Short-term Housing Rentals and Corporatization of Peer-to-Peer Platforms

Han Zhu, Mehmet Gümüş, Saibal Ray
Desautels Faculty of Management, McGill University, Montreal, Quebec H3A 1G5
han.zhu@mail.mcgill.ca, mehmet.gumus@mcgill.ca, saibal.ray@mcgill.ca

Abstract

Owner-customer interactions on online short-term housing rental platforms are going through a transformation. While it traditionally involved individual owners dealing with individual customers in a peer-to-peer (P2P) form, these platforms have recently experienced an influx of corporate players on the supply side who control multiple assets that they rent out to customers; in effect, P2P platforms are morphing into business-to-consumer (B2C) ones. To understand the implications of this phenomenon, which we term as *corporatization*, for relevant stakeholders, in this work we develop a game-theoretical model with two different pricing strategies to capture the differences between P2P and B2C schemes. We show that when a P2P platform changes to a B2C one, it (i) increases the asset prices and the asset supply to the platform, but lowers asset utilization; and (ii) increases profits for asset owners and decreases surpluses for consumers. Data from Airbnb for multiple cities around the world are in alignment with some of our findings. We also extend our model in various ways to show that our results are relatively robust. An important social implication of our analysis is that the change in the nature of interaction between owners and customers due to the entry of B2C players might result in a capacity loss in the long-term rental market that should be of concern to policymakers (as is evident from the popular press). This paper also suggests how the platform provider should modify its strategy in the face of this phenomenon and how policymakers can most effectively deal with it so that the long-term rental channel is not too adversely affected.

Keywords: Sharing economy, online house-rental platforms, pricing strategy, long-term rentals, P2P vs B2C

1 Introduction

Recently, there has been an emergence of a number of online platforms facilitating short-term rentals of assets. In these platforms, owners with relatively underutilized assets rent them out for customers who require such assets for short-term use. This is a part of the bigger movement towards collaborative consumption or shared services. Online platforms have been used for short-term rentals of a variety of assets including houses, cars, boats, large equipments, etc. In this paper, we focus on the short-term rental of housing assets, although certain elements of our model are also applicable to other kinds of assets, especially cars. For the rest of the paper, any reference to an online sharing platform will imply its use for short-term rentals of housing assets, unless otherwise specified.

The most popular example of such a platform is Airbnb. Airbnb was launched in 2008 and in less than 10 years has earned annual revenue of 2.6 billion USD, posts over 4 million lodging listings annually in 65,000 cities and 191 countries, and has facilitated over 260 million check-ins (Wikipedia 2018). However, there are a number of other such platforms as well, including Homeaway, Booking.com, VRBO, etc. The emergence of such platforms has provided more options for customers and has created vigorous competition for hotels (Xie and Kwok 2017, Zervas et al. 2017). Many of the house sharing platforms, including Airbnb, started as pure P2P channels where individual owners rent out to individual customers. As no single individual controls a significant number of assets in this setting, none of the owners is able to influence the platform's price; rather, the rental rate is largely determined by a market mechanism that matches supply and demand, with the platform provider acting as a matchmaker and collecting a fixed proportion of fee from each transaction. However, a more recent development in this space has been the entry of commercial operators (e.g., corporatestays.com, pillow.com, sonder.com) that control a large number of assets listed on a platform. Such multi-listings provide these players with pricing power and they act as businesses renting to consumers in a B2C fashion via the platform. They take turnkey control of the assets and set the price on behalf of the owners in order to maximize the profits under the condition that the revenue will be shared with individual owners based on a pre-determined sharing ratio. While many owners on Airbnb are still individuals, commercial operators are becoming much more relevant (Curbed 2018). We term this phenomenon, i.e., the change in the nature of platform interaction between consumers and owners from a P2P to a B2C manner, as *corporatization* of the platform. For example, recent data suggests 12% of Airbnb hosts in New York City, or 6,200 of the city's 50,500 hosts, are commercial operators, but they earn 28% of the city's Airbnb revenue (Citylab 2018). A similar phenomenon has also been noted in most major cities around the world (Wachsmuth et al. 2017). Below, we provide examples of three cities from three different continents based on data collected from Insideairbnb.com in 2018 and in each case approximately 60%

Table 1: Histogram of Airbnb listings in three different cities

# of listing(s) posted by a host:		1	2	3	4	5	6-10	11-20	20+	Total
Hong Kong	# of listings	3723	994	543	352	295	1393	1317	1131	9748
	percentage%	38.19	10.20	5.57	3.61	3.03	14.29	13.51	11.60	100
San Fransisco	# of listings	3043	1126	555	400	206	261	331	1150	7072
	percentage%	43.03	15.92	7.85	5.66	2.91	3.69	4.68	16.26	100
Amsterdam	# of listings	6983	2954	1458	780	530	1371	1437	2923	18436
	percentage%	37.88	16.02	7.91	4.23	2.87	7.44	7.79	15.85	100

Note. For example, in Hong Kong, 295 (3.03%) listings are owned by the hosts who have 5 listings.

of the assets are multi-listings, i.e., listings from owners with more than one listed asset. In fact, more than 20% of the listings are from owners with at least 10 listed assets suggesting that corporatization is already an important phenomenon in the short-term house rental world.

In this paper, our goal is to understand the implications of a P2P platform changing to a B2C one on direct and indirect stakeholders of the platform. To address this, we develop a modeling framework abstracting a platform-based short-term house rental system. Our platform has three direct stakeholders: (i) homogeneous owners with housing assets available for renting; (ii) heterogeneous customers (e.g., travelers) who require such assets for short-term stays; and (iii) the platform itself.[1] The indirect stakeholders are the long-term rental and hotel channels. In our framework, utility-maximizing owners first decide between two options: i) listing their assets on the sharing platform for short-term rentals, knowing that they face risks regarding the rental price and occupancy; or ii) renting out the assets for longer terms at a risk-free rate. Subsequently, the uncertainty about customer demand for short-term rentals is resolved. Each customer then chooses either a non-platform option (e.g., a hotel room) or a platform asset for a short-term stay by comparing the utilities of the two. Customer utility comprises the value received from the stay and the relevant price. In addition, customers incur a hassle cost when they opt for the platform channel, and they are heterogeneous with respect to this cost. Finally, all platform transactions are mediated by the platform provider. We initially focus on pure play platforms: the platform operates either in a pure P2P fashion or there is a single corporate entity controlling and renting out all the assets on the platform (B2C model). Moreover, in our base model hotels and long-term channels are considered exogenous, although their prices impact the direct stakeholders' decisions. Subsequently, we analyze extensions where P2P and B2C schemes coexist on the platform, hotel and long-term rental channels are price-sensitive and asset owners have heterogeneous

[1] Throughout the paper, we refer to "owners" as females and "customers" as males.

values for their assets.

We use the above framework to study the impact of corporatization by comparing P2P and B2C schemes. Specifically: i) under the P2P scheme, no single individual has multiple listings on the platform; so the owners are price-takers and price is determined “naturally” based on supply-demand matching between the owners and customers with the platform acting as the matchmaker; and ii) under the B2C scheme, a commercial operator controls all the assets listed on the platform and “deliberately” sets the price on behalf of the owners so as to maximize the profit; the platform is still just the mediator. Under both schemes, the platform-provider receives the same fixed share of each transaction on the platform. Our goal is to answer the following research questions:

- What are the implications of the transformation of a P2P interaction based platform to a B2C one (i.e., corporatization) on the equilibrium: i) platform *price*; ii) number of assets listed on the platform (*availability*); and iii) *occupancy* rate of the listed assets; as well as payoffs for customers, owners, and the platform provider?

- What implications does the corporatization have for the platform provider and policymakers and how robust are the results?

We fully characterize the relevant equilibrium decisions for both P2P and B2C schemes. We show that an owner’s incentive to join the platform is driven by a trade-off between the *potential price premium* that she can garner from joining the platform and the *potential occupancy* risk that she faces by doing so, compared to the risk-free long-term rental channel. When the former is quite high and/or the latter is very low, more owners list their assets on the platform. Interestingly, we show that a high price premium potential can attract owners to the platform even when they know that their assets have a high chance of being unoccupied. The reverse scenario is also true, wherein owners do not join the platform even if they are quite confident of their assets being rented since the potential price premium is quite low (or even negative). In other cases, the trade-off decision is more involved with the demand uncertainty also playing an important role. In general, the B2C scheme results in higher prices for platform customers. Under the P2P scheme, the matching oftentimes ends up with a relatively low price to accommodate all customers. However, this never happens under the B2C context; rather, the corporate player sometimes charges higher price even at the risk of lower demand and, hence, more unoccupied assets. Thus, attracted by higher revenue, the availability is actually higher under the B2C scheme, although some of this capacity often remains un-rented, i.e., the occupancy rate is higher under the P2P scheme. We are able to validate the above results about price and occupancy rate based on data collected from Airbnb. In summary, our analyses suggest that movement from a P2P to a B2C platform (i.e., corporatization of the platform) might result in higher prices for customers, but also higher supply on the platform (and potentially lower capacity in the long-term rental market) with more of those assets remaining deliberately unoccupied.

As for the stakeholders, higher prices under the B2C scheme trump higher chances of occupancy under the P2P scheme for the owners and so they prefer corporatization. On the other hand, customers prefer the P2P scheme since they are charged lower prices. The platform provider actually is better off under the corporate pricing scheme, although our analyses suggest that the platform provider should reduce its share of the transaction price with corporatization. Of particular concern to the society and policymakers should be the potential lower supply to the long-term rental market as a result of corporatization. The effects are already being felt in a number of cities around the world (e.g., New York (NYT 2019), Toronto (VICE 2019), Montreal (CTV 2019)). Price control measures like rent control might be counterproductive in this context; rather, measures that regulate corporatization, as has already been adopted by certain cities, might be more fruitful (e.g., Vancouver (Global and Mail 2018), and San Francisco (CNET 2018)). An important point to note is that our results are not driven by the comparison between two pure play cases. They, in general, remain valid even when we allow P2P and B2C schemes to co-exist on the platform. They remain valid even when: i) the two external channels - hotel and long-term rental - are not exogenous; rather, demand on them are sensitive to the platform price; and ii) owners are heterogeneous in terms of their reservation asset value and so some of them might not rent out until the platform price is high enough.

2 Related Literature

As sharing platforms become popular in practice, there has been a resultant growing body of literature providing insights about various aspects of this business model. These include issues like how a platform affects an individual's purchasing decision (Benjaafar et al. 2018b, Fraiberger and Sundararajan 2017, Jiang and Tian 2018), how supply and demand are matched on a platform (Allon et al. 2012, Hu and Zhou 2016, Ozkan and Ward 2017), how search/application costs may improve the efficiency of a matching market (Arnosti et al. 2018, Basu et al. 2018, Kanoria and Saban 2017), and how wages change the staffing/self-scheduling capacity of a platform (Gurvich et al. 2016, Cachon et al. 2017, and

Hu and Zhou 2017), etc. Narasimhan et al. (2017) provides a review of the extant literature.

Our paper is related to an emerging stream of research that examines pricing strategies on short-term asset rental platforms. For example, Li et al. (2016) empirically examine experienced hosts' and inexperienced amateurs' pricing behavior on Airbnb. They find that experienced hosts are more likely to earn a higher revenue due to their frequent price adjustments and prompt response to instances of high demand. Cui et al. (2019) study the influence on Airbnb's pricing of the utility drawn from social interactions. Wang and Nicolau (2017) and Gibbs et al. (2018) identify the factors that determine the rental prices on Airbnb. On the other hand, analyzing the effects of Airbnb's pricing on the performance of the hotel channel, Zervas et al. (2017) find that the low-end hotels and the hotels that do not cater to business travelers are more heavily affected by Airbnb. Using data from Airbnb as well, Barron et al. (2018) assess the impact of home-sharing on residential house prices and rents. Among theoretical works, Banerjee et al. (2015) and Cachon et al. (2017) study the impacts of static and dynamic pricing strategies, respectively, on ride-sharing platforms, while Bimpikis et al. (2016) explore the benefits of spatial price discrimination for such platforms. Mai et al. (2018) build an evolutionary game theory model to investigate how riders' and drivers' behavior evolves in response to an online platform's operational decisions. Guan et al. (2019) formulate a multi-stage game-theoretic model to analyze the manufacturer's incentive of building an exclusive product sharing platform to respond to the competition from the emerging peer-to-peer product sharing platforms in the downstream market.

In most theoretical models, the platform's objective is to maximize its profit or revenue, e.g., Banerjee et al. (2015), Bai et al. (2018), Benjaafar et al. (2018a), Cohen and Zhang (2018), Taylor (2018), and Guda and Subramanian (2018). However, literature has also considered other possible pricing schemes. For example, Benjaafar et al. (2018b) investigate a scheme in which a not-for-profit platform aims to maximize social welfare. On the other hand, Jiang and Tian (2018) consider a market-clearing mechanism that matches supply and demand in a collective consumption model. They develop an analytical framework to examine the strategic and economic impacts of product sharing among consumers in a P2P manner. While most of the above papers consider a single scheme, our research focuses on the implications for sharing platforms by comparing P2P and B2C schemes.

The paper most similar to ours is Benjaafar et al. (2018b). The authors study a model wherein individuals with varying usage levels make decisions about whether to own a shared product or to rent it. They compare systems with and without sharing under both profit- and welfare-maximizing schemes.

Our work is different from theirs in three ways. First, in Benjaafar et al. (2018b) any individual can be an owner or a renter, i.e., they are not distinct groups, while we consider two separate groups of owners and customers. Second, in addition to the B2C scheme studied in their work, we also investigate the P2P scheme and compare the two.[2] Third, the non-platform channels in our setting and their interactions with the rental platform are not considered in Benjaafar et al. (2018b). In summary, our focus on the effect of corporatization as a result of rental platforms changing from a P2P to a B2C context enables us to reveal important insights and suggest policy prescriptions that we feel are novel contributions to the socially responsible operations management literature.

3 Basic Model Framework

Our model of a two-sided asset rental platform has three direct stakeholders: (i) owners with housing assets available for listing on the platform for short-term rentals; (ii) travellers (customers) who require such assets; and (iii) the platform serving as a mediator. We now discuss each of these stakeholders.

– *Owners:* We focus on utility-maximizing owners who are considering only between short-term rental via the platform and long-term rental for their unutilized housing assets when they are still uncertain about the customer demand on the platform. Assuming that each such owner has one unit of unutilized asset and there are N such owners, the number of assets available for rentals is N. Each owner needs to make a choice between the following risky and risk-free channels for listing her asset: i) the sharing platform where she faces both *price and occupancy risks* for the listing; or ii) a non-platform channel where she will receive a *risk-free* payment p_r for a longer term rental. For now, we assume that all owners have access to the same exogenous p_r and they get no utility from keeping the asset for themselves; we relax them in §5.1 and §5.2, respectively.

To understand the two types of risks that owners face on the sharing platform, note that the demand state denoted by θ (i.e., the number of customers who are looking for short-term rentals) can be either high H or low L. The *price risk* is associated with the actual amount p_θ that can be charged per customer for rental on the platform depending on the demand state. The *occupancy* risk q_θ arises from the matching probability of a representative owner's asset with a customer under demand state θ on the platform. Then, the expected payoff for a representative owner, if she joins the rental platform,

[2] Note that Benjaafar et al. (2018b) also refer to the pricing strategy in our P2P scheme as a possibility: "*[p]rices may then be determined through a market clearing mechanism (i.e., the price under which supply equals demand).*"

can be expressed as $\mathbb{E}[\pi] \equiv E_\theta[(1-\alpha)p_\theta q_\theta], \theta \in \{L, H\}$, where $(1-\alpha) \in (0,1)$ is a pre-determined fixed proportion of each rental payment p_θ that an owner receives, with the platform provider keeping αp_θ as a service fee. Both price and occupancy risks depend on the mismatch between supply and demand realized under each state on the platform. A representative owner's decision regarding whether or not to list on the platform then is as follows:

Join the sharing platform if $\mathbb{E}[\pi] \geq p_r$; otherwise, opt for the risk-free long-term rental channel.

Let S denote the total number of asset owners who list on the platform; thus, $N-S$ owners opt for long-term rentals. S then represents the "*availability*" of assets on the platform for short-term rentals.

– *Customers:* As indicated before, the demand from customers (e.g., travelers) for short-term assets is uncertain. Suppose this uncertainty can be represented by $M_\theta, \theta \in \{L, H\}$; specifically, the number of customers who are looking for short-term rentals can be either high M_H or low M_L with equal probabilities. Again, we only consider customers who are choosing between two short-term channels. If they decide not to use the sharing platform, they can rent a hotel room by paying a fixed price p_e. For now, we assume p_e to be exogenous but also analyze an endogenous p_e setting in §5.1. On the other hand, if the customers decide to use the platform, they might be able to find a rental option at price p_θ. The customers in our model are heterogeneous. Although each of them gets the same fixed utility from her short-term stay, they differ in terms of the hassle cost c that they incur when they rent through the platform. This hassle cost represents the added inconvenience associated with using the sharing platform relative to those provided by a hotel, such as a more reliable booking process, quality standards, flexibility, security, and complimentary services in the latter channel. The hassle cost's heterogeneity is represented by $c \in U[0, \bar{c}]$, although our results remain valid for more general distributions (details available from the authors on request). Consequently, the renting decision for a customer with hassle cost c is as follows:

Choose the platform option if $p_\theta + c \leq p_e$; otherwise, stay in a hotel.

