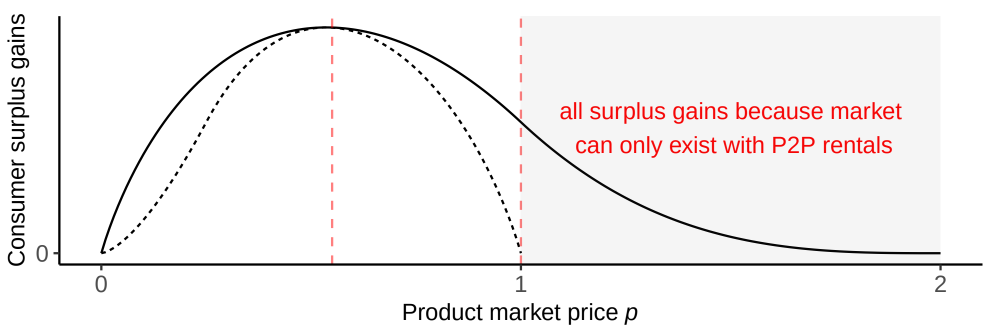
(a) Market-clearing rental rate in the short- and long-run.



(b) Product ownership in the short- and long-run.



(c) Aggregate consumer surplus gains in the short- and long-run.



Notes: This figure plots short- and long-run rental market outcomes after the introduction of the P2P rental market, for the case of uniformly distributed consumer valuations on the unit interval, i.e., $\alpha \sim U[0,1]$. The short-run equilibrium is indicated by the dashed line, and the long-run equilibrium by the solid line. In the short-run, a glut occurs if $p \leq 1/4$ and $r_S = 0$, otherwise the market clears at $r_S = 2(1-\sqrt{2}\sqrt{1-\sqrt{p}})$. In the long-run equilibrium, $r_L = p$, and ownership is $\theta = \frac{1}{8}(2-p)^2$. Panel (a) shows the P2P market-clearing rental rates, Panel (b) plots the level of ownership, and Panel (c) plots the aggregate consumer surplus gains. In all panels, the shaded area denotes the market expansion region due to the P2P rental option.

4 Economic effects for consumers

4.1 Using, renting, and the distributional consequences

Following the introduction of the P2P rental option, owners decrease their consumption, from $x^*(\alpha) = \alpha$ to $x_O(r;\alpha) = \alpha - \frac{r}{2}$. While owners' utility from consuming the good decreases, their utility from renting increases by a greater amount. The net increase equals

$$\Delta u_O = (1-\alpha)r + \frac{r^2}{4}. \tag{12}$$

From Equation 12, we see that if $r > 0$ then $\Delta u_O > 0$; hence, the utility of all owners increases. As $\frac{d\Delta u_O}{d\alpha} < 0$, owners with low valuations obtain the greatest benefits from renting out their goods: as usage is analogous to valuation, owners with low valuations have more excess capacity to rent out. If the short-run rental rate r_S is lower than the purchase price p, then the rental rate increases in the long-run equilibrium, that is, $r_L > r_S$. Consequently, owners see their utility further increase in the long-run, as they rent out their excess capacity at a higher price. The opposite holds in the case where the short-run rental rate exceeds the purchase price.

With P2P rentals, non-owners—who previously obtained zero utility—can become renters and consume some of the good, increasing their consumption from 0 to $x_R(r;\alpha) = \alpha - \frac{r}{2}$, and obtaining utility

$$\Delta u_R = \left(\alpha - \frac{r}{2}\right)^2. \tag{13}$$

Unlike owners, it is the higher-valuation renters who benefit most from the introduction of the P2P rental option. As such, if the short-run rental rate r_S is lower than the purchase price p, renters see their utility decrease in the long-run (and vice versa), relative to the short-run equilibrium, but their utility is still higher than the pre-"sharing" status quo. The rental option does not benefit every non-owner: non-owners with very low valuations will still not consume any of the good.

The biggest beneficiaries from the emergence of the P2P rental market are consumers near the extensive margin, i.e., the breakeven point for ownership. In the short-run, these consumers see their utilities increase the most, as they constitute the highest-valuation non-owners and the lowest-valuation owners (see Equation 12 and 13). In the long-run, at-the-margin consumers who revise their ownership see the largest utility gains: maintaining their ownership status-quo is made more attractive than without the P2P rental option, and hence consumers who revise their ownership decisions are made even better off.

It is worthwhile noting that owners never rent out their entire capacity. This commonly cited "pathological" outcome never occurs, as owners have higher valuations than renters, and any price that would incentivize owners to rent out their entire capacity would be met with zero demand.[14] Furthermore, owners always use the good more than renters (see Equations 2 and 4). As such, total consumption of the good strictly increases following the emergence of a P2P rental market.

4.2 Owning

Some commentators on the "sharing economy" have argued that the emergence of P2P rental markets would unambiguously reduce ownership. Their argument assumes that there is a fixed amount of consumption for goods—a "lump of consumption"—, and that when unused goods are pulled into the market, demand can be met with fewer goods owned.

Our model shows that reduced ownership may or may not follow, and identifies the condition leading to decreased and increased ownership.[15] Ownership decreases in the long-run if the short-run equilibrium rental rate r_S is lower than the purchase price p, and vice versa. If the short-run rental rate is below the purchase price, it is attractive for some owners to abandon ownership and become renters. In this case, rental demand for the good grows, and rental prices increase in the long-run. Conversely, if the short-run rental rate is higher than the purchase price, some current renters are better off purchasing the good; hence, ownership increases in the long-run.

Although ownership can go either way in a P2P rental market, "sharing" always has a market-expanding effect, in the sense that the "sharing" option can increase the price at which there is non-zero demand for purchasing a good. The market-expansion property is depicted by the shaded area in Figure 3. Before the rental market emerges, the highest price that would be met with positive demand for the good is $p = 1$. In the long-run equilibrium of the P2P market, however, consumers demand $\alpha - p/2$, and hence a market can be supported up to $p = 2$ (see Equation 2).

[14]This result may no longer hold in the presence of consumers with heterogeneous BTM costs; we examine this case in Section 6.3. Furthermore, cases such as owners who allegedly rent out their apartments full-time in home-sharing P2P rental markets, indicate that corner solutions may arise in markets where additional goods cannot be readily produced.

[15]This result is conceptually similar to Jevon's paradox—the P2P rental market increases usage efficiency which increases demand, potentially more than the efficiency "savings."

4.3 Surplus

The aggregate consumer surplus before the rental option is introduced is

$$U_0 = \int_{\sqrt{p}}^{1} \left(\alpha^2 - p\right) dF(\alpha). \tag{14}$$

After the P2P rental option emerges, the short-run consumer surplus becomes

$$U_S = U_0 + \underbrace{\int_{\sqrt{p}}^{1} \left(1 - \alpha + \frac{r_S}{4}\right) r_S \, dF(\alpha)}_{\text{increase in owners' utility}} + \underbrace{\int_{r_S/2}^{\sqrt{p}} \left(\alpha - \frac{r_S}{2}\right)^2 dF(\alpha)}_{\text{increase in non-owners' utility}} . \tag{15}$$

It is straightforward to show that $U_S \geq U_0$: owners put underutilized capacity to use and non-owners consume more of the good. As the rental rate r_S multiplies the surplus term for owners, in the case of a glut ($r_S = 0$), all market gains accrue to renters, and the utility of owners does not increase relative to the pre-P2P rental market status quo.

It is worthwhile noting that the greatest gains in short-run surplus are obtained when non-owners value the good nearly as highly as owners, that is, when the valuation distribution function F has significant mass around $\sqrt{p}$. This suggests that product markets where income—rather than taste or planned usage—primarily explains ownership can benefit the most from the existence of a P2P rental option. To see why, assume that each consumer also has a budget constraint $\bar{p} \sim G$, such that $\bar{p}$ is uncorrelated with α, and a consumer purchases the good only if $\alpha' = \min\{\alpha, \sqrt{\bar{p}}\}$ exceeds $\sqrt{p}$ (see Equation 1). A direct implication of the budget constraint is that some consumers with valuations exceeding $\sqrt{p}$, and who would otherwise buy the good, are excluded from consumption; the emergence of the P2P rental market allows these high-valuation consumers to obtain high utilities from renting the good.

The long-run consumer surplus with P2P rentals is

$$U_L = \int_{p/2}^{1} \left(\alpha - \frac{p}{2}\right)^2 dF(\alpha). \tag{16}$$

This formula harkens back to Equation 1, that is, $u^*(\alpha) = \alpha^2$: all rental payments can be ignored since they are simply transfers between owners and renters. Furthermore, note that although ownership may either increase or decrease in the long-run equilibrium, we do not have to explicitly account for this effect in the calculation of U_L: the reason is that the "sharing" option decouples consumption from ownership, and the consumption of both owners and renters depends only on their valuations for the good, and the rental rate.

We can show that $U_L \geq U_S$, that is, that the aggregate consumer surplus further increases in the long-run equilibrium of the P2P rental market. To calculate the change in total consumer surplus, we can ignore changes in rental rates, as the corresponding changes in rental incomes and expenditures for consumers that did not revise their ownership, as these changes simply constitute transfers. As such, we need focus only on consumers who revise their ownership decisions. Consumers revise their ownership decisions because doing so increases their utilities. Hence, their actions are surplus-improving.

