Subsidy strategies for coordinating supply and demand in sharing economy

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Abstract

Technological advances in internet and increasing use of smartphones have enabled sharing economy a massive scale by reducing search and transaction costs. Motivated by the sensitive relationship between supply and demand through platform's subsidy level, we develop a two-sided market model to study how the platform should strategically choose the subsidy object and the subsidy level in sharing economy. We consider providers heterogeneous in their opportunity cost or time cost and customers heterogeneous in their valuation of the performance of the platform. Our analysis shows that when the customer's net benefit per trade is less than the total net benefit per trade of a provider and the platform, the platform should subsidize the customers; when the sharing gap between the platform and provider is small, the platform should subsidize the providers. Counterintuitively, we find that the subsidy level for customers strictly increases with the strength of positive network effects on customer side.

Introduction

A private car sits unused for most time of its useful life. Cars are just one of many goods, from apartments to home appliances, which are privately owned but barely used. Unlocking this excess capacity is the initial idea of the sharing economy, which has enabled individuals to collaboratively use the under-utilized capacity via fee-based sharing and emerged as a major trend in recent years. Recent technological advances in online and mobile communications have enabled sharing economy a massive scale by reducing search and transaction costs. Typical sharing economy platforms, in the form of websites, apps and social media platforms which are two-sided or even multi-sided, have attracted consumers to share all kinds of goods and services, such as car rides (Uber, DiDi), cars (Zipcar, FlightCar), short-term rental (Airbnb, Easynest), parking spaces (JustPark, Parking Panda) and skills (TaskRabbit, Elance).

In order to fascinate more providers and customers taking part in transactions on platforms, subsidies play an important role both in marketing campaigns during the introduction period of the platform and in coordinating demand and supply during the stable operation period. For example, Lyft in the U.S. give back a 5 percent bonus per transaction during the introduction period. In China, Uber raised one billion U.S. dollars to promote the adoption the network of customers and providers in 2015, subsidizing drivers as much as triple times of the regular fare per transaction. Its main competitor, DiDi, provided the same generous subsidies for customers in the form of vouchers in the same period, the number of its registered users increased to 250 million at the end of 2015. Recently, after accumulating a large amount of users, DiDi has almost stopped the subsidy for drivers while still offering customers subsidy.

From the product or service providers' perspective, they can earn flexible income from sharing underused assets or idle time at their own discretion. Because it's not an employment relationship between a provider and the platform, work participation of independent providers is primarily driven by earnings, which increase with subsidy levels from the platform. From the customers'

perspective, they can gain access to expensive or infrequently used goods that they may prefer not to own by paying affordable prices, which decreases with subsidy levels from the platform. From the platform's perspective, product-sharing or service-providing transactions involve the sharing platform charging a certain percentage of the product price from bilateral users as a transaction fee. Although, recent technological advances enable a platform to implement and adjust subsidies easily, there are some challenges for a sharing economy platform in coordinating endogenous supply and demand of the sharing goods or services by offering subsidy. First, determining the right subsidy level for product/service providers to get the right supply can be a tricky task. If the platform offers provider a higher subsidy level, more providers will participate in transactions, boosting product diversity or more efficient service, so more customers will participate in transactions with higher utility which can be magnified by cross-side network effects, more customers in turn further attract more providers, however, more work participation will increase the subsidy cost of the platform. Second, choosing the right subsidy level for customers to attract the right demand also involves risk because of the existence of network effects. If the platform provides a lower subsidy level for customers, less customers are willing to take part in, especially in the introduction period of the platform, so less providers will participate because of less trading opportunities, which further decreases the number of participating customers. In a word, the platform faces a trade-off between subsidy cost and market size in the presence of indirect network effects. Third, in practice, DiDi subsidizes more to customers while Uber subsidizes more to drivers, different subsidy objective may lead to different market equilibrium. In this paper, we study the following research questions: What are the key factors affecting the platform's subsidy decision for providers and customers when the platform faces a trade-off between the subsidy cost and market size? Should the platform subsidize customers or providers in order to gain more profits?