Given the above discussion, the customer demand for the platform is $D_\theta = \left(\frac{p_e - p_\theta}{\bar{c}}\right) M_\theta$, while that for the hotel is $(M_\theta - D_\theta)$. Since the platform has no incentive to charge a price higher than p_e or lower than $p_e - \bar{c}$, without loss of generality, we consider that $p_e - \bar{c} \leq p_\theta \leq p_e$.

The owners' participation decisions and the number of customers wanting to rent create a mismatch between the two sides of the platform. The *occupancy* rate of the assets shared on the platform is then denoted as $q_\theta = \min(1, \frac{D_\theta}{S})$, and the total transaction volume on the platform, i.e., the number of customers who are actually able to rent through the platform is denoted as $Q_\theta = Sq_\theta$. We do not explicitly model the decision-making process of long-term renters; however, our model will reveal how the pricing strategy of the platform impacts the capacity available for long-term renters.

– *Platform provider:* Finally, all transactions between customers and owners who decide to join the sharing system are mediated by the platform provider. As indicated earlier, the provider keeps α proportion of p_θ received from each customer. A particularly important issue in the context of this paper is how the transaction price p_θ is determined by the platform. We consider two strategies that capture the idiosyncrasies of P2P and B2C schemes:

- In the P2P scheme there are peer-to-peer interactions whereby individual owners list on the platform for possible rentals by individual customers. The atomistic owners do not have price-setting power; so, p_θ is determined "naturally" by the market so as to clear the supply and demand on the platform as much as possible under both demand states; the platform provider is passive.

- Under the B2C scheme, a corporate player (e.g., Sonder - refer to Forbes (2018)) takes control of all assets on the platform. Because of the volume, the corporation has pricing power and can "deliberately" set the price p_θ on behalf of the owners to maximize its own profit Π_θ given the supply and demand information under each demand state; the platform provider is still a passive mediator.

For now, we assume that the platform is either "pure" P2P or "pure" B2C. This enables us to clearly understand the trade-offs involved between the scenarios. In §4.4 we analyze a setting where the two schemes coexist on the platform. The above model structure is illustrated in Figure 1. Lastly, the

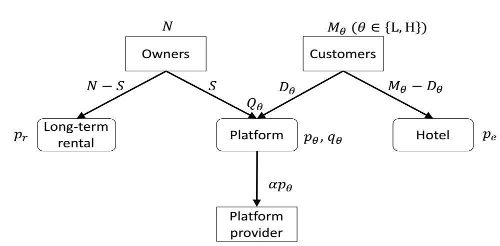


Figure 1: Model structure

sequence of events in our framework is summarized in Figure 2. The problem can be divided into two stages: participation and pricing. Given the non-platform options available to owners and customers, at Stage 1, each owner decides whether or not to list her asset on the sharing platform. Then, the uncertainty regarding the number of customers looking for short-term rentals is realized. The price is then determined at Stage 2 based on whether it is a P2P or a B2C platform. Finally, each customer with a hassle cost c decides whether to rent through the platform or to stay in a hotel. A summary of relevant notations is provided in Table 5 of the Appendix.

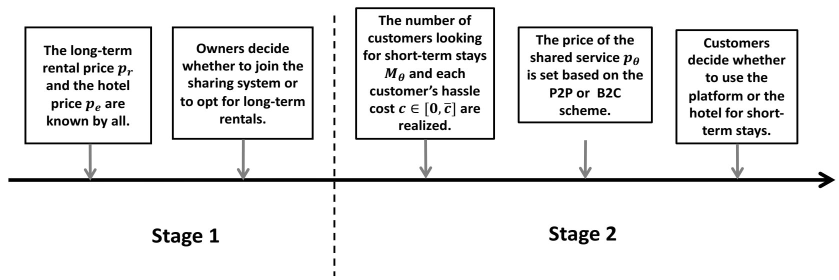


Figure 2: Sequence of events

4 Equilibrium Analysis of Platform Schemes

In §3, we see that the representative owner's participation decision depends on the pricing and occupancy probability under each demand state, both of which are realized after all owners and customers make their participation decisions and renting choices, respectively. Therefore, we employ the rational expectations approach to solve the equilibrium (as in Su (2007), and Liu and Van Ryzin (2008)). In our setting, this implies that, in equilibrium, the owners' beliefs about the price p_θ and the occupancy probability q_θ should satisfy the following two consistency conditions: (i) p_θ solves the pricing problem under each pricing scheme for each demand state θ; and (ii) q_θ is equal to the matching probability between owners and customers under the usual random rationing rule, which stipulates that if there are more owners than customers, i.e., $S > D_\theta$, then each owner is equally likely to be matched to a customer with probability D_θ/S, i.e., $q_\theta = \min(1, \frac{D_\theta}{S})$. In order to avoid uninteresting cases, we make the following assumption about the non-platform channel prices and the maximum hassle cost.

Assumption 1. *i)* $p_e(1-\alpha) > p_r$, *and ii)* $\bar{c} < p_e$.

If the first part of the above assumption is violated, then there would be no incentive for any owner to join a sharing platform. On the other hand, if the second part is violated, then it would imply that there are some customers who would never consider the platform option even when it is free (i.e.,

$p_\theta = 0$). We now solve the rational expectations equilibrium by working backward from the pricing stage.

4.1 P2P interaction-based Platform

In this case, there are N owners deciding whether or not to list on the platform individually knowing that the asset might be rented by a customer through the platform. Given that they individually are too insignificant to have any price-setting power, we assume that there is a market clearance mechanism at work that results in the equilibrium price on the platform. Specifically, the equilibrium price is the one that clears the market by matching supply with demand (as in Jiang and Tian (2018)). However, since the supply is decided before the demand realization, there is a possibility that some of the supply will not be cleared even if all customers opt for the platform. In this case, we assume random rationing rule for allocation, as explained before. We have the following results.

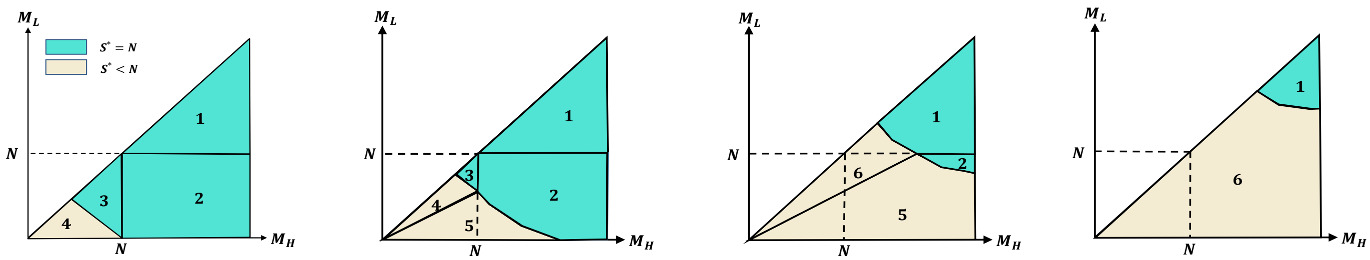
- If supply is less than the realized market demand, i.e., $S \leq M_\theta$, then the supply is completely cleared and the clearance price solves $D_\theta(p_\theta) = S$. This yields $q_\theta = 1$ (i.e, 100% occupancy rate) and $p_\theta = p_e - \frac{S\bar{c}}{M_\theta}$, which will be referred to as the *supply-clearance* price.
- If supply is more than the realized market demand, i.e., $S > M_\theta$, then there will be some supply that can not be matched with the customer. In this case, the price will drop to the minimum level that will make the platform demand equal to the market one, i.e., $D_\theta(p_\theta) = M_\theta$. This results in $q_\theta = \frac{M_\theta}{S}$ (i.e., occupancy rate $< 100\%$) and $p_\theta = p_e - \bar{c}$, guaranteeing that all customers are served by the platform (and do not opt for hotels); this is termed the *maximum-coverage* price.

In short, given S, p_θ^* that solves the above supply-demand matching is:

$$p_\theta^* = \begin{cases} p_e - \frac{S\bar{c}}{M_\theta} & \text{if } M_\theta \geq S \\ p_e - \bar{c} & \text{o.w.} \end{cases}$$

Using the fact that expected revenue for an owner from the platform channel is given by $\mathbb{E}[\pi] = \mathbb{E}[(1-\alpha)p_\theta^* q_\theta^*]$, we then characterize the first stage participation decision for the owners where they compare the reward p_r of the risk-free channel and the expected revenue $\mathbb{E}[\pi]$ from the platform channel. For ease of exposition, without loss of generality, we replace $\frac{p_r}{1-\alpha}$ by p_r in our analysis. Relegating the details to the Appendix, we present the overall equilibrium for the P2P strategy as follows:

Proposition 1. *In a P2P interaction-based platform, the equilibrium is fully characterized in Table 2. Specifically, the equilibrium can be divided into six regions as shown in Figure 3.*



(A)$p_r \leq \frac{1}{2}(p_e - \bar{c})$ (B) $\frac{1}{2}(p_e - \bar{c}) \leq p_r \leq p_e - \bar{c}$ (C) $p_e - \bar{c} \leq p_r \leq p_e - \frac{1}{2}\bar{c}$ (D) $p_r \geq p_e - \frac{1}{2}\bar{c}$

Figure 3: Equilibrium regions for the P2P scheme

Table 2: Equilibrium outcomes in the P2P scheme

Regions	S^*	p_H^*	p_L^*	q_H^*	q_L^*
1	N	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$	1	1
2	N	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \bar{c}$	1	$\frac{M_L}{S^*}$
3	N	$p_e - \bar{c}$	$p_e - \bar{c}$	$\frac{M_H}{S^*}$	$\frac{M_L}{S^*}$
4	$\frac{(p_e-\bar{c})(M_H+M_L)}{2p_r} < N$	$p_e - \bar{c}$	$p_e - \bar{c}$	$\frac{M_H}{S^*}$	$\frac{M_L}{S^*}$
5	$\frac{(\frac{1}{2}p_e-p_r)+\sqrt{(p_r-\frac{1}{2}p_e)^2+(p_e-\bar{c})\bar{c}\frac{M_L}{M_H}}}{\bar{c}/M_H} < N$	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \bar{c}$	1	$\frac{M_L}{S^*}$
6	$\frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}} < N$	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$	1	1

$p_e - \frac{S^*\bar{c}}{M_\theta}$: supply-clearance price; $p_e - \bar{c}$: maximum-coverage price

This characterization of the equilibrium reveals a number of interesting insights. First of all, note that although the price and occupancy rate look similar for regions 1&6, 2&5, 3&4, they are actually different, as the expressions depend on the availability and the equilibrium availability expressions (S^*) are different in those regions. Second, in regions 1, 2, and 3, all N owners list their assets for rentals through the sharing platform, resulting in high availability; this obviously reduces the supply available for long-term rentals. This phenomenon has been empirically observed and reported in Horn and Merante (2017) and Wachsmuth et al. (2017). However, interestingly, in region 3, all owners are joining the platform knowing that some of the assets will not be occupied, even if the demand turns out to be high. On the other hand, in regions 4, 5, and 6, the unique stable equilibrium is where $\mathbb{E}[\pi] = p_r$ (p_r is the reward of the risk-free channel) and $S^*(< N)$ owners opt for the platform channel; in every other situation, there is an incentive to deviate. In this case, note region 6 where not everyone joins the platform knowing that those who join are assured of 100% occupancy, even for low demand.

Below we illustrate how the availability on the platform itself is affected by the tension between price premium potential (or risk) and occupancy potential (or risk).

- *Price premium potential:* The platform will never charge a price p_θ less than $p_e - \bar{c}$ at which it can surely attract all M_θ customers looking for rentals. On the other hand, owners will never list their assets on the platform if p_θ is less than the risk-free rental price p_r. We term the difference $(p_e - \bar{c} - p_r)$ as the price premium potential for the platform. As we move from panel A to D, the potential decreases (since p_r increases); while it is highly positive in A, in panel D it is quite low and can even be negative. Consequently, it is more likely that all owners list on the platform in Scenario A which results in potentially less capacity available for long-term rentals. On the other hand, since the owners know that the p_θ cannot be much higher than p_r and can actually be lower, depending on the realization of θ in Scenario D, the price risk then reduces the chance that all owners will opt for the platform; rather, many of them select the long-term channel.

- *Occupancy potential:* Although panel A in the above figure mostly results in lots of owners listing on the platform, there is a small region 4 where this does not occur. The reason is that the demand M_θ in region 4 is relatively small compared to the supply N; hence, although the owners are confident of a significant price premium on the platform, they also know that the potential for their shared assets to be occupied (occupancy potential) is relatively low. This occupancy risk dissuades many of them from joining the platform, reducing the availability S^*. In contrast, all owners list on the platform in region 1 of panel D since they know that the occupancy potential on the platform in that region is quite high ($M_\theta >> N$) even though the platform cannot charge a high price.

The interesting behavior of regions 3 and 6 indicated above is due to the interaction of the above two potentials. Specifically, in region 3, high price premium potential attracts a lot of owners. Therefore, the availability S^* is high (specifically, $S^* = N$). The number of potential customers is also substantial in this region. However, a high number of potential customers and the consequent high potential occupancy rate does not actually result in 100% occupancy; indeed, because of high availability, it turns out to be lower. On the other hand, in region 6, the price premium potential is very low and so a relatively fewer number of owners join the platform—this low availability ensures that those who are joining are assured of 100% occupancy. Still, the low price premium means that not all owners join the platform, since they realize that if they join then the occupancy rate might also go down.

4.2 B2C interaction-based Platform

In this scheme, the owners know that a corporate player will take control of all assets listed on the platform. Because of the large volume of assets under its control, the corporate player can be a price-setter and so, at the pricing stage, sets the price so as to maximize the profit generated from the shared assets. Similar to the P2P case, we assume that the platform provider keeps α portion of the total profit, and the remaining $1-\alpha$ is shared among all the assets in the sharing platform. In other words, for each demand state—M_L or M_H—the corporate player solves a constrained optimization problem as follows.

$$\begin{aligned} &\max_{p_\theta \geq 0} \ (1-\alpha) p_\theta Q_\theta \\ &\text{s.t. } Q_\theta \leq S, \ \ Q_\theta \leq D_\theta \ \text{ and } \ Q_\theta \leq M_\theta. \end{aligned} \tag{4.1}$$

where Q_θ denotes the number of customers that will be served by the platform under demand state θ. Analysis of the above shows that there are three possible candidates for optimal price. In addition to the *supply-clearance* and *maximum-coverage* prices characterized in §4.1, the optimal price can also be $p_\theta = \frac{p_e}{2}$ given by the solution to the first-order condition of the objective function. If the hotel price is relatively high ($p_e > 2\bar{c}$), the interior point price is lower than the minimum amount that the customers are willing to pay to join the platform. In that case, the corporate player can opt for the maximum coverage price ($= p_e - \bar{c}$) that provides higher revenue than the interior point price and also attracts all customers. However, for a low hotel price ($p_e \leq 2\bar{c}$), the interior point price is higher than the maximum coverage one. In that case, charging the maximum coverage price is no longer justified for the corporate player. Rather, it should sacrifice some demand to the hotel channel, which is anyway attractive due to low p_e, in order to get a higher revenue by charging a relatively premium price. In this case, given S, optimizing (4.1) results in the following:

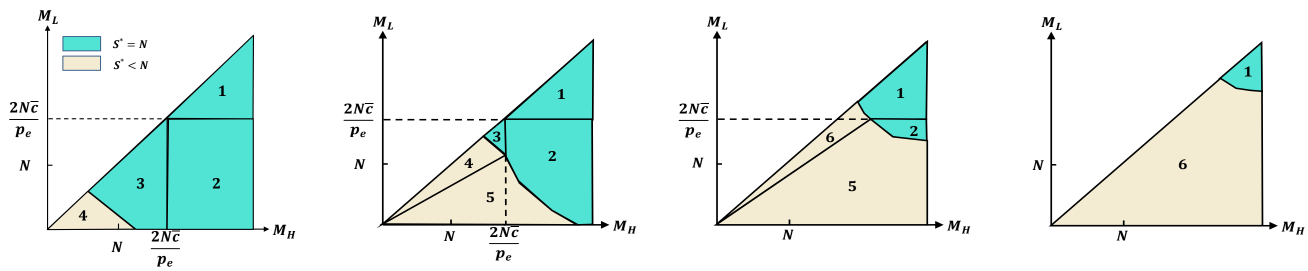
$$p_\theta^* = \begin{cases} p_e - \frac{S\bar{c}}{M_\theta} & \text{if } M_\theta \geq \frac{2S\bar{c}}{p_e} \\ \frac{p_e}{2} & \text{o.w.} \end{cases} \tag{4.2}$$

Given the optimal pricing policy on the platform, we then characterize the first stage participation decision for the owners and the overall equilibrium in the same way as done in the previous section.

Proposition 2. *In a B2C interaction-based platform, the equilibrium is fully characterized in Tables 2 and 9 in Appendix A. Specifically, the equilibrium regions are:*

- *As shown in Figure 4 when $p_e \leq 2\bar{c}$; and,*
- *The same as the ones characterized in Figure 3 of Proposition 1 when $p_e > 2\bar{c}$.*

Figure 4: Equilibrium regions under the B2C scheme



(A) $p_r \leq \frac{1}{4}p_e$ (B) $\frac{1}{4}p_e \leq p_r \leq \frac{1}{2}p_e$ (C) $\frac{1}{2}p_e \leq p_r \leq \frac{3}{4}p_e$ (D) $p_r \geq \frac{3}{4}p_e$

Note: In regions 1-3 where $S^* = N$, the boundary condition in Equation (4.2) that separates supply-clearance from profit-maximizing prices is $M_\theta = \frac{2N\bar{c}}{p_e}$, which is shown as the boundary line between regions 1-3 in Figure 4.