The highest short- and long-run surplus gains are obtained when $r_S = r_L = p$. Let $\Delta U(p) = U_L(p) - U_0(p)$. Clearly, $\Delta U(0) = 0$, as the P2P rental option is of no benefit when a good can be purchased at no cost. The first order derivative of the surplus gains yields

$$\frac{d}{dp}\Delta U(p) = \underbrace{\int_{\sqrt{p}}^{1} dF(\alpha)}_{\text{pre-P2P rental capacity}} - \underbrace{\int_{p/2}^{1}\left(\alpha - \frac{p}{2}\right) dF(\alpha)}_{\text{long-run consumption with P2P rentals}} \tag{17}$$

If $r_S > p$, ownership decreases in the long-run equilibrium, which implies that the pre-P2P rental market capacity exceeds the total consumption of the good in the long-run market equilibrium, and hence $\frac{d}{dp}\Delta U(p) > 0$. Similarly, if $r_S < p$, then $\frac{d}{dp}\Delta U(p) < 0$. Therefore, Equation 17 implies that the long-run surplus gains are maximized when no consumers revise their ownership decisions in the long-run. Furthermore, as $U_S \geq U_L$, with the equality holding only when no consumers revise their ownership decisions, short-run surplus gains are also maximized when $r_S = p$.

These results are graphically depicted in the bottom panel of Figure 3c, for the case of uniformly distributed consumer valuations. There exist consumer surplus gains in the short-run equilibrium, and these gains further increase in the long-run equilibrium. Equality holds only when no consumers revise their ownership decisions in the long-run, that is, when $r_S = p$, in which case both the maximum short- and long-run surplus gains are obtained. An additional source of surplus is found in the market-expanding region, depicted in the shaded area, where demand would be zero in the absence of a P2P rental market. This kind of surplus is fundamentally different from the previous cases, and is not captured in the formulation of Equation 16.

A complete assessment of the surplus implications of P2P rentals would necessarily consider industry-specific factors. As the consumption of the focal good increases, so will the consumption of complementary goods and labor, which further increase surplus. However, increased consumption of goods with negative externalities—say, an Airbnb rental in a building creates unwanted disturbance to neighbors—may lead to a decrease in surplus, and possibly to a market failure (Filippas and Horton, 2018). Another assumption in our surplus calculations is that there exist no pecuniary externalities, that is, that the purchase price of the focal good does not increase following the introduction of P2P rentals. Price changes in markets can have important practical and distributional consequences, but they have traditionally been viewed as neutral from an efficiency standpoint: every transaction has both a buyer and a seller, and hence pecuniary externalities constitute transfers, and are of little policy import. We further discuss this point in Section 6.1.

5 Bring-to-market costs

We have thus far assumed that owners can rent out their unused capacity at zero cost. We next extend our model by assuming that owners incur "bring-to-market" (BTM) costs. Some BTM costs are straightforward: labor costs for goods that require a labor input, complementary consumables, and asset depreciation from use. For example, driving with Uber requires both labor and gas, and increases the mileage on a car. BTM costs in most contexts also include the transaction costs inherent in finding trading partners, coming to terms, executing payments, and handing off the good. An Airbnb rental, for example, requires finding and dealing with the customer, cleaning the unit, and passing out the keys. The time it takes to re-set a good is essentially capacity that cannot be sold. A big part of what "sharing economy" platforms do in practice is try to reduce this lost time e.g., ride-sharing companies work to improve dispatch procedures to raise driver utilization, or the time spent with paying customers (Hall et al., 2019).

Goods generally differ in their BTM costs, and these differences in turn affect whether a P2P rental market is feasible, and if so, its characteristics. The relative significance of the different components of BTM costs is determined by the attributes of the goods being rented. For example, one such attribute is how amenable a good is to "temporal division." Goods for which usage can be planned or easily adjusted are presumably easier to rent out. Similarly, goods that are used in large chunks of time—with no use in between—can presumably be rented out more easily than goods whose optimal usage is broken up into many small chunks of time. We examine how these attributes affect BTM costs in Section 6.4, and measure how amenable various goods are to temporal division in Section 7. To start, we will stay very general and simply assume some BTM cost proportional to the "amount" rented out.

Owners incur BTM costs at rate γ, linear in the amount of that they try to rent, and of the same magnitude for all owners.[16] The owners' consumption problem becomes

$$x_O(r;\alpha) = \underset{x\in[0,1]}{\operatorname{argmax}} \quad 2\alpha x - x^2 + \underbrace{(r-\gamma)(1-x)}_{\text{rental income}} = \max\left\{0, \alpha - \frac{r-\gamma}{2}\right\}. \tag{18}$$

With BTM costs, renting becomes less profitable. As a result, owners use the good more, and make less available on the P2P rental market. Owners' utility becomes

$$u_O(r;\alpha) = \alpha^2 - p + \left(1 - \alpha + \frac{r-\gamma}{4}\right)(r-\gamma). \tag{19}$$

Equation 19 shows that increases in γ result in larger decreases in the utility of lower-valuation owners. The reason is that owners with lower valuations use the good less, and have more excess capacity that they rent out through the P2P rental market. As BTM costs increase, these owners incur larger utility losses. The renters' decision problem is unaffected, in the sense that they only respond to the rental rate r (see Equations 4 and 5). Of course, r is affected by the BTM costs.[17]

5.1 Market emergence and short-run equilibria

Given BTM costs, some product markets will not support an associated P2P rental market. To see why, consider the marginal non-owner, that is, the highest-valuation potential renter, who was previously indifferent between owning and not owning the good. The valuation of the marginal non-owner is $\sqrt{p}$, and hence for rentals demand to be positive, $r \leq 2\sqrt{p}$. As owners have an incentive to rent only if $r \geq \gamma$, the necessary condition for a P2P rental market to emerge is $\gamma \leq 2\sqrt{p}$. In words, when the price of a good is so low that nearly everyone owns it and there are BTM costs, there will not be a sufficient pool of non-owners. For example, nearly every household owns a pair of scissors, and despite being used very infrequently (on average, probably seconds a day), there is not a latent pool of non-owners who would like access to the scissors of owners. If a P2P rental market can be supported, then the short-run market clearing process is similar to the $\gamma = 0$ case.

For a given BTM cost, a glut is more likely to occur in the short-run equilibrium if the good's purchase price is low. The reason is that for low prices, the pool of owners is larger, and hence the idle supply is more likely to exceed the demand for rentals. As prices increase, fewer consumers own the good, and more consumers want to rent it. The glut disappears,

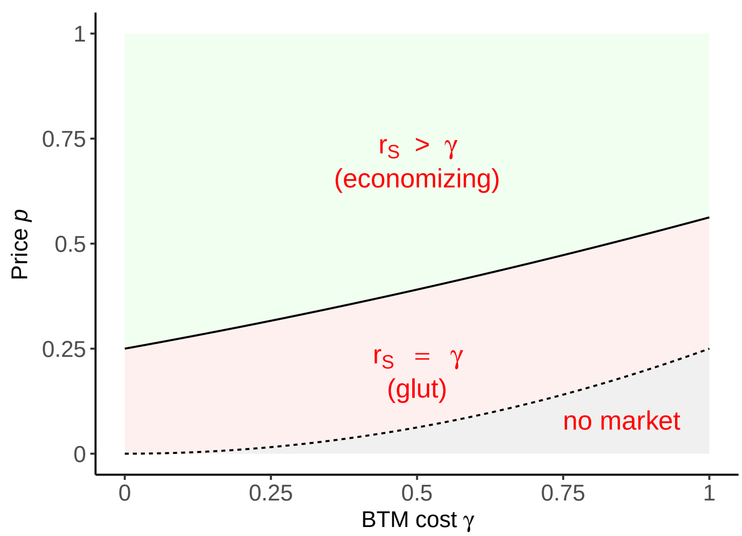
[16] If consumers have heterogeneous BTM costs, the predictions of our model about who rents and who owns can change. We examine the implications of BTM cost heterogeneity in Section 6.3.

[17] The derivations of the results for the case of positive BTM costs are similar to those for the case of zero BTM costs. For brevity, we choose to present these derivations in Appendix A.

and, in the "economizing" region, owners will begin reducing their consumption to rent out their good more.

Figure 4 illustrates this result for the case of uniformly distributed consumer valuations. The BTM cost γ is plotted on the x-axis, and the good's purchase price p is plotted on the y-axis. For fixed BTM costs and high enough purchase price, few owners own they good, and these owners reduce their consumption when a P2P rental market emerges. As purchase prices decrease, the idle capacity exceeds the demand for rentals, and a glut occurs. Furthermore, if the purchase price is sufficiently low, owners would incur losses to rent out the good, and so a P2P rental market does not emerge. It is worthwhile noting that, in the long-run equilibrium, the "no market" region is identical, but economizing and glut regions no longer exist (see Section 4).

Figure 4: Short-run market outcomes with BTM costs.



Notes: This figure depicts the possible short-run outcomes of the P2P rental market as a function of the BTM costs γ and the purchase price p, for the case of uniformly distributed consumer valuations on the unit interval. A market fails to emerge for $\gamma \leq 2\sqrt{p}$. If a market emerges and $\sqrt{p} \leq \frac{1}{2} + \frac{\gamma}{4}$, a glut results, and $r_S = \gamma$. Otherwise, the demand for renting the good is higher than the unused capacity, owners decrease their usage, and the market clears at $r_S = 2 - 2\sqrt{(1-\sqrt{p})(2-\gamma)}$.