In view of the sensitive relationship between supply and demand through platform's subsidy level, we develop an analytical framework to study how the platform should strategically choose the subsidy object and the subsidy level. In our framework, we present a model of a monopoly sharing platform with two-sided networks. Our model captures an operation environment where: (1) two-side network externalities are incorporated into the two sides' utility function to model the fact that the value of transactions to one side users is dependent on the participation number of the other side users; (2) providers are heterogeneous in their opportunity cost or time cost; (3) customers are heterogeneous in their valuation of the performance of the platform.

We highlight a few major findings from our analysis. First, when the customer's net benefit per trade is less than the total net benefit per trade of a provider and the platform, the platform should subsidize the customers; when the sharing gap between the platform and provider is small, the platform should subsidize the providers. More specifically, when the strength of positive network effect on provider side is relatively strong or the strength of positive network effect on customer side is relatively weak, the platform chooses to give a positive subsidy level for customers. However, if the strength of positive network effect on customer side is strong, the customers obtain much benefit from provider side, so the platform optimally gives up subsidizing customers. When the strength of positive network effect on customer side is strong or the strength of positive network effect on provider side is weak, the platform realizes more transactions by subsidizing providers.

Second, both the participation number of customers and providers increase with both the

strength of positive network effects on customer side and on provider side, the maximum profit obtained by the platform also increases with both the strength of positive network effects on customer side and on provider side. If the strength of positive network effects on customer side is stronger, each additional provider will bring a higher utility to a customer than before, so the number of participating customers increases, which in turn increases a participating provider's utility, so the number of participating providers increases.

Third, if the platform subsidizes both customers and providers who participate in transactions, the subsidy level for customers increases with the strength of positive network effects on provider side and the subsidy level for providers increases with the strength of positive network effects on customer side. Counterintuitively, the subsidy level for customers also strictly increases with the strength of positive network effects on customer side. One may intuit that when the subsidy level for customers is high, the utilities for customers participating in transactions are high, so the platform can gain more customer surplus by decreasing customer subsidy level. Our analysis shows that when the platform chooses to subsidize customers, the utilities for customers participating in transactions are so low, resulting few customers entering the market currently, so it's more profitable for the platform to increase subsidy level to attract more customers than reducing subsidy level to cut cost.

We organize the remainder of this paper as follows. We provide a brief review of related literature in Section 2. A basic model of two-sided sharing platform is presented in Section 3. In Section 4, we extend the basic model to the case when the objective of the platform is to maximize the social welfare. Finally, in Section 5, we finish by a short conclusion and future work.

Literature Review

The sharing economy platforms we study are essentially a type of two-sided platform (or two-sided market). Two-sided platforms involve two groups of agents in interacting through an intermediary, and the utility of one group is affected by the participation of the other group because of the existing cross-sided network effect (Rochet & Tirole, 2003, 2006), which, in fact, is a special form of indirect network effects (Katz & Shapiro, 1985, 1994) such that the number of agents on one side depends on the number of agents of the other side. Our study builds upon the growing literature on two-sided markets focused on platform's pricing strategies (Andrei & Daniel, 2013; Armstrong, 2006; Caillaud & Jullien, 2003; Rochet & Tirole, 2003, 2006; Roson, 2005). Specifically, the seminal paper on two-sided markets by (Rochet & Tirole, 2003) develop a model of platform competition to study the optimal price allocation between the two sides under different governance structures. Following this study, (Armstrong, 2006) studies models of two-sided markets with different structures: a model of a monopoly platform, a model of competing platforms where agents join a single platform and a model of "competitive bottlenecks" where one group joins all platforms. He shows that the pricing structure depends on relative strength of cross-sided network effect, whether fees are levied on a lump-sum or per-transaction basis, and whether agents join one platform or several platforms. Based on the basic framework they set up, a surge of applied theoretical contributions emerge in the past several years, covering various sectors, especially online platforms. (Bhargava & Choudhary, 2004) analyze models of online marketplace to examine their pricing and product line design strategies. (Andrei & Daniel, 2013) focus on pricing strategies considering first-party content. (Hao, Guo, & Easley, 2017) study platform's in-app advertising contract. As we know, rare literatures study the sharing economy platform on the framework of two-sided theory, except (Kung & Zhong, 2017), who explore the