A comparison of the above proposition to Proposition 1 in §4.1 shows that the values and behavior of the equilibrium decisions under the two pricing schemes have some similarities as well as dissimilarities. We will discuss their differences in detail in the next section; we mention some of their similarities here.

First of all, when the hotel price is relatively high ($p_e > 2\bar{c}$), there is naturally a high demand for the sharing platform, so P2P and B2C schemes turn out to be exactly the same. When the hotel price is relatively low ($p_e \leq 2\bar{c}$), irrespective of the pricing mechanism, in regions 1, 2, and 3, all N owners opt to share their assets via the platform ($S^* = N$), resulting in possibly lower capacity in the long-term rental market, whereas in regions 4, 5, and 6, not all owners list on the sharing platform ($S^* < N$). Secondly, the two main factors that contribute to the equilibrium behavior are also the same: price premium potential and occupancy potential. However, as discussed earlier, under the B2C scheme, the corporate player will never charge a price p_θ less than the interior point price $\frac{1}{2}p_e$. The owners' perspective still remains the same—they will never list their assets on the sharing platform if p_θ is too low. It turns out that the price premium potential is now $\frac{1}{2}p_e - p_r$, which is higher than the price premium potential $p_e - \bar{c} - p_r$ under the P2P scheme (for $p_e \leq 2\bar{c}$), but it is analogously positive for low p_r and negative for high p_r. Like in §4.1, we again note that the owners are less likely to list on the platform as p_r increases from panel A to panel D.

4.3 Impact of Corporatization on Equilibrium Platform Performance

In this section, we discuss the implications of corporatization by comparing the P2P and B2C schemes. Specifically, we discuss how the equilibrium values of the three most relevant performance measures of the platform—price charged to customers, number of owners listing their assets for rentals on the platform (availability), and proportion of listed assets that are actually rented (occupancy rate)—compare under the two schemes. We are also interested in how the equilibrium payoffs to the direct stakeholders of the system are affected by the pricing strategy of the platform.

The platform provider's equilibrium payoff is obviously its expected profit denoted by $\mathbb{E}[\alpha p_\theta Q_\theta]$. With regard to the owners' surplus OS, we can show that it can always be expressed as $OS = N\mathbb{E}[\pi]$. Since the consumers are heterogeneous in their hassle cost c, we can compute the total consumer surplus CS by integrating each consumer's payoff over her hassle cost (refer to the Appendix for details). As shown in the last section, the equilibrium expressions and the applicable regions are quite different for the two schemes. Therefore, when we compare the equilibrium values and payoffs, we need to overlap the regions in Figures 3 and 4 and conduct a pairwise comparison of each overlapping region separately. Due to this and the complicated expressions of the equilibrium decisions, we consider a restricted case to perform the analytical comparisons.

Proposition 3. *Suppose (i) $\underline{N} \leq N \leq \bar{N}$, and (ii) $\underline{p} \leq \frac{p_r}{p_e} \leq \bar{p}$, where the expressions for $\underline{N}$, $\bar{N}$, $\underline{p}$, and $\bar{p}$ are provided in Appendix A. Then, compared to the P2P platform, the B2C platform will result in:*
1) Equilibrium performance measures: higher expected platform price ($\mathbb{E}[p_\theta^*]$), higher availability (S^*), and lower occupancy rate (q_θ^*); and
2) Equilibrium payoffs: higher total expected surplus for owners, higher profit for the platform provider, and lower total expected surplus for consumers.

To begin, the conditions characterized in Proposition 3 stipulate that both the total number of assets available for short-term rentals in the market and the ratio of the prices of the non-platform channels—p_r and p_e—are in the medium range. Intuitively speaking, these conditions ensure that both occupancy potential and price premium potential are moderate. Analytically speaking, these conditions help us to avoid comparing the corner solutions where not only the expressions but also the regions would change as we alter the pricing schemes.

We now discuss the rationale behind the above results. Recall that in the P2P platform, the price equilibrates to clear the market by matching supply with demand (as much as possible). Therefore, although the equilibrium availability S^* also plays a role in the matching process, it is perhaps not that surprising that the equilibrium occupancy rate (q_θ^*) realized in the P2P platform is, in general, higher than those realized under the B2C one. However, it is quite interesting to observe that (the expected) low occupancy rates under the B2C scheme do not stop the asset owners from joining the sharing platform. Indeed, quite surprisingly, more asset owners list their assets for rental on the platform under the B2C scheme than those under the P2P scheme. Thus, some assets on the sharing platform are strategically kept underutilized in the B2C platform even though there is a demand in the market. In fact, the platform then trades off the occupancy rate to charge a premium price. This is driven by the corporate player as the pricing authority under the B2C scheme. This ensures that when the hotel price is relatively low, the platform price is never too low, even if it means some of the assets shared on the platform remain unoccupied. This is especially important when the demand turns out to be low. In this case, the excess supply on the sharing platform can really push the price below the interior point solution in the P2P platform, since there is no single agent who can coordinate the actions of the individual owners. Our comparative analyses show that higher prices under the B2C scheme incentivize more asset owners to join the sharing platform compared to the P2P scheme, even if they run a higher risk of not finding a renter. This also implies that there is a possibility of relatively less capacity available for long-term renters under the B2C scheme.

With regard to payoffs, it is clear that the platform provider's preference would be for the B2C scheme since this strategy is designed to maximize its payoff. The above discussion about the impact of pricing schemes on the equilibrium decisions would naturally lead one to conclude that asset owners are better off and consumers are worse off in the B2C platform. Indeed, from the asset owners' perspective, this conclusion is true, because all the asset owners compare the total revenue that they expect to earn on the sharing platform to the risk-free long-term rental revenue, and more asset owners joining the platform under the B2C scheme implies that they are better off under this scheme. However, from the consumers' perspective, there are two counteracting effects. On one hand, the platform price is higher under the B2C scheme and this is undesirable for customers. On the other hand, there are more asset owners listing on the platform (i.e., higher availability) under the B2C scheme, even after one takes into account underutilized assets, which makes the scheme more enticing. Our results show that the positive effect of a higher supply is outweighed by the negative effect of higher prices. Hence, consumers are worse off under the B2C scheme compared to the P2P scheme.

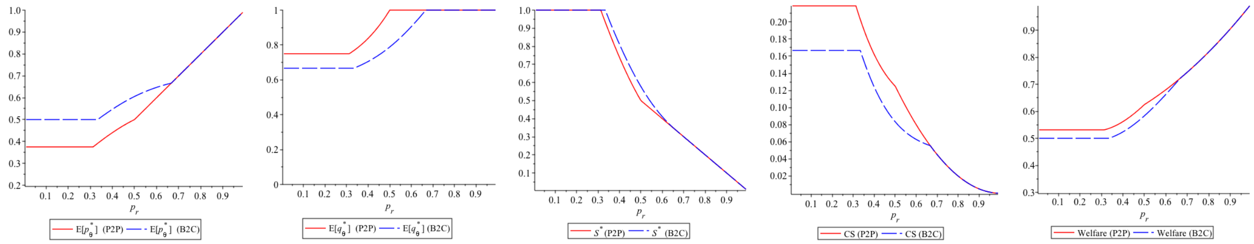


Figure 5: Numerical comparisons between P2P and B2C pricing schemes ($M_L = 0.5$, $M_H = 1.5$, $N = 1$, $\bar{c} = 0.75$, $p_e = 1$)

Closed-form equilibrium characterizations in the last section enable us to conduct a numerical comparison of the two schemes even for values other than those specified in Proposition 3 as shown in Figure 5, which is aligned with the results in Proposition 3. The comparison also shows that the loss of consumer surplus due to a higher price under the B2C scheme is not able to be mitigated by the higher benefits accrued by the owner and the platform provider under that scheme. Therefore, as shown in the rightmost panel of Figure 5, the total welfare of all the direct stakeholders of the platform is worse off under the B2C scheme. Lastly, we note that as the long-term rent p_r increases, the equilibrium measures and payoffs under the two schemes tend to converge. This is expected because, in such a case, the supply to the platform is quite low and hence the profit-maximization mechanism also results in the using up of the entire supply. We have already seen that when the hotel price p_e is relatively large ($p_e \geq 2\bar{c}$), the two schemes are exactly the same due to the high price premium potential and high customer demand for the shared assets on the platform. On the other hand, when p_e is very low, most customers opt for the hotel channel and hence a low demand on the platform channel makes the two schemes similar. In summary, the effect of corporatization, i.e., maximum disparity between the two schemes, is most significant for low p_r and medium values of p_e.

4.4 "Mixed" (P2P and B2C) Platforms

§4.1 and 4.2 discussed the equilibrium characterization of "pure" P2P and B2C platforms, respectively. Now, we consider a more general case where both schemes coexist on the platform. More specifically, each of the N house owners when making her joining decision has three choices: i) to list the asset for long-term rental; ii) to list the asset on the sharing platform and rent it out herself in a P2P manner; and iii) to list on the platform and delegate the renting and pricing of the asset to a corporate player. In the second case, the individual owner behaves as the owners in the P2P scheme, while in the last case, the corporate player determines the price as in the B2C scheme. For model tractability, we consider only one demand state. Also, to differentiate between the two schemes, we assume customers who choose a rental asset from an individual owner (i.e., via a P2P scheme) incur a hassle cost γc while those who choose a rental asset from a corporate player (i.e., via a B2C scheme) incur a hassle cost c. Furthermore, we assume $\gamma > 1$ to capture the degree of inconvenience due to the asset being managed by an individual owner rather than a more professional corporate player. We characterize the equilibrium analytically as presented below.

Proposition 4. *When both P2P and B2C schemes coexist on the platform, the equilibria are characterized in Table 13 in Appendix A. Moreover, more owners opt for the B2C scheme than the P2P one, i.e.,* $S^*_{P2P} \leq S^*_{B2C}$.

We also numerically compare the two schemes when they coexist as shown in Figure 6. Clearly, more owners join the B2C scheme than the P2P one. Also, the price under the B2C scheme is higher than that under the P2P one, while the occupancy rate under the B2C scheme is lower. All these results are consistent with those in the basic model. Figure 6 also suggests that as γ increases, i.e., as the

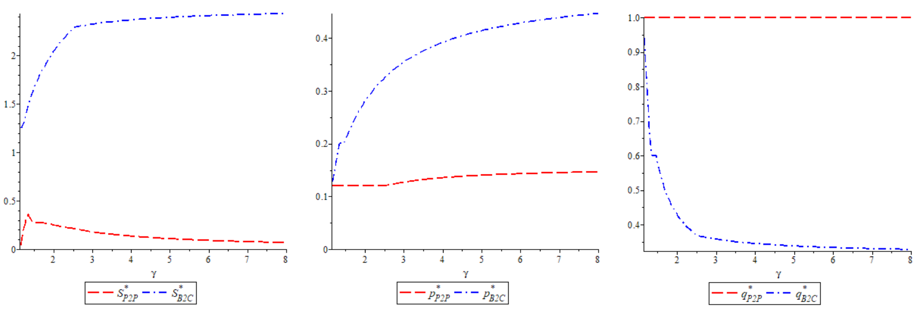


Figure 6: Coexistence of both pricing schemes ($p_r = 0.12$, $p_e = 1$, $\bar{c} = 0.8$ $M = 1.25$, $N = 2.5$)

two systems become more differentiated due to the corporate player providing even more convenience than the P2P system, the gap between the number of owners joining each scheme tends to increase. In particular, when γ is very high, the B2C scheme becomes so much superior to the P2P one, that the model becomes almost identical to the pure B2C scheme with nearly all owners delegating their assets to the corporate player. In addition, as γ increases, we also find that the number of owners joining the long-term rentals decrease. This implies that the long-term rental availability decreases as corporatization becomes more popular, which is also consistent with our previous results.

Now we validate some of the above results to understand whether the theoretical effects of corporatization exist in reality. For that, we use data from Airbnb, one of the most popular house-sharing platforms as discussed in §1. We collect data from `www.airbnb.com` for listings located in different

Table 3: Results from Collected Data

	Barcelona		London		NYC	
	B2C listings	P2P listings	B2C listings	P2P listings	B2C listings	P2P listings
Price (local currency)	152	68	160	92	162	150
Occupancy (%)	34.9	53.4	44.3	67.1	56.7	66.5

cities, including Barcelona, London and New York City. Each listing has a host. We categorize them into two groups: 1) individual owners who list their spare rooms or apartments/houses for rent in a P2P fashion, and the system behave as in the P2P scheme; 2) corporate players who manage multiple properties at the same time for the owners and the system behave as in the B2C scheme. We define corporate players as those who have at least four unique assets listed on Airbnb. The results are introduced in Table 3. It can be observed that for all three cities, the average price for B2C listings is higher than that for P2P listings, and the occupancy rate for B2C listings is lower than that for P2P listings. These are in line with our analytical results in §4.1 - §4.3.

5 Model Generalizations

In this section, we generalize our basic model framework and analysis by relaxing some of the assumptions regarding the non-platform hotel and long-term rental channels, the listing behavior of owners and the commission rate charged by the platform.

5.1 Price-sensitive Non-platform Channels

Until now, we make two assumptions about the non-platform channels: i) the price p_e for the hotel stay option, as well as ii) the risk-free reward p_r for long-term rental are exogenous. In this section, we relax these two assumptions, one at a time, so as to investigate the robustness of our results.

− **Price-sensitive hotel channel:** Suppose that the price charged by the hotel p_e is sensitive to the number of short-term stay customers; everything else in the model framework remains the same as §3. Considering the substitution effect between the sharing platform and the hotel, we expect that the higher is the price charged by the hotels, the more are the customers who join the sharing platform; this results in fewer hotel customers (and vice versa). For the sake of tractability, we model this effect as follows: $p_e(\theta) = a_e - b_e(M_\theta - Q_\theta)$, where $p_e(\theta)$ is the state-dependent hotel price. Even though endogenizing p_e considerably complicates the equilibrium analyses, we are able to fully characterize the equilibria under both schemes as shown in the following proposition.

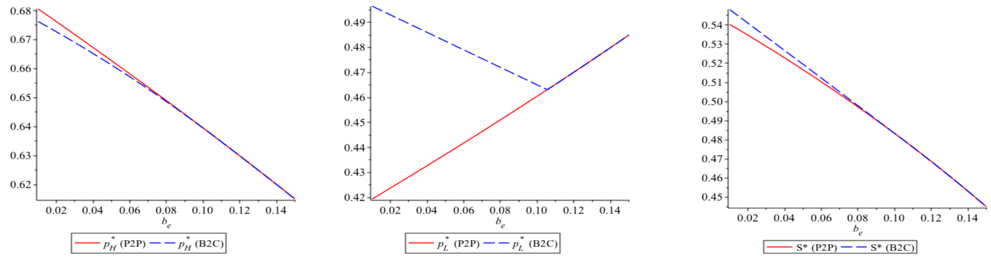
Proposition 5. *The equilibrium platform prices for each demand state θ and the number of owners listing their assets on the platform (i.e., availability) for P2P and B2C schemes are fully characterized in Tables 15 and 16 of Appendix A, respectively.*

Note that both P2P and B2C equilibria under endogenous p_e are structurally similar to their counterparts, characterized in Propositions 1 and 2 in §4.1 and §4.2, respectively. Therefore, in order to avoid a repetitive discussion, we only focus on the impact of the sensitivity of $p_e(\theta)$ with respect to the number of customers who opt for the hotel option (i.e., the impact of b_e).

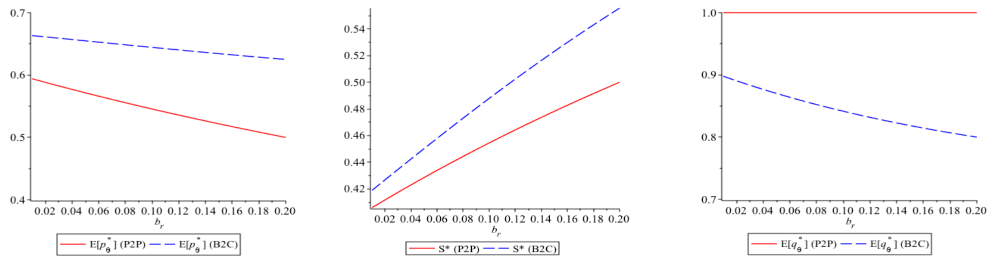
First, if p_e becomes more sensitive to M_θ, then the hotel channel competes more actively with the platform, and it then becomes a more appealing option for the customers; this puts a downward pressure on the platform price. On the other hand, as the price advantage of the sharing platform gets eroded, there are fewer asset owners who want to list on the platform; this boosts the price of any shared asset. As shown in the first graph of panel (A) in Figure 7, under a high-demand state, the negative effect due to a large market size M_H dominates the positive effect due to availability; hence, the asset price under the high-demand state, i.e., p_H^*, decreases in b_e under both tschemes. On the other hand, under the low-demand state, the total availability exceeds the relatively small market size M_L. Hence, interestingly, as shown in the second graph in Figure 7(A), p_L^* either always or eventually increases in b_e under P2P and B2C schemes, respectively. Our numerical results show that the expected price $\mathbb{E}[p_\theta^*]$ is always non-increasing in b_e. Perhaps a more important result in this context is that, as shown in the third graph of Figure 7(A), the equilibrium availability S^* on the platform always decreases in b_e for both pricing schemes, since the price advantage of the platform gets eroded due to a more competitive non-platform option, resulting in fewer listings on it. This also means that a more competitive hotel channel might have a positive impact on the capacity availability for the long-term rental channel.