5.2 Ownership

BTM costs affect who owns and who rents. Consumers with higher valuations now tilt towards ownership, while consumers with low valuations tilt towards renting. The economic rationale behind this separation result is that consumers with higher valuations want to use the good more, and since they bear no BTM costs from own-consumption, they find ownership relatively more attractive than renting. The "sharing" option decouples preferences—consumer valuations for the good—from ownership decisions, if BTM costs are zero, and introducing positive BTM costs couples preferences and ownership again. Of course, this directly depends on the nature of the BTM costs, and may be reversed if alternative cost structures are assumed. For example, if there are diminishing costs to renting or large fixed costs, ownership may revert to lower-valuation consumers. We further discuss the implications of alternative BTM cost structures in Section 6.3.

5.3 Pass-through

Rental rates increase in BTM costs because rental supply decreases while demand remains the same. However, there is incomplete pass-through of the BTM costs to the rental price, both in the short- and in the long-run. The argument that BTM costs are less than fully passed through becomes intuitive if we consider that γ plays a role equivalent to a per-unit sales tax. Formally, the pass-through rate is

$$\rho = \frac{1}{1 + |\epsilon_D|/\epsilon_S},$$

where ϵ_D is the elasticity of the demand (renters), and ϵ_S is the elasticity of the supply (owners). Extreme cases help see the incidence logic: if ϵ_S is finite but $\epsilon_D = -\infty$ (a horizontal demand curve), then $\rho = 0$, and owners are unable to pass-through any of the γ to renters. If $\epsilon_S = \infty$ (a horizontal supply curve) but ϵ_D is finite, then $\rho = 1$, and owners are able to pass through all of the γ to renters. However, so long as the distribution of consumer valuations has continuous support, neither side is completely inelastic with respect to price changes. As a result, the incidence of the BTM costs will not fall wholly on the demand side—as would be the case if $r_L = p + \gamma$.

An important implication of the incomplete pass-through result is that, as BTM costs increase, it becomes increasingly unprofitable for anyone to buy a good solely to rent it out. This result, however, hinges upon the assumption that there are no economies of scale in offering rental services. We show in Appendix A that, for uniformly distributed consumer valuations, the pass-through of BTM costs in the short-run equilibrium is non-zero and increasing in both p and γ, as supply is reduced and demand (weakly) increases.

An additional implication of the incomplete pass-through is that both renting and owning become less profitable as BTM costs increase. However, increases in BTM costs may either increase or decrease ownership, depending on the incidence. The valuation of the marginal owner, α_L, who is indifferent between owning and renting, is

$$\alpha_L = \frac{1+p}{2} - \left(\rho - \frac{1}{2}\right)\left(1 - \frac{\gamma}{2}\right).$$

In equilibrium, the higher the pass-through, the greater the number of owners. If we look at how marginal changes in the BTM costs affect ownership, we have

$$\frac{d\alpha_L}{d\gamma} = \frac{\left(\rho - \frac{1}{2}\right)}{2} - \left(1 - \frac{\gamma}{2}\right)\frac{d\rho}{d\gamma}.$$

Assuming the relative elasticities do not change very much in γ i.e., $\frac{d\rho}{d\gamma} \approx 0$, we can see that the sign of the effect on ownership from greater BTM costs depends on whether pass-through is relatively biased towards owners or renters.[18] The comparative statics are somewhat counterintuitive. If $\rho > 1/2$—implying that a greater share of BTM costs are passed through to renters—slightly higher BTM costs make ownership *less* attractive (α_L moves higher) because the premium on own-consumption is lower. In contrast, if $\rho < 1/2$, things work in reverse—owners can pass through a relatively smaller fraction of the higher BTM costs, increasing the return to own-consumption, and hence towards ownership.

6 Discussion

6.1 Product demand and prices

We have so far said little about how the rise of the "sharing economy" might affect the product market. As the introduction of the P2P rental market allows owners to monetize their unused capacity, some commentators have argued that this will result in an overall increase in purchase prices for goods that can be rented. While this outcome is certainly plausible in a monopolistic setting, it becomes less plausible in the long-run as the market structure approaches perfect competition. While this is beyond the scope of this paper, our model illustrates a number of additional possible effects on the product market.

First, we showed that the emergence of a P2P rental market always leads to increased consumption. For goods that depreciate rapidly with use, this may result in an overall increase in purchases. Second, as renting out goods requires complementary consumables and labor, production firms may find success in making their goods more "shareable," while

[18] Note that we cannot simply take the limit as $\gamma \to 0$ to compute the long-run equilibrium without BTM costs, as the preference decoupling result causes the market supply and demand elasticities to both become infinite, as all participants approach indifference between owning and renting. In nutshell, we can not assume that $d\rho/d\gamma = 0$.

entering the markets for complementary consumables. Two relevant examples can be found with building developers making their apartments "Airbnb-friendly," and car manufacturers investing in acquiring mobile-based vehicle unlocking technology.[19] Third, consumers who consider purchasing a good are now able to rent it before making a decision, thereby reducing their uncertainty about their valuation for the good; this can positively affect product demand, especially for expensive goods.

Recall that without rentals, the maximum price at which positive demand exists is $p_{\max} = 1$, and after a P2P rental market emerges, $p_{\max} = 2$. This market expansion property shows that P2P rental markets can help support a product market in cases where high production costs would otherwise make a product prohibitively costly to purchase. This effect can be of substantial interest to companies that produce new but costly technological products. 3D printers and drones provide a salient example; their early adoption was aided by a number of associated P2P rental markets.[20]

Even if market prices for products rise, this does not necessarily imply that consumers are made worse off. In real-life markets, one example of the renting-increases-demand phenomenon is the market for season tickets to professional sports teams. Many teams now facilitate a resale market for their season ticket holders, charging a modest fee to enable resales of individual games over the Internet. Presumably, these teams find that this quasi-secondary market increases demand for season tickets; the increases in ticket price is now covered by the additional revenue consumers earn through rentals. Along the same line, Belk (2014) points to the example of time-sharing condominiums expanding, rather than contracting, the second-home vacation market.

6.2 Competition with conventional rental firms

Our model predicts that in the long-run, owning a good purely to rent it out offers no profit when BTM costs are zero, and produces a loss when BTM costs are positive. This result potentially is grim news for conventional rental firms, although if there are economies of scale in rentals, say, due to fixed costs or lesser BTM costs at scale, the situation is improved, and possibly reversed.

There is already some evidence that P2P rental markets are negatively affecting traditional rental firms: Zervas et al. (2017) find that Airbnb is already winning customers from hotels that cater to the lower end of the market. The entrance of Airbnb lowered revenues by as much as 10% in some market segments; it also seems to be lowering prices. Neeser

[19] See `http://techcrunch.com/2018/08/21/getaround-raises-300-million-series-d-round-led-by-softbank`, and `https://www.niido.com/`.

[20] See also `https://dronelife.com/2018/01/24/drone-rental-sites/`

et al. (2015) do not find the same revenue effects but do offer some evidence that Airbnb may have pushed down prices in hotel Nordic countries. Farronato and Fradkin (2018) find that near-capacity hotels extract lower price premia because Airbnb supply flexibly adjusts to market demand.

On the ride-sharing side, there is clear and dramatic evidence that Uber is securing market share at the expense of existing taxi firms, such as falling medallion prices, notable bankruptcies, and fierce efforts by the taxi industry to restrict Uber.[21] The effects of competition are also potentially showing up in service quality: Wallsten (2015) presents suggestive evidence from Chicago that consumer complaints for traditional taxis fell following the entry of Uber.

Firms nevertheless maintain some advantages over consumer-owners. They can enjoy economies of scale and expertise in minimizing transaction costs. For example, a storefront tuxedo-rental firm has the advantage over owners of carrying many sizes, and the ability to make minor alterations, such as shortening sleeves. Edelman and Geradin (2015) provide the example of the ways a conventional hotel can, with a front-desk, handle the exchange of keys for hundreds of guests—a common source of friction for Airbnb rentals. However, they also point out that, unsurprisingly, P2P rental platforms invest heavily in trying to solve these kinds of problems. Indeed, Fradkin (2012) finds that in the case of Airbnb, matching probability increased 18% over a two-year span, after controlling for search intensity. A contributing factor was Airbnb's success in reducing transaction costs through, for example, minimizing the amount of information that had to be exchanged before completing a booking. In addition to these platform-led efforts, there is now a burgeoning industry providing complementary services to Airbnb hosts and Uber drivers.[22]

6.3 Alternative BTM cost structures

We assumed that BTM costs are constant and linear in the amount of the good rented. However, other possible structures are quite plausible. Although we do not formally model other types of cost structures, it is useful to think through their economic import, albeit somewhat informally.

We assumed costs that are linearly proportional to the amount rented, but there could also be a fixed cost. Fixed costs to renting would create an economy of scale that would favor consumers who could make more capacity available on the P2P rental market, that is, lower

[21] Taxi medallions in New York City sold for more than $1.2 million in 2013. By 2018, they have plummeted in price by 80% (see `https://www.bloomberg.com/opinion/articles/2018-06-19/uber-taxi-medallions-and-new-york-city-s-cab-bubble`).