optimal pricing strategy for two-sided platform delivery in the sharing economy. In their model, the shopper is compensated with a per matching subsidy as a wage paid by the platform, so the study essentially focuses on the pricing strategy of the platform. In the stream of literature on pricing strategy for two-sided platform, taking the advantage of the cross-side network effect, the platform can attract one side of the market by subsidizing the other side (Eisenmann, Parker, & Van Alstyne, 2006), the key pricing strategies are of a "divide-and-conquer" nature, subsidizing the partition of one side and recovering the loss on the other side (Caillaud & Jullien, 2003). Characterizing the price structure of a monopolistic platform, (Parker & Van Alstyne, 2005) show that deciding which side to subsidize depends on the relative network externality benefits.

Our paper differs from this stream of research in the following aspects. Firstly, this stream of research indirectly explores the subsidy effects by studying pricing strategies, we study the subsidy strategy of the platform by directly setting subsidy levels for the two side agents to observe the effects of subsidy intuitively. In some cases, the effect of pricing on platform's profits could offset the impact of subsidy on platform's profits when considering pricing strategy and subsidy strategy together. Secondly, in sharing economy, the prices of products or services are determined by providers on some platforms, for example, on online short-term rental platforms such as Airbnb, while all the prices are set by platforms in some cases, for example, on car rides sharing platform such as Uber. Moreover, in most two-sided market pricing research, the platforms only choose the usage fee and access fee, which are irrelevant to the product/services. In order to focus on subsidy effects, we set the price of the products/services and the fee charged by platforms fixed to avoid intricate pricing effects, while making the model applicable across a range of very different platforms.

Our study also adds to the body of research modeling transactions among users in sharing economy. Recent developments of various sharing economy platforms have motivated researchers to explore various operational issues. A number of researchers have recently explored the process for matching providers to customers in the context of on-demand services (Banerjee, Riquelme, & Johari, 2015; Gurvich, Lariviere, & Moreno, 2015; Hu & Zhou, 2017; Tang, Bai, So, Chen, & Wang, 2016; T. Taylor, 2016), which are also called peer-to-peer offering of services (Jiang & Tian, 2016). They study the on-demand service platform's optimal per-service prices for customers and wages for providers, which are dynamically based on the current number of customers requesting services and the number of providers in the system. In the research of (Gurvich et al., 2015; Hu & Zhou, 2017), the customer demand is assumed to be independent of waiting time and the supply is assumed to be independent of utilization. In contrast, (Tang et al., 2016; T. Taylor, 2016) study queueing systems in which the arrivals of customers and provider are endogenously determined based on customer's waiting time and the system utilization, respectively. In all versions of their models, the platform selects static prices and wages, while (Banerjee et al., 2015; Cachon, Daniels, & Lobel, 2017) consider surge pricing. A typical on-demand platform, Uber, which is the leader in ride-sharing market in U.S., has attracted much attention of both modeling and empirical research, beside the stream of queueing system research above. (Zheng, Ren, Tan, & Chen, 2016) address the effect of sales promotion on drivers' willingness to use the ride-sharing app. (Burtch, Carnahan, & Greenwood, 2016) examine how the entry of sharing economy platforms, such as Uber X, influences local entrepreneurial activity empirically. By investigating how the entry of Uber influences the rate of alcohol related motor vehicle homicides, (Greenwood & Wattal, 2017) find a significant drop in the rate of homicides after the introduction of Uber. Besides the peer-to-peer