– **Price-sensitive long-term rental channel:** Similar to the previous case, to capture the competition for house owners between the short-term platform and the long-term rental channel, for the sake of tractability, we consider the following relation between the equilibrium $p_r(S)$ and the number of owners who opt for the long-term channel $(N - S)$: $p_r(S) = a_r - b_r(N - S)$ where $b_r \geq 0$. [3] We are still able to fully characterize the equilibria as shown in the following proposition.

[3] Note that we get back to the baseline model from both models in §6.1 when $a_e = p_e,\ b_e = 0$ or $a_r = p_r,\ b_r = 0$.



(A) The impact of b_e ($p_r = 0.55$, $a_e = 1$, $\bar{c} = 0.75$, $M_H = 1.3$, $M_L = 0.7$, $N = 1$)



(B) The impact of b_r ($a_r = 0.6$, $p_e = 1$, $\bar{c} = 0.75$, $M_H = 1.5$, $M_L = 0.5$, $N = 1$)

Figure 7: Impact of b_e and b_r on equilibrium platform performance under P2P and B2C schemes

Proposition 6. *The equilibrium platform prices for each demand state θ and the number of owners listing their assets on the platform (i.e., availability) for P2P and B2C schemes are fully characterized in Tables 17 and 18 of Appendix A, respectively.*

An interesting aspect of a price-sensitive long-term rental channel is to understand what happens when p_r becomes more sensitive to $(N - S)$, i.e., as b_r increases. Note that higher b_r results in lower long-term rental price p_r. As shown in the first graph of Figure 7(B), the decrease in p_r (i.e., increase in b_r) is then followed by a decrease in short-term rental price $E[p_\theta^*]$ due to the increased competition between long- and short-term rental channels. However, the rate of decrease in the platform rental price is steeper than that of short-term platform. Hence, as b_r increases, the platform becomes more attractive to the house owners, which results in an increase in the listings (S^*) – see the second graph of Figure 7(B). Finally, as shown in the third graph of Figure 7(B), the occupancy rate does not change under P2P, however, it decreases in b_r under B2C. This is related to the corporate player reducing occupancy in order to prevent the prices from being too low due to the increased availability.

5.2 Owners' Listing Decisions under Heterogeneous Reservation Asset Value

Although we assumed until now that owners always need to rent their assets through the platform or the long-term channel, in reality, they also have the option of keeping the asset for themselves. That is, the owners might be part-time renters who rent out their assets only if the platform price is high enough. To capture this behavior, we assume that each owner has three options: 1) to rent out her asset through the long-term channel; 2) to list her asset on the rental platform; and 3) to keep the asset for herself. Moreover, in order to capture the heterogeneity among owners, we assume that they receive a value of ϵ from keeping the asset for themselves where ϵ is uniformly distributed in $[\underline{\epsilon}, \bar{\epsilon}]$. In the P2P scheme, an individual owner on the platform may choose to keep the asset for herself after observing the demand state and anticipating a relatively low price. However, such behavior is not allowed in the B2C scheme, as the commercial operator is managing the asset on behalf of owners (but owners can still choose to keep their own asset at the first beginning, i.e., at the participation stage).

We are still able to fully characterize the equilibria under both schemes - refer to Proposition 7 in Appendix A. Although it is difficult to analytically compare them, we use numerical examples to illustrate the different impacts of the two pricing schemes – see Table 4. In equilibrium, the owners are divided into three segments based on ϵ. The low-end owners ($\epsilon < \hat{\epsilon}_R$) choose to put their assets for long-term rentals (S_r^*), while the high-end owners ($\epsilon \geq \hat{\epsilon}_U$) always keep the assets for themselves (S_u^*). The medium-level owners ($\hat{\epsilon}_R < \epsilon \leq \hat{\epsilon}_U$) choose to join the sharing platform (S^*). In particular, under the P2P scheme, some of the owners can make their assets unavailable for renting and keep them for themselves, if the realized platform price turns out to be quite low.[4]

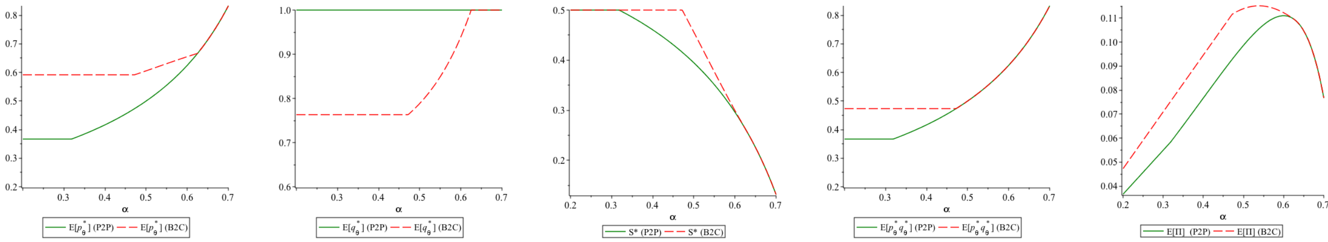
Table 4: Numerical results for owners with reservation prices

	S^*	S_u^*	S_r^*	p_H	p_L	$\mathbb{E}[\Pi]$	$\hat{\epsilon}_R$	$\hat{\epsilon}_U$
P2P scheme	1.33	1.02	0.65	0.33	0.27	0.27	0.24	0.33
B2C scheme	1.04	1.50	0.46	0.50	0.50	0.33	0.23	0.30

$p_e = 1$, $\bar{c} = 0.8$, $M_H = 1.6$, $M_L = 0.4$, $N = 3$, $p_r = 0.3$, $\underline{\epsilon} = 0.2$, $\bar{\epsilon} = 0.4$

An interesting observation from Table 4 is that there are more owners joining the sharing platform under the P2P scheme than that under the B2C scheme. This is because compared to our base model, the P2P scheme now provides an added advantage to the owners compared to the B2C scheme in the form of higher flexibility. Namely, owners under the P2P scheme even after joining the sharing platform may still choose to keep the assets for themselves after demand/price realization, which is impossible under the B2C scheme. However, note that the number of owners joining the long-term rental channel is smaller under B2C than under P2P. This implies that the availability of the long-term rentals is still lower for the B2C platform than for the P2P one.

[4]Note that the total number of assets available for rent is not anymore constant; rather, it is variable. So, if the market conditions are quite favorable, then more assets will be released for long- and short-term rentals, and vice versa.



(A) $E[p_\theta^*]$ (B)$E[q_\theta^*]$ (C) S^* (D) $E[p_\theta^* q_\theta^*]$ (E) $E[\Pi]$

Figure 8: The impact of commission rate α under P2P and B2C schemes ($M_L = 0.5$, $M_H = 1.5$, $p_e = 1$, $p_r = 0.25$, $\bar{c} = 0.95$, $N = 0.5$)

5.3 Endogenous platform provider commission rate

Until now, we assume that the platform provider is passive and takes a fixed, exogenous proportion α of revenue from each transaction conducted on the platform. In this section, we relax this assumption by adding stage 0 at the beginning of the timeline for the base model (Figure 2 in §3). Specifically, in stage 0, the platform provider actively decides her commission rate α; then in stage 1, the house owners decide whether to list on the platform or to opt for the long-term rental, and finally in stage 2 the demand uncertainty realizes and the price is determined according to P2P or B2C scheme. Our goal is to determine how the optimal α for the platform provider is related to the type of platform.

We note that equilibrium characterization of the base model can be generalized by redefining the long-term rent p_r as $\frac{p_r}{1-\alpha}$ in all the expressions. We can then obtain short-term platform provider's profit as a function of α. Let $E[\Pi(\alpha)] = \alpha E[p_\theta^*(\alpha) q_\theta^*(\alpha) S^*(\alpha)]$ denote the total expected commission fees collected by the platform provider. First of all, the higher α is, the larger is the portion of the transaction revenue that goes to the platform provider. However, the total transaction revenue itself depends on the price, occupancy rate, and availability. All three of them depend not only on α, but also on whether the platform is a P2P or a B2C one. In order to evaluate the impact of the interaction scheme on the optimal α, we numerically plot the provider's revenue $E[\Pi(\alpha)]$ and each constituent factor with respect to α under the two schemes - see Panels A-E in Figure 8.

It can be seen from Panel E of Figure 8 that the platform provider can collect more revenue in the B2C scheme than in the P2P scheme, as already established in Proposition 3. As shown in Panels C and D of Figure 8, the reason is that under the B2C scheme, the platform can attract more owners (S^*, platform availability) and the expected revenue generated by each listing ($E[p_\theta^* q_\theta^*]$) is also higher. Both factors contribute to higher revenue for the platform provider. More importantly, the optimal commission rate in the B2C scheme is, in general, less than that in the P2P scheme, i.e., *the platform provider should reduce its commission rate to deal with corporatization.* The rationale behind this is as follows. The presence of commercial operator under the B2C scheme already keeps prices relatively at a higher level (compared to the P2P scheme), which reduces the occupancy rate. Hence, in order not to reduce the occupancy rate further, the platform provider should lower her commission rate. On the other hand, under the P2P scheme, the occupancy rate is already too high, therefore the platform provider can increase commission rate without hurting the occupancy rate for the house owners. Another interesting observation is that as α increases, the expected revenue generated by each listing (i.e., $E[p^*_\theta q^*_\theta]$) becomes larger. This is because as α increases, fewer owners join the sharing platform, and a higher price is charged at the platform and thus each house owner can have a higher expected revenue.

6 Concluding Discussion

Online short-term house rental platforms initially connected individual owners with individual customers (P2P). But, recently there has been an influx of corporate players on the supply side resulting in a B2C type interaction on the platforms. In this paper, we analyze the implications of this change (*corporatization*) for the direct and indirect stakeholders of the platform. We do so by comparing two schemes that capture the possible adaptation in pricing strategy as a result of the entry of corporate players. In the P2P model, no individual owner has pricing power and so assets are priced based on a market-clearing mechanism, whereas in the B2C scheme, corporate players price the assets on behalf of the owners with the objective of maximizing revenue. We develop a two-stage, stylized model to capture platform-mediated interactions between owners and consumers for both schemes.

First of all, *ceteris paribus*, homeowners are more likely to list their assets on the sharing platform under both P2P and B2C schemes if the *occupancy potential* for their assets goes up. In certain cases, this results in a significant number of owners opting for the platform, thus reducing available capacity in the long-term rental market. This happens even if they predict with certainty that their assets will be underutilized on the rental platform. This brings to light the importance of a second factor—if the *price premium potential* of the platform over the long-term rental market is high, the owners are still incentivized to join the platform lured by the possibility of higher (expected) rental revenue, even after occupancy risk is taken into account. Second, we find that when a platform moves from a P2P scheme to a B2C one, it results in higher revenues for asset owners and lower surplus for consumers. The reason is that the corporate player's pricing power under the latter scheme at times keeps the prices strategically high, even at the cost of lower demand, in order to maximize the expected revenue, which in turn hurts the consumers. Interestingly, even though this engenders a *lower proportion of occupied assets on the platform under the B2C scheme, the attraction of higher prices under that scheme results in more owners listing their assets on the platform under the B2C scheme than the P2P one.* Data from Airbnb for multiple cities are in alignment with the above results.

We also analytically generalize our basic framework by relaxing some of its assumptions. First, in contrast to the basic model where we assume "pure" P2P or B2C platforms, we allow both schemes to coexist on the platform. It turns out that all our results still remain valid. They remain valid even when the two external channels—long-term rentals and hotels— are not exogenous. A more price-sensitive hotel option for the consumers results in lower asset availability on the platform (i.e., higher availability on the long-term rental market). On the other hand, a more price-sensitive long-term rental channel increases the supply to the platform. The only scenario when our results might not be valid is if the owners have a heterogeneous reservation value for keeping the assets for themselves and they are provided an extra flexibility under the P2P setting (compared to the B2C one) whereby they can join the platform but still decide not to rent the asset if the realized platform price turns out to be quite low. However, even in this scenario, corporatization of the platform accelerates the capacity loss on the long-term rental market.

Our results have some key implications both for policymakers and platform providers. First, regardless of the owner-consumers interaction scheme, online house rental platforms may fall well short of their original promise of improving asset efficiency. Interestingly, we show that the presence of unrented assets on a platform is not due to short-term demand fluctuations but because of "deliberate" excess supply to the platform. Second, we suggest that the corporatization of the rental platforms, and the resulting B2C scheme, can exacerbate the problem of deliberate oversupply to platforms. This not only leads to less efficient utilization of assets but also hurts customers and the long-term rental market. As indicated in §1, this is an issue of real concern to the society and policymakers. Our study provide suggestions as to what types of policy prescriptions might (and which ones might not) be able to control such oversupply. Along these lines, *volume(of asset rental)-restriction policies* that encourage a P2P scheme by putting certain types of limitations on corporatization might be worthwhile. For example, certain cities are experimenting with new rules about how many and what types for properties can be listed for short-term rentals (e.g., Vancouver (Global and Mail 2018), and San Francisco (CNET 2018)). Creating more competitive secondary channels for asset owners and consumers (e.g., a cheaper hotel channel) can also help to alleviate the excess supply problem. On the other hand, price restriction policies in the long-term rental market like rent controls that have been employed to increase accessibility might be counter-productive since it actually encourages even more asset owners to list on the platform. From platform providers' perspective there are two issues to keep in mind. First, as we demonstrate, they need to customize their commission rates depending on the size of the asset listing entities, especially increasing it for corporate players. Second, while it is true that corporate players might now contribute the lion's share of the revenue on rental platforms, their pricing power and their incentives to keep their assets under-utilized, might have adverse long-term consequences for the platform in terms of its popularity. Hence, encouraging a P2P platform is not only good for policymakers but may even help platform providers to generate longer-term sustainable traffic. Finally, our model provides an indication as to how other short-term asset rental platforms that are primarily P2P in nature until now (e.g. Turo.com, a new short-term car-rental platform) will evolve over time as inevitable corporatization takes hold there.

We acknowledge that our model has scope for further generalizations. First, the price formation process in the long-term rental market and/or the capacity in the hotel channel could be micro-modeled. This would help to link the short-term and long-term supply and demand dynamics in a more endogenous fashion. Second, perhaps it is possible to think about incorporating home prices into the model, although that would need us to consider more macroeconomic issues. We hope that this paper provides a framework to evaluate the implications, including social ones, of various owner-customer interaction schemes on asset rentals in general, and the housing industry, in particular.

References

Allon, G., A. Bassamboo, E. B. Çil. 2012. Large-scale service marketplaces: The role of the moderating firm. *Management Science* **58**(10) 1854–1872.

Arnosti, N., R. Johari, Y. Kanoria. 2018. Managing congetion in matching market. *ssrn.com/abstract=247960* .

Bai, J., K. C. So, C. S. Tang, X. Chen, H. Wang. 2018. Coordinating supply and demand on an on-demand service platform with impatient customers. *Manufacturing & Service Operations Management* Forthcoming.

Banerjee, S., R. Johari, C. Riquelme. 2015. Pricing in ride-sharing platforms: A queueing-theoretic approach. *ssrn.com/abstract=2568258* .

Barron, K., E. Kung, D. Proserpio. 2018. The sharing economy and housing affordability: Evidence from airbnb. *ssrn.com/abstract=3006832* .

Basu, A., S. R. Bhaskaran, R. Mukherjee. 2018. An analysis of search and authentication strategies for online matching platforms. *Management Science* Forthcoming.

Benjaafar, S., J.-Y. Ding, G. Kong, T. Taylor. 2018a. Labor welfare in on-demand service platforms. *ssrn.com/abstract=3102736* .

Benjaafar, S., G. Kong, X. Li, C. Courcoubetis. 2018b. Peer-to-peer product sharing: Implications for ownership, usage, and social welfare in the sharing economy. *Management Science* Forthcoming.

Bimpikis, K., O. Candogan, D. Saban. 2016. Spatial pricing in rideshare networks. *ssrn.com/abstract=286808* .

Cachon, G. P., K. M. Daniels, R. Lobel. 2017. The role of surge pricing on a service platform with self-scheduling capacity. *Manufacturing & Service Operations Management* **19**(3) 368–384.

Citylab. 2018. What airbnb did to new york city. *https://www.citylab.com/equity/2018/03/what-airbnb-did-to-new-york-city/552749/* .

CNET. 2018. Airbnb purges thousands of san francisco listings overnight. *https://www.cnet.com/news/airbnb-purges-thousands-of-its-san-francisco-listings-overnight/* .

Cohen, M. C., R. P. Zhang. 2018. Coopetition and profit sharing for ride-sharing platforms. *ssrn.com/abstract=3028138* .

CTV. 2019. Little burgundy tenants fight eviction in place of short-term rentals. *https://montreal.ctvnews.ca/little-burgundy-tenants-fight-eviction-in-place-of-shortterm-rentals-14254943* .