[22] Recently-launched startup Guesty aims to be a Airbnb rentals management company. Cargo provides ride-sharing drivers with in-car vending machines.

valuation consumers. In the presence of significant fixed costs, ownership tilts towards those who do not value their own consumption, e.g., traditional rental firms. Costs that diminish in renting activity, such as would have the same effect.

We assume constant marginal costs, but in some cases marginal costs may rise with the quantity provided. To illustrate the rising cost context, Uber drivers may find it cheap to supply one hour of labor after their 9-5 jobs, but may find supplying two hours nearly impossible—if, for example, they have to pick up their kids from daycare at 6pm. Indeed, Hall and Krueger (2018) report that Uber drivers work surprisingly few hours relative to taxi drivers despite generally higher wages, suggesting that they face increasing marginal costs per shift. Chevalier et al. (2018) find that Uber drivers' surplus more than doubles because of the flexibility of schedule that ride-sharing affords them.

Although we assumed homogeneous costs, in practice costs will differ across sellers. In both the case of differential costs and in the case of costs that rise with output, the equilibrium is broadly similar—owners will be operating at the margin with BTM costs of γ. However, many owners will be reaping inframarginal benefits because their BTM costs are below those priced into the market price. Both the heterogeneity of costs and the possibility of fixed costs suggest that the extensive margin of supply is likely important in practice: when rental rates go up, more owners are pulled into the market.

6.4 Attributes of goods and the feasibility of "sharing"

A question of substantial practical import is identifying which goods are more or less amenable to being "shared." We argue there are factors separate from durability or reset cost considerations per se—namely, factors that are related to how a good is habitually used. We identify two attributes of goods that directly affect BTM costs: (1) the "chunkiness" of usage, that is, the duration of a single rental session, and the (2) predictability of usage, that is, how long in advance consumers know whether they will need the good,

Chunkiness of usage can affect a good's suitability for rentals. The reason is that fixed per-rental costs do not depend on the rental session's duration. To illustrate, for cars and apartments such costs would include cleaning and inspecting for damage, and costs to finding and assessing trading partners before each rental. In our base model, we treat goods as if they are perfectly and costlessly divisible: owner-consumers derive the same utility from providing all of their idle capacity to one renter, or a small fraction of it to many renters—all that matters for market clearing is total quantities balancing. However, a homeowner with 3 months of idle capacity would surely find it easier (would incur fewer costs) to lend the whole 3 months to a single renter, rather to 12 different renters, each of whom wants one week.[23]

Let x be an owners' excess capacity, and $\bar{x}$ be the good's chunk size. Then the smaller the chunk size $\bar{x}$, the greater the total costs an owner faces—they would be proportional to $x/\bar{x}$. As such, to lend out the same "amount" of a good, owners incur greater total BTM costs for goods with low chunkiness.

Another important determinant of how amenable a good is to being rented is the predictability of its usage. In most real markets, the buyer and seller need find and assess each other, and this process takes time.[24] In general, the more time before the good or service is desired, the easier it is to form a match—lining up a vacation home for next week is costlier than lining one up 3 months in the future. If a match has to be formed in a short amount of time, it will require more intensive—and hence more costly—search effort. This intuitive perspective can be made more formal with a directed search perspective (Guerrieri et al., 2017).

Suppose owner-consumers publicly commit to the market clearing rental rate, r and an agreed-upon chunk size. Assume that the rental price is determined by competition, and hence an equal number of renters and owners are attracted, say of measure n, and the market clears. Consider now the following matching process: owners and renters match according to a matching function in one "round," and anyone not matched moves on to the next round. Each "round" is costly to play, but sunk, and so no one exits the market if they do not match in the previous round. Assume a matching function with constant returns to scale, such that the first "round" of matches is $M_1 = m(n, n) = m(1, 1)n$, the second round is $M_2 = m(n - M_1, n - M_1) = m(1, 1)(n - M_1)$, and so on.

Matching continues unless everyone is matched. For any $m(1, 1) > 0$, get that $\sum_{i=1}^{\infty} M_i = n$, that is, everyone is matched as the number of "rounds" goes to infinity.[25] The end result—n goods traded at rental rate r—is the same as in our base model. In the matching process sketched above, everyone eventually matches, with a cost proportional to the expected number of rounds played. If a good is desired sooner than later, then, all other factors equal, the matching process must be compressed into a short time frame, which requires more effort, and is likely to be costlier.[26]

[23]As we argued in Section 5, the incomplete cost pass-through implies that an owner will have to incur at least some part of the additional cost.

[24]Some exceptions can be found with markets with unusual microstructures, such as the market for trading securities with a double book.

[25]To see why, let $k = 1 - m(1, 1)$. After round 1, the number of unmatched consumers is nk. After round 2, the number of unmatched consumers is nk^2. For any $k > 0$, $\lim_{x\to\infty} nk^x = 0$, which proves our claim.

[26] An alternative formulation is that with less time to match, we might think of more buyers and sellers being unable to match, and so the realized quantity transacted would be lower than n, with some buyers and sellers failing to match (and hence the quantities being transacted being smaller, *as if* they faced a higher BTM cost).

What is then likely to lead to very short or very long matching periods for a good? We argue that one main factor that determines the length of the matching process is the predictability of usage: when both owners and renters know they will not want to use (for owners) and want to use a good (for renters) far in the future, they have ample time to find each other, and hence costs will be lower. Conversely, if both idle capacity and rental demand are realized at the "last minute," it will take prodigious effort to form a match. As a result, goods with low predictability of usage will inherently have higher BTM costs, and vice versa for goods with predictable usage.

For goods with unpredictable usage, the platform often exerts substantial effort in improving the matching function. In the case of ride-sharing, for example, although the good is inherently unpredictable, the platform utilizes information on the drivers' and passengers' whereabouts to create a highly efficient matching function.

Following the arguments we developed in Section 5, P2P rental markets for goods with low-chunkiness and low-predictability are less likely to be feasible, and if they are, such markets are less profitable. Examining the relationship between "shareability" and the patterns of how goods are characteristically used is a promising research direction. In Section 7, we find empirical support that goods with unpredictable usage, or with usage that occurs in small chunks, are more likely to be owned and hence less likely to be rented.

7 Assessing model assumptions and predictions

Our model posits that the valuations of consumers, and the purchase price and BTM costs of a good determine the feasibility and outcomes of a P2P rental market. In this section tests some of the core model assumptions and predictions empirically. We use data on a set of goods collected through a consumer survey conducted on Amazon Mechanical Turk.[27]

7.1 The relationship of planned usage and ownership

The core assumption in our model is that consumers are more likely to own if they plan to use the good more often. Consumers consider how much they will use a good, and compare their expected utility from using the good against its purchase price. To test this assumption, we asked respondents to select how often they would use a good if they used it, and whether

[27] All details of the survey methodology, including the full list of goods and the survey questions, can be found in Appendix B.

they do own it. Column (1) of Table 1 reports an OLS estimate of

$$\text{Own}_{ig} = \beta_0 + \beta_1 \log x_{ig} + c_g + \epsilon_g, \tag{20}$$

where Own_{ig} indicates ownership by respondent i of good g, x_{ig} is the respondent's reported fraction of time they estimate they would spend using the good, and c_g is a good-specific fixed effect. Column (2) adds a control for the log of family income, and Column (3) adds a respondent fixed effect.

We find evidence that ownership is positively associated with higher estimated usage. The coefficient on the estimated usage regressor in Column (1) of Table 1 implies that a doubling of expected usage for some good—say using a BBQ grill two hours a week instead of one hour—is associated with about a 2.5 percentage point increase in the probability that the good is owned. In Column (2), the coefficient on the usage regressor is of the same magnitude, despite including self-reported household income in the specification. As we would expect given that most of the goods listed are normal, a higher income is associated with greater probability of ownership. A 10% increase in household income is associated with a 1% increase in the probability of ownership. However, the lack of change in the usage regressor implies that the pattern found in Column (1) is not the result of higher income respondents being more likely to own and report greater expected usage, e.g., because of greater leisure time. In Column (3), we re-estimate Column (1) including respondent-specific fixed effects. The strong positive relationship between expected usage and ownership persists. Indeed, the coefficient on log estimated usage changes little across specifications.

The results in Table 1 suggest that both income and predicted usage are important for explaining ownership decisions. In Figure 5, we plot the per-good percentage of non-owners citing income as the reason for non-ownership (out of non-owners that cited either income or usage—very few cited space). Explanations for non-ownership tilt strongly towards usage rather than income considerations. The only goods where a larger fraction of respondents cited income rather than usage were high-end headphones and vacation homes.