offering of services, research pertaining customer-to-customer sharing of products in sharing economy has also come to fore. (Jiang & Tian, 2016) develop a two-period game-theoretical approach to examine the strategic and economic impact of product sharing among consumers and show that transaction cost in the sharing market have a non-monotonic effect on the firm's profits. (Benjaafar, Kong, Li, & Courcoubetis, 2015) study how collaborative consumption affects ownership and usage of resources and show that depending on the rental price, collaborative consumption can result in either lower or higher ownership and usage levels, with higher ownership and usage levels more likely when the cost of ownership is high. With explosive attention to sharing economy, studies for other operation modes have sprung up, including online marketplace (Allon, Bassamboo, & Cil, 2012; Moreno & Terwiesch, 2014), car sharing (Bellos, Ferguson, & Toktay, 2017; He, Mak, Rong, & Shen, 2017), crowdsource (Hu & Zhou, 2017; Huang, Singh, & Srinivasan, 2014), etc. Our paper differs from this stream of research in the following aspects, one the one hand, we analysis the sharing economy platform from the two-sided market perspective, distinguished from the other researches. On the other hand, we focus on subsidy strategy to maximize the platform's profits, which has not been covered by sharing economy studies so far. Moreover, without considering the specific matching process and intricate pricing problem, the model we develop is applicable across a range of very different platforms, including services offering platform and product sharing platform.

Our work is also part of a stream of work in operations management that study the impact of subsidy in supply chain coordination. (Drèze & Bell, 2003; T. A. Taylor, 2002; Zhang, Krishna, & Dhar, 2000) focus on rebates, a payment from a manufacturer to a retailer or consumer. From the retailer's perspective, a rebate is similar to a sales subsidy in that both reward the retailer for purchasing. From the consumer's perspective, a rebate is similar to a purchase subsidy in that both reward the consumer for purchasing. (Drèze & Bell, 2003) find that manufacturers can design the scan-back, which rewards the retailers based on sales, to leave both themselves and retailers better off. (T. A. Taylor, 2002) shows that a properly designed target rebate, in which the rebate is paid for each unit sold beyond a specified target, achieves coordination and a win-win outcome. As distinguished from the channel rebate, a payment from a manufacturer to a retailer, considered by (T. A. Taylor, 2002), (Zhang et al., 2000) focus on different forms of consumer rebates. (Xiao, Yu, Sheng, & Xia, 2005) investigate a price-subsidy rate contract, in which the subsidy rate encourages the retailer to invest in sales promotions, to coordinate the investments of two competing retailers and demand disruptions. However, the sharing economy market, which is part of two-sided market, has a different market structure from the traditional supply chain. In this paper, the platform, who doesn't produce any products, offer subsidies for both supply side and demand side, while a manufacturer plays a role of supplier and subsidy provider simultaneously. Moreover, we study the effects of subsidy considering cross-side network effects, which are not considered in this stream of research.

Conclusion

Recent technological advances in online and mobile communications have enabled sharing economy a massive scale by reducing search and transaction costs. In this study, we extend the two-sided market model of balancing supply and demand by pricing or other on-price instruments to capture the specific characteristics of the sharing economy platforms. In view of the sensitive relationship between supply and demand though platform's subsidy level, we develop an analytical framework to study how the platform with cross-side effects should strategically choose

the subsidy object and the subsidy level to maximize its profits. We consider providers heterogeneous in their opportunity cost or time cost and customers heterogeneous in their valuation of the performance of the platform.

There are several future research directions to enrich our findings. First, our results hold for monopoly platforms. It would be interesting to expand the model to competitive model, in which the incumbent platform's ability to extract customer and provider surplus will be moderated. From the perspective of customers and providers, they may benefit more from the sharing, depending on the level of competition and whether they are single-homing or multi-homing. Second, we only study the subsidy strategies in one period, in which the platform selects a single pair of subsidy levels. We can future include two more periods to study dynamic subsidy strategies. Third, introducing a general matching function allow us to characterize the number of transactions in a general and tractable way without considering the complicated transaction process. Future research can complement the model with micro-level approach that characterizes the specific transaction process considering the effect of customers' waiting time on demand or the effect of congestion on supply.

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