Cui, Y., A. Y. Orhun, M. Hu. 2019. Under the same roof: Value of shared living in airbnb. *ssrn.com/abstract=3136138* .

Curbed. 2018. Airbnbusiness: As professionals find success on the platform, is there still room for sharers? *https://www.curbed.com/2018/2/21/17032100/airbnb-business-profit-hotel-property-management* .

Forbes. 2018. Sonder raises $135 million to turn airbnb-style apartments into a different kind of hotel. *https://www.forbes.com/sites/bizcarson/2018/08/23/sonder-raises-135-million-to-turn-airbnb-style-apartments-into-a-different-kind-of-hotel* .

Fraiberger, S. P., A. Sundararajan. 2017. Peer-to-peer rental markets in the sharing economy. *ssrn.com/abstract=2574337* .

Gibbs, C., D. Guttentag, U. Gretzel, J. Morton, A. Goodwill. 2018. Pricing in the sharing economy: a hedonic pricing model applied to airbnb listings. *Journal of Travel & Tourism Marketing* **35**(1) 46–56.

Global, T., Mail. 2018. Airbnb agrees to help vancouver enforce new short-term rental rules. *https://www.theglobeandmail.com/canada/british-columbia/article-airbnb-agrees-to-help-vancouver-enforce-new-short-term-rental-rules/* .

Guan, H., X. Geng, H. Gurnani. 2019. Peer-to-peer sharing platforms with quality differentiation: Manufacturer's strategic decision under sharing economy. *Production and Operations Management* Forthcoming.

Guda, H., U. Subramanian. 2018. Your uber is arriving: Managing on-demand workers through surge pricing, forecast communication and worker incentives. *Management Science* Forthcoming.

Gurvich, I., M. Lariviere, A. Moreno. 2016. Operations in the on-demand economy: Staffing services with self-scheduling capacity. *ssrn.com/abstract=2336514* .

Horn, K., M. Merante. 2017. Is home sharing driving up rents? Evidence from airbnb in boston. *Journal of Housing Economics* **38** 14–24.

Hu, M., Y. Zhou. 2016. Dynamic type matching. *ssrn.com/abstract=2592622* .

Hu, M., Y. Zhou. 2017. Price, wage and fixed commission in ondemand matching. *ssrn.com/abstract=2949513* .

Jiang, B., L. Tian. 2018. Collaborative consumption: Strategic and economic implications of product sharing. *Management Science* **64**(3) 1171–1188.

Kanoria, Y., D. Saban. 2017. Facilitating the search for partners on matching platforms: Restricting agents' actions. *web.stanford.edu/ dsaban/facilitating-search.pdf* .

Li, J., A. Moreno, D. J. Zhang. 2016. Pros vs joes: Agent pricing behavior in the sharing economy. *ssrn.com/abstract=2708279* .

Liu, Q., G. J. Van Ryzin. 2008. Strategic capacity rationing to induce early purchases. *Management Science* **54**(6) 1115–1131.

Mai, Y., B. Hu, Y. Hu, S. Pekeč, Z. Zou. 2018. Courteous or crude? Understanding and shaping user behavior in ride-hailing. *Working Paper.* `https://papers.ssrn.com/abstract_id=3263680` .

Narasimhan, C., P. Papatla, B. Jiang, P. K. Kopalle, P. R. Messinger, S. Moorthy, D. Proserpio, U. Subramanian, C. Wu, T. Zhu. 2017. Sharing economy: Review of current research and future directions. *Customer Needs and Solutions* 1–14.

NYT. 2019. Inside the rise and fall of a multimillion-dollar airbnb scheme. *https://www.nytimes.com/2019/02/23/nyregion/airbnb-nyc-law.html* .

Ozkan, E., A. Ward. 2017. Dynamic matching for real-time ridesharing. *ssrn.com/abstract=2844451* .

Su, X. 2007. Intertemporal pricing with strategic customer behavior. *Management Science* **53**(5) 726–741.

Taylor, T. A. 2018. On-demand service platforms. *Manufacturing & Service Operations Management* **20**(4) 704–720.

VICE. 2019. How airbnb is squeezing toronto's housing market. *https://news.vice.com/en/ca/article/nexgx7/el-chapo-demands-court-probe-alleged-juror-misconduct-for-possible-retrial* .

Wachsmuth, D., D. Kerrigan, D. Chaney, A. Shillol. 2017. Short-term cities airbnb's impact on canadian housing markets. *upgo.lab.mcgill.ca/airbnb/Short-term%20Cities%202017-08-10.pdf* .

Wang, D., J. L. Nicolau. 2017. Price determinants of sharing economy based accommodation rental: A study of listings from 33 cities on airbnb.com. *International Journal of Hospitality Management* **62** 120–131.

Wikipedia. 2018. Airbnb. *https://en.wikipedia.org/wiki/Airbnb* .

Xie, K. L., L. Kwok. 2017. The effects of airbnb's price positioning on hotel performance. *International Journal of Hospitality Management* **67** 174–184.

Zervas, G., D. Proserpio, J. W. Byers. 2017. The rise of the sharing economy: Estimating the impact of airbnb on the hotel industry. *Journal of Marketing Research* **54**(5) 687–705.

Online Appendix to "Short-term Housing Rentals and Corporatization of Platform Pricing"

Table 5: Notation Summary

Notation	Meaning
N	the number of house owners
θ	demand state ($\theta = \{H, L\}$)
M_θ	the number of customers who are looking for short-term stays
p_r	the long-term rental price
p_e	the hotel price
c	the hassle cost of a customer with the largest possible value $\bar{c}$
p_θ	the price of an asset on the platform when demand state is θ
q_θ	the occupancy rate of an asset on the platform when demand state is θ
α	the proportion of each payment that an owner on the platform receives
$\mathbb{E}[\pi]$	the expected payoff of an asset owner on the platform
S	the number of owners who join the platform
D_θ	the number of customers looking for short-term stays on the platform when demand state is θ
Q_θ	the transaction volume of the platform when demand state is θ
$\mathbb{E}[\Pi]$	the expected commission fees collected by the platform provider
a_e, b_e	the coefficients in the demand-price function in the price-sensitive hotel channel
a_r, b_r	the coefficients in the demand-price function in the price-sensitive long-tern rental channel
ϵ	the valuation of an owner keeping the asset by himself and $\underline{\epsilon} \le \epsilon \le \bar{\epsilon}$
ϵ_R, ϵ_U	the thresholds for an owner with valuation ϵ joining the sharing platform
S_u^*	the number of owners keeping the assets by themselves
S_r^*	the number of owners joining the long-term rentals
S_{P2P}^* (S_{B2C}^*)	the number of owners joining the P2P (B2C) scheme
p_{P2P}^* (p_{B2C}^*)	the price of an asset in the P2P (B2C) scheme
q_{P2P}^* (q_{B2C}^*)	the occupancy rate of an asset in the P2P (B2C) scheme

A Proofs of Propositions

Proposition 1 In a P2P interaction-based platform, the equilibrium is fully characterized in Table 2. Specifically, the equilibrium can be divided into six regions as shown in Figure 3.

- Regions 1, 2, and 3: In these regions, $\mathbb{E}[\pi] > p_r$ and all N owners opt for listing on the platform.
- Regions 4, 5, and 6: In these regions, $\mathbb{E}[\pi] = p_r$ and only $S^* < N$ owners list on the sharing platform; other $(N - S^*)$ owners opt for the risk-free long-term channel.

The equilibrium platform price (p_θ^*), availability (S^*), and occupancy probability (q_θ^*) for each demand state θ in these regions are presented in Table 2.

Proof of Proposition 1. In equilibrium, given S^* owners on the platform and M_θ customers looking for short-term rental stays, the optimal price p_θ is of the supply-clearance type ($p_\theta^* = p_e - \frac{S^*\bar{c}}{M_\theta}$) if $S < M_\theta$; otherwise, it is of the maximum-coverage type ($p_\theta^* = p_e - \bar{c}$). In addition, the equilibrium in which an owner's payoff from renting the asset through the risk-free long-term rental channel is strictly higher than the expected payoff from listing the asset on the platform, i.e. $p_r > E_\theta(p_\theta q_\theta)$, is never sustainable. We consider the following three separate scenarios.

- $S^* \le M_L$. In this scenario, for both realizations of M (M_H and M_L), the optimal price is given by $p_\theta^* = p_e - \frac{S^*\bar{c}}{M_\theta}$ in equilibrium. Since all customers are attracted to the platform, it follows that $p_H^* = p_e - \frac{S^*\bar{c}}{M_H}$, $p_L^* = p_e - \frac{S^*\bar{c}}{M_L}$, $q_H^* = 1$ and $q_L^* = 1$. To guarantee $\mathbb{E}[p_\theta^* f_\theta^*] \ge p_r$, we have $S^* \le \frac{2(p_e-p_r)M_H M_L}{\bar{c}(M_H+M_L)}$. Since $S^* \le N$, we have $S^* = \min\{\frac{2(p_e-p_r)M_H M_L}{\bar{c}(M_H+M_L)}, N\}$. Specifically,
  - if $\frac{2(p_e-p_r)M_H M_L}{\bar{c}(M_H+M_L)} \le M_L$, i.e. $\frac{p_r}{p_e} \ge 1 - \frac{1}{2}\frac{\bar{c}}{p_e}(1 + \frac{M_L}{M_H})$, then
    - $S^* = \frac{2(p_e-p_r)M_H M_L}{\bar{c}(M_H+M_L)}$, when $\frac{2(p_e-p_r)M_H M_L}{\bar{c}(M_H+M_L)} \le N$; see Case 1 in Table 6;
    - $S^* = N$, when $N \le \frac{2(p_e-p_r)M_H M_L}{\bar{c}(M_H+M_L)}$; see Case 2 in Table 6.
  - if $\frac{2(p_e-p_r)M_H M_L}{\bar{c}(M_H+M_L)} \ge M_L$, $S^* = N$. That is,
    - $S^* = N \le M_L$, when $p_e(1 + \frac{M_L}{M_H}) \le \bar{c}(1 + \frac{M_L}{M_H}) + 2p_r \le 2p_e$; see Case 5 in Table 7;
    - $S^* = N \le M_L$, when $\bar{c}(1 + \frac{M_L}{M_H}) + 2p_r \le p_e(1 + \frac{M_L}{M_H})$; see Case 9 in Table 8;

- $M_L \le S^* \le M_H$. In this scenario, when $M = M_H$, the optimal price p_H^* is $p_H^* = p_e - \frac{S^*\bar{c}}{M_H}$. When $M = M_L$, the optimal price is given by $p_L^* = p_e - \bar{c}$ with $f_L^* = \frac{M_L}{S^*}$. By $\mathbb{E}[p_\theta^* f_\theta^*] \ge p_r$, it follows that $S^* \le \frac{(\frac{1}{2}p_e - p_r) + \sqrt{(p_r - \frac{1}{2}p_e)^2 + (p_e-\bar{c})\bar{c}\frac{M_L}{M_H}}}{\bar{c}/M_H} \equiv S_{P2P}^3$. Then we have $M_L \le S^* = \min\{S_{P2P}^3, N\} \le M_H$. Specifically,
  - if $M_L \le S_{P2P}^3 \le M_H$, i.e., $\frac{1}{2}(1 - \frac{\bar{c}}{p_e})(1 + \frac{M_L}{M_H}) \le \frac{p_r}{p_e} \le 1 - \frac{1}{2}\frac{\bar{c}}{p_e}(1 + \frac{M_L}{M_H})$, then
    - $S^* = S_{P2P}^3$, when $S_{P2P}^3 \le N$; see Case 3 in Table 7;
    - $S^* = N$, when $M_L \le N \le S_{P2P}^3$; see Case 4 in Table 7.
  - if $S_{P2P}^3 \ge M_H$, i.e., $\frac{p_r}{p_e} \le \frac{1}{2}(1 - \frac{\bar{c}}{p_e})(1 + \frac{M_L}{M_H})$, then $S^* = N$; see Case 8 in Table 8.

- $S^* \ge M_H$. In this scenario, for both realizations of M, the providers set $p_\theta = p_e - \bar{c}$ to attract all customers. It follows that $q_H^* = \frac{M_H}{S^*}$ and $q_L^* = \frac{M_L}{S^*}$. By $\mathbb{E}[\pi] \ge p_r$, it follows that $S^* \le \frac{(p_e-\bar{c})(M_H+M_L)}{2p_r}$. Then we have $M_H \le S^* = \min\{\frac{(p_e-\bar{c})(M_H+M_L)}{2p_r}, N\}$. Specifically,

- $S^* = \frac{(p_e-\bar{c})(M_H+M_L)}{2p_r}$, when $\frac{(p_e-\bar{c})(M_H+M_L)}{2p_r} \le N$; see Case 6;
- $S^* = N$, when $M_H \le N \le \frac{(p_e-\bar{c})(M_H+M_L)}{2p_r}$; see Case 7.

The proof ends.

Table 6: Equilibrium 1 in P2P when $\frac{p_r}{p_e} \ge 1 - \frac{1}{2}\frac{\bar{c}}{p_e}(1+\frac{M_L}{M_H})$

	Equilibrium 1	
	Case 1	Case 2
Condition	$N \ge \frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}}$	$N \le \frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}}$
p_H^*	$p_e - \frac{2(p_e-p_r)M_L}{M_H+M_L}$	$p_e - \frac{N\bar{c}}{M_H}$
p_L^*	$p_e - \frac{2(p_e-p_r)M_H}{M_H+M_L}$	$p_e - \frac{N\bar{c}}{M_L}$
q_H^*	1	1
q_L^*	1	1
S^*	$\frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}}$	N

Note: $S^* \le M_L$ in Cases 1 and 2.

Table 7: Equilibrium 2 in P2P when $\frac{1}{2}(1-\frac{\bar{c}}{p_e})(1+\frac{M_L}{M_H}) \le \frac{p_r}{p_e} \le 1 - \frac{1}{2}\frac{\bar{c}}{p_e}(1+\frac{M_L}{M_H})$

	Equilibrium 2		
	Case 3	Case 4	Case 5
Condition2	$N \ge \frac{(\frac{1}{2}p_e-p_r)+\sqrt{(p_r-\frac{1}{2}p_e)^2+(p_e-\bar{c})\bar{c}\frac{M_L}{M_H}}}{\bar{c}/M_H}$	$M_L \le N \le \frac{(\frac{1}{2}p_e-p_r)+\sqrt{(p_r-\frac{1}{2}p_e)^2+(p_e-\bar{c})\bar{c}\frac{M_L}{M_H}}}{\bar{c}/M_H}$	$N \le M_L$
p_H^*	$p_r + \frac{1}{2}p_e - \sqrt{(p_r-\frac{1}{2}p_e)^2+(p_e-\bar{c})\bar{c}\frac{M_L}{M_H}}$	$p_e - \frac{N\bar{c}}{M_H}$	$p_e - \frac{N\bar{c}}{M_H}$
p_L^*	$p_e - \bar{c}$	$p_e - \bar{c}$	$p_e - \frac{N\bar{c}}{M_L}$
q_H^*	1	1	1
q_L^*	$\frac{\sqrt{(p_r-\frac{1}{2}p_e)^2+(p_e-\bar{c})\bar{c}\frac{M_L}{M_H}}-(\frac{1}{2}p_e-p_r)}{p_e-\bar{c}}$	$\frac{M_L}{N}$	1
S^S	$\frac{(\frac{1}{2}p_e-p_r)+\sqrt{(p_r-\frac{1}{2}p_e)^2+(p_e-\bar{c})\bar{c}\frac{M_L}{M_H}}}{\bar{c}/M_H}$	N	N

Note: $M_L \le S^* \le M_H$ in Cases 3 and 4, with $S^* \le M_L$ in Case 5.

Table 8: Equilibrium 3 in P2P when $\frac{p_r}{p_e} \le \frac{1}{2}(1-\frac{\bar{c}}{p_e})(1+\frac{M_L}{M_H})$

	Equilibrium 3			
	Case 6	Case 7	Case 8	Case 9
Condition	$N \ge \frac{(p_e-\bar{c})(M_H+M_L)}{2p_r}$	$M_H \le N \le \frac{(p_e-\bar{c})(M_H+M_L)}{2p_r}$	$M_L \le N \le M_H$	$N \le M_L$
p_H^*	$p_e - \bar{c}$	$p_e - \bar{c}$	$p_e - \frac{N\bar{c}}{M_H}$	$p_e - \frac{N\bar{c}}{M_H}$
p_L^*	$p_e - \bar{c}$	$p_e - \bar{c}$	$p_e - \bar{c}$	$p_e - \frac{N\bar{c}}{M_L}$
q_H^*	$\frac{2p_r M_H}{(p_e-\bar{c})(M_H+M_L)}$	$\frac{M_H}{N}$	1	1
q_L^*	$\frac{2p_r M_L}{(p_e-\bar{c})(M_H+M_L)}$	$\frac{M_L}{N}$	$\frac{M_L}{N}$	1
S^*	$\frac{(p_e-\bar{c})(M_H+M_L)}{2p_r}$	N	N	N

Note: $S^* \ge M_H$ in Cases 6 and 7, with $M_L \le S^* \le M_H$ in Case 8, and $S^* \le M_L$ in Case 9.