7.2 Predictability, chunkiness, and the feasibility of "sharing"

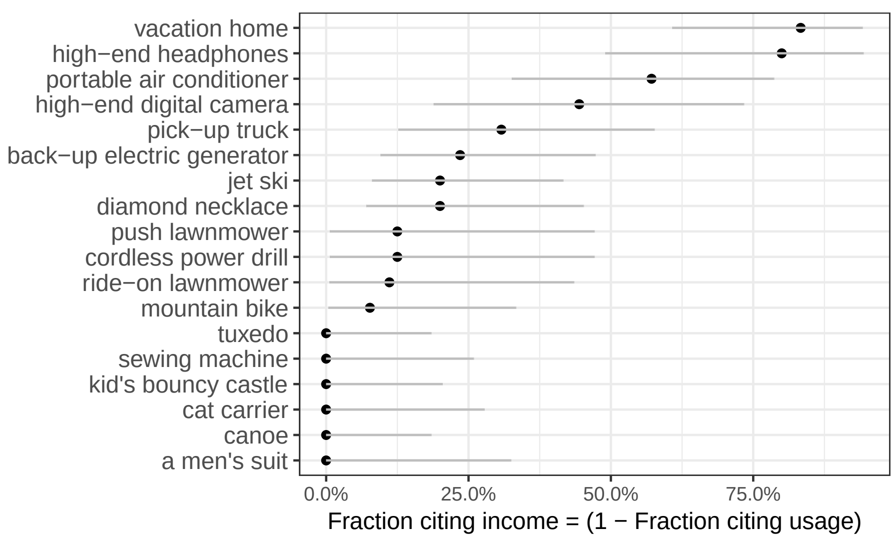
In Section 6.4, we argued that the predictability and size of use sessions of goods can be thought of as being inversely analogous to BTM costs, and hence can be important determinants of how amenable a good is to being "shared." For example, a hammer is used in small chunks of time and this usage is unpredictable—e.g., when hanging a picture. On the other hand, a tuxedo is used for a substantial amount of time, and that usage can be predicted

Table 1: Respondent estimates of the usage of a good, and ownership decisions

	Dependent variable:		
	Respondent owns the item?, ($\text{OWN}_{ig} = 1$)		
	(1)	(2)	(3)
Log estimated usage, $\log x_{ig}$	0.0262**	0.0259**	0.0264**
	(0.0111)	(0.0109)	(0.0110)
Log household income, $\log y_i$		0.1019***	
		(0.0254)	
Good FE	Y	Y	Y
Respondent FE	N	N	Y
Observations	411	411	411
R^2	0.4447	0.4651	0.5672

Notes: This table reports OLS regressions where the dependent variable indicates whether a respondent reported owning a particular good. In Column (1), the independent variable is that respondent's estimate of the fraction of time s/he would spend using the good (in logs). In Column (2), we add a regressor for the log of the respondent's self-reported household income. In Column (3), we add a respondent-specific fixed effect to the specification of Column (1). The sample is restricted to respondents who reported positive predicted usage of the good, and reported their household income. All regressions include good-specific fixed effects, and standard errors are clustered at the good level. Significance indicators: $p \leq 0.05 : *$, $p \leq 0.01 : **$, and $p \leq .001 : ***$.

Figure 5: Fraction of respondents citing income as the reason for not owning a good



Notes: This figure plots the fraction of non-owners for each good citing income, among those that cited either income or usage as the reason for non-ownership. Non-owners were asked for the primary reason for not owning a good and could cite usage ("We wouldn't use it enough to justify the purchase price"), income ("We would use it, but we simply do not have the money") or space ("We don't have space for this item."). Goods with seven or more non-owners are included. Each point estimate is contained within a 95% CI, calculated using the Wilson method (Wilson, 1927).

far in advance—e.g., when attending a wedding.[28]

We asked subjects to rate the unpredictability and chunkiness of their use for a set of goods. We plot their responses in Figure 6. We observe a strong relationship between chunkiness and predictability.[29] Goods near the origin—for which use occurs in large chunks—are often goods for which conventional rental markets already exist. Examples include formal wear (tuxedos), vacation homes, bikes, sporting equipment (canoes and jet skis for rent at lakes), and so on. Rental markets are less likely to exist for goods such as lawnmower and jewelry, which are a bit further from the origin, but these goods seem to have the attributes necessary to support such a market—assuming enough high-valuation non-owners exist.

We may also examine the relationship of predictability and chunkiness measures to individual ownership. In Column (1) of Table 2, we report an estimate of

$$\textsc{Own}_{ig} = \beta_0 + \beta_1 \textsc{UnpredictabilityScore}_{ig} + c_i + \epsilon_i, \quad (21)$$

where $\textsc{UnpredictabilityScore}_{ig}$ is the normalized unpredictability score by respondent i for good g.

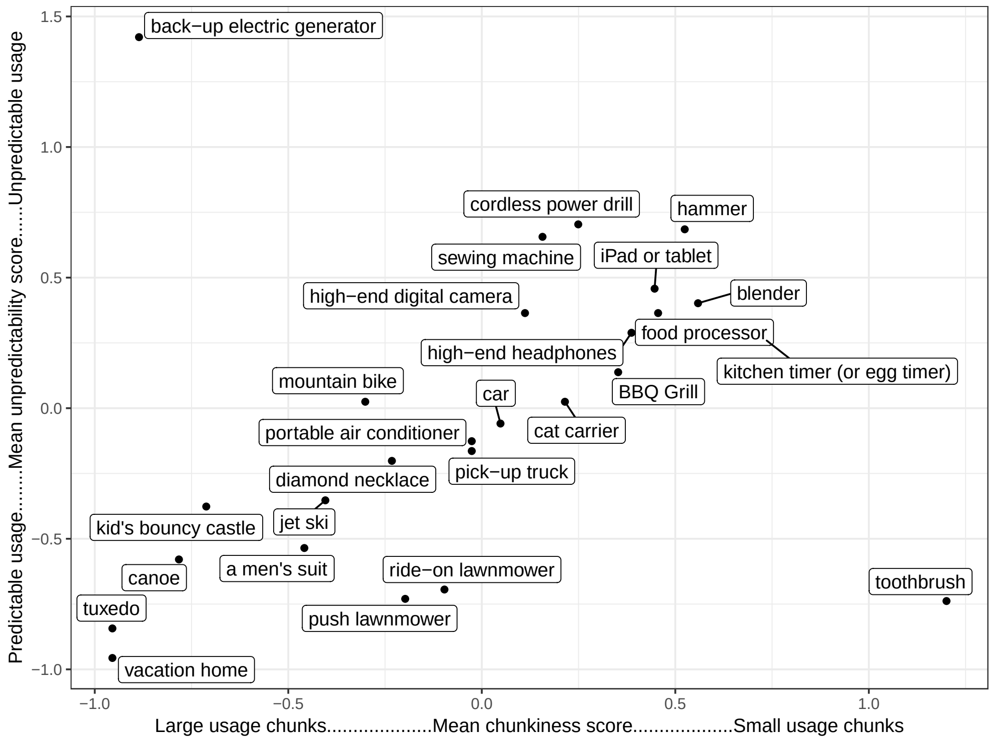
The coefficient of the unpredictability score is positive and highly significant. A one standard deviation decrease in predictability increases the probability of ownership by about 14 percent. Column (2) uses the chunkiness measure as the predictor, and it also finds a positive and highly significant effect of roughly the same magnitude. These estimates support our argument that goods with unpredictable usage that occurs in small chunks are substantially more likely to be owned. We interact the chunkiness and predictability measures in Column (3). The effect for each measure is reduced, though a formal hypothesis test would fail to reject a difference relative to the estimate when each measure appeared alone. Their interaction term, while negative, is small and far from significant. In words, predictability and chunkiness are not simply capturing some single latent "rentability" measure. Each seems to exert an independent effect on the probability of ownership.

One concern with our approach might be that respondents prone to reporting high or low chunkiness and predictability scores might be idiosyncratically more or less likely to own the good. In other words, the patterns from Columns (1) through (3) might reflect individual differences rather than general attributes about the good. Column (4) uses the

[28]Benkler points out that some goods are "lumpy," that is, less than some threshold amount cannot be bought, but once purchased, an owner invariably has excess capacity. Benkler provides the example of a personal computer, which cannot be purchased in fractional amounts but, once purchased, remains unused for prolonged amounts of time.

[29]Two notable outliers are the toothbrush and the generator. A toothbrush is used in small chunks (2 minutes according to the ADA) and its use is highly predictable (after every meal, if ADA prescriptions are followed). The back-up electric generator is the toothbrush's conceptual opposite—power can go out for days or even weeks during a disaster, and this event is rarely predictable.

Figure 6: Usage predictability versus chunkiness



Notes: This figure plots goods' mean unpredictability score (1 is highly predictable, 5 is highly unpredictable) versus their mean chunkiness score (1 is high chunkiness, and 5 is low chunkiness). Scores are calculated by normalizing the 1-5 scores across all goods and all respondents. Lower chunkiness scores imply that the good is characteristically used in large chunks, and low unpredictability score implies that usage is relatively predictable.

same specification as Column (3), but includes a good-specific effect. With this effect, the coefficients on each regressor ends up close to zero, which supports the notion that the patterns in the previous regressions are indeed driven by the nature of the good.

8 Conclusion

The "sharing economy" has dramatically impacted several important markets in just a few years, most notably those for ride-sharing services and home-sharing. Given the energy and vision of entrepreneurs, new developments in both technology and the effective communication of information, P2P rental markets have the potential to transform additional markets.

One area where P2P rental markets could have a beneficial long-term effect is on the diversity of goods most individuals consume. Consider that in some economic formulations

Table 2: The relationship of unpredictability and chunkiness with good ownership.

	Dependent variable:			
	Item is owned			
	(1)	(2)	(3)	(4)
Unpredictability Score (US)	0.139***		0.095***	0.003
	(0.030)		(0.034)	(0.034)
Chunkiness Score (CS)		0.135***	0.091***	−0.018
		(0.025)	(0.029)	(0.025)
US x CS			−0.009	0.006
			(0.018)	(0.018)
Respondent FE	Y	Y	Y	Y
Good FE	N	N	N	Y
Observations	489	489	489	489
R^2	0.170	0.169	0.191	0.500

Notes: This table reports OLS regressions where the dependent variable is an indicator for whether a respondent reported owning a particular good. In Column (1), the independent variable is the respondent's estimate of the unpredictability of using that good. In Column (2), the independent variable is the respondent's estimate of the chunkiness of using that good. The two independent variables are normalized responses to the 1-5 scale questions on usage chunkiness and unpredictability, pooled over all respondents and goods (see Appendix B for the actual survey language and responses). Toothbrushes and backup generators are excluded from the sample. In each regression, a respondent-specific fixed effect is included. Standard errors are clustered at the level of the individual respondent. Significance indicators: $p \leq 0.05 : *$, $p \leq 0.01 : **$, and $p \leq .001 : ***$.

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 fine-grained distinctions among "goods." For example, Amazon currently lists more than 9,000 results for "blender" in the Home & Kitchen category. Presumably most households own far fewer than this number, with most owning one or none.[30] The reason for this pattern in the language of this model is clear: a consumer's valuation α for Blender 2 *conditional* upon owning Blender 1 is quite low. Thus, a second blender is not purchased. However, if a low-BTM P2P rental market existed for both blender types, consumers could act upon their taste for diversity and use both types without owning both blenders.

One potential long-term reaction to the rise of P2P rental markets is that firms will develop new goods, and substantially change goods that they currently produce. For example, P2P rental markets may support autonomous vehicles, and, more prosaically, locks on cars and houses that allow remote entry will be developed. The emerging Internet-of-Things will make it easier to identify goods that are not being used at a moment in time, and will facilitate nearly seamless trade. Once autonomous transport mechanisms, such as drones and wheeled vehicles, become commonplace, even the seemingly unavoidable transaction costs

[30] As of May 7, 2019.

associated with moving goods to where they are needed might diminish substantially.[31] Similarly, technologies that make it easier to monitor usage (GPS, embedded sensors, streaming video of how goods are being used, and so on) should make contracting easier and reduce some of the informational asymmetries that generate transaction costs. As more of economic and social life is computer- and Internet-mediated, platforms will use the information gained to verify the identity and reputation of buyers and sellers, thereby reducing both moral hazard and adverse selection. In the not-too-distant future, much as e-commerce has already supplanted traditional retail markets in many realms, P2P rental markets, as opposed to use-what-you-own markets, may be the predominant form over vast swaths of the economy.

[31] Thanks to Jonathan Hall for making this point.

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A Derivations for linear BTM costs

A.1 Short-run equilibrium

A.1.1 Structure and uniqueness

We assume in what follows that $\gamma \leq 2\sqrt{p}$, i.e., that the product market can support an associated P2P rental market. In the short-run, ownership is fixed, and the total supply offered in the P2P rental market at rental rate r is

$$S(r;\sqrt{p},\gamma) = \begin{cases} \int_{\sqrt{p}}^{1} \left(1-\alpha+\frac{r-\gamma}{2}\right) dF(\alpha), & \text{for } r > \gamma \\ 0, & \text{for } r \leq \gamma \end{cases}, \tag{A1}$$

Let $S_0 = S(\gamma;\sqrt{p},\gamma)$ be the minimum available supply, that is, the total amount of time that owners' products were unused before renting was an option. Renter demand is

$$D(r;\sqrt{p},\gamma) = \begin{cases} 0, & \text{for } r > 2\sqrt{p} \\ \int_{r/2}^{\sqrt{p}} \left(\alpha-\frac{r}{2}\right) dF(\alpha), & \text{for } r \leq 2\sqrt{p} \end{cases}, \tag{A2}$$

with $D_0 = D(\gamma;\sqrt{p},\gamma)$ denoting the maximum demand under any P2P rental market that can be supported for BTM cost γ.

If the pre-rental unused capacity exceeds the unfulfilled demand for the good, i.e., $S_0 \geq D_0$, a glut results. Owners then compete on rental prices, and the market clears at $r_S = \gamma$, with rental rate being pushed to the marginal "production" cost—the BTM cost γ. If $S_0 < D_0$, owners reduce their usage intensity in order to rent the good out more on the P2P rental market. As $S(r;\sqrt{p},\gamma)$ is increasing in r, and $D(r;\sqrt{p},\gamma)$ is decreasing in r with $D(2\sqrt{p};\sqrt{p},\gamma) = 0$, the market clears at the rental rate $r_S \in (\gamma, 2\sqrt{p})$ for which $S(r_S;\sqrt{p},\gamma) = D(r_S;\sqrt{p},\gamma)$, which can also be usefully rewritten as

$$\int_{\sqrt{p}}^{1} 1dF(\alpha) - \underbrace{\int_{r/2}^{1} \alpha dF(\alpha) + \int_{r/2}^{\sqrt{p}} \frac{r}{2} dF(\alpha)}_{\text{(I)}} + \underbrace{\int_{\sqrt{p}}^{1} \frac{r}{2} dF(\alpha)}_{\text{(II)}} - \underbrace{\int_{\sqrt{p}}^{1} \frac{\gamma}{2} dF(\alpha)}_{\text{(III)}} = 0. \tag{A3}$$

By the monotonicity property of the supply and demand curves, the equilibrium market-clearing rental rate is unique.[32]

[32] Note that the derivations for the case of zero BTM costs and positive BTM costs are similar, i.e., adding BTM costs does not substantially change the predictions of our model.

A.1.2 Pass-through of BTM costs in the short-run equilibrium

The short-run equilibrium rental rate r_S is increasing in γ, as it becomes less profitable for owners to reduce their usage and provide their excess supply, while demand remains unchanged. Formally, if a glut occurs then $r_S = \gamma$, and hence r_S is increasing in γ and there is complete pass-through of costs. If demand for rentals outweighs the unused capacity, we see from Equation A3 that Term (III) increases in γ, and terms (I) and (II) increase in r. Clearly, increases in γ have to be offset by increases in r_S for equilibrium to occur. Furthermore, there is incomplete pass-through of costs to the rental rate; assuming the opposite would require term (I) to not increase in r, which can only happen for infinitely elastic demand. But for infinitely elastic demand, either every consumer would already own the good or no consumer would rent the good, which makes our analysis trivial.

A.1.3 Example: pass-through in the case of uniform valuations

For uniformly distributed valuations, from Equations A1 and A2, we find that the rental rate elasticity of demand r is

$$\epsilon_D = -\frac{r}{\sqrt{p} - \frac{r}{2}},$$

and the rental rate elasticity of supply is

$$\epsilon_S = \frac{r}{1 - \sqrt{p} + r - \gamma}.$$

The BTM cost pass-through is then

$$\rho = \frac{\epsilon_S}{\epsilon_S - \epsilon_D} = \frac{\sqrt{p} - \frac{r}{2}}{1 + \frac{r}{2} - \gamma}.$$

As we would expect, the pass-through of the BTM costs in this case depends on two quantities: (i) the good's purchase price, with higher prices increasing the pass-through, as they imply higher rental demand and lower rental supply, and (ii) on the current BTM costs, with the pass-through increasing in BTM costs, as they imply lower rental supply.

A.2 Long-run equilibrium

A.2.1 Structure and uniqueness

To derive the long-run equilibrium with BTM costs, we first observe that for any $\gamma > 0$, if $u_O(r; \alpha_0) \geq u_R(r; \alpha_0)$, then for every $\alpha > \alpha_0$ we have $u_O(r; \alpha) > u_R(r; \alpha)$, as the utility from owning increases faster in valuation than the utility of renting (see Equations 5 and 19). Following the same argument, if $u_O(r;\alpha_0) \leq u_R(r;\alpha_0)$ then for every $\alpha < \alpha_0$ we get $u_O(r;\alpha) < u_R(r;\alpha)$. Consequently, the equilibrium is characterized by a critical valuation α_L, above which consumers own and below which consumers rent. This critical valuation is the valuation of the marginal owner—the consumer who is indifferent between renting and buying the good—for whom $u_O(r;\alpha_L) = u_R(r;\alpha_L)$, which simplifies to

$$\alpha_L = \frac{p - r(1-\frac{\gamma}{2}) + \gamma(1-\frac{\gamma}{4})}{\gamma}. \tag{A4}$$

The long-run equilibrium is then characterized by a critical valuation α_L and a rental rate r_L for which market supply equals market demand, that is, $S(r_L;\alpha_L,\gamma) = D(r_L;\alpha_L,\gamma)$.[33]

For any triplet (p,γ,F), a P2P rental market can be sustained if there exists some $r_L \geq \gamma$ for which $\alpha_L \in (\gamma/2, 1)$—if $\alpha_L \leq \gamma/2$, no renting takes place. This happens when $\gamma \leq 2\sqrt{p}$. If a market forms, there exists a unique equilibrium: as α_L is continuous and decreasing in r, for any distribution F that has a density with continuous support, $S(r;\alpha_L,\gamma)$ is continuous and increasing in r, and $D(r;\alpha_L,\gamma)$ is continuous and decreasing in r, and uniqueness follows.