Table 9: Equilibrium outcomes under the profit-based pricing scheme

Regions	S^*	p_H^*	p_L^*	q_H^*	q_L^*
1	N	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$	1	1
2	N	$p_e - \frac{S^*\bar{c}}{M_H}$	$\frac{1}{2}p_e$	1	$\frac{p_e M_L}{2S^*\bar{c}}$
3	N	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$\frac{p_e M_H}{2S^*\bar{c}}$	$\frac{p_e M_L}{2S^*\bar{c}}$
4	$\frac{M_H+M_L}{2\bar{c}p_r}(\frac{1}{2}p_e)^2 < N$	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$\frac{p_e M_H}{2S^*\bar{c}}$	$\frac{p_e M_L}{2S^*\bar{c}}$
5	$\frac{(p_e-2p_r)+\sqrt{(p_e-2p_r)^2+(p_e)^2 M_L/M_H}}{2\bar{c}/M_H} < N$	$p_e - \frac{S^*\bar{c}}{M_H}$	$\frac{1}{2}p_e$	1	$\frac{p_e M_L}{2S^*\bar{c}}$
6	$\frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}} < N$	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$	1	1

$p_e - \frac{S^*\bar{c}}{M_\theta}$: supply-clearance price; $\frac{1}{2}p_e$: interior point price

$\square$

Proposition 2. In a B2C interaction-based platform, the equilibrium is fully characterized in Tables 2 and 9 in Appendix A. Specifically, the equilibrium regions are:

- If $p_e > 2\bar{c}$, then the equilibrium is the same as Proposition 1 of §4.1.
- If $p_e \leq 2\bar{c}$, then the equilibrium is as described below and shown in Figure 4 and Table 9.
  - Regions 1, 2, and 3: In these regions $\mathbb{E}[\pi] > p_r$ and all N owners list on the platform.
  - Regions 4, 5, and 6: In these regions $\mathbb{E}[\pi] = p_r$ and and only $S^* < N$ owners list on the sharing platform; the other $(N - S^*)$ opt for risk-free long-term rentals.

Proof of Proposition 2. The objective function under the B2C pricing scheme is given by

$$\begin{aligned} &\max_{p_\theta \geq 0} \ (1-\alpha)p_\theta Q_\theta \\ &\text{s.t. } Q_\theta = \frac{p_e - p_\theta}{\bar{c}} M^\theta, \ \ Q_\theta \leq S, \ \ Q_\theta \leq D_\theta \ \text{ and } \ Q_\theta \leq M_\theta. \end{aligned} \tag{A.1}$$

Given S owners on the platform and M_θ customers looking for short-term rental stays,

- If $p_e > 2\bar{c}$, the optimal price p_θ is the same as §4.1. That is, if $S < M_\theta$, then p_θ is of the supply-clearance type $(p_e - \frac{S^*\bar{c}}{M^\theta})$; otherwise, it is of the maximum-coverage type $(p_e - \bar{c})$.
- If $p_e \leq 2\bar{c}$, then the optimal price is of the supply-clearance type if $S < \frac{M_\theta p_\theta}{2\bar{c}}$, otherwise, it is given by the interior point solution $\frac{p_e}{2}$.

Similar to the P2P case, using the above prices, we then characterize the first stage participation decision for the owners where they compare p_r of the risk-free channel and expected revenue $E_\theta(p_\theta q_\theta)$

from the platform channel. When $p_e > 2\bar{c}$, it is easy to see the equilibria are totally the same as those in §4.1, since they have the same pricing options. When $p_e \leq 2\bar{c}$, following the same logic, the proof mimics that of Proposition 1. The results are listed in Tables 10-12.

Table 10: Equilibrium 1 in B2C when $p_e \leq 2\bar{c}$

Conditions	Equilibrium 1 $\frac{p_r}{p_e} \leq \frac{1}{4} + \frac{1}{4}\frac{M_L}{M_H}$			
	Case 1 $N \geq \frac{M_H+M_L}{2\bar{c}p_r}(\frac{1}{2}p_e)^2$	Case 2 $\frac{p_e M_H}{2\bar{c}} \leq N \leq \frac{M_H+M_L}{2\bar{c}p_r}(\frac{1}{2}p_e)^2$	Case 3 $\frac{p_e M_L}{2\bar{c}} \leq N \leq \frac{p_e M_H}{2\bar{c}}$	Case 4 $N \leq \frac{p_e M_L}{2\bar{c}}$
p_H^*	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$p_e - \frac{N\bar{c}}{M_H}$	$p_e - \frac{N\bar{c}}{M_H}$
p_L^*	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$p_e - \frac{N\bar{c}}{M_L}$
q_H^*	$\frac{4p_r M_H}{p_e(M_H+M_L)}$	$\frac{p_e M_H}{2N\bar{c}}$	1	1
q_L^*	$\frac{4p_r M_L}{p_e(M_H+M_L)}$	$\frac{p_e M_L}{2N\bar{c}}$	$\frac{p_e M_L}{2N\bar{c}}$	1
S^*	$\frac{M_H+M_L}{2\bar{c}p_r}(\frac{1}{2}p_e)^2$	N	N	N

Table 11: Equilibrium 2 in B2C when $p_e \leq 2\bar{c}$

Conditions	Equilibrium 2 $\frac{p_r}{p_e} \geq \frac{3}{4} - \frac{1}{4}\frac{M_L}{M_H}$	
	Case 5 $N \geq \frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}}$	Case 6 $N \leq \frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}}$
p_H^*	$p_e - \frac{2(p_e-p_r)M_L}{M_H+M_L}$	$p_e - \frac{N\bar{c}}{M_H}$
p_L^*	$p_e - \frac{2(p_e-p_r)M_H}{M_H+M_L}$	$p_e - \frac{N\bar{c}}{M_L}$
q_H^*	1	1
q_L^*	1	1
S^*	$\frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}}$	N

Table 12: Equilibrium 3 in B2C when $p_e \leq 2\bar{c}$

Conditions	Equilibrium 3 $\frac{1}{4} + \frac{1}{4}\frac{M_L}{M_H} \leq \frac{p_r}{p_e} \leq \frac{3}{4} - \frac{1}{4}\frac{M_L}{M_H}$		
	Case 7 $N \geq \frac{(p_e-2p_r)+\sqrt{(p_e-2p_r)^2+(p_e)^2 M_L/M_H}}{2\bar{c}/M_H}$	Case 8 $\frac{p_e M_L}{2\bar{c}} \leq N \leq \frac{(p_e-2p_r)+\sqrt{(p_e-2p_r)^2+(p_e)^2 M_L/M_H}}{2\bar{c}/M_H}$	Case 9 $N \leq \frac{p_e M_L}{2\bar{c}}$
p_H^*	$\frac{p_e}{2} + p_r - \sqrt{(\frac{p_e}{2} - p_r)^2 + (\frac{p_e}{2})^2 \frac{M_L}{M_H}}$	$p_e - \frac{N\bar{c}}{M_H}$	$p_e - \frac{N\bar{c}}{M_H}$
p_L^*	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$p_e - \frac{N\bar{c}}{M_L}$
q_H^*	1	1	1
q_L^*	$\sqrt{(1-\frac{2p_r}{p_e})^2 + \frac{M_L}{M_H}} - (1 - \frac{2p_r}{p_e})$	$\frac{p_e M_L}{2N\bar{c}}$	1
S^*	$\frac{(p_e-2p_r)+\sqrt{(p_e-2p_r)^2+(p_e)^2 M_L/M_H}}{2\bar{c}/M_H}$	N	N

□

Proof of Proposition 3. We first provide the following expressions. $\underline{p} = 1 - \frac{1}{2}\frac{\bar{c}}{p_e}(1 + \frac{M_L}{M_H})$, $\bar{p} = \frac{1}{4}(1 + \frac{M_L}{M_H})$, $\overline{N} = \min\{\frac{2(p_e - p_r)M_H M_L}{(M_H + M_L)\bar{c}}, \frac{p_e M_H}{2\bar{c}}\}$ and $\bar{N} = \frac{M_H + M_L}{2\bar{c}p_r}(\frac{1}{2}p_e)^2$. That is, we here consider case 1 in the P2P scheme and case 2 in the B2C scheme. For the sake of exposition, below we annotate variables with "~" to denote the corresponding variables in the B2C scheme. For example, $\tilde{p}_H^*$ denotes the optimal price when demand state is H in the B2C scheme.

Equilibrium decisions: (a) by $\frac{p_r}{p_e} \leq \frac{1}{4} + \frac{1}{4}\frac{M_L}{M_H} \leq \frac{1}{2} \leq 1 - \frac{1}{4}(1 + \frac{M_L}{M_H})$, it is easy to check $p_L^* \leq \tilde{p}_L^*$ and $\mathbb{E}(p_\theta^*) = p_r \leq \frac{1}{2}p_e = \mathbb{E}(\tilde{p}_\theta^*)$. (b) $q_H^* = q_L^* = 1$, and $\tilde{q}_L^* \leq \tilde{q}_H^* \leq 1$. (c) We have $S^* \leq N$ and $\tilde{S}^s = N$. Equilibrium payoffs: (a) & (c) $\mathbb{E}[\pi] = \mathbb{E}[p_\theta^* q_\theta^*] = p_r$ in P2P and $\mathbb{E}[\tilde{\pi}] = \mathbb{E}(\tilde{p}_\theta^* \tilde{q}_\theta^*) \geq p_r$ in B2C. It follows that $OS = N\mathbb{E}[\pi] \geq N\mathbb{E}[\tilde{\pi}] = \widetilde{OS}$. (b) $CS = \frac{1}{2\bar{c}}\frac{2(p_e - p_r)^2 M_H M_L}{M_H + M_L}$, and $\widetilde{CS} = \frac{1}{2\bar{c}}\frac{1}{8}(p_e)^2(M_H + M_L)$. It suffices to show $\frac{2(p_e - p_r)^2 M_H M_L}{M_H + M_L} \geq \frac{1}{8}(p_e)^2(M_H + M_L)$, or equivalently, $\frac{p_r}{p_e} \leq 1 - \frac{1}{4}(\sqrt{\frac{M_H}{M_L}} + \sqrt{\frac{M_L}{M_H}})$. Since $\frac{p_r}{p_e} \leq \frac{1}{4}(1 + \frac{M_L}{M_H})$, we only need to show $\frac{1}{4}(1 + \frac{M_L}{M_H}) \leq 1 - \frac{1}{4}(\sqrt{\frac{M_H}{M_L}} + \sqrt{\frac{M_L}{M_H}})$. Moreover, by $1 - \frac{1}{2}\frac{\bar{c}}{p_e}(1 + \frac{M_L}{M_H}) \leq \frac{1}{4} + \frac{1}{4}\frac{M_L}{M_H}$, it follows that $\frac{M_L}{M_H} \geq \frac{4}{1 + 2\bar{c}/p^H} - 1 \geq \frac{1}{3}$, where the last inequality holds due to $\bar{c} \leq p_e$. Define $a \equiv \frac{M_L}{M_H} \in [\frac{1}{3}, 1]$, it suffices to show $g(a) \equiv a + \sqrt{a} + \sqrt{\frac{1}{a}} - 3 \leq 0$ for $a \in [\frac{1}{3}, 1]$. This directly holds due to $g(\frac{1}{3}) \leq 3$, $g(1) = 0$, and $g''(a) \geq 0$ for $a \in [\frac{1}{3}, 1]$. □

Proposition 4. When P2P and B2C pricing schemes coexist, the equilibria are characterized in Table 13 in Appendix A.

Table 13: Equilibria with P2P and B2C coexistence

No.	S_{P2P}^*	S_{B2C}^*	p_{P2P}^* and p_{B2C}^*
1	$(p_e - \frac{2\gamma-1}{\gamma-1}p_r)\frac{M}{2\gamma\bar{c}}$	$\frac{\gamma-1}{4\gamma}\frac{1}{p_r}(p_e + \frac{p_r}{\gamma-1})^2\frac{M}{\bar{c}}$	$p_{P2P}^* = \frac{\gamma-1}{2\gamma}(p_e - \frac{S_m^*}{M}2\gamma\bar{c})$
2	S_{P2P}^2	$N - S_{P2P}^*$	$p_{B2C}^* = \frac{\gamma-1}{2\gamma}(p_e - \frac{S_{P2P}^*}{M}\bar{c})$
3	$(\frac{p_e - p_r}{\bar{c}} - 1)\frac{M}{\gamma-1}$	$\frac{p_e - \bar{c}}{p_r}(\gamma - \frac{p_e - p_r}{\bar{c}})\frac{M}{\bar{c}}$	$p_{P2P}^* = p_e - [1 + \frac{S_{P2P}^*}{M}(\gamma - 1)]\bar{c}$
4	$\frac{N - \sqrt{N^2 - \frac{4(p_e - \bar{c})}{(\gamma-1)\bar{c}}(N-M)M}}{2}$	$N - S_{P2P}^*$	$p_{B2C}^* = p_e - \bar{c}$
5	$(1 - \frac{p_r}{(\gamma-1)\bar{c}})\frac{M}{2}$	$[2 + \frac{(\gamma-1)\bar{c}}{p_r} + \frac{p_r}{(\gamma-1)\bar{c}}]\frac{M}{4}$	$p_{P2P}^* = (1 - 2\frac{S_{P2P}^*}{M})(\gamma - 1)\bar{c}$
6	$N - \frac{M}{2} - \sqrt{N^2 - 2MN + \frac{5}{4}M^2}$	$N - S_{P2P}^*$	$p_{B2C}^* = (1 - \frac{S_{P2P}^*}{M})(\gamma - 1)\bar{c}$

$$S_{P2P}^2 = \frac{M}{\bar{c}}\frac{[(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma}] - \sqrt{[(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma}]^2 - (4\gamma-3)(\frac{2\gamma-1}{2\gamma}\frac{N\bar{c}}{M} - p_e)p_e}}{4\gamma-3}$$

Proof of Proposition 4. Given the price of an individual owner (p_{P2P}) and the price of the commercial agent (p_{B2C}), we are able to compute the number of customers choosing an individual owner and an commercial agent, denoted as $Q_{P2P}(p_{P2P}, p_{B2C})$ and $Q_{B2C}(p_{P2P}, p_{B2C})$, respectively.

$$Q_{P2P}(p_{P2P}, p_{B2C}) = \begin{cases} \min\{\frac{p_{B2C} - p_{P2P}}{(\gamma-1)\bar{c}}, 1\}M, & \text{if} \quad \frac{p_{B2C} - p_{P2P}}{\gamma - 1} \leq p_e - p_{B2C} \\ \min\{\frac{p_e - p_{P2P}}{\gamma\bar{c}}, 1\}M, & \text{if} \quad \frac{p_{B2C} - p_{P2P}}{\gamma - 1} \geq p_e - p_{B2C} \end{cases} \tag{A.2}$$

$$Q_{B2C}(p_{P2P}, p_{B2C}) = \begin{cases} (\min\{\frac{p_e - p_{B2C}}{\bar{c}}, 1\} - \min\{\frac{p_{B2C} - p_{P2P}}{(\gamma-1)\bar{c}}, 1\})M, & \text{if} \quad \frac{p_{B2C} - p_{P2P}}{\gamma - 1} \leq p_e - p_{B2C} \\ 0, & \text{if} \quad \frac{p_{B2C} - p_{P2P}}{\gamma - 1} \geq p_e - p_{B2C} \end{cases} \tag{A.3}$$

It is easy to check that $\pi_{B2C}(p_{B2C}) = p_{B2C}Q_{B2C}$ is a quadratic concave function, then we define the following interior-point solution p^i_{B2C} for p^*_{B2C}.

$$p^i_{B2C} = \begin{cases} \frac{(\gamma-1)p_e + p^*_{P2P}}{2\gamma}, & \text{if} \quad 2\gamma\bar{c} + p^*_{P2P} - (\gamma+1)p_e \geq 0 \\ p_e - \bar{c}, & \text{if} \quad (\gamma+1)\bar{c} + p^*_{P2P} - 2p_e \geq 0 \quad \text{and} \quad 2\gamma\bar{c} + p^*_{P2P} - (\gamma+1)p_e \leq 0 \\ \frac{(\gamma-1)\bar{c} + p^*_{P2P}}{2}, & \text{if} \quad (\gamma+1)\bar{c} + p^*_{P2P} - 2p_e \leq 0 \end{cases} \tag{A.4}$$

In equilibrium, each individual owners are matched with a customer, and thus the equilibrium price for them is the supply-clearance price $p^*_{P2P} = p^*_{B2C} - \frac{S_{P2P}}{M}(\gamma-1)\bar{c}$; and the corporate player sets the interior-point solution $p^*_{B2C} = p^i_{B2C}$. By (A.4), we consider the following three separate cases.