A.2.2 pass-through of BTM costs in the long-run equilibrium

In the long-run equilibrium, the rental rate r_L increases in the BTM costs γ, but there is incomplete pass-through. To see why, consider any triplet (p,γ,F) and let α_L, r_L be the resulting long-run equilibrium of the P2P rental market. For equilibrium to occur, demand should equal supply, from which we get

$$\int_{\alpha_L}^{1} 1 - \left(\alpha - \frac{r_L - \gamma}{2}\right) dF(\alpha) = \int_{r_L/2}^{\alpha_L} \left(a - \frac{r_L}{2}\right) dF(\alpha). \tag{A5}$$

Now assume that BTM costs increase by some amount $\epsilon > 0$. This results in a decrease of the available market supply (LHS in the equation above), but demands remains constant, and hence prices should increase for the market to clear. If r increases by some amount greater or equal to ϵ, then all previous owners still decide to own, as the utility from owning remains the same, and the utility from rentals decreases (see Equations 5 and 19). These owners also rent out the same amount—or more—as they did before (see Equation 18). Furthermore, as renting becomes more expensive, some previous renters may now choose to now own the good. As a result, supply does not decrease. At the same time, demand decreases both in size (lower integration limit in the RHS of the equation above) and in intensity (integrand

[33] The supply and demand terms are as in Equations A1 and A2, with the only difference being that the integrand limit—which was formerly determined only by the price of the good—is now an equilibrium quantity.

in RHS). The resulting contradiction proves that there cannot be perfect cost pass-through, i.e. that the new market equilibrium rental rate is lower than $r_L + \epsilon$. We can similarly prove that r_L has to increase, and hence that there is incomplete pass-through.

B Design of the survey

We hired US-based "Master" workers to answer questions about a consumer good.[34] We asked questions about a total of 26 goods, selected because we thought that they would yield interesting answers, and because they varied in purpose (e.g., recreation, home improvement, cooking and so on), purchase price, predictability, and usage size. We asked MTurk workers 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 owned the good; whether they would use the good in one large chunk, or in many small chunks; whether their usage was predictable; why they did not own the good; and finally, their household income.

B.1 Choice of goods and sample

Goods that traditionally have been rented are expensive, durable goods that are used infrequently but whose usage can be planned in advance. Examples include cars and hotels in distant cities, tuxedos, certain kinds of specialty tools (e.g., rototillers, carpet shampooers), and so on. In the language of our model, these are goods with high purchase price p, broad-based appeal (meaning a large pool of non-owners with a non-zero valuation α), and a sufficiently low BTM cost (low γ) relative to the purchase price.

Other goods make poor rental candidates because their usage is difficult to plan. Some goods have a highly predictable usage pattern—a family might arrange to rent a vacation home months in advance—whereas other goods are much less predictable in their normal patterns of usage—the need for a back-up electric generator is almost always a surprise in most locales. Goods with hard-to-plan usage are unlikely to be rented easily as the temporal division problem is acute.

Another factor that affects suitability for rental is how much value a single session of usage offers, and thus whether renting can overcome the inherent transaction costs. While amount of time rented is not necessarily proportional to the value created,[35] the time of use is almost always related to value. Goods that are used in small sessions are likely to make poor rental candidates. Goods surely differ on this dimension: a person might use her vacation home in week-long chunks of time, her lawn-mower in hour-long chunks, and her

[34]Although MTurk offers a convenience sample, there is little reason to think its members would have highly idiosyncratic consumption patterns. Furthermore, for our purposes, the MTurk population is well-suited to answer a tedious set of questions carefully. Workers on MTurk whose work is "rejected" by dissatisfied employers become ineligible for the highest-paying jobs on the marketplace, and therefore are diligent, making them useful for certain types of questions. For example, Kuziemko et al. (2015) use MTurk to study elasticities of demand for redistribution.

[35] Consider that owners of champion racehorses can earn many hundreds of thousands of dollars from renting their animal's stud services for what could be a very small amount of time.

toothbrush in minute-long chunks.

We asked questions about a total of 26 goods that we selected because we thought they would yield interesting answers and varied in purpose (e.g., recreation, home improvement, cooking and so on), purchase price, predictability, and usage size. The goods we administered the survey for 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 digital [sic] camera, iPad or tablet, jet ski, kid's bouncy [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.

Each "human intelligence task," or HIT, comprised a total of eight questions about one particular good, with one question about family income. Workers were allowed to answer for each of the sampled goods.

B.2 Survey questions

The survey questions were the following:

1. Does your household own a **good**?
    - Yes
    - No
2. Have you ever lent your **good** to someone else?
    - Yes
    - No
    - NA - we do not own one.
3. Have you ever borrowed a **good** from someone else?
    - Yes
    - No
    - NA - we own one.
4. Have you ever rented a **good**?
    - Yes
    - No

- NA - we own one.

5. 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)

6. 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

7. 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.

8. 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

9. 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

It is worth making some observations about choices we made in designing the survey. First, to elicit expected usage, we asked respondents to select how often they would use a good in time units, using familiar measures of time to label the responses, e.g., one hour a week, one hour a day and so on. We framed the choices as being approximately on a logarithmic scale, with each increase in usage being approximately a doubling of the fraction of time. Second, in our estimation, incomes were imputed by taking the midpoint of the range associated with each bin (i.e., a respondent's selecting $10,000-$19,999 is imputed to have a $15K family income). There was only one top-coded respondent, who was given an imputed income of 1.5 times the censoring threshold.

B.3 Aggregate ownership and renting patterns

The recent flourishing of P2P rental markets helped motivate this paper. Thus, asking respondents whether they have rented a particular good in such a market would likely yield few results, given how new these markets are. Existing P2P rental market platforms seem to be focusing on sectors where conventional rental markets already existed (or at least met the same want, say in the case of Airbnb offering a substitute for hotels). As such, asking respondents if they have ever rented a good at all might be a reasonable proxy for whether they would eventually rent such a good in a P2P rental market.

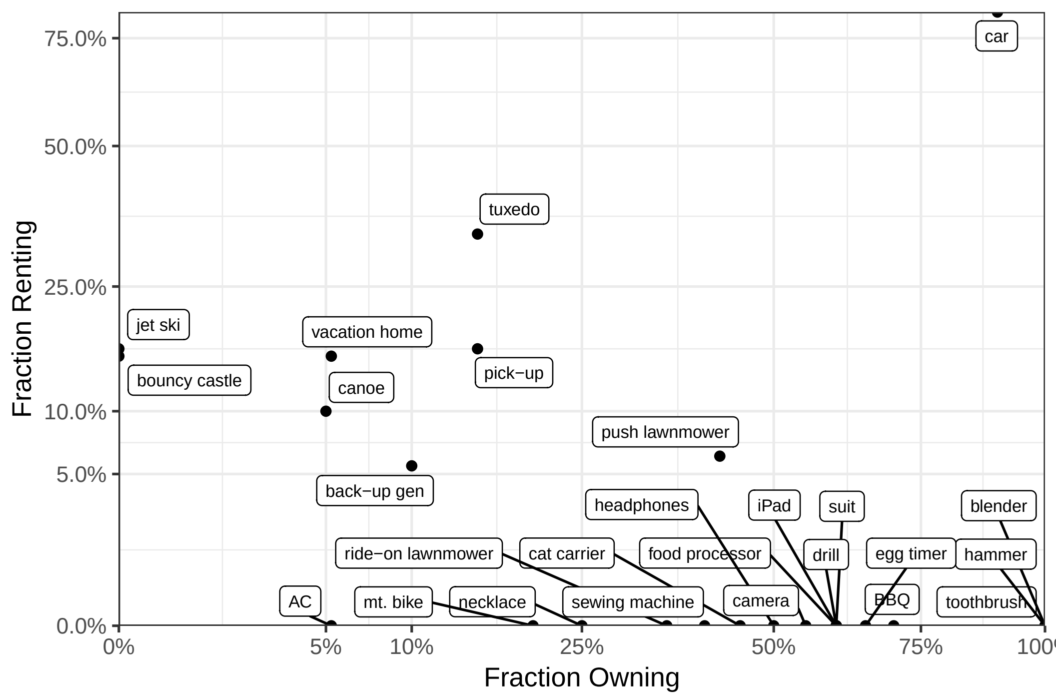
For each good, we asked whether the respondent's household (a) owned the good and (b) had ever rented the good. In Figure 7, the fraction owning is plotted on the x-axis and the fraction renting on the y-axis. Both axes employ a square root scale to better display the data. Some notable goods are labeled—see Appendix B.4 for the precise by-good fractions for every good. Renting and owning are gross substitutes in the data, when cars are excluded—cars show a high level of both ownership and rental. Unsurprisingly, goods that are nearly universally owned show little renting. There are a number of goods that show medium ownership levels (e.g., around 50%) and yet zero recorded instances of renting, which could indicate potential P2P rental market candidates. Goods used during special occasions such as weddings, celebrations, and vacations show the highest rates of rental and lowest rates of ownership, e.g., tuxedos, vacation homes, jet ski, tuxedos, canoes, and bouncy castles.

B.4 Additional empirical results

Figure 8a shows the fraction of respondents reporting owning various goods, as well as 95% confidence intervals for that point estimate computing using the Wilson method for a binary proportion. There are few surprises: nearly everyone owns a toothbrush, a hammer, and a blender; no one reported owning a jet ski, and only one respondent reported owning a vacation home. Figure 8b 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.

The mean unpredictability scores by good seem sensible: Figure 9a 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 9b shows the

Figure 7: Fraction of respondents reporting having rented versus fraction owning a good

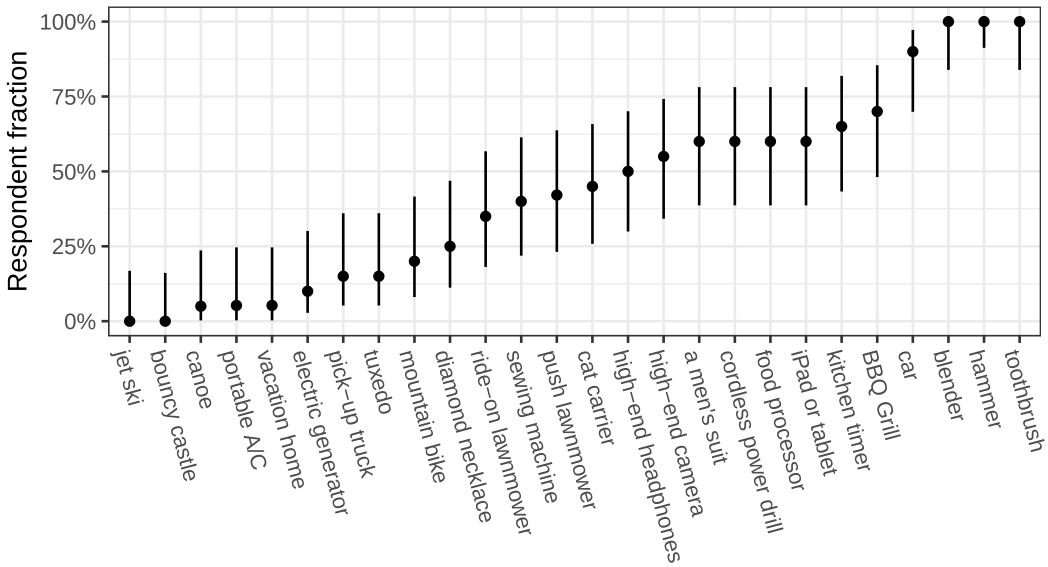


Notes: This figure plots the fraction of respondents reporting having renting good at least once, versus the fraction reporting owning the good.

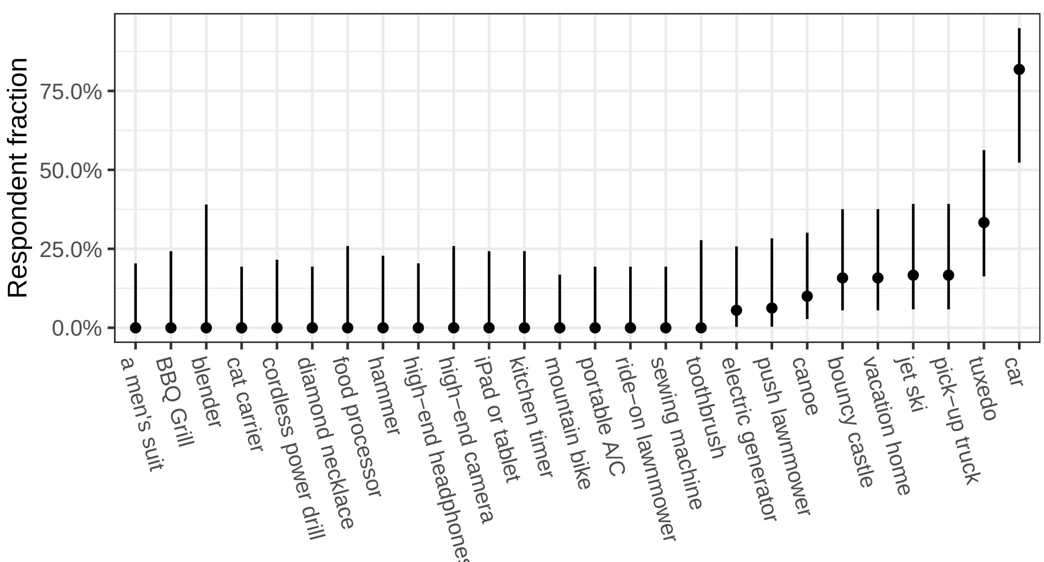
mean chunkiness index per good. There appears to be some similarity in highly predictable usage, but some goods used in small chunks of time also appear to have highly predictable usage—namely the toothbrush.

Figure 8: Fraction of respondents reporting owning and renting various goods

(a) Fraction of respondents reporting owning various goods



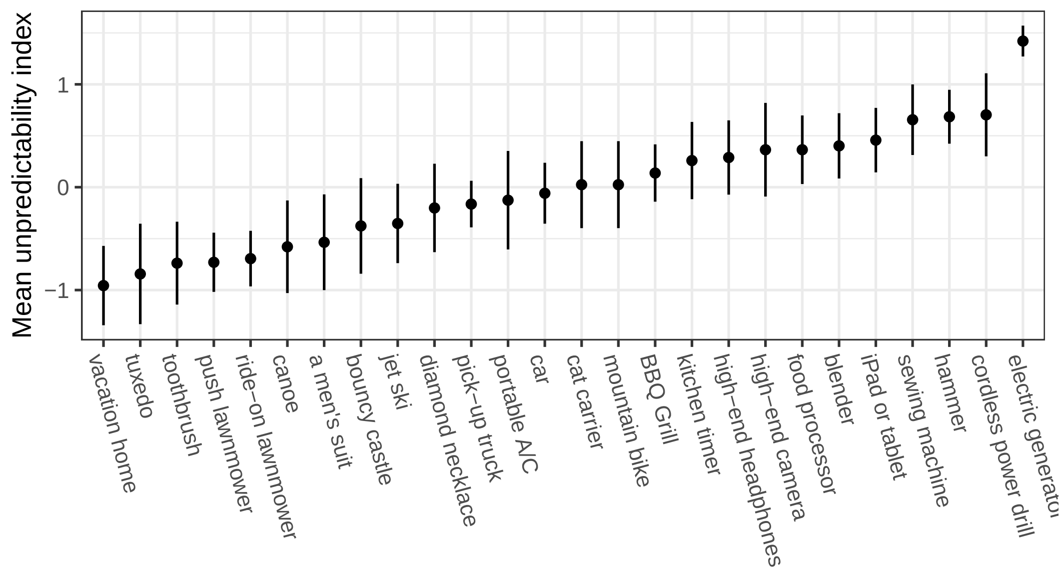
(b) Fraction of respondents reporting having rented various goods.



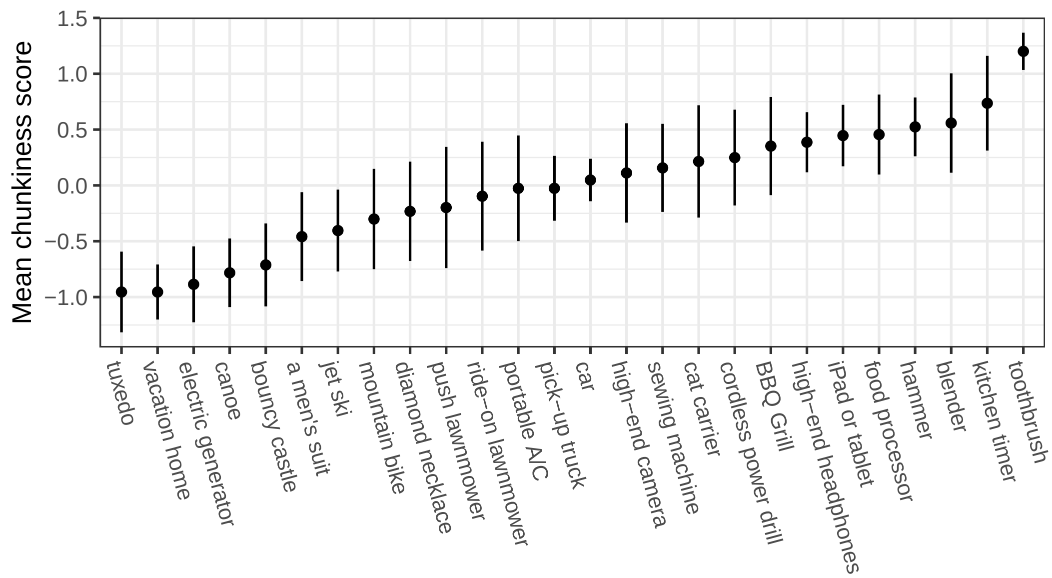
Notes: This figure plots the fractions of respondents reporting owning and having rented various goods. The 95% confidence intervals is plotted for each point estimate, computed using the Wilson method for a binary proportion.

Figure 9: Mean unpredictability and chunkiness indices for various goods

(a) Mean unpredictability index by good



(b) Mean chunkiness index by good.



Notes: This figure plots the mean unpredictability and chunkiness indices reported by the survey respondents, for the goods surveyed. A 95% confidence interval is plotted for each point estimate.