Case 1:

$$\begin{cases} p^*_{P2P} = p^*_{B2C} - \frac{S_{P2P}}{M}(\gamma-1)\bar{c} \\ p^*_{B2C} = \frac{(\gamma-1)p_e + p^*_{P2P}}{2\gamma} \end{cases} \Longrightarrow \begin{cases} p^*_{P2P} = \frac{\gamma-1}{2\gamma-1}(p_e - \frac{S_{P2P}}{M}2\gamma\bar{c}) \\ p^*_{B2C} = \frac{\gamma-1}{2\gamma-1}(p_e - \frac{S_{P2P}}{M}\bar{c}) \end{cases}$$

Case 2:

$$\begin{cases} p^*_{P2P} = p^*_{B2C} - \frac{S_{P2P}}{M}(\gamma-1)\bar{c} \\ p^*_{B2C} = p_e - \bar{c} \end{cases} \Longrightarrow \begin{cases} p^*_{P2P} = p_e - (1 + \frac{S_{P2P}}{M}(\gamma-1))\bar{c} \\ p^*_{B2C} = p_e - \bar{c} \end{cases}$$

Case 3:

$$\begin{cases} p^*_{P2P} = p^*_{B2C} - \dfrac{S_{P2P}}{M}(\gamma-1)\bar{c} \\ p^*_{B2C} = \dfrac{(\gamma-1)\bar{c} + p^*_{P2P}}{2} \end{cases} \Longrightarrow \begin{cases} p^*_{P2P} = (1 - 2\dfrac{S_{P2P}}{M})(\gamma-1)\bar{c} \\ p^*_{B2C} = (1 - \dfrac{S_{P2P}}{M})(\gamma-1)\bar{c} \end{cases}$$

Case 1A: $S_{P2P} + S_{B2C} \leq N$, and $(2\gamma - 1 - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - \gamma p_e \geq 0$

$p^*_{P2P} = p_r$, $p^*_{B2C} = \frac{\gamma-1}{2\gamma}p_e + \frac{1}{2\gamma}p_r$.

$S_{P2P} = (p_e - \frac{2\gamma-1}{\gamma-1}p_r)\frac{M}{2\gamma\bar{c}}$, $Q_{P2P} = S_{P2P}$, $S_{B2C} = \frac{\gamma-1}{4\gamma}\frac{1}{p_r}(p_e + \frac{p_r}{\gamma-1})^2\frac{M}{\bar{c}}$, $Q_P = (p_e + \frac{p_r}{\gamma-1})\frac{M}{2\bar{c}}$.

Conditions: $S_{P2P} + S_{B2C} \leq N$, $(2\gamma - 1 - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - \gamma p_e \geq 0$, and $Q_{B2C} \leq S_{B2C}$, i.e.,

$$[\frac{\gamma-1}{2}\frac{p_e^2}{p_r} + 2p_e - \frac{4\gamma-3}{2(\gamma-1)}p_r]\frac{M}{2\gamma\bar{c}} \leq N \tag{A.5}$$

$$2\gamma\bar{c} + p_r \geq (\gamma+1)p_e \tag{A.6}$$

$$(2\gamma-1)p_r \leq (\gamma-1)p_e \tag{A.7}$$

Case 1B: $S_{P2P} + S_{B2C} = N$, and $(2\gamma - 1 - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - \gamma p_e \geq 0$

$S_{P2P} = \frac{M}{\bar{c}}\frac{(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma} - \sqrt{[(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma}]^2 - (4\gamma-3)(\frac{2\gamma-1}{\gamma}\frac{N\bar{c}}{M} - p_e)p_e}}{4\gamma-3}$, $Q_{P2P} = S_{P2P}$,

$S_{B2C} = \frac{M}{\bar{c}}\frac{2(\gamma-1)\frac{N\bar{c}}{M} + \frac{p_e}{2\gamma} + \sqrt{[(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma}]^2 - (4\gamma-3)(\frac{2\gamma-1}{\gamma}\frac{N\bar{c}}{M} - p_e)p_e}}{4\gamma-3}$,

$Q_{B2C} = \frac{M}{\bar{c}}\frac{\gamma}{4\gamma-3}[-\frac{N\bar{c}}{M} + \frac{4\gamma-1}{2\gamma}p_e + \frac{1}{2\gamma-1}\sqrt{[(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma}]^2 - (4\gamma-3)(\frac{2\gamma-1}{\gamma}\frac{N\bar{c}}{M} - p_e)p_e}]$

$p^*_{P2P} = \frac{2(\gamma-1)}{4\gamma-3}[p_e - \gamma\frac{N\bar{c}}{M} + \frac{\gamma}{2\gamma-1}\sqrt{[(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma}]^2 - (4\gamma-3)(\frac{2\gamma-1}{\gamma}\frac{N\bar{c}}{M} - p_e)p_e}]$,

$p^*_{B2C} = \frac{\gamma-1}{4\gamma-3}[\frac{4\gamma-1}{2\gamma}p_e - \frac{N\bar{c}}{M} + \frac{1}{2\gamma-1}\sqrt{[(2\gamma-1)\frac{N\bar{c}}{M} - \frac{p_e}{2\gamma}]^2 - (4\gamma-3)(\frac{2\gamma-1}{\gamma}\frac{N\bar{c}}{M} - p_e)p_e}]$

Conditions: $p^*_{P2P} \geq p_r$, $2\gamma\bar{c} + p^*_{P2P} - (\gamma+1)p_e \geq 0$, and $Q_{B2C} \leq S_{B2C}$, i.e.,

$$\frac{N}{M} \leq \frac{1}{\gamma\bar{c}}[\frac{\gamma-1}{4}\frac{p_e^2}{p_r} + p_e - \frac{4\gamma-3}{4(\gamma-1)}p_r] \tag{A.8}$$

$$[(1+\gamma)p_e - 2\gamma\bar{c}]\frac{N}{M} \leq p_e - \bar{c} - \frac{[(2\gamma-1)\bar{c} - \gamma p_e]^2}{(\gamma-1)\bar{c}} \tag{A.9}$$

$$\frac{N}{M} \geq \frac{\gamma}{2\gamma-1}\frac{p_e}{\bar{c}} \tag{A.10}$$

Case 2A: $S_{P2P} + S_{B2C} \leq N$, $(\gamma - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - p_e \geq 0$, and $(2\gamma - 1 - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - \gamma p_e \leq 0$

$p^*_{P2P} = p_r$, $p^*_{B2C} = p_e - \bar{c}$,

$S_{P2P} = (\frac{p_e - p_r}{\bar{c}} - 1)\frac{M}{\gamma-1}$, $Q_{P2P} = S_{P2P}$ $S_{B2C} = \frac{p_e - \bar{c}}{p_r}(\gamma - \frac{p_e - p_r}{\bar{c}})\frac{M}{\gamma-1}$, $Q_{B2C} = (\gamma - \frac{p_e - p_r}{\bar{c}})\frac{M}{\gamma-1}$

Conditions: $S_{P2P} + S_{B2C} \leq N$, and $(\gamma - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - p_e \geq 0$,$(2\gamma - 1 - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - \gamma p_e \leq 0$, and

$Q_{B2C} \leq S_{B2C}$, i.e.,

$$\frac{1}{p_r}[p_e - \bar{c} - \frac{(p_e - p_r - \bar{c})^2}{(\gamma-1)\bar{c}}] \leq \frac{N}{M} \tag{A.11}$$

$$(\gamma+1)\bar{c} + p_r - 2p_e \geq 0 \tag{A.12}$$

$$2\gamma\bar{c} + p_r - (\gamma+1)p_e \leq 0 \tag{A.13}$$

$$p_e \geq p_r + \bar{c} \tag{A.14}$$

Note $S_{P2P} = Q_{P2P} \leq Q_{B2C} \leq S_{B2C}$, where the first inequality follows from (A.12).

Case 2B: $S_{P2P} + S_{B2C} = N$, $(\gamma - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - p_e \geq 0$, and $(2\gamma - 1 - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - \gamma p_e \leq 0$

$p^*_{P2P} = p_e - \bar{c} - (\gamma-1)\bar{c}\frac{\frac{N}{M} - \sqrt{(\frac{N}{M})^2 - 4\frac{p_e-\bar{c}}{(\gamma-1)\bar{c}}(\frac{N}{M}-1)}}{2}$, $p^*_{B2C} = p_e - \bar{c}$,

$S_{P2P} = \frac{N - \sqrt{N^2 - 4\frac{p_e-\bar{c}}{(\gamma-1)\bar{c}}(N-M)M}}{2}$, $Q_{P2P} = S_{P2P}$,

$S_{B2C} = \frac{N + \sqrt{N^2 - 4\frac{p_e-\bar{c}}{(\gamma-1)\bar{c}}(N-M)M}}{2}$, $Q_{B2C} = M - \frac{N}{2} + \frac{1}{2}\sqrt{N^2 - 4\frac{p_e-\bar{c}}{(\gamma-1)\bar{c}}(N-M)M}$

Conditions: $p^*_{P2P} \geq p_r$, $(\gamma - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - p_e \geq 0$, and $(2\gamma - 1 - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - \gamma p_e \leq 0$ and $Q_{B2C} \leq S_{B2C}$, i.e.,

$$\frac{N}{M} \leq \frac{1}{p_r}[p_e - \bar{c} - \frac{(p_e - p_r - \bar{c})^2}{(\gamma-1)\bar{c}}] \tag{A.15}$$

$$[(\gamma+1)\bar{c} - 2p_e]\frac{N}{M} \geq \frac{(\gamma\bar{c} - p_e)^2}{(\gamma-1)\bar{c}} - (p_e - \bar{c}) \tag{A.16}$$

$$[(1+\gamma)p_e - 2\gamma\bar{c}]\frac{N}{M} \geq p_e - \bar{c} - \frac{[(2\gamma-1)\bar{c} - \gamma p_e]^2}{(\gamma-1)\bar{c}} \tag{A.17}$$

$$N \geq M \tag{A.18}$$

Case 3A: $S_{P2P} + S_{B2C} < N$ and $(\gamma - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - p_e \leq 0$

$p^*_{P2P} = p_r$, $p^*_{B2C} = \frac{1}{2}p_r + \frac{(\gamma-1)\bar{c}}{2}$,

$S_{P2P} = (1 - \frac{p_r}{(\gamma-1)\bar{c}})\frac{M}{2}$, $Q_{P2P} = S_{P2P}$, $S_{B2C} = [2 + \frac{(\gamma-1)\bar{c}}{p_r} + \frac{p_r}{(\gamma-1)\bar{c}}]\frac{M}{4}$, $Q_{B2C} = (1 + \frac{p_r}{(\gamma-1)\bar{c}})\frac{M}{2}$

Conditions: $S_{P2P} + S_{B2C} \leq N$, $(\gamma - \frac{S_{P2P}}{M}(\gamma-1))\bar{c} - p_e \leq 0$ and $Q_{B2C} \leq S_{B2C}$, i.e.,

$$M + \frac{1}{4}[\frac{(\gamma-1)\bar{c}}{p_r} - \frac{p_r}{(\gamma-1)\bar{c}}]M \leq N \tag{A.19}$$

$$(\gamma+1)\bar{c} + p_r - 2p_e \leq 0 \tag{A.20}$$

$$(\gamma-1)\bar{c} \geq p_r \tag{A.21}$$

Case 3B: $S_{P2P} + S_{B2C} = N$ and $(\gamma - \frac{S_{P2P}}{M}(\gamma - 1))\bar{c} - p_e \le 0$

$p^*_{P2P} = [2 - \frac{2N}{M} + \sqrt{4(\frac{N}{M})^2 - 8\frac{N}{M} + 5}](\gamma - 1)\bar{c}$, $p^*_{B2C} = [\frac{3}{2} - \frac{N}{M} + \sqrt{(\frac{N}{M})^2 - 2\frac{N}{M} + \frac{5}{4}}](\gamma - 1)\bar{c}$,

$S_{P2P} = N - \frac{M}{2} - \sqrt{N^2 - 2MN + \frac{5}{4}(M)^2}$, $Q_{P2P} = S_{P2P}$,

$S_{B2C} = \frac{M}{2} + \sqrt{N^2 - 2MN + \frac{5}{4}(M)^2}$, $Q_{B2C} = -N + \frac{3M}{2} + \sqrt{N^2 - 2MN + \frac{5}{4}(M)^2}$.

Conditions: $p^*_{P2P} \ge p_r$, $(\gamma - \frac{S_{P2P}}{M}(\gamma - 1))\bar{c} - p_e \le 0$ and $Q_{B2C} \le S_{B2C}$, i.e.,

$$M + \frac{1}{4}[\frac{(\gamma - 1)\bar{c}}{p_r} - \frac{p_r}{(\gamma - 1)\bar{c}}]M \ge N \tag{A.22}$$

$$[(\gamma + 1)\bar{c} - 2p_e]\frac{N}{M} \le \frac{(\gamma\bar{c} - p_e)^2}{(\gamma - 1)\bar{c}} - (p_e - \bar{c}) \tag{A.23}$$

$$M \le N \tag{A.24}$$

Table 14: P2P and B2C Coexistence Equilibrium Summary

Main Regions	$S_{P2P} + S_{B2C} \le N$, i.e., $p^*_{P2P} = p_r$			$S_{P2P} + S_{B2C} = N$, i.e., $p^*_{P2P} \ge p_r$		
Sub Regions	$p^*_{B2C} \ge p_e - \bar{c}$	$p^*_{B2C} = p_e - \bar{c}$	$p^*_{B2C} \le p_e - \bar{c}$	$p^*_{B2C} \ge p_e - \bar{c}$	$p^*_{B2C} = p_e - \bar{c}$	$p^*_{B2C} \le p_e - \bar{c}$
Case	1A	2A	3A	1B	2B	3B
Main Region Condition	(A.5)	(A.11)	(A.19)	(A.8)	(A.15)	(A.22)
Sub Region Condition	(A.6)	(A.12)-(A.13)	(A.20)	(A.9)	(A.16)-(A.17)	(A.23)
Additional Condition	(A.7)	(A.14)	(A.21)	(A.10)	(A.18)	(A.24)

Proposition 5. The equilibrium platform prices for each demand state θ and the number of owners listing their assets on the platform (i.e., availability) for P2P and B2C pricing schemes are fully characterized in Tables 15 and 16.

Table 15: Equilibria under P2P scheme when p_e is endogenous

No.	S^*	p^*_H	p^*_L
1	N	$a_e - b_eM_H - (\frac{\bar{c}}{M_H} - b_e)S^*$	$a_e - b_eM_L - (\frac{\bar{c}}{M_L} - b_e)S^*$
2	N	$a_e - b_eM_H - (\frac{\bar{c}}{M_H} - b_e)S^*$	$a_e - \bar{c}$
3	N	$a_e - \bar{c}$	$a_e - \bar{c}$
4	$\frac{(a_e - \bar{c})(M_H + M_L)}{2p_r}$	$a_e - \bar{c}$	$a_e - \bar{c}$
5	$\frac{(\frac{a_e - b_eM_H}{2} - p_r) + \sqrt{(\frac{a_e - b_eM_H}{2} - p_r)^2 + (\frac{\bar{c}}{M_H} - b_e)(a_e - \bar{c})M_L}}{\frac{\bar{c}}{M_H} - b_e}$	$a_e - b_eM_H - (\frac{\bar{c}}{M_H} - b_e)S^*$	$a_e - \bar{c}$
6	$\frac{a_e - \frac{b_e}{2}(M_H + M_L) - p_r}{\frac{\bar{c}}{2}(\frac{1}{M_H} + \frac{1}{M_L}) - b_e}$	$a_e - b_eM_H - (\frac{\bar{c}}{M_H} - b_e)S^*$	$a_e - b_eM_L - (\frac{\bar{c}}{M_L} - b_e)S^*$

$a_e - b_eM_\theta - (\frac{\bar{c}}{M_\theta} - b_e)S^*$: supply-clearance price; $a_e - \bar{c}$: maximum-coverage price

Proof of Proposition 5. Similar to the baseline model, we make the following three assumptions in order to avoid trivial cases: (i) $a_e - b_eM_H \ge p_r$, (ii) $a_e - b_eM_H \ge \bar{c}$, and (iii) $\bar{c} - b_eM_H \ge 0$. The first condition eliminates the uninteresting case in which no asset-owner has incentive to list her asset on the platform even under the high-demand state. The second and third conditions assure that a scenario

Table 16: Equilibria under B2C scheme when p_e is endogenous

No.	S^*	p_H^*	p_L^*
7	N	$a_e - \bar{c}$	$\frac{a_e - b_e M_L}{2}$
8	N	$a_e - \bar{c}$	$a_e - b_e M_L - (\frac{\bar{c}}{M_L} - b_e)S^*$
9	N	$a_e - b_e M_H - (\frac{\bar{c}}{M_H} - b_e)S^*$	$\frac{a_e - b_e M_L}{2}$
10	N	$\frac{a_e - b_e M_H}{2}$	$\frac{a_e - b_e M_L}{2}$
11	N	$\frac{a_e - b_e M_H}{2}$	$a_e - b_e M_L - (\frac{\bar{c}}{M_L} - b_e)S^*$
12	$\frac{(\frac{a_e - b_e M_L}{2} - p_r) + \sqrt{(\frac{a_e - b_e M_L}{2} - p_r)^2 + (\frac{a_e - b_e M_H}{2})^2 (\frac{\bar{c}}{M_L} - b_e)/(\frac{\bar{c}}{M_H} - b_e)}}{\frac{\bar{c}}{M_L} - b_e}$	$\frac{a_e - b_e M_H}{2}$	$a_e - b_e M_L - (\frac{\bar{c}}{M_L} - b_e)S^*$
13	$\frac{1}{8p_r}[\frac{(a_e - b_e M_H)^2}{\frac{\bar{c}}{M_H} - b_e} + \frac{(a_e - b_e M_L)^2}{\frac{\bar{c}}{M_L} - b_e}]$	$\frac{a_e - b_e M_H}{2}$	$\frac{a_e - b M_L}{2}$
14	$\frac{(\frac{a_e - b_e M_H}{2} - p_r) + \sqrt{(\frac{a_e - b_e M_H}{2} - p_r)^2 + (\frac{a_e - b_e M_L}{2})^2 (\frac{\bar{c}}{M_H} - b_e)/(\frac{\bar{c}}{M_L} - b_e)}}{\frac{\bar{c}}{M_H} - b_e}$	$a_e - b_e M_H - (\frac{\bar{c}}{M_H} - b_e)S^*$	$\frac{a_e - b_e M_L}{2}$
15	$\frac{(\frac{a_e - b_e M_L}{2} - p_r) + \sqrt{(\frac{a_e - b_e M_L}{2} - p_r)^2 + (\frac{\bar{c}}{M_L} - b_e)(a_e - \bar{c})M_H}}{\frac{\bar{c}}{M_L} - b_e}$	$a_e - \bar{c}$	$a_e - b_e M_L - (\frac{\bar{c}}{M_L} - b_e)S^*$
16	$\frac{1}{2p_r}[(a_e - \bar{c})M_H + \frac{(a_e - b_e M_L)^2}{4(\frac{\bar{c}}{M_L} - b_e)}]$	$a - \bar{c}$	$\frac{a_e - b_e M_L}{2}$

$a_e - b_e M_\theta - (\frac{\bar{c}}{M_\theta} - b_e)S^*$: supply-clearance price; $a_e - \bar{c}$: convenience price; $\frac{a_e - b_e M_\theta}{2}$: profit-maximizing price

where no customer opts for the sharing platform even when it is charging a zero price never arises. We next provide the proof briefly.

For the P2P scheme, first, suppose $S^* \leq M_L$. It follows that $Q = S^*$ and $q_H^* = q_L^* = 1$ in this case and thus $p_\theta^* = a_e - b_e M - (\frac{\bar{c}}{M} - b_e)S^*$ for both realizations of M. Then by $\mathbb{E}[\pi] \geq p_r$, we have $S^* \leq \min\{N, \frac{a_e - \frac{b_e}{2}(M_H + M_L) - p_r}{\frac{\bar{c}}{2}(\frac{1}{M_H} + \frac{1}{M_L}) - b_e}\}$. For the remaining proof, it mimics that of Proposition 1. For the proof for the cases $M_L \leq S^* \leq M_H$ and $S^* \geq M_H$, they are also similar to that of Proposition 1.

For the B2C scheme, suppose $Q = S^*$. This implies $S^* \leq \frac{(a_e - b_e M + bQ - p_\theta)M}{\bar{c}}$, or equivalently, $p_\theta \leq a_e - b_e M - (\frac{\bar{c}}{M} - b_e)S^*$. Since $\pi = S^* p_\theta$, it is easy to see the optimal price is $p_\theta^* = a_e - b_e M - (\frac{\bar{c}}{M} - b_e)S^*$. Therefore, we only need to consider the following case where $Q = \frac{(a_e - b_e M + bV - p_\theta)M}{\bar{c}}$. It follows that $Q = \frac{a_e - b_e M - p_\theta}{\frac{\bar{c}}{M} - b_e}$. Taking this into $p_\theta \geq a_e - b_e M + bQ - \bar{c}$, we have $p_\theta \geq a_e - \bar{c}$. By $S^* \geq \frac{(a_e - b_e M + b_e Q - p_\theta)M}{\bar{c}}$, we also have $p_\theta \geq a_e - b_e M - (\frac{\bar{c}}{M} - b_e)S^*$. Since the platform's profit in this case can be expressed as $\alpha \frac{a_e - b_e M - p_\theta}{\frac{\bar{c}}{M} - b_e} p_\theta$, we have $p_\theta = \max\{\frac{a_e - b_e M}{2}, a_e - \bar{c}, a_e - b_e M - (\frac{\bar{c}}{M} - b_e)S^*\}$. If $\frac{a_e - b_e M_L}{2} \leq a_e - \bar{c}$, it can be easily checked that optimal prices in this case are the same as those in Proposition 5. If $\frac{a_e - b_e M_L}{2} \geq a_e - \bar{c} \geq \frac{a_e - b_e M_H}{2}$ or $\frac{a_e - b_e M_H}{2} \geq a_e - \bar{c}$, the proof mimics that of Proposition 2. □

Proposition 6. The equilibrium platform prices for each demand state θ and the number of owners listing their assets on the platform (i.e., availability) for P2P and B2C pricing schemes are fully characterized in Tables 17 and 18.

Table 17: Equilibria under P2P scheme with price-sensitive long-term rentals

No.	S^*	p_H^*	p_L^*
1	N	$p_e - \frac{\bar{c}}{M_H}S^*$	$p_e - \frac{\bar{c}}{M_L}S^*$
2	N	$p_e - \frac{\bar{c}}{M_H}S^*$	$p_e - \bar{c}$
3	N	$p_e - \bar{c}$	$p_e - \bar{c}$
4	$\frac{-(a_r-b_rN)+\sqrt{(a_r-b_rN)^2+2b_r(p_e-\bar{c})(M_H+M_L)}}{2b_r}$	$p_e - \bar{c}$	$p_e - \bar{c}$
5	$\frac{\frac{p_e}{2}-(a_r-b_rN)+\sqrt{[\frac{p_e}{2}-(a_r-b_rN)]^2+(\frac{\bar{c}}{M_H}+2b_r)(p_e-\bar{c})M_L}}{\frac{\bar{c}}{M_H}+2b_r}$	$p_e - \frac{\bar{c}}{M_H}S^*$	$p_e - \bar{c}$
6	$\frac{p_e-(a_r-b_rN)}{\frac{\bar{c}}{2}(\frac{1}{M_H}+\frac{1}{M_L})+b_r}$	$p_e - \frac{\bar{c}}{M_H}S^*$	$p_e - \frac{\bar{c}}{M_L}S^*$

$p_e - \frac{\bar{c}}{M_\theta}S^*$: supply-clearance price; $p_e - \bar{c}$: maximum-coverage price

Table 18: Equilibria under B2C scheme with price-sensitive long-term rentals

No.	S^*	p_H^*	p_L^*
1	N	$p_e - \frac{\bar{c}}{M_H}S^*$	$p_e - \frac{\bar{c}}{M_L}S^*$
2	N	$p_e - \frac{\bar{c}}{M_H}S^*$	$p_e - \bar{c}$
3	N	$\frac{p_e}{2}$	$\frac{p_e}{2}$
4	$\frac{-(a_r-b_rN)+\sqrt{(a_r-b_rN)^2+\frac{1}{2}b_r(p_e)^2\frac{M_H+M_L}{\bar{c}}}}{2b_r}$	$\frac{p_e}{2}$	$\frac{p_e}{2}$
5	$\frac{\frac{p_e}{2}-(a_r-b_rN)+\sqrt{[\frac{p_e}{2}-(a_r-b_rN)]^2+(\frac{\bar{c}}{M_H}+2b_r)(\frac{p_e}{2})^2\frac{M_L}{\bar{c}}}}{\frac{\bar{c}}{M_H}+2b_r}$	$p_e - \frac{\bar{c}}{M_H}S^*$	$\frac{p_e}{2}$
6	$\frac{p_e-(a_r-b_rN)}{\frac{\bar{c}}{2}(\frac{1}{M_H}+\frac{1}{M_L})+b_r}$	$p_e - \frac{\bar{c}}{M_H}S^*$	$p_e - \frac{\bar{c}}{M_L}S^*$

$p_e - \frac{\bar{c}}{M_\theta}S^*$: supply-clearance price; $\frac{p_e}{2}$: interior point price

Proof of Proposition 6. We introduce the sketch of the proof. Given S, the platform's optimal pricing decisions are the same as those in the baseline models, and the long-term rental price is $a_r - b_r(N-S)$. Recall that $\mathbb{E}[\pi]$ denotes the revenue collected from the sharing platform. In equilibrium, we have $\mathbb{E}[\pi] \geq a_r - b_r(N-S)$. $\square$

Proposition 7.[Owners' Listing Decisions under Reservation Asset Value] When owners have the option of keeping the asset for themselves, the equilibrium platform prices for each demand state θ and the number of owners listing their assets on the platform (i.e., availability) for P2P and B2C pricing schemes are fully characterized in Tables 19 and 20.

Proof of Proposition 7. Define $\Delta\epsilon \equiv \bar{\epsilon} - \underline{\epsilon}$. The results for the P2P pricing schemes are summarized in Table 19. Let $p_\theta^t = \frac{p_e \frac{M_\theta}{\bar{c}} + \frac{\bar{\epsilon}}{\Delta\epsilon} N - S - S_u}{\frac{M_\theta}{\bar{c}} + \frac{N}{\Delta\epsilon}}$ be the matching price such that $\underline{\epsilon} \leq p_\theta^t \leq \bar{\epsilon}$ and the numbers of owners making their asset available and customers looking for short-term rentals are equal.

Table 19: Equilibria under P2P

No.	S^*	S_u^*	S_r^*	p_H^*	p_L^*
1	N	0	0	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$
2	N	0	0	$p_e - \frac{S^*\bar{c}}{M_H}$	p_θ^t
3	$(p_H^* - \underline{\epsilon})\frac{N}{\Delta\epsilon}$	$(\bar{\epsilon} - p_H^*)\frac{N}{\Delta\epsilon}$	0	p_θ^t	p_θ^t
4	$N - S_r^* - S_u^*$	$(\bar{\epsilon} - p_H^*)\frac{N}{\Delta\epsilon}$	$N - \frac{\frac{p_e \frac{M_H}{\bar{c}} + \frac{\bar{\epsilon}}{\Delta\epsilon}N}{\frac{M_H}{\bar{c}} + \frac{N}{\Delta\epsilon}} + \frac{p_e \frac{M_L}{\bar{c}} + \frac{\bar{\epsilon}}{\Delta\epsilon}N}{\frac{M_L}{\bar{c}} + \frac{N}{\Delta\epsilon}} - 2p_r}{\frac{1}{\frac{M_H}{\bar{c}} + \frac{N}{\Delta\epsilon}} + \frac{1}{\frac{M_L}{\bar{c}} + \frac{N}{\Delta\epsilon}}}$	p_θ^t	p_θ^t
5	$\frac{(p_e - 2p_r)(\frac{M_L}{\bar{c}} + \frac{N}{\Delta\epsilon}) + p_e \frac{M_L}{\bar{c}} + \frac{\bar{\epsilon}}{\Delta\epsilon}N}{1 + \frac{M_L}{M_H} + \frac{\bar{c}N}{\Delta\epsilon M_H}}$	0	$N - S^*$	$p_e - \frac{S^*\bar{c}}{M_H}$	p_θ^t
6	$\frac{2(p_e - p_r)M_H M_L}{(M_H + M_L)\bar{c}}$	0	$N - S^*$	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$

Under the P2P pricing schemes, compared to keeping the assets on their own, owners tend to join the sharing platform at first, as they may still choose to use the assets after demand realization. However, there may be still some customer who always use the assets by their own, irrespective of the price after demand realization. For ease of statement, we simply assume such customers do not join the sharing system and thus those who join the sharing system will make their assets available under at least one demand state.

Let S_u denote the number of owners who choose to use their assets by their own, excluding those who put their assets on the short-term rental platform part-time. In other words, S_u denotes the number of owners who choose neither long-term nor short-term rentals. It is easy to check that in regions 1-2 and 5-6, $S_u = 0$; while in regions 3-4, $S_u = \frac{\bar{\epsilon} - p_H^*}{\Delta\epsilon} N$.

Table 20: Equilibria under B2C (when $\underline{\epsilon} \leq p_r \leq \bar{\epsilon}$)

Regions	S^*	S_u^*	S_r^*	p_H^*	p_L^*	q_H^*	q_L^*
1	N	0	0	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$	1	1
2	N	0	0	$p_e - \frac{S^*\bar{c}}{M_H}$	$\frac{1}{2}p_e$	1	$\frac{p_e M_L}{2S^*\bar{c}}$
3	N	0	0	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$\frac{p_e M_H}{2S^*\bar{c}}$	$\frac{p_e M_L}{2S^*\bar{c}}$
4	$\frac{M_H+M_L}{2\bar{c}p_r}(\frac{1}{2}p_e)^2$	$\frac{\bar{\epsilon}-p_r}{\Delta\epsilon}N$	$\frac{p_r-\underline{\epsilon}}{\Delta\epsilon}N - S^*$	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$\frac{p_e M_H}{2S^*\bar{c}}$	$\frac{p_e M_L}{2S^*\bar{c}}$
5	$\frac{(p_e-2p_r)+\sqrt{(p_e-2p_r)^2+(p_e)^2 M_L/M_H}}{2\bar{c}/M_H}$	$\frac{\bar{\epsilon}-p_r}{\Delta\epsilon}N$	$\frac{p_r-\underline{\epsilon}}{\Delta\epsilon}N - S^*$	$p_e - \frac{S^*\bar{c}}{M_H}$	$\frac{1}{2}p_e$	1	$\frac{p_e M_L}{2S^*\bar{c}}$
6	$\frac{2(p_e-p_r)M_H M_L}{(M_H+M_L)\bar{c}}$	$\frac{\bar{\epsilon}-p_r}{\Delta\epsilon}N$	$\frac{p_r-\underline{\epsilon}}{\Delta\epsilon}N - S^*$	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$	1	1
7	$\frac{p_e-\underline{\epsilon}}{\frac{\Delta\epsilon}{N}+\frac{\bar{c}}{2}(\frac{1}{M_H}+\frac{1}{M_L})}$	$N - S^*$	0	$p_e - \frac{S^*\bar{c}}{M_H}$	$p_e - \frac{S^*\bar{c}}{M_L}$	1	1
8	$\frac{\frac{1}{2}p_e-\underline{\epsilon}+\sqrt{(\frac{1}{2}p_e-\underline{\epsilon})^2+\frac{1}{2}(\frac{\Delta\epsilon}{N}+\frac{1}{2}\frac{\bar{c}}{M_H})p_e^2\frac{M_L}{\bar{c}}}}{2(\frac{\Delta\epsilon}{N}+\frac{1}{2}\frac{\bar{c}}{M_H})}$	$N - S^*$	0	$p_e - \frac{S^*\bar{c}}{M_H}$	$\frac{1}{2}p_e$	1	$\frac{p_e M_L}{2S^*\bar{c}}$
9	$\frac{-\underline{\epsilon}+\sqrt{\underline{\epsilon}^2+\frac{1}{2}\frac{\Delta\epsilon}{N}p_e^2\frac{M_H+M_L}{\bar{c}}}}{2\frac{\Delta\epsilon}{N}}$	$N - S^*$	0	$\frac{1}{2}p_e$	$\frac{1}{2}p_e$	$\frac{p_e M_H}{2S^*\bar{c}}$	$\frac{p_e M_L}{2S^*\bar{c}}$

To solve the equilibrium, we assume that all owners who choose to use the assets by themselves first join the sharing system, and after demand realization they decide to leave. It is easy to see that it is not harmful to those owners to do so. Let S' denote the number of owners who do not join the long-term rentals, i.e., $S' = N - S_r$. We consider the case $\underline{\epsilon} \geq p_e - \bar{c}$. This means the demand-supply matching price at which demand equals to supply must be higher than $\underline{\epsilon}$. As a result, in any possible equilibrium, $q_\theta = 1$. In addition, when $\frac{p_e-\bar{\epsilon}}{\bar{c}}M_\theta \geq S'$, it implies that there are customers than owners if the price is set at $\bar{\epsilon}$, and thus to match the demand with supply, the price is raised to $p_\theta = p_e - \frac{S'\bar{c}}{M_\theta}$. Otherwise, when $\frac{p_e-\bar{\epsilon}}{\bar{c}}M_\theta \geq S'$, the price is set at p_θ^t to make the supply and demand matched. We next consider three separate cases.

- $\frac{p_e-\bar{\epsilon}}{\bar{c}}M_H \geq \frac{p_e-\bar{\epsilon}}{\bar{c}}M_L \geq S'$: $E[\pi] = \frac{1}{2}(p_e - \frac{S\bar{c}}{M_H} + p_e - \frac{S\bar{c}}{M_L}) \geq p_r$, and $S^* = \min\{S_4, N\}$;
- $\frac{p_e-\bar{\epsilon}}{\bar{c}}M_H \geq S' \geq \frac{p_e-\bar{\epsilon}}{\bar{c}}M_L$: $E[\pi] = \frac{1}{2}(p_e - \frac{S\bar{c}}{M_H} + p_L^t) \geq p_r$, and $S^* = \min\{S_5, N\}$;
- $S' \geq \frac{p_e-\bar{\epsilon}}{\bar{c}}M_H \geq \frac{p_e-\bar{\epsilon}}{\bar{c}}M_L$: $E[\pi] = \frac{1}{2}(p_H^t + p_L^t) \geq p_r$, and $S^* = \min\{S_6, N\}$.

The results for the B2C pricing schemes are summarized in Table 20. The decisions at the pricing stage are the same as those in the basic models. The only difference lies in the owners' joining decisions.

Owners now may choose to keep the assets by themselves, and number of such owners is given as follows.

$$S_u = \min\{N, \frac{\max\{0, \overline{\epsilon} - E[\pi]\}}{\Delta\epsilon} N\} = \begin{cases} N, & \text{if } E[\pi] \leq \underline{\epsilon}, \\ \dfrac{\overline{\epsilon} - E[\pi]}{\Delta\epsilon} N, & \text{if } \underline{\epsilon} \leq E[\pi] \leq \overline{\epsilon}, \\ 0, & \text{if } E[\pi] \geq \overline{\epsilon}, \end{cases} \tag{A.25}$$

where $E[\pi]$ is the expected revenue of a full-time short-term renter collected from the platform. $\